

DEPARTMENT OF ENVIRONMENT
ENVIRONMENTAL PROTECTION SERVICE
PACIFIC REGION

PROPOSED PETROCHEMICAL PLANT AND
TERMINAL FACILITIES IN THE PROVINCE
OF BRITISH COLUMBIA - An Overview

S. Hum
G. Miller
D. Poon

For the DOE/DFO Petrochemical Task Force

April 1982

LIBRARY
DEPT. OF THE ENVIRONMENT
ENVIRONMENTAL PROTECTION SERVICE
PACIFIC REGION

TD Hum, S. (Suling)
899 Proposed petrochemical
C5 plant and terminal
H84 facilities in the
1982 Province of B.C. :
an overview.

TD Hum, S. (Suling)
899 Proposed petrochemical
C5 plant and terminal
H84 facilities in the
1982 Province of B.C. :
an overview.

Date Due

ENVIRONMENTAL PROTECTION BOARD
PROVINCE OF BRITISH COLUMBIA
DEPT. OF THE ENVIRONMENT
VICTORIA

SUMMARY

A number of petrochemicals are of serious concern when discharged to the environment. These include: vinyl chloride (VCM), ethylene dichloride (EDC), ammonia, acids or bases, chlorine, benzene, and ethylbenzene.

The greatest potential for major environmental impacts from petrochemical developments will be from spills related to marine loadout facilities (docks and storage terminals), pipelines and railcar transportation. Risk analysis and contingency planning is very important in preventing and mitigating spill events. Shipment of hazardous or toxic chemicals in bulk on important salmon resource water bodies such as the Fraser River is not recommended.

Technology is available to control wastewater discharges and atmospheric emissions from petrochemical plants. Resource companies have indicated that "Best Available Control Technology (BAT)" will be installed to minimize emission levels.

The application of advanced wastewater treatment technology will generate solid wastes for disposal - some of which may be considered hazardous. Currently, there are no hazardous waste landfills in British Columbia. Toxic leachates may be produced from landfill operations in coastal areas subjected to high rainfall.

TABLE OF CONTENTS

	<u>Page</u>
SUMMARY	
1 BACKGROUND	1
2 B.C. PETROCHEMICAL DEVELOPMENT PROPOSALS	4
3 PACIFIC COASTAL PLANT AND TERMINAL SITING	8
4 FEDERAL ENVIRONMENTAL LEGISLATIVE MANDATE FOR PETRO- CHEMICAL PLANT FACILITIES, TERMINALS AND APPROACHES	12
4.1 Federal Acts and Environmental Review Processes	12
4.1.1 Petrochemical Plant Facilities	13
4.1.1.1 Fisheries Act	13
4.1.1.2 Clean Air Act	14
4.1.1.3 Ocean Dumping Control Act	14
4.1.1.4 Environmental Contaminants Act	14
4.1.2 Petrochemical Transshipment, Loadout Facilities and Approaches	15
4.1.2.1 Fisheries Act	15
4.1.2.2 Migratory Birds Convention Act	15
4.1.2.3 Navigable Waters Protection Act	16
4.1.2.4 Canada Shipping Act and Regulations	16
4.1.2.5 National Harbours Board Act and Harbour Commission Act	17
4.1.2.6 Transportation of Dangerous Goods Act	17
4.1.2.7 Railway Act	17
4.1.2.8 National Energy Board Act	18
4.1.3 Environmental Review Processes	18
4.1.3.1 Environmental Assessment and Review Process (EARP)	18

		<u>Page</u>
4.1.3.2	TERMPOL	19
4.2	Provincial Legislation	20
4.3	Federal - Provincial Accords	20
5	PETROCHEMICAL PLANT DISCHARGES AND WASTES	22
5.1	Atmospheric Emissions	22
5.2	Wastewater Discharges	23
5.3	Solid and Liquid Wastes	24
5.4	Canterra Proposal	24
5.5	Canoxy - Dome Proposal	25
5.6	Westcoast Fertilizer Proposal	26
5.7	Other Proposals	26
6	ENVIRONMENTAL PROPERTIES OF MAJOR CHEMICALS	26
6.1	Aquatic Concerns for Major Chemicals	29
6.1.1	Ammonia	29
6.1.2	Chlorine	29
6.1.3	Ethylene Dichloride	29
6.1.4	Hydrogen Chloride	30
6.1.5	Methanol	30
6.1.6	Sodium Hydroxide	30
6.1.7	Vinyl Chloride Monomer	31
6.1.8	Acetic Acid	31
6.1.9	Benzene	31
6.1.10	Ethylbenzene	32
6.1.11	Styrene (Monomer)	32
6.1.12	Vinyl Acetate	33
7	PETROCHEMICAL SPILLS AND GASEOUS RELEASES	34

	<u>Page</u>
REFERENCES	36
APPENDIX I LIST OF CHEMICALS: PRODUCTS, INTERMEDIATES AND AND FEEDSTOCKS	38
APPENDIX II LIST OF CHEMICALS FOR POSSIBLE EXPORT FROM ALBERTA	39
APPENDIX III EXCERPTS FROM THE "HANDBOOK OF TOXIC AND HAZARDOUS CHEMICALS" by Marshall Sittig	40

1 BACKGROUND

With the increased interest and potential for petrochemical mega-development, production and movement within the Province of B.C., Dr. J. Wiebe, Chairman, Pacific Regional Screening and Coordinating Committee requested that the DOE/DFO Petrochemical Task Force prepare an overview report of the petrochemical plant and terminal developments potentially affecting the Province. The development generally fell into two categories. One was the manufacture of petrochemicals within the Province, and demanded guaranteed, inexpensive sources of feedstock; adequate and efficient transportation infrastructures; ample storage and processing facilities and terminal capacities for ocean going vessels. The other involved the movement of Alberta produced petrochemical products through B.C. to a common marine terminal on the Pacific Coast for product transshipment to export markets, notably the Pacific Rim countries.

Late last year, Dr. George W. Grovier agreed to chair hearings under the B.C. Natural Gas Allocation Process held to determine actual provincial reserves of natural gas. Terms of reference for the hearing cover natural gas, ethane, propane and butane and involve finding answers to five basic questions: What are the domestic requirements, now and in the future? What is the domestic supply? What procedures should the province use in determining the surpluses? What are the magnitudes of the surpluses and what specific permitting procedures should be established for industries using surplus gas? The inquiry report is expected in May, 1982.

Simultaneously, under the Natural Gas Allocation Process, the B.C. Ministry of Energy, Mines and Petroleum Resources with assistance from other provincial ministries and informal input from members of the DOE/DFO Petrochemical Task Force is evaluating the eleven natural gas proposals competing for use of the gas surplus in terms of benefit to the province, including potential for job creation, provincial revenues and development of gas reserves. The proposals include pipeline, LNG and petrochemical/

fertilizer projects. Taken in total, the projects would consume far more than the currently available supply of natural gas in B.C. It is generally felt that present B.C. supplies will only support one or two new petrochemical plants and/or one LNG project.

Companies whose proposals are ultimately selected by the provincial process will then likely be subjected to a thorough provincial assessment involving either the Environmental Management Act or the Public Utilities Commission Act. They will also be subject to an intensive federal review, either through the Environmental Assessment Review process, or through normal regulatory procedures. For example, any manufacturing plant will have to satisfy requirements of the Fisheries Act with respect to effluents discharged to waters frequented by fish and potential alienation of habitat due to foreshore development. Plants manufacturing vinyl chloride or polyvinyl chloride must meet the requirements of the Vinyl Chloride National Emission Standards Regulations promulgated under the Federal Clean Air Act. Spill contingency plans and a good prevention program will also be required by Environment Canada and by Fisheries and Oceans Canada. In addition, a federal assessment through TERMPOL, a review mechanism administered by the Canadian Coast Guard, is possible. In the case of TERMPOL, Environment Canada and Fisheries and Oceans Canada together with the Canadian Coast Guard, will undertake a TERMPOL code review of any new marine terminal proposed to handle petrochemicals.

The Alberta government is currently requesting proposals for the construction and operation of a petrochemical liquid bulk terminal facility in B.C. to handle Alberta petrochemical products. Two alternative proposed sites, both at Prince Rupert, include the south end of Kaien Island (owned by B. C. Development Corporation) and a site at Ridley Island south of the planned coal terminal (owned by National Harbours Board). The facility will be expected to begin operation in late 1984. Initially, it will have

a capacity for 2.0 million tonnes per annum, but eventually will have a capability for 4.0 million tonnes per annum.

The DOE/DFO Petrochemical Task Force members have already provided technical information and opinions to the Province of B. C. on a number of issues of federal interest arising from the natural gas proposals for B. C. In the near future, they will participate in the evaluation of the various Alberta petrochemical port and storage facility proposals. And recently, they completed a review of the petrochemical industry's processes and process wastes, the applicable federal legislative requirements, and the physical and chemical properties and environmental effects of the chemicals involved.

2 B.C. PETROCHEMICAL DEVELOPMENT PROPOSALS

The petrochemical industry is experiencing strong growth in Alberta. Some 15 projects costing approximately \$5 billion by completion date in 1986, are in the construction or planning stages (Canadian Petroleum Association, 1982). In B.C., with an estimated annual surplus of only 50-75 bcf of natural gas available to the petrochemical industry, feedstock is one of the limiting factors. Project development proposals submitted last December at the request of the B.C. government have a combined gas requirement of more than 830 bcf per annum and a total capital investment of more than \$14 billion.

In its December 2, 1982 press release, the B. C. Ministry of Energy, Mines and Petroleum Resources published brief descriptions of nine of the proposals. They include the following:

2.1 Mitsui Toatsu Chemicals Inc.

A \$324-million project requiring 14 bcf of gas a year. It would produce ammonia and urea and had a projected start-up date of late 1985 or early 1986. During construction, the project would employ a work force of 840 and when completed, provide 224 permanent jobs. There is no site specified for this project.

2.2 Ocelot Industries Ltd.

Two projects with a combined value of \$446 million requiring 25 bcf of gas a year. Products from the development would be methanol, ammonia and urea and the project has a 1984 start-up date. The company's proposal calls for a construction work force of 700 and the project would create 185 permanent jobs. The project would be located at Kitimat.

2.3 Canterra Energy Ltd., Enterprise Miniere et Chimique Sumitomo Corporation.

The consortium proposed a \$1.6-billion investment in a project

which would produce ethylene-based petrochemicals, potassium sulphate fertilizer and sodium sulphates. Annual gas requirement would be 32 bcf a year and the project would start up in 1986. The estimated construction work force would be 3,000 and the project would provide 660 permanent jobs. A site in the lower Mainland or on the North Coast would be suitable for this project, they say. However, the consortium has recently identified two acceptable Lower Mainland sites: a 500 acre site on the west end of Annacis Island, and a 650 acre site of river front industrial land between Nelson and Number 7 Road in southeast Richmond. The Richmond landfill occupies part of the latter area.

2.4 Petro-Canada Exploration Inc., Westcoast Inc., Westcoast Transmission Co. Ltd., Mitsui & Co. Ltd.

This proposal outlines a \$1.4-billion project to produce liquified natural gas and would require 115 bcf of gas annually. Start-up date would be 1987. A total of 1,565 jobs would be created during construction and when in operation the project would have 69 permanent employees. Kitimat is the proposed site.

2.5 B.C. Resources Investment Corporation, Union Oil Company of California, Westcoast Transmission Co. Ltd.

This consortium proposed a \$630-million development to produce ammonia and urea, with an annual gas requirement of 20 bcf. The construction work force for the project, which has a 1985 start-up date, would be 850 and it would create 240 permanent jobs. Powell River, Port Mellon or Duke Point are listed as possible project sites, depending on the route selection for the Vancouver Island pipeline.

2.6 Carter Energy Ltd., Noranda Gas Industries, Canadian Hunter Exploration Ltd., Daewoo Industrial Co. Ltd., Sumitomo Corp., Marubeni Corp.

Two projects with a combined value of \$5.6 billion are outlined

by this consortium, one involving production of liquified natural gas, the other, ethane-based petrochemicals. The annual gas requirements for the two developments would be 200 bcf and start-up date would be 1987. The construction work force would be 2,700 and the two developments would create 650 permanent jobs. This project would be located somewhere on the North Coast.

2.7 Dome Petroleum Ltd., Trans-Canada Pipelines, Nova - an Alberta Corporation, NIC Resources Inc.

This proposal outlines a \$3-billion investment to build a pipeline, liquefaction and shipping facilities, including special ships, to carry liquified natural gas. It would require 170 bcf of gas a year and have a start-up-date of late 1985 or early 1986. During construction, the work force would be 1,600 and the development would create 92 permanent jobs. The proposal has identified the Grassy Point area, about 25 kilometers north of Prince Rupert, as the preferred site for the LNG plant and marine terminal.

2.8 Canadian Occidental Petroleum Ltd., Dome Petroleum Ltd., Mitsubishi Companies, Westcoast Transmission Co. Ltd.

This consortium proposes a \$1.4-billion project to produce ethane-based petrochemicals. It would require 36 bcf of gas a year and start operations in 1986. The development would involve an inland feedstock complex, likely near Chetwynd, and a petrochemical complex, which has been considered for the Prince Rupert area, although other areas of the province are still under active consideration. The project would have a work force of 4,500 during its construction stage and when completed, result in 652 permanent jobs.

2.9 Westcoast Transmission Co. Ltd.

The proposal calls for extension of existing export contracts

to the United States from 1989 to 1999. This gas would be required to meet the expected export demands when existing contracts expire. The requirements of the proposal are for 220 bcf annually. Existing facilities will be used so there will be no construction costs or work force requirements.

3 PACIFIC COASTAL PLANT AND TERMINAL SITING

In selecting site(s) for petrochemical plants and terminals, environmental, socioeconomic, safety, engineering and economic parameters should be examined. Environmentally speaking, plant and terminal siting and process activities can change the integrity and use of the coastal zone. The fact that both the products and intermediaries are considered to be generally hazardous and/or toxic materials to marine and freshwater ecosystems, as well as to people are further complications to siting decisions. A challenge therefore exists for ensuring that siting of these facilities will minimize impact and protect sensitive coastal habitat and resources.

Some work related to petrochemical facility and terminal siting and alternatives has been done previously by ...

3.1 Dow Bulk Terminal Proposal for Tilbury Island

In 1978, Dow Chemical Company proposed to locate a bulk loadout terminal and storage facility for ethylene dichloride and sodium hydroxide at Tilbury Island at the mouth of the Fraser River. A joint DOE/DFO review of this project identified a major risk to the salmon resource of the Fraser River and Estuary if a large spill were to occur at the terminal. Investigations by Dow with assistance from NHB identified an alternate site in Burrard Inlet. A federal precedent has therefore been established regarding the storage and shipment of hazardous or toxic chemicals on the Fraser River.

3.2 Previous Port Siting and Selection Studies

Responding to enquiries as to possible locations for bulk chemical port and for tidewater industrial sites, the B. C. Ministry of Environment prepared a set of criteria applicable to selecting potential sites; then identified potential port sites either at or within 30 km of existing railheads. Two areas not included in the report - Sechelt

Peninsula and Vancouver Island - were both of interest to the DOE/DFO Task Force for one of the development proposals identified sites in those two locations.

A workshop consisting of various federal and provincial agency representatives was then held. Its purpose was to analyze the listed sites with a view to determining the general suitability for bulk chemical handling, to highlighting factors which might severely limit their potential utility, and to identifying major environmental and technical constraints to petrochemical port siting on the West Coast. The document (Slater and Abs, 1981) which resulted from this workshop did an adequate job of overviewing and highlighting the key known concerns and issues for each of the sites. The sites included 9 in the Prince Rupert area, 6 within the Kitimat area, 3 within Howe Sound, 4 within the Vancouver area, and 4 in the Lower Fraser River. No one site was recommended over another.

It is noted that Fisheries and Oceans Canada asked that fisheries related comments be deleted from the report and that contact on such matters be made directly with the Department. The Department felt that a more comprehensive evaluation of potential impacts on fisheries was required.

3.3 RSCC Review Paper

An overview paper (J. Millen, 1981) reviewing possible locations for marine terminals to export petrochemical products via the B.C. Coast. Based on rail access, site choices were limited to the following areas:

- Lower Mainland - Fraser River
 - Roberts Bank
 - Burrard Inlet
 - Howe Sound

- Kitimat

- Prince Rupert
- Inner Harbour
- Ridley Island
- Port Simpson

The review provided the following conclusions:

- There are very few sites on the B. C. coast adequately served by rail, physically suitable for a terminal and which do not encroach on valuable estuarial habitat.
- The following sites seem to be worth a detailed examination:
 - Burrard Inlet for expansion of existing terminals
 - Howe Sound - Britannia Beach, etc.
 - Port Simpson depending on potential development of rail access
 - Ridley Island
 - Roberts Bank for a non-toxic product
- Any new major terminal to handle a variety of products should be a 'common carrier' terminal providing facilities to all requiring service. This would help avoid the proliferation of terminals, reduce the pressure to encroach on more shorelands and minimize environmental disruption.
- Sites suitable for terminals should be retained for that purpose and not used for manufacturing industries so as to prevent foreclosure on options for the future transportation of products.

3.4 LNG Siting Documents

Detailed information and analysis in particular areas, two confidential LNG siting documents (Dunbar, 1982 and Tera Environmental Consultants Ltd., 1981) are referenced.

The Petro-Canada report (Dunbar, 1982) using ratings in 4 categories of safety, environmental, socio-economics and project economics selected Kitimat Arm to be the best location on the B. C. coast for the LNG export terminal of over 33 potential sites. Five sites on Kitimat Arm - Gobeil Bay, Clio Bay, Bish Bay, Emsley Cove, and Markland Point - were found to be of approximately equal suitability.

The Dome report (Tera Environmental Consultant, 1981 and the Swan Wooster Engineering Co. Ltd., 1981) evaluated 26 potential terminal sites and finally produces the following ranking of preferred sites: Grassy Point (Port Simpson Bay), Chesnucknuw Creek/Colemen Creek (Alberni Inlet), Britannia (Howe Sound), Emsley Cove/Bish Creek (Kitimat Arm), Texada Island (Strait of Georgia). Grassy Point was identified as the preferred terminal location.

As described in studies mentioned above, only a few coastal areas such as the Lower Mainland (Port of Vancouver) region and the Prince Rupert /Kitimat area are able to meet the needs of such mega-developments.

On April 6, 1982, Energy Minister Bob McClelland and Industry Minister Don Phillips announced that:

- the provincial government wanted development of natural gas processing industries restricted to the interior and north of the province, thereby eliminating the Canterra Energy Limited petrochemical/fertilizer project proposed for the Lower Mainland area;
- the government endorsed development of an ammonia/urea fertilizer industry or a petrochemical industry;
- the government was also in favour of an LNG project, although gas for such a plant would have to come from outside B.C.

4 FEDERAL ENVIRONMENTAL LEGISLATIVE MANDATE FOR PETROCHEMICAL
PLANT FACILITIES, TERMINALS AND APPROACHES

4.1 Federal Acts and Environment Review Processes

The federal acts and environmental review processes of significance to the petrochemical proposals are listed below:

- Fisheries Act;
 - Clean Air Act;
 - Ocean Dumping Control Act;
 - Environmental Contaminants Act;
 - Migratory Birds Convention Act;
 - Navigable Waters Protection Act;
 - Canada Shipping Act and Regulations;
 - National Harbours Board Act and Harbour Commission Act;
 - Transportation of Dangerous Goods Act; and
 - Railway Act.
-
- Environmental Assessment and Review Process (EARP); and
 - TERMPOL.

4.1.1 Petrochemical Plant Facilities

For purposes of this section, reference to federal environmental legislative mandate will deal with plant operations which include processing units and offsites. Offsites may include tank farms, feed water treatment, steam or power generation units, cooling towers, loading docks and flare equipment. Feedstock and product pipelines and separate loadout terminals will be dealt with in section 4.1.2

4.1.1.1 Fisheries Act

General provisions of the Fisheries Act under Sections 31 and 33 specifically prohibit the harmful alteration, disruption or destruction of fish habitat and the deposition of deleterious substances of any kind into waters supporting fish. These Sections apply to the construction and operation of petrochemical facilities. In addition, Section 33.(13) allows for the establishment of regulations which deal with the authorization of the deposit of deleterious substances.

Currently, there are no specific federal regulations to control wastewater discharges from petrochemical or fertilizer plant operations. However, general provisions of the Fisheries Act apply in this case. Normally, wastewater discharges from industrial operations are controlled through the effluent permit system administered by the Ministry of Environment for British Columbia. This will be dealt with in more detail in the section on Federal-Provincial accords.

4.1.1.2 Clean Air Act

Regulations have been promulgated under the Clean Air Act to control emissions of vinyl chloride to the atmosphere from vinyl chloride or polyvinyl chloride plants in Canada. There are no other regulations that are applicable to the petrochemical industry.

Ambient air quality objectives have also been established under the Clean Air Act for sulphur dioxide, carbon monoxide, suspended particulate matter, ozone and nitrogen dioxide.

As with the Fisheries Act, federal concerns are normally implemented by the Ministry of Environment for B. C. through its administration of the air emission permit system.

4.1.1.3 Ocean Dumping Control Act

The disposal of wastes at sea is regulated by a permit system under the Ocean Dumping Control Act. Permits are designed to protect human health, marine life and any other legitimate use of the sea. Wastes are classified under three schedules depending on their potential effects on the marine environment.

Petrochemical plants located in coastal areas of British Columbia may attempt to dispose of some of their solid or liquid wastes or dredge spoils at sea as an alternative to land disposal. Under the Ocean Dumping Control Act, there are restrictions on the dumping of materials at sea which contain heavy metals (mercury, cadmium, arsenic, lead, copper, zinc, chromium), organohalogen compounds (chlorinated hydrocarbons), oils and plastics.

4.1.1.4 Environmental Contaminants Act

The Environmental Contaminants Act is directed at the protection of the environment through control of the importation, manufacture, use,

disposal and sources of entry of substances resulting in a threat to human health or the environment.

To date, regulations have been developed for the use of polychlorinated biphenyls (PCB's), polybrominated biphenyls (PBB's), Mirex, polychlorinated terphenyls (PCT's) and chlorofluorocarbons (CFC's) in Canadian commerce. PCB's are now prohibited for use in new electrical transformers and capacitors.

Other chemicals are under investigation to determine whether regulations or other action is necessary. These candidate substances include: cadmium, chlorophenols, chlorobenzenes, hexachlorobutadiene (HCBD), organotins, phthalic acid esters, chlorinated paraffins, chloroethanes, chloroethylenes and chloromethanes.

Proposed petrochemical or fertilizer plants manufacturing or using any of these chemical compounds (most likely the latter four compounds) must conform to current and possible future regulations under the Environmental Contaminants Act.

4.1.2 Petrochemical Transshipment, Loadout Facilities and Approaches

4.1.2.1 Fisheries Act

General pollution provisions of the Fisheries Act apply to the transport and storage of bulk chemicals, particularly for spill related events. Reference section 4.1.1.1 for more detail.

4.1.2.2 Migratory Birds Convention Act

Regulations under Section 35 of this Act make it an offence for any person to deposit or permit the deposit of oil, oil wastes or any other substance harmful to migratory birds in water or areas frequented by

migratory birds, including wildlife sanctuaries. This provision can have some application to the regulation of discharge of oil and other hazardous polluting substances from onshore and offshore facilities and estuarine habitats or sanctuaries.

Fines are nominal however and no permit system has been included.

4.1.2.3 Navigable Waters Protection Act

The Ministry of Transport administers this Act. It was developed to protect navigable waters for the purposes of navigation.

The Act is explicit with respect to the building or placing of work in, upon, over, under, through or across navigable water unless the work and the site and plans have been approved by the Minister or his designated representative prior to the commencement of construction. Anyone contravening the conditions may be ordered to remove the work or to have it removed for him with all costs to be recovered from the owner. This Act is applicable to loadout terminals and other shore facilities which would interfere with navigation.

4.1.2.4 Canada Shipping Act and Regulations

The Act's environmental provisions are two fold. The first deals with prohibiting pollutant discharges and the second with civil consequences which arise because of the discharge.

The Act authorizes Cabinet to make regulations prohibiting the discharge from ships of any pollutant specified in the Regulations. The Regulations, therefore, not the Act itself prohibits the discharge. Examples of Regulations include the following:

- Oil Pollution Prevention Regulations - the discharge of oils and persistent oily mixtures is prohibited;

- Pollutant Substances Regulations - the discharge of 21 substances including arsenic, lead, mercury and phosphorus is prohibited; and
- Garbage Pollution Prevention Regulations - the discharge of garbage but not sewage is prohibited.

Regulations with respect to the transportation of dangerous goods is also stipulated.

4.1.2.5 National Harbours Board Act and Harbour Commission Act

The Acts govern harbour operation giving the respective port authorities basic control over the use and occupancy of the harbour. Where a proposal will be sited on National Harbours Board or Commission land, the federal agency is responsible for administering the property. It also has control over shipping transport within the boundaries of its jurisdiction.

The harbours relevant to B. C. under the NHB Act are Vancouver and Prince Rupert Harbours. Those relevant to the Harbour Commission Act are: Fraser River, Nanaimo, North Fraser River and Port Alberni.

4.1.2.6 Transportation of Dangerous Goods Act

The Act intends to establish uniform, non-conflicting standards applicable to the handling and transport of dangerous goods by all modes of transportation in Canada with the exception of dangerous goods under the control or direction of the Minister of National Defence, the transport of oil and gas by pipeline and the transport of dangerous goods within the intent of the Canada Shipping Act.

The Act encompasses the protection of public safety and the environment. The mechanisms for its administration and enforcement are currently being developed between the federal and provincial governments.

4.1.2.7 Railway Act

This Act regulates the construction, operation, maintenance and abandonment of railways. Railway companies are subject to the jurisdiction of the Canadian Transport Commission's (CTC's) broad powers for regulating all railway companies and railways involved in interprovincial movement of goods and services. These powers extend to making orders and regulations to provide for the protection of property and the protection, safety, accommodation and comfort of the public. The protection of the environment is not explicitly stated except in those cases where a threat to public safety results from a discharge of oil or other hazardous polluting substances to the environment. Also, prior to construction of new facilities or additions, public hearings may be held if such would be in the best interest of the public.

4.1.2.8 National Energy Board Act

The purpose of the Act includes the approval and regulation of the construction and operation of interprovincial and international oil and gas pipelines and international power lines as well as the export of oil and gas. These functions are the responsibility of the National Energy Board (NEB) established under the Act. In addition, the NEB has developed environmental and socioeconomic guidelines.

The National Energy Board is responsible to the Minister of Energy, Mines and Resources.

4.1.3 Environmental Review Processes

4.1.3.1 Environmental Assessment and Review Process (EARP)

EARP is applicable to all federal departments for projects initiated by the federal government or where federal funds and/or property is involved. It serves to ensure that:

- environmental impacts are identified and taken into account early in the planning of new federal projects, programs and activities;
- an environmental assessment is carried out for all projects which may have an adverse effect on the environment before commitments or irreversible decisions are made; and
- the results of these assessments are used in planning, decision-making and implementation.

Use of EARP is not binding on the National Harbours Board or on the Harbour Commissions, but remains an option which can be pursued. Its application will ensure federal government protection concerns are dealt with.

4.1.3.2 TERMPOL

The TERMPOL Code is a code for recommended standards for prevention of pollution in marine terminal systems. It outlines acceptable ship terminal standards, defines ship terminal system analysis and assessment criteria and develops operating practices and procedures for ship terminals. It also provides guidelines on environmental and risk analysis factors.

The provisions of the TERMPOL Code are not in themselves mandatory. However, the assessment criteria of the Code are used by the Canadian Coast Guard in determining the technical needs, if any, for making regulations or implementing special precautionary measures limiting navigation within the ship terminal system.

The Code does not concern itself with the terrestrial environmental areas within the ship terminal system. These areas include:

- all land areas and rivers above the tidal influence;

- shore installations; and
- hinterland cargo handling or storage facilities.

Adherence to the TERMPOL Codes recommendations and procedures will reduce the risk of marine accidents, minimize the pollution hazard, and provide reliable guidelines in the selection of a ship terminal site.

4.2 Provincial Legislation

Current Pollution Control Objectives for the Chemical and Petroleum Industries (B.C. Pollution Control Branch, 1974) issued under the provincial Pollution Control Act are not broad enough in scope to cover off the proposed petrochemical and fertilizer plant operations. The existing guidelines can only be changed through a process involving a public inquiry. However, as an interim measure, the Waste Management Branch may issue control requirements on a plant-by-plant basis. Therefore, requirements for specific parameters not outlined in the current objectives for the chemical industry may be included in permits issued by the Director of the Waste Management Branch.

Permits may be appealed to an independent Environmental Appeal Board as specified by the Waste Management Act.

An ongoing cooperative federal-provincial effort has been established to determine what constitutes best available treatment technology and criteria for chemical concentrations in the receiving environment.

4.3 Federal - Provincial Accords

No formal accord has been signed between Environment Canada and the province of British Columbia detailing the way in which the two government agencies will implement federal legislation.

However, the Environmental Protection Service has established an informal mechanism for reviewing provincial air, wastewater and solid waste permits to allow input of federal concerns to the Provincial process.

If a mutual federal-provincial agreement cannot be reached on a specific issue, then the Environmental Protection Service and/or the Department of Fisheries and Oceans may deal directly with the company on the matter.

5 PETROCHEMICAL PLANT DISCHARGES AND WASTES

Technology is available to control atmospheric emissions and wastewater discharges from petrochemical plants to a high degree. Most proponents have stated that they will install Best Available Control Technology to minimize plant emissions.

There are four broad categories of emissions associated with petrochemical type operations:

- Atmospheric Emissions
- Wastewater Discharges
- Solid and Liquid Wastes
- Spills and Plant Upsets

Petrochemical spills and gaseous releases will be dealt with separately in Section 7.

5.1 Atmospheric Emissions

Captive and fugitive emissions of vinyl chloride will emanate from vinyl chloride and polyvinyl chloride plants.

Hydrocarbons will be emitted from all types of petrochemical plants. Sources of hydrocarbon emissions include material handling, raw material and product storage and manufacturing processes. Oxides of sulphur, oxides of nitrogen, carbon monoxide and particulate matter will be released from the manufacturing processes - especially from the combustion of fuels. Quantities of emission are dependent upon plant capacity, the type of fuel used, types of process adopted, and type of product manufactured. In addition, depending on the chemical produced, various types of volatile organic compounds will be emitted in the form of captive and fugitive emissions.

An assessment of the impact of air emissions must take into consideration the physical setting of the plant, meteorological conditions of the area, and local air quality as affected by other emission sources and land use patterns. Environmental concern is due to the fact that vinyl chloride and other chlorinated hydrocarbons pose human health risks, hydrocarbons are precursors of photochemical oxidants, and many volatile organic compounds have unpleasant odours.

5.2 Wastewater Discharges

Modern petrochemical plants may be designed to maximize water reuse. This will reduce the quantity of wastewater discharged as well as fresh water make-up requirements.

Water reuse may be accomplished by extensive process wastewater and storm runoff treatment followed by recycling of the upgraded water back to process units, steam utilities or the cooling tower circuit. This limits major discharges to cooling tower blowdown, unused stormwater and other streams which are relatively clean.

Process wastewater treatment steps may include: neutralization (pH control), oil and grease removal, total suspended solids and/or dissolved solids removal, biological oxidation for the removal of organic and nitrogen compounds and finally filtration and/or activated carbon as a final polishing step.

Storm runoff collection and treatment facilities deserve special consideration in areas of high rainfall. Adequate retention capacity must be provided so that treatment systems are not overloaded.

Cooling tower blowdown requires treatment for the removal of zinc and hexavalent chromium prior to discharge. These heavy metals are used to control algal growth in the cooling tower circuit to prevent the fouling of heat exchange equipment. Zinc and hexavalent chromium may be removed by ion exchange and precipitation. This produces a hazardous waste sludge containing heavy metals.

5.3 Solid and Liquid Wastes

A number of hazardous solid and liquid wastes may be generated from petrochemical plant operations. These may include: chlorinated organic compounds, process catalysts, inorganic salts and heavy metal sludges.

Normally, chlorinated organic compounds are destroyed on-site by high temperature incineration. There is some concern that small quantities of toxic compounds such as dioxin are present in the combustion off-gases from these types of operations.

The provision of best available control technology (BAT) for atmospheric and wastewater discharges may also produce hazardous solid and liquid wastes. A good example are the heavy metal sludges removed from cooling water blowdown.

Currently, there are no landfill-type operations in British Columbia capable of handling hazardous wastes. Compounding this problem, the proposed plants will be located in coastal areas subjected to high rainfall. Infiltration into on-site landfills may require leachate treatment for detoxification prior to discharge into receiving waters.

A joint Federal-Provincial committee for hazardous waste disposal has been working on this problem. Most likely, a secure landfill will be located in the British Columbia interior where rainfall and subsequent infiltration will be minimal. A central disposal facility will require a regional collection, pretreatment and transportation network.

5.4 Canterra Proposal

There are two major water pollution concerns for the proposed Canterra petrochemical plant to be located in the lower mainland. They are:

- disposal of large quantities of hazardous wastes; and
- potential for spills of hazardous chemicals being shipped on the Fraser River. Example: ethylene dichloride.

In order to minimize the quantity and quality of process wastewater discharged to the Fraser River, Canterra will produce a number of hazardous solid wastes from evaporation processes - one of which will be 60,000 kg/day of calcium and sodium salt mixture contaminated with chlorinated organics and copper. There are no secure landfills in the lower mainland capable of handling this type of material. There are also reservations about allowing the material to be dumped at sea.

Until the Canterra plant can market all of its PVC domestically, some Ethylene Dichloride (EDC) must be exported. The proposal calls for shipment of this material on the Fraser River from Annacis Island or a site near the Richmond landfill. EDC is a toxic material that will sink in water. A transportation or loading accident on the Fraser River could have serious impact on the salmon resource depending upon the time of year. Also due to the flow in the river, the EDC would be impossible to recover. The impact of EDC on the Fraser River estuary is of concern.

As for air pollution, concern is raised regarding the VCR (Vapourization of Chlorinated Residues) process, for which a backup measure has not been indicated. In the event of a VCR process upset, a large amount of chlorinated chemicals will be released into the atmosphere.

5.5 Canoxy-Dome Proposal

There was insufficient information provided by the proponent to adequately review the project. The disposal of hazardous materials is of concern because of the high rainfall in the Prince Rupert area. Significant infiltration into a secure landfill would require leachate treatment prior to discharge to a receiving environment.

Concerning air pollution, this proposal indicated the use of low NOx burner. The use of this technology should be encouraged. Also, backup systems should be provided for the VCM incinerator and the flare. In the event of malfunctioning, the backup system would prevent large amounts of VCM and other contaminants from being released into the atmosphere.

5.6 Westcoast Fertilizer Proposal

There are three major water related concerns not adequately addressed by the proponent in its preliminary submissions. These are:

- removal of ammonia and urea from process wastewater;
- removal of zinc and hexavalent chromium from cooling tower blowdown; and
- contamination of cooling water with ammonia from process vents.

Ammonia is both a nutrient and a known fish toxicant. Therefore, this material must be removed adequately from process wastewater and cooling tower blowdown prior to discharge to the marine environment.

Zinc and hexavalent chromium are toxic heavy metals. These must also be removed by ion exchange and precipitation prior to discharge.

5.7 Other Proposals

Not enough information was available to review other proposals.

6 ENVIRONMENTAL PROPERTIES OF MAJOR CHEMICALS

Large volume chemicals that may be manufactured or used in the proposed petrochemical or fertilizer plants have been listed in Appendix I. This list was compiled from company submissions. Chemicals have been

classified as feedstocks, intermediates or products. Intermediates are those chemicals which are formed and then processed to manufacture other chemicals on-site or sold as product.

Smaller quantities of other chemicals or those formed as by-products in process reactions have been excluded from the list of chemicals in Appendix I.

Chemicals which may be transported to the West Coast from new facilities or plant expansions in Alberta are listed in Appendix II.

These chemicals were evaluated for their environmental effects based on the following designations (Sittig, 1981) indicating whether the substance is a:

- carcinogen
- priority pollutant (EPA)
- hazardous substance (EPA)
- hazardous waste (EPA)

Chemicals which are suspected or proven carcinogens are included in the first category. EPA "Hazardous Substances" are those defined under the U.S. Clean Water Act primarily on the basis of toxicity to aquatic life. EPA "Hazardous Wastes" are those defined by the U.S. Resource Conservation and Recovery Act dealing with sources, transportation and disposal of solid and liquid wastes. EPA "Priority Pollutants" include all priority toxic water pollutants defined under the consent decrees of 1976 and 1979 which resulted in final criteria for 129 substances in 1980.

Chemicals identified in Appendix I and II that fall under any of the above four categories are summarized in Tables 6.1 and 6.2 respectively.

TABLE 6.1 MAJOR CHEMICALS OF ENVIRONMENTAL CONCERN FOR BC PROPOSALS

Chemical/Compound	Environmental Category (a)			
	1	2	3	4
Ammonia	-	-	X	-
Chloride	-	-	X	-
Ethylene Dichloride	X	X	X	X
Hydrogen Chloride	-	-	X	-
Methanol	-	-	-	X
Sodium Hydroxide	-	-	X	-
Vinyl Chloride Monomer	X	X	-	X

- (a)
- 1 - Carcinogen
 - 2 - EPA Priority Pollutant
 - 3 - EPA Hazardous Substance
 - 4 - EPA Hazardous Waste

TABLE 6.2 MAJOR CHEMICALS OF ENVIRONMENTAL CONCERN FROM ALBERTA

Chemical/Compound	Environmental Category (a)			
	1	2	3	4
Acetic Acid	-	-	X	-
Ammonia	-	-	X	-
Benzene	X	X	X	X
Ethylene Dichloride	X	X	X	X
Methanol	-	-	-	X
Styrene Monomer	-	-	X	-
Ethylbenzene	-	X	X	-
Vinyl Acetate	-	-	X	-
Vinyl Chloride Monomer	X	X	-	X

(a) refer to Table 6.1

6.1 Aquatic Concerns for Major Chemicals

Under the Federal Fisheries Act, any liquid effluents released from the proposed petrochemical plants to freshwater or marine waters frequented by fish must be non-acutely lethal. EPA has proposed ambient water quality criteria for most of the chemicals of concern. Further information concerning these chemicals may be found in Appendix III.

6.1.1 Ammonia

Ammonia (NH₃) is a colourless, strongly alkaline and extremely soluble gas with a characteristic pungent odour.

Aquatic Criteria: EPA has proposed a limit of 0.02 mg/l (as unionized ammonia) for the protection of freshwater aquatic life.

6.2.1 Chlorine

Chlorine (Cl₂) is a greenish-yellow gas with a pungent odour and slightly soluble in water. As part of the halogen group, it is one of the most chemically reactive of all the elements.

Aquatic Criteria: EPA has proposed the following limits for residual chlorine in water: 0.002 mg/l for salmonid fish and 0.01 mg/l for other fresh water and marine organisms. Chlorine also reacts readily with organic substances to form chlorohydrocarbons some of which are proven or suspected carcinogens.

6.1.3 Ethylene Dichloride

Ethylene Dichloride (Cl-CH₂=CH₂-Cl) or 1,2-dichloroethane is a colourless, flammable liquid, denser than water, moderately soluble in water (0.8 g/100 g) with a boiling point of 84 deg. C.

Aquatic Criteria: For the protection of freshwater aquatic life: acute toxicity basis of 118 mg/l; chronic toxicity basis of 20 mg/l. For the protection of saltwater aquatic life: 113 mg/l on an acute toxicity basis. To protect human health - preferably zero in drinking water.

6.1.4 Hydrogen Chloride

Hydrogen chloride (HCl) is a colourless non-flammable gas and soluble in water.

Aquatic Criteria: Hydrogen chloride when dissolved in water forms hydrochloric acid which lowers the pH. EPA has recommended a pH range of 6.5 - 9.0 to protect freshwater aquatic life and a range of 6.5 - 8.5 for saltwater.

6.1.5 Methanol

Methanol (CH₃OH) or methyl alcohol is a colourless, flammable, volatile liquid with a mild odour and boils at 64.7 deg. C. It is infinitely soluble in water.

Aquatic Criteria: EPA has recommended an ambient objective of 3.6 mg/l based on health effects.

6.1.6 Sodium Hydroxide

Sodium Hydroxide (NaOH) is a white, deliquescent material sold as a solid or dissolved in water. Aqueous solutions are known as caustic soda or lye.

Aquatic Criteria: Sodium Hydroxide when dissolved in water will raise the pH. EPA has recommended a pH range of 6.5 - 9.0 to protect freshwater aquatic life and a range of 6.5 - 8.5 to protect saltwater aquatic life. For drinking water a pH of 5.0 - 9.0 has also been recommended.

6.1.7 Vinyl Chloride Monomer

Vinyl chloride monomer ($\text{CH}_2=\text{CHCl}$) or chloroethylene/chloroethene/monochloroethylene is a colourless, flammable gas at room temperature. It is usually handled and stored in liquid form. VCM is slightly soluble in water (0.11 g/100g @ 25 deg. C.).

Aquatic Criteria: For the protection of human health - preferably zero. There are no ambient water quality criteria for the protection of freshwater and saltwater aquatic life.

6.1.8 Acetic Acid

Acetic Acid ($\text{CH}_3\text{-COOH}$) or ethanoic acid is a colourless liquid with a characteristic pungent vinegar-like odour.

Aquatic Criteria: EPA has proposed an ambient level of 0.35 mg/l based on health effects.

6.1.9 Benzene

Benzene (C_6H_6) is a colourless, volatile, highly flammable liquid with a characteristic odour.

Aquatic Criteria: For the protection of freshwater aquatic life: 5.3 mg/l on an acute toxicity basis. For saltwater: 5.1 mg/l on an acute toxicity basis. To protect human health - preferably zero.

6.1.10 Ethylbenzene

Ethylbenzene ($C_6H_5CH_2CH_3$) is a colourless, flammable liquid with a pungent aromatic odour. Bp of 136 deg. C.

Aquatic Criteria: For the protection of freshwater aquatic life: 32 mg/l on an acute toxicity basis. For saltwater: 4.3 mg/l on an acute toxicity basis. To protect human health: 0.0014 mg/l.

Health Hazard: Causes smarting of the skin and first-degree burns on short exposure; may cause secondary burns on long exposure. Odour Threshold: 140 ppm.

6.1.11 Styrene Monomer

Styrene ($C_6H_5CH=CH_2$) or styrene monomer or vinylbenzene is a colourless to yellowish, very refractive oily liquid with a penetrating odour. Bp of 145 deg. C.

Aquatic Criteria: The US National Academy of Sciences/National Research Council has proposed a no-adverse effects limit of 0.9 mg/l for drinking water.

Health Hazard: Severe skin irritant; causes second and third degree burns on short contact and is very injurious to the eyes. Harmful if swallowed.

6.1.12 Vinyl Acetate

Vinyl acetate ($\text{CH}_3\text{-COOH-CH}_2$) or vinyl acetate monomer is a colourless flammable liquid with a Bp of 73 deg. C.

Aquatic Criteria: No ambient water quality criteria has been proposed for this chemical. Fish bioassays have shown vinyl acetate to be acutely lethal in low concentrations.

- 96 hour TLm of 18 mg/l to bluegill in freshwater
- 48 hour LC50 greater than 100 mg/l to flounder in saltwater

Health Hazard: temporary smarting of eyes or respiratory system if present in high concentrations.

7 PETROCHEMICAL SPILLS AND GASEOUS RELEASES

Accidental liquid spills and gaseous releases from the manufacture, storage and transport of bulk chemicals may have serious impacts on human populations and the environment. These chemical releases normally result from equipment failure, human error or a combination of both of these factors.

Flammable chemicals present fire and explosion hazards. Ignition may result in death and injury to employees and local residents and major loss of equipment or property.

Inhalation of corrosive or toxic chemicals such as ammonia and chlorine may also result in death or serious injury to humans. The extent of damage will depend on exposure. This in turn depends on the quantity and duration of the release, physical properties of the chemical and prevailing meteorological conditions.

Spills of chemicals to marine and fresh waters may have acute and chronic effects on mammals, migratory birds, fish and other aquatic life through direct contact. Chemical contamination of fresh water from spills may render it unfit for human consumption. Some chemicals may persist in the environment and bioaccumulate through the food chain ultimately posing risks to higher species including man. Spills of chemicals may destroy habitat and thereby reduce local resource populations such as salmon.

Spills to land may destroy vegetation and contaminate soils and groundwater.

Due to the potential for serious environmental damage from spills, the proposed petrochemical developments must be critically reviewed to prevent such occurrences or mitigate the effects of accidental releases. A technique known as "potential problem analysis"

may be used for this purpose. It consists of three steps:

- problem anticipation
- threat assessment (risk analysis)
- followup action

Problem anticipation involves asking the question "what could go wrong" about equipment operation or operating procedures that could lead to spill events. Threat assessment or risk analysis involves determining the probability that a spill event will occur and a judgement on the seriousness of the environmental impact. An evaluation of the need to reduce the threat or accept the risk must then be made.

If the environmental impact is high or unacceptable, prevention is required. This involves anticipating the causes and selection of preventative action to reduce the probability of occurrence.

If protection of the environment is required from the spill event contingency action must be planned to mitigate the seriousness of the environmental impacts. In some cases, both preventative and mitigative measures may be required.

This process is quite general and applies to the evaluation of equipment, procedures and training requirements required for prevention and mitigation (contingency planning) of spills.

Redundant or backup equipment and containment devices may be incorporated into plant and transportation system designs to prevent the occurrence of spills or gaseous releases to the environment. Siting considerations, buffer zones, cleanup equipment and contingency plans may be used to reduce the environmental impacts of spill events.

REFERENCES

- B.C. Pollution Control Branch. Pollution Control Objectives for the Chemical and Petroleum Industries of British Columbia. Report from a public inquiry held by the Director of the Pollution Control Branch, March 19, 1974. Refer to Table IX for Chemical Industry Objectives for Marine and Freshwater.
- Canada Interdepartmental Committee on Water and Ontario Interministry Committee on the Great Lakes Water Quality Agreement. Existing and Proposed Programs and Measures for the Prevention of Discharges of Oil or Hazardous Polluting Substances from Onshore and Offshore Facilities. Environment Canada and Ontario Ministry of Environment, 1981.
- Canadian Petroleum Association. "Petrochemical Boom in Alberta", CPA Review, 6 (February, 1982), p. 1-3.
- Canadian Petroleum Association. "B.C. Natural Gas Submission", CPA Review, 6 (February, 1982), p. 7-8.
- Dunbar, R.B. "Siting Rim Gas Project: Site Selection Study for an LNG Facility and Terminal on the West Coast of B.C." A Confidential Report for Petro-Canada, 1982.
- Ince, John G. Environmental Law: A Study of Legislation Affecting the Environment of British Columbia. Vancouver: West Coast Environmental Law Research Foundation, 1981.
- McIntyre, A.D. to D.S. Lacate. "RSCC Project No. P-130, Dow Tilbury Island Storage Tank Farm and Shipping Facility". Memo, Environmental Protection Service, Environment Canada, June 15, 1978, 7pp.
- Millen, J. "Overview of Siting of Petrochemical Marine Terminals in B.C." Unpublished discussion draft, Environmental Protection Service, Environment Canada, 1981.

News Release, B.C. Ministry of Energy, Mines and Petroleum Resources,
December 2, 1981, p. 1-4.

Sittig, M. Handbook of Toxic and Hazardous Chemicals. New Jersey: Noyes
Publications, 1981

Slater, Jim and Susam Abs. "Potential West Coast Port/Industrial Sites. An
Overview 1981-11." A working report, Assessment and Planning
Division, Ministry of Environment, Province of B.C., 1981, 36 pp.

Swan Wooster Engineering Co. Ltd. "Engineering Considerations in LNG
Terminal Selection for Dome Petroleum Limited." A confidential
report, 1981.

Tera Environmental Consultants Ltd. "Environmental Considerations in LNG
Terminal Site Selection for Dome Petroleum Limited." A confidential
report, 1981.

APPENDIX I LIST OF CHEMICALS: PRODUCTS, INTERMEDIATES AND FEEDSTOCKS

Chemical/Compound	Petrochemical Plant (a)			
	1	2	3	4
Ammonia (anhydrous)			I,P	I,P
Butane	p(b)	P		
Chlorine	I	I,P		
Ethane	F	F		
Ethylene	I	I		
Ethylene Dichloride	I,P	I,P		
Hydrochloric Acid	I	I		
Methanol				P
Polyethylene	P	P		
Polyvinyl Chloride	P			
Pentanes plus (condensates)	P	P		
Potassium Chloride (potash)	F			
Potassium Sulphate	P			
Propane	P	P		
Pyrolysis Gasoline	P			
Sodium Chloride (sea salt)	F	F		
Sodium Hydroxide (caustic soda)		P		
Sodium Sulphate	P			
Sulphur	F			
Sulphuric Acid	I			
Urea			P	P
Vinyl Chloride Monomer	P	I,P		

(a) 1 - Canterra Energy Limited
 2 - Canadian Occidental Petroleum Limited
 3 - Westcoast Transmission Limited/Union Oil Limited
 4 - Ocelot Limited

(b) P - Product
 I - Intermediate
 F - Feedstock

APPENDIX II LIST OF CHEMICALS FOR POSSIBLE EXPORT FROM ALBERTA

Chemical/Compound

Acetic Acid
Ammonia
Benzene
Ethylbenzene
Ethylene Dichloride
Ethylene Glycol
Methanol
Phosphatic Fertilizers
Polyethylene
Polyvinylchloride
Styrene Monomer
Urea
Vinyl Acetate
Vinyl Chloride Monomer

HANDBOOK OF TOXIC AND HAZARDOUS CHEMICALS

by
Marshall Sittig

NOYES PUBLICATIONS
Park Ridge, New Jersey, U.S.A.
.1981

Foreword

This handbook presents concise chemical, health and safety information on nearly 600 toxic and hazardous chemicals, so that responsible decisions can be made by chemical manufacturers, safety equipment producers, toxicologists, industrial safety engineers, waste disposal operators, health care professionals, and the many others who may have contact with or interest in these chemicals due to their own or third party exposure.

Included in the book are *all* of the substances whose allowable concentrations in workplace air are adopted or proposed by the American Conference of Governmental Industrial Hygienists (ACGIH), *all* of the substances considered to date in the Standards Completion Program of the National Institute of Occupational Safety and Health (NIOSH), *all* of the priority toxic water pollutants defined by the U.S. Environmental Protection Agency (EPA), and *most* of the chemicals in the following classifications: EPA "hazardous wastes;" EPA "hazardous substances;" chemicals reviewed by EPA in Chemical Hazard Information Profiles (CHIPS) documents; and chemicals reviewed in NIOSH Information Profile documents.

The necessity for informed handling and controlled disposal of hazardous and toxic materials has been spotlighted over and over in recent days as news of fires and explosions at factories and waste sites and groundwater contamination near dump sites has been widely publicized. In late 1980 the EPA imposed long-delayed regulations governing the handling of hazardous wastes—from creation to disposal. Prerequisite to control of hazardous substances, however, is knowledge of the extent of possible danger and toxic effects posed by any particular chemical. This book provides the prerequisites.

The chemicals are presented alphabetically and each is classified as a "carcinogen," "hazardous substance," "hazardous waste," and/or a "priority toxic pollutant"—as defined by the various federal agencies, and explained in the comprehensive Introduction to the book.

Data is furnished, to the extent currently available, on any or all of these important categories:

Chemical Description	Routes of Entry
Code Numbers	Harmful Effects and Symptoms
DOT Designation	Points of Attack
Synonyms	Medical Surveillance
Potential Exposure	First Aid
Incompatibilities	Personal Protective Methods
Permissible Exposure Limits in Air	Respirator Selection
Determination in Air	Disposal Method Suggested
Permissible Concentration in Water	References
Determination in Water	

Essentially the book attempts to answer six questions about each compound (to the extent information is available):

- (1) What is it?
- (2) Where do you encounter it?
- (3) How much can one tolerate?
- (4) How does one measure it?
- (5) What are its harmful effects?
- (6) How does one protect against it?

An outstanding and noteworthy feature of this book is the Index of Carcinogens.

This book will thus be a valuable addition to industrial and medical libraries.

Advanced composition and production methods developed by Noyes Data are employed to bring these durably bound books to you in a minimum of time. Special techniques are used to close the gap between "manuscript" and "completed book." Industrial technology is progressing so rapidly that time-honored, conventional typesetting, binding and shipping methods are no longer suitable. We have bypassed the delays in the conventional book publishing cycle and provide the user with an effective and convenient means of reviewing up-to-date information in depth.

The alphabetical table of contents serves as a subject index and provides easy access to the information contained in the book.

ABOUT THE AUTHOR

Marshall Sittig, a chemical engineer, is President and Managing Director of Sittig & Noyes, International Chemical and Process Industries Consultants, and was formerly with E.I. Du Pont de Nemours & Co., Inc. in chemicals manufacturing, Ethyl Corporation in liaison between research and sales, and Princeton University as Director of Governmental Relations.

Introduction

The toxic chemicals problem in the United States and indeed in all the world is a frightening problem with news stories about Love Canal, the Valley of the Drums, the Valley of Death in Brazil and the like. All these generate emotional responses, often from people uninformed about science or technology. On the other hand, one encounters some industrialists who tell us that toxic chemicals are present in nature and that industrial contributions are just the price we have to pay for progress. Somewhere in between lies the truth—or at least an area in which we can function. It is the aim of this book to present data on specific industrial chemicals from an unemotional point of view so that decisions can be made by:

Chemicals manufacturers
Protective safety equipment producers
Toxicologists
Industrial hygienists
Lawyers
Doctors
Industrial safety engineers
Analytical chemists
Industrial waste disposal operators
Legislators
Enforcement officials
First aid squad members
Fire department personnel
Schoolteachers
The informed public

This book gives the highlights of available data on nearly 600 important toxic and hazardous chemicals. Importance is defined by inclusion in official and semi-official listings as follows:

- All the substances whose allowable concentrations in workplace air are adopted or proposed by the American Conference of Government Industrial Hygienists as of 1980 (over 500 sub-

stances). In the interests of conserving space, however, detailed entries are not given for "nuisance particulates" nor for "simple asphyxiants."

- All the substances considered to date in the Standards Completion Program by the National Institute of Occupational Safety and Health (some 380 substances).
- All the priority toxic water pollutants defined by the U.S. Environmental Protection Agency as a result of consent decrees in 1976 and 1979 which resulted in draft criteria in 1979 and final criteria in 1980 (for 65 pollutants and classes of pollutants which yielded 129 specific substances).
- Most of the chemicals in the following categories: (1) EPA "Hazardous wastes" as defined under the Resource Conservation and Recovery Act in April 1980 (A-52); (2) EPA "hazardous substances" as defined under the Clean Water Act; (3) chemicals which EPA has made the subject of Chemical Hazards Information Profiles or "CHIPS" review documents; and (4) chemicals which NIOSH has made the subject of "Information Profile" review documents.

All this information from U.S. Government sources has been supplemented by a careful search of, and citations to, publications from the United Kingdom, European and Japanese sources as well as United Nations and World Health Organization publications.

The result, we believe, is a handbook that is more than a handbook. When one looks at most handbooks, one simply expects to get numerical data. Here, we have tried wherever possible to reference the source of the numerical values and to provide a literature reference to some sort of timely review document which opens the door to a much wider field of published materials.

This book covers about 2½ times as many compounds as an earlier work by the same author entitled *Hazardous and Toxic Effects of Industrial Chemicals*. Further, it covers each item on a broader, more comprehensive basis. There are about 100 carcinogens identified in the present volume.

As pointed out in May 1980 by the Toxic Substances Strategy Committee, an interagency group, in a report to President Carter (A-47):

Exposures to toxic substances are linked to a variety of health problems. The immediate effects of high level exposures for a short time include burns, rashes, nausea, loss of eyesight, and fatal poisoning. Prolonged exposure to low doses can cause chronic lung disease (e.g., from coal or cotton dust), heart disease (from exposure to cadmium or carbon monoxide), sterility (from dibromochloropropane-DBCP), and kidney, liver, brain, nerve, and other damage. Exposure to industrial solvents can cause depression, and carbon disulfide workers are associated with a higher suicide rate than the general population. Although most chemicals do not cause cancers, exposure to some has been linked to cancer. Some workers exposed to asbestos, even for a short time, have developed a rare cancer of the chest and stomach linings 30 to 40 years after initial exposure. Vinyl chloride gas is linked to a rare liver cancer, to a brain cancer, and possibly to lung cancer. Diethylstilbestrol (DES), when taken by

pregnant
vaginal car-
sons. Met
ments on
poisoning.

A single subs
route and level
produced in sub
National Occur
which more than
Bank of the N
(human and an
stances were ch
could suggest di

Table 1:

Substance

Acetone
Acrylonitrile
Ammonia
Asbestos
Cresol
Dichloromethane
Diethylene glyco
2-Ethoxyethanol
Ethylene glycol
Lead
Methyl ethyl ket
2-Methyl-2,4-pen
Oxalic acid
Phenol
Sodium hydroxide
Sulfuric acid
Talc
1,1,1-Trichloroe
Trichloroethyler

Source: Nation

Each chem
line or checkl
tion was avail

Under the
indicating who

- A ca
natu
whet
giver

pregnant women to prevent miscarriages, led to increased risk of vaginal cancer in their daughters and abnormal sexual organs in their sons. Methylmercury, formed by the action of bacteria in sediments on mercury metal and on mercuric ions, can cause acute poisoning, deafness, brain damage, and a range of birth defects.

A single substance can have several kinds of adverse effects, depending on the route and level of exposure. Some effects of exposure to chemicals which are produced in substantial quantities are shown in Table 1. Chemicals listed in the National Occupational Hazard Survey were preselected for all chemicals to which more than 100,000 workers are potentially exposed. The Toxicology Data Bank of the National Library of Medicine was then searched for evidence (human and animal) of chronic or acute effects for all targets, and the 19 substances were chosen to illustrate the multiple target effects. Other data bases could suggest different target specificity.

Table 1: Selected High Volume Substances and Effects of Exposure

Substance	Kidney	Liver	Central Nervous System	Reproductive System	Pulmonary System	Skin
Acetone	x	x				
Acrylonitrile					x	x
Ammonia	x	x			x	x
Asbestos					x	x
Cresol	x	x	x		x	
Dichloromethane	x	x	x		x	x
Diethylene glycol	x	x	x		x	x
2-Ethoxyethanol	x	x	x	x	x	x
Ethylene glycol	x	x	x	x	x	x
Lead	x	x	x		x	
Methyl ethyl ketone	x	x	x	x		
2-Methyl-2,4-pentanediol	x	x			x	x
Oxalic acid	x		x		x	x
Phenol	x	x	x	x	x	x
Sodium hydroxide					x	x
Sulfuric acid					x	x
Talc	x	x			x	x
1,1,1-Trichloroethane	x	x	x		x	x
Trichloroethylene	x	x	x		x	x

Source: National Institute for Occupational Safety and Health, 1979

Each chemical covered in this volume has been discussed using the same outline or checklist of topics, and these have been filled in to the extent information was available.

Under the title of each substance, there are first four "bulleted" designations indicating whether the substance is:

- A carcinogen (the agency making such a determination, the nature of the carcinogenicity—whether human or animal and whether positive or suspected, and a literature reference are given in each case);

4 Handbook of Toxic and Hazardous Chemicals

- A "hazardous substance" as defined by the U.S. Environmental Protection Agency primarily on the basis of toxicity to aquatic life (A-51).
- A "hazardous waste" or "hazardous waste constituent" as defined by the U.S. Environmental Protection Agency (A-52).
- A "priority toxic pollutant" as defined by the U.S. Environmental Protection Agency (A-53).

Then each substance has data furnished to the extent available, under each of the following categories:

Description
Code Numbers
DOT Designation
Synonyms
Potential Exposure
Incompatibilities
Permissible Exposure Limits in Air
Determination in Air
Permissible Concentration in Water
Determination in Water
Routes of Entry
Harmful Effects and Symptoms
Points of Attack
Medical Surveillance
First Aid
Personal Protective Methods
Respirator Selection
Disposal Method Suggested
References

In the pages which follow, these categories will be discussed with reference to scope, sources, nomenclature employed, and the like. Omission of a category indicates a lack of available information.

Description: The chemical formula, the color, the odor and the melting or boiling point are given. Structural formulas are given in the cases of complex molecules.

Code Numbers: Three different code numbers are given for each material if they have been assigned:

- (1) The Chemical Abstract Service Registry number. It is simply given as CAS XXX-XX-X. It can be used to provide access to the MEDLARS® computerized literature retrieval services of the National Library of Medicine in Washington, DC.
- (2) The NIOSH Registry of Toxic Effects of Chemical Substances (RTECS) number is simply given as RTECS ABXXXXXXX (A-49). It is a 9-digit number and can also be used to provide access to updated detailed printouts from the MEDLARS® services cited above.
- (3) The United Nations numbers (A-46) for individual chemical commodities. These numbers are now being utilized by the U.S. Department of Transportation (A-50) to assist in the designation of hazardous materials. In some cases an NA number

Use of
verify de
when it
chemical
on mate
response
emergen
In this l
or ident
UN listi

DOT
lished li
required

Haza
the U.S
risk to
has been

Expli
common
instanta
is other

Class
types o
Transpo

Class
detonat
powder:

Class
or Clas
certain

Blast
found t
initiatio

Com
200°F.

Corr
human

Flan

Pyro
air at or

Com
sure ex
any liq
100°F.

which is a North American identification number (A-50) is cited in parentheses when a UN number has not been assigned.

Use of these identification numbers for hazardous materials will (a) serve to verify descriptions of chemicals; (b) provide for rapid identification of materials when it might be inappropriate or confusing to require the display of lengthy chemical names on vehicles; (c) aid in speeding communication of information on materials from accident scenes and in the receipt of more accurate emergency response information; and (d) provide a means for quick access to immediate emergency response information in the Emergency Response Guidebook (A-56). In this latter volume, the various compounds are simply given "ID Numbers" or identification numbers which correspond closely (but not precisely) to the UN listing (A-46) and to the earlier DOT listing (A-50).

DOT Designation: The U.S. Department of Transportation (A-50) has published listings of chemical substances which give a hazard classification and required labels. The DOT designations are defined as follows:

Hazardous Material – A substance or material which has been determined by the U.S. Secretary of Transportation to be capable of posing an unreasonable risk to health, safety, and property when transported in commerce, and which has been so designated.

Explosive – Any chemical compound, mixture, or device, the primary or common purpose of which is to function by explosion, i.e., with substantially instantaneous release of gas and heat, unless such compound, mixture, or device is otherwise specifically classified.

Class A Explosive – Detonating or otherwise of maximum hazard. The nine types of Class A explosives are defined in Section 173.53 of CFR Title 49-Transportation.

Class B Explosive – In general, function by rapid combustion rather than detonation and include some explosive devices such as special fireworks, flash powders, etc. Flammable hazard.

Class C Explosive – Certain types of manufactured articles containing Class A or Class B explosives, or both, as components but in restricted quantities, and certain types of fireworks. Minimum hazard.

Blasting Agents – A material designed for blasting which has been tested and found to be so insensitive that there is very little probability of accidental initiation to explosion or of transition from deflagration to detonation.

Combustible Liquid – Any liquid having a flash point above 100°F and below 200°F.

Corrosive Material – Any liquid or solid that causes visible destruction of human skin tissue or a liquid that has a severe corrosive rate on steel.

Flammable Liquid – Any liquid having a flash point below 100°F.

Pyrophoric Liquid – Any liquid that ignites spontaneously in dry or moist air at or below 130°F.

Compressed Gas – Any material or mixture having in the container a pressure exceeding 40 psia at 70°F, or a pressure exceeding 104 psia at 130°F; or any liquid flammable material having a vapor pressure exceeding 40 psia at 100°F.

6 Handbook of Toxic and Hazardous Chemicals

Flammable Gas – Any compressed gas meeting the requirements for lower flammability limit, flammability limit range, flame projection, or flame propagation criteria as specified in Section 173.300(b) of CFR Title 49.

Nonflammable Gas – Any compressed gas other than a flammable compressed gas.

Flammable Solid – Any solid material, other than an explosive, which is liable to cause fires through friction, retained heat from manufacturing or processing, or which can be ignited readily and when ignited burns so vigorously and persistently as to create a serious transportation hazard.

Organic Peroxide – An organic compound containing the bivalent –O–O– structure and which may be considered a derivative of hydrogen peroxide where one or more of the hydrogen atoms have been replaced by organic radicals must be classed as an organic peroxide.

Oxidizer – A substance such as chlorate, permanganate, inorganic peroxide, or a nitrate, that yields oxygen readily to stimulate the combustion of organic matter.

Poison A – Extremely Dangerous Poisons: Poisonous gases or liquids of such nature that a very small amount of the gas, or vapor of the liquid, mixed with air is dangerous to life.

Poison B – Less Dangerous Poisons: Substances, liquids, or solids (including pastes and semisolids), other than Class A or Irritating Materials, which are known to be so toxic to man as to afford a hazard to health during transportation; or which, in the absence of adequate data on human toxicity, are presumed to be toxic to man.

Irritating Material – A liquid or solid substance which upon contact with fire or when exposed to air gives off dangerous or intensely irritating fumes, but not including any poisonous material, Class A.

Etiologic Agent – A viable microorganism, or its toxin which causes or may cause human disease.

Radioactive Material – Any material, or combination of materials, that spontaneously emits ionizing radiation, and having a specific activity greater than 0.002 microcuries per gram.

Other Regulated Materials – Any material that does not meet the definition of a hazardous material, other than a combustible liquid in packagings having a capacity of 110 gallons or less, and is specified as an ORM material or that possesses one or more of the characteristics described in ORM-A through E below. Note: an ORM with a flash point of 100° to 200°F, when transported with more than 110 gallons in one container shall be classed as a combustible liquid.

ORM-A: A material which has an anesthetic, irritating, noxious, toxic, or other similar property and which can cause extreme annoyance or discomfort to passengers and crew in the event of leakage during transportation.

ORM-B: A material (including a solid when wet with water) capable of causing significant damage to a transport vehicle or vessel from leakage during transportation. Materials meeting one or both of the following criteria are ORM-B materials: (a) a liquid substance that has a corrosion rate exceeding 0.250 inch

per year
perature
Standard

ORM-C:
describes
for ship
portation

ORM-D:
though
presents
quantity

ORM-E:
class. M
hazardous
offered
when the
reportable
regulatory
means a
fast requ
would be
zation to

The following are
hazardous materials

Consumer Commodity – A material contributed in a form instrumentalities or household use.

Flash Point – The temperature at which flammable vapors are evolved from a liquid at normal pressure.

Forbidden – A material not accepted for transportation.

Limited Quantity – A material specified in those tables where there are specific limitations.

Spontaneously Combustible – A material which, under conditions of normal transportation, contact with the atmosphere, or contact with water, is liable to undergo spontaneous combustion.

Water Reactive – A material (including sludges and pastes) which reacts with water to produce a flammable or toxic gas, or a flammable or toxic liquid.

Synonyms – A list of synonyms for each compound as well as the chemical name.

Potential Exposure – A list of potential exposure conditions for each compound and the corresponding health effects.

per year (IPY) on aluminum (nonclad 7075-T6) at a test temperature of 130°F. An acceptable test is described in NACE Standard TM-01-69.

ORM-C: A material which has other inherent characteristics not described as an ORM-A or ORM-B but which make it unsuitable for shipment, unless properly identified and prepared for transportation.

ORM-D: A material such as a consumer commodity which, though otherwise subject to the regulations of this section, presents a limited hazard during transportation due to its form, quantity and packaging.

ORM-E: A material that is not included in any other hazard class. Materials in this class include: (a) hazardous waste; (b) hazardous substances, which means a quantity of a material offered for transportation in one package, or transport vehicle when the material is not packaged, that equals or exceeds the reportable quantity (RQ) specified for the material in EPA regulations at 40 CFR Parts 116 and 117. "Hazardous waste" means any material that is subject to the hazardous waste manifest requirements of the EPA specified in 40 CFR Part 262 or would be subject to these requirements absent an interim authorization to a state under 40 CFR Part 123, Subpart F.

The following are offered to explain additional terms used in preparation of hazardous materials for shipment.

Consumer Commodity - (See ORM D.) A material that is packaged or distributed in a form intended and suitable for sale through retail sales agencies or instrumentalities for consumption by individuals for purposes of personal care or household use. This term also includes drugs and medicines.

Flash Point - The minimum temperature at which a substance gives off flammable vapors which in contact with spark or flame will ignite.

Forbidden - The hazardous material is one that must not be offered or accepted for transportation.

Limited Quantity - The maximum amount of a hazardous material; as specified in those sections applicable to the particular hazard class, for which there are specific exceptions from the requirements.

Spontaneously Combustible Material (Solid) - A solid substance (including sludges and pastes) which may undergo spontaneous heating or self-ignition under conditions normally incident to transportation or which may upon contact with the atmosphere undergo an increase in temperature and ignite.

Water Reactive Material (Solid) - Any solid substance (including sludges and pastes) which, by interaction with water, is likely to become spontaneously flammable or to give off flammable or toxic gases in dangerous quantities.

Synonyms: Some of the more commonly used synonyms are given for each compound as well as some of the more common registered trade names.

Potential Exposure: A brief indication is given of the nature of exposure to each compound in the industrial environment. Where pertinent, some indications are given of background concentration and occurrence from other than

8 Handbook of Toxic and Hazardous Chemicals

industrial discharges such as water purification plants. Obviously in a volume of this size, this coverage must be very brief. Additional information on numbers of workers exposed and specific occupations which may be exposed are available from the National Institute of Occupational Safety and Health.

It is of course recognized that nonoccupational exposures may be important as well and the reader is referred to an EPA review document on the topic (A-55) for more detail.

Incompatibilities: Important, potentially hazardous incompatibilities of each substance are listed where available. These are primarily drawn from information developed under the NIOSH Standards Completion Program (A-4).

Permissible Exposure Limits in Air: The permissible exposure limit (PEL), as found in 29 CFR 1910.1000 as of January 1977, has been cited as the Federal standard where one exists. Where NIOSH has published a recommended revision to the OSHA regulation, the NIOSH recommended level is also noted. Where the American Conference of Governmental Industrial Hygienists (ACGIH) has recommended revision of the OSHA regulation and NIOSH has not, the ACGIH revised threshold limit value (TLV®) is also noted.

Except where otherwise noted, the PELs are work-shift time-weighted average (TWA) levels. Ceiling levels and TWAs averaged over other than full work-shifts are noted.

Where the Federal standard and the ACGIH (1980) value are identical, the ACGIH designation is implied but not stated, in order to conserve space.

The short-term exposure limit (STEL) values are derived from the ACGIH publication (A-6). This value is the maximal concentration to which workers can be exposed for a period up to 15 minutes continuously without suffering from: irritation; chronic or irreversible tissue change; or narcosis of sufficient degree to increase accident proneness, impair self-rescue, or materially reduce work efficiency, provided that no more than four excursions per day are permitted, with at least 60 minutes between exposure periods, and provided that the daily TWA also is not exceeded.

The "Immediately Dangerous to Life or Health" (IDLH) concentration (A-4) is listed in either ppm or mg/m³. This concentration represents a maximum level from which one could escape within 30 minutes without any escape-impairing symptoms or any irreversible health effects.

Determination in Air: The citations to analytical methods are drawn from various sources, such as:

- The NIOSH "Pocket Guide" (A-4) which summarizes information from the Standards Completion Program. Where references are given to NIOSH Method Set letters or numbers, the complete methods may be found in PB reports available from the National Technical Information Service, Springfield, Virginia, using the following order numbers:

Set Code	NTIS No.	Set Code	NTIS No.
A	PB245850	G	PB265026
B	PB245851	H	PB265027
C	PB245852	I	PB265028
D	PB245935	J	PB263959
E	PB246148	K	PB254227
F	PB246149	L	PB250159

Set C

M

N

O

P

Q

R

S

- A pu
tabul
meth
techn

Permissi
are drawn f

— TI

lis

— TI

pt

— TI

dr

— TI

m

so

Determi
primarily l
pollutant ar

Routes
substance a
(A-4) but ar

Harmful
publications:
draft criteri
sources. The

— EP

inc

— NI

— EP

inc

Points of
the NIOSH
points of at

Medical
publication
treatment a
(A-35) whic
Program.

Set Code	NTIS No.	Set Code	NTIS No.
M	PB265029	T	PB262404
N	PB258433	U	PB262405
O	PB262402	V	PB262542
P	PB258434	W	PB262406
Q	PB258435		
R	PB262403	Set 1	PB271712
S	PB263871	Set 2	PB271464

- A publication of the DuPont Company (A-1) which summarizes in tabular form most of the ACGIH threshold limit values, sampling methods, sample sizes, suggested sampling rates and analytical techniques for airborne substances.

Permissible Concentrations in Water: The permissible concentrations in water are drawn from various sources also, including:

- The U.S. Environmental Protection Agency's "red book" published in 1976 (A-3).
- The National Academy of Sciences/National Research Council publication, *Drinking Water and Health* published in 1977 (A-2).
- The priority toxic pollutant criteria published by U.S. EPA in draft form in 1979 and in final form in 1980 (A-53).
- The multimedia environmental goals for environmental assessment study conducted by EPA (A-37). Values are cited from this source when not available from other sources.

Determination in Water: The sources of information in this area have been primarily U.S. EPA publications including the test procedures for priority pollutant analysis (A-54).

Routes of Entry: The toxicologically important routes of entry of each substance are listed. These are primarily taken from the NIOSH Pocket Guide (A-4) but are drawn from other sources as well (A-5).

Harmful Effects and Symptoms: These are primarily drawn from NIOSH publications (A 4) and (A 5) but are supplemented from information from the draft criteria documents for priority toxic pollutants (A-33) and from other sources. The other sources include:

- EPA Chemical Hazard Information Profiles (CHIPS) cited under individual entries.
- NIOSH Information Profiles cited under individual entries.
- EPA Health and Environmental Effect Profiles cited under individual entries.

Points of Attack: This category is based in part on the "Target Organs" in the NIOSH Pocket Guide (A-4) but the title has been changed as many of the points of attack are not organs (blood, for example).

Medical Surveillance: This information is drawn primarily from a NIOSH publication (A-5). Where additional information is desired in areas of diagnosis, treatment and medical control, the reader is referred to a private publication (A-35) which is adapted from the products of the NIOSH Standards Completion Program.

First Aid: Simple first aid procedures are listed for response to eye contact, skin contact, inhalation, and ingestion of the toxic substance as drawn to a large extent from the NIOSH Pocket Guide (A-4) but supplemented by information from recent commercially available volumes in the U.S. (A-39), in the U.K. (A-44)(A-48) and in Japan (A-38).

Personal Protective Methods: This information is drawn heavily from NIOSH publications (A-4)(A-5) and supplemented by information from the U.S. (A-39), the U.K. (A-48) and Japan (A-38).

Respirator Selection: Whereas in all the other categories, it has been attempted to provide guidance in brief readable English, it has been necessary in the interest of brevity to use hieroglyphics to designate respirator selection. A condensed table of allowable respirator use is provided from a NIOSH tabulation (A-4) when available. Each line of this item lists a maximum use concentration (in ppm, mg/m³, µg/m³, or mppcf) or condition (e.g., escape) followed by a series of codes representing classes of respirators. Individual respirator codes are separated by slanted (/) lines.

The recommendations for respirator use are based upon the OSHA permissible exposure level. Any approved respirator of a given category can be utilized at any concentration equal to, or less than, the category's listed maximum use concentration for the toxic substance of interest. Codes employed for the various categories of respirator are as follows:

CCR	Chemical cartridge respirator	
CCRAG	Chemical cartridge respirator with acid gas cartridge(s)	
CCRAGF	CCRAG with a full facepiece	
CCRAGFHiE	CCRAG with a full facepiece and with a high-efficiency filter	
CCROV	Chemical cartridge respirator with organic vapor cartridge(s)	
CCROVAG	CCROV with acid gas cartridge(s)	
CCROVAGF	CCROV with acid gas cartridge(s) and full facepiece	
CCROVD	CCROV with dust filter	
CCROVDM	CCROV with dust and mist filter	
CCROVDMF	CCROV with dust and mist filter and full facepiece	
CCROVDMFuPest	CCROV with dust, mist, and fume filter, including pesticide respirators meeting these requirements	
CCROVDMFPest	CCROV with dust and mist filter, including pesticide respirators meeting these requirements	
CCROVDPest	CCROV with dust filter, including pesticide respirators	
CCROVF	CCROV with full facepiece	
CCROVFuHiE	CCROV with fume or high-efficiency filter	
CCROVFD	CCROV with full facepiece and dust filter	
CCROVFDm	CCROV with full facepiece and dust and mist filter	
CCROVFDmFuPest	CCROV with full facepiece and dust, mist and fume filter, including pesticide respirators meeting these requirements	
CCROVFDmFPest	CCROV with full facepiece and dust and mist filter, including pesticide respirators meeting these requirements	
CCROVFDPest	CCROV with dust filter and full facepiece, including pesticide respirators with full facepiece	
CCROVFFuHiE	CCROV with full facepiece and fume or high-efficiency filter	
CCROVFFHiE	CCROV with high-efficiency particulate filter and full facepiece	
CCROVFS	CCROV with full facepiece providing protection against the specific compound of concern	
		CCROVHiEP
		CCROVHiEPes
		CCROVS
		D
		DM
		DMFu
		DMXS
		DMXSPest
		DMXSQ
		DMXSQPest
		DXS
		DXSPest
		DXSQ
		FuHiEP
		FuHiEPes
		GMAG
		GMAGHiE
		GMAGP
		GMAGS
		GMOV
		GMOVc
		GMOVfb
		GMOVAG
		GMOVAGF
		GMOVAGHiE
		GMOVAGP
		GMOVD
		GMOVDFuMPes
		GMOVDM
		GMOVDMFPest
		GMOVF
		GMOVFFuHiE
		GMOVFFHiE
		GMOVFP
		GMOVHiEP
		GMOVPPest
		GMFPest
		GMS
		GMSc
		GMSfb

CCROVHiEP	CCROV with high-efficiency particulate filter
CCROVHiEPest	CCROV with high-efficiency filter, including pesticide respirators meeting these requirements
CCROVS	CCROV providing protection against the specific compound of concern
D	Dust mask
DM	Dust and mist respirator
DMFu	Dust, mist, and fume respirator
DMXS	DM, except single-use respirators
DMXSPest	DM, except single-use respirators, including pesticide respirators
DMXSQ	DM, except single-use and quarter-mask respirators
DMXSQPest	DM, except single-use and quarter-mask respirators including pesticide respirators
DXS	Dust mask, except single-use
DXSPest	Dust mask, except single-use, including pesticide respirators
DXSQ	Dust mask, except single-use and quarter-mask respirators
FuHiEP	Fume or high-efficiency particulate respirator
FuHiEPs	FuHiEP providing protection against the specific compound of concern
GMAG	Gas mask with an acid gas canister (chin-style or front- or back-mounted canister)
GMAGHiE	GMAG with high-efficiency filter
GMAGP	GMAG with particulate filter
GMAGS	GMAG providing protection against the specific compound of concern
GMOV	Gas mask with organic vapor canister (chin-style or front- or back-mounted canister)
GMOVc	Chin-style GMOV
GMOVfb	Front- or back-mounted GMOV
GMOVAG	GMOV providing protection against acid gases
GMOVAGF	GMOV, with full facepiece, providing protection against acid gases
GMOVAGHiE	GMOV with high-efficiency filter and acid gas canister
GMOVAGP	GMOV with acid gas canister and particulate filter
GMOVd	GMOV with dust filter
GMOVDFuMPest	GMOV with dust, fume, and mist filter, including pesticide respirators meeting these requirements
GMOVDM	GMOV with dust and mist filter
GMOVDMest	GMOV with dust and mist filter, including pesticide respirators
GMOVf	GMOV with full facepiece
GMOVFFuHiE	GMOV with full facepiece and fume or high-efficiency filter
GMOVFFuHiE	GMOV with full facepiece and high-efficiency filter
GMOVFP	GMOV with full facepiece and particulate filter
GMOVHiEP	GMOV with high-efficiency particulate filter
GMOVp	GMOV with particulate filter
GMOVPPest	GMOV with particulate filter, including pesticide respirators
GMPest	Gas mask with pesticide canister (chin-style or front- or back-mounted canister)
GMS	Gas mask with canister providing protection against the compound of concern (chin-style or front- or back-mounted canister)
GMSc	GMS with chin-mounted canister
GMSfb	GMS with front- or back-mounted canister

GMSF	GMS with full facepiece	
GMSHiE	GMS with high-efficiency filter	
GMSOVPPest	GMS with organic vapor canister and particulate filter, including pesticide respirators meeting these requirements	
GMSF	GMS with particulate filter	
HiEP	High-efficiency particulate respirator	
HiEPAG	HiEP with acid gas cartridge	
HiEPF	HiEP with full facepiece	
HiEPFu	HiEP or a fume filter respirator	
HiEPFPest	HiEP with full facepiece, including pesticide respirators meeting these requirements	
HiEPPest	HiEP, including pesticide respirators meeting these requirements	
MXS	Mist respirator, except single-use	
MXSQ	Mist respirator, except single-use and quarter-mask respirator	
PAPCCROVHiEP	Powered air-purifying respirator with organic vapor cartridge and high-efficiency particulate filter	
PAPCCROVHiEP	PAPCCROVHiEP with full facepiece	
PAPCCROVHiEPPest	PAPCCROVHiEP with full facepiece, including pesticide respirators meeting these requirements	
PAPHiE	Powered air-purifying respirator with high-efficiency filter	
PAPHiEF	PAPHiE with full facepiece	(A-1) E.I. Ana- plie
PAPHiEOV	PAPHiE with organic vapor cartridge	
PAPHiEOVF	PAPHiE with organic vapor cartridge and full facepiece	(A-2) Nat. DC,
PAPHiEPest	PAPHiE, including pesticide respirators meeting these requirements	(A-3) U.S. Wasi
SA	Supplied-air respirator	
SA:PD,PP,CF	Type C SA operated in pressure-demand or other positive pressure or continuous-flow mode	(A-4) Nati Pock 78-2
SAF	SA with full facepiece, helmet, or hood	
SAF:PD,PP,CF	Type C SA with full facepiece operated in pressure-demand or other positive pressure mode or with full facepiece, helmet, or hood operated in continuous-flow mode	(A-5) Nati Dise: No. 5
SCBA	Self-contained breathing apparatus	
SCBAF	SCBA with full facepiece	(A-6) Ame: Limit room ACG:
SCBAF:PD,PP	SCBA with full facepiece operated in pressure-demand or other positive pressure mode	(A-7) Wortl Britis

Disposal Method Suggested: The disposal methods for various chemical substances have been drawn from earlier works by this author on disposal, incineration and landfill disposal (A-31) as well as a more recent volume (A-32) which treats pesticide disposal methods more specifically. Another source is a recent book on the degradation of chemical carcinogens (A-43).

References: The general bibliography for this volume follows immediately. It includes general reference sources and references dealing with analytical methods.

The references at the end of individual product entries are generally restricted to:

- references dealing only with that particular compound;
- references which in turn contain bibliographies giving references to the original literature on toxicological and other behavior of the substance in question.

- (A-1) E.I. Ana-
plie
- (A-2) Nat.
DC,
- (A-3) U.S.
Wasi
- (A-4) Nati
Pock
78-2
- (A-5) Nati
Dise:
No. 5
- (A-6) Ame:
Limit
room
ACG:
- (A-7) Wortl
Britis
- (A-8) Altsh
of Cro
1180
- (A-9) Diggle
Anhyc
- (A-10) Natio
of An
Public.

Disposal Method Suggested: Incineration (A-31).

References

- 1) U.S. Environmental Protection Agency, *Chemical Hazard Information Profile: Acetaldehyde*, (Preliminary), Washington, DC (1979).
- 2) U.S. Environment Protection Agency, *Acetaldehyde*, Health and Environmental Effects Profile No. 1, Washington, DC, Office of Solid Waste (April 30, 1980).

ACETIC ACID

- Hazardous substance (EPA)

Description: CH_3COOH , acetic acid, is a colorless liquid with a pungent vinegary odor. Glacial acetic acid contains 99% acid. It boils at 117° to 118°C.

Code Numbers: CAS 64-19-7 RTECS AF1225000 UN 2789

DOT Designation: Corrosive material.

Synonyms: Ethanoic acid, ethylic acid, methane carboxylic acid, pyroigneous acid, vinegar acid.

Potential Exposure: Acetic acid is widely used as a chemical feedstock for the production of vinyl plastics, acetic anhydride, acetone, acetonilide, acetyl chloride, ethyl alcohol, ketene, methyl ethyl ketone, acetate esters, and cellulose acetates. It is also used alone in the dye, rubber, pharmaceutical (A-41), food preserving, textile, and laundry industries. It is utilized, too, in the manufacture of Paris green, white lead, tint rinse, photographic chemicals, stain removers, insecticides (A-32) and plastics.

Incompatibilities: Strong oxidizers, chromic acid, sodium peroxide, nitric acid, strong caustics.

Permissible Exposure Limits in Air: The Federal standard (TWA) is 10 ppm (25 mg/m³). The tentative STEL value is 15 ppm (37 mg/m³). The IDLH value is 1,000 ppm.

Determination in Air: Acetic acid may be collected by impinger or fritted bubbler and then determined by titration (A-1). See also reference (A-10).

Permissible Concentration in Water: No limit has been established. However, EPA (A-37) has proposed an ambient environmental goal of 345 µg/l based on health effects.

Determination in Water: Acetic acid in water may be determined by titration.

Route of Entry: Inhalation of vapor.

Harmful Effects and Symptoms: *Local* — Acetic acid vapor may produce irritation of the eyes, nose, throat, and lungs. Inhalation of concentrated vapors may cause serious damage to the lining membranes of the nose, throat, and lungs. Contact with concentrated acetic acid may cause severe damage to the skin and severe eye damage, which may result in loss of sight. Repeated or prolonged exposure to acetic acid may cause darkening, irritation of the skin, erosion of the exposed front teeth, and chronic inflammation of the nose, throat, and bronchi (A-5). See also (A-35).

Systemic — Bronchopneumonia and pulmonary edema may develop fol-

lowing acute overexposure. Chronic exposure may result in pharyngitis and catarrhal bronchitis. Ingestion, though not likely to occur in industry, may result in penetration of the esophagus, bloody vomiting, diarrhea, shock, hemolysis, and hemoglobinuria which is followed by anuria.

Points of Attack: Respiratory system, skin, eyes, teeth.

Medical Surveillance: Consideration should be given to the skin, eyes, teeth, and respiratory tract in placement or periodic examinations.

First Aid: If this chemical gets into the eyes, irrigate immediately. If this chemical contacts the skin, flush with water immediately. If a person breathes in large amounts of this chemical, move the exposed person to fresh air at once and perform artificial respiration. When this chemical has been swallowed, get medical attention. Give large quantities of water and do not induce vomiting.

Personal Protective Methods: When working with glacial acetic acid, personal protective equipment, protective clothing, gloves, and goggles should be worn. Eye fountains and showers should be available in areas of potential exposure. Wear appropriate clothing to prevent any possibility of skin contact with liquids of >50% content or repeated or prolonged contact with liquids of 10 to 49% content. Wear eye protection to prevent any possibility of eye contact. Employees should wash immediately with soap when skin is wet or contaminated with liquids of >50% content and promptly if liquids of 10 to 49% acetic acid are involved. Remove clothing immediately if wet or contaminated with liquids containing 50% and promptly remove if liquid contains 10 to 49% acetic acid. Provide emergency eyewash if liquids containing >5% acetic acid are involved, drench if >50% acetic acid is involved.

Respirator Selection:

500 ppm: CGROVF/GMOV/SAF/SCBAF

1,000 ppm: SAF:PD,PP,CF

Escape: GMOV/SCBA

Disposal Method Suggested: Incineration (A-31).

ACETIC ANHYDRIDE

- Hazardous substance (EPA)

Description: $(\text{CH}_3\text{CO})_2\text{O}$, acetic anhydride, is a colorless, strongly refractive liquid which has a strongly irritating odor. It boils at 140°C.

Code Numbers: CAS 108-24-7 RTECS AK1925000 UN 1715

DOT Designation: Corrosive material.

Synonyms: Acetic oxide, acetyl oxide, ethanoic anhydride.

Potential Exposures: Acetic anhydride is used as an acetylating agent or as a solvent in the manufacture of cellulose acetate, acetanilide, synthetic fibers, plastics, explosives, resins, perfumes, and flavorings; and it is used in the textile dyeing industry. It is widely used as a pharmaceutical intermediate (A-41) and as a pesticide intermediate (A-32).

Incompatibilities: Water, alcohols, strong oxidizers, chromic acid, amines, strong caustics.

DOT Designation: —

Synonyms: α -Aminopyridine.

Potential Exposures: 2-Aminopyridine is used in the manufacture of pharmaceuticals, especially antihistamines (A-41).

Incompatibilities: Strong oxidizers.

Permissible Exposure Limits in Air: The Federal standard is 0.5 ppm (2 mg/m³). The proposed STEL is 2.0 ppm (4 mg/m³). The IDLH level is 5.0 ppm.

Determination in Air: Adsorption on Tenax GC, thermal desorption and gas chromatographic analysis (A-10).

Permissible Concentration in Water: No criteria set.

Routes of Entry: Inhalation, ingestion, eye and skin contact and absorption through the skin.

Harmful Effects and Symptoms: Headaches, dizziness, excited state, nausea, flushed appearance, high blood pressure, respiratory distress, weakness, convulsions, stupor.

Points of Attack: Central nervous system, respiratory system.

Medical Surveillance: Consider the points of attack in preplacement and periodic physical examinations.

First Aid: If this chemical gets into the eyes, irrigate immediately. If this chemical contacts the skin, flush with water immediately. If a person breathes in large amounts of this chemical, move the exposed person to fresh air at once and perform artificial respiration. When this chemical has been swallowed, get medical attention. Give large quantities of water and induce vomiting. Do not make an unconscious person vomit.

Personal Protective Methods: Wear appropriate clothing to prevent any reasonable probability of skin contact. Wear eye protection to prevent any reasonable probability of eye contact. Employees should wash immediately when skin is wet or contaminated. Work clothing should be changed daily if it may be that clothing is contaminated. Remove nonimpervious clothing immediately if wet or contaminated. Provide emergency showers.

Respirator Selection:

5 ppm: SAF/SCBAF

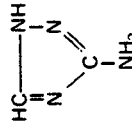
Escape: GMOV/SCBA

Disposal Method Suggested: Incineration with NO_x removal from effluent gas.

3-AMINO-1,2,4-TRIAZOLE

• Carcinogen (Animal Positive, IARC) (1)

Description: C₂H₄N₄ with the structural formula



This is a colorless crystalline solid melting at 158° to 159°C.

Code Numbers: CAS 61-82-5 RTECS XZ3850000 UN 2588

DOT Designation: —

Synonyms: Amitrole, Weedazol®, Cytrol®, Azolan®, Amitrol-T®, Amizol®.

Potential Exposures: Those involved in the manufacture (A-32), formulation and application of this herbicide.

Permissible Exposure Limits in Air: ACGIH has classified amitrole as an industrial substance suspect of carcinogenic potential for man with no assigned TLV.

Permissible Concentration in Water: No criteria set.

Harmful Effects and Symptoms: Carcinogenicity is the primary observed effect.

Disposal Method Suggested: Amitrole is resistant to hydrolysis and the action of oxidizing agents. Burning the compound with polyethylene is reported to result in >99% decomposition (A-32).

References

- (1) International Agency for Research on Cancer, *IARC Monographs on the Carcinogenic Risks of Chemicals to Humans*, 7, 31, Lyon, France (1974).

55

AMMONIA

• Hazardous substance (EPA)

Description: NH₃, ammonia is a colorless, strongly alkaline, and extremely soluble gas with a characteristic pungent odor.

Code Numbers: CAS 7664-41-7 RTECS B00875000 UN 1005

DOT Designation: Nonflammable gas.

Synonyms: Anhydrous ammonia.

Potential Exposures: Ammonia is used as a nitrogen source for many nitrogen-containing compounds. It is used in the production of ammonium sulfate and ammonium nitrate for fertilizers and in the manufacture of nitric acid, soda, synthetic urea, synthetic fibers, dyes, and plastics. It is also utilized as a refrigerant and in the petroleum refining and chemical industries. It is used in the production of many drugs (A-41) and pesticides (A-32).

Other sources of occupational exposure include the silvering of mirrors, glue-making, tanning of leather, and around nitriding furnaces. Ammonia is produced as a by-product in coal distillation and by the action of steam on calcium cyanamide, and from the decomposition of nitrogenous materials.

Incompatibilities: Strong oxidizers, calcium, hypochlorite bleaches, gold, mercury, silver, halogens.

Permissible Exposure Limits in Air: The Federal standard for ammonia is an 8-hour time-weighted average of 50 ppm (35 mg/m³). NIOSH has recommended 50 ppm expressed as a ceiling and determined by a 5-minute sampling period. ACGIH has set TWA values of 25 ppm (18 mg/m³). The tentative STEL value is 35 ppm (27 mg/m³). The IDLH level is 500 ppm.

Determination in Air: Collection by midget impinger and colorimetric analysis using Nessler's reagent (A-10). Ammonia may also be determined using long-duration detector tubes (A-11).

Permissible Concentration in Water: EPA in 1976 (A-3) proposed a limit of 0.02 mg/l (as unionized ammonia) for the protection of freshwater aquatic life. As of 1980, EPA (2) first proposed adding ammonia to the list of priority toxic pollutants and developing criteria for it, but then withdrew the proposal. NAS/NRC proposed (A-2) a limit of 0.5 mg/l for drinking water.

Routes of Entry: Inhalation of gas, ingestion, skin and eye contact.

Harmful Effects and Symptoms: *Local* — Contact with anhydrous liquid ammonia or with aqueous solutions is intensely irritating to the mucous membranes, eyes, and skin. Eye symptoms range from lacrimation, blepharospasm, and palpebral edema to a rise of intraocular pressure, and other signs resembling acute-angle closure glaucoma, corneal ulceration, and blindness. There may be corrosive burns of skin or blister formation. Ammonia gas is also irritating to the eyes and to moist skin.

Systemic — Mild to moderate exposure to the gas can produce headache, salivation, burning of throat, anosmia, perspiration, nausea, vomiting, and substernal pain. Irritation of ammonia gas in eyes and nose may be sufficiently intense to compel workers to leave the area. If escape is not possible, there may be severe irritation of the respiratory tract with the production of cough, glottal edema, bronchospasm, pulmonary edema, or respiratory arrest. Bronchitis or pneumonia may follow a severe exposure if patient survives. Urticaria is a rare allergic manifestation from inhalation of the gas.

Points of Attack: Lungs, respiratory system, eyes.

Medical Surveillance: Preemployment physical examinations for workers in ammonia exposure areas should be directed toward significant changes in the skin, eyes, and respiratory system. Persons with corneal disease, and glaucoma, or chronic respiratory diseases may suffer increased risk. Periodic examinations should include evaluation of skin, eyes, and respiratory system, and pulmonary function tests to compare with baselines established at preemployment examination.

First Aid: If this chemical gets into the eyes, irrigate immediately. If this chemical contacts the skin, flush with water immediately. If a person breathes in large amounts of this chemical, move the exposed person to fresh air at once and perform artificial respiration. When this chemical has been swallowed, get medical attention. Do not induce vomiting.

Personal Protective Methods: Where ammonia hazards exist in concentrations above the standard, respiratory, eye, and skin protection should be provided. Fullface gas masks with ammonia canister or supplied air respirators, both with full facepieces, afford good protection. In areas where exposure to liquid ammonia occurs, goggles or face shields, as well as protective clothing impervious to ammonia and including gloves, aprons, and boots should be required. Where ammonia gas or concentrated ammonia solution is splashed in eyes, immediate flooding of the eyes with large quantities of water for 15 minutes or longer is advised, followed at once by medical examination.

In heavy concentrations of ammonia gas, workers should be outfitted with complete self-contained protective suits impervious to ammonia, with supplied air source, and full headpiece and facepiece. Appropriate clothing should be

worn to prevent any possible skin contact with liquids of >10% content or reasonable probability of contact with liquids of <10% content. Wear eye protection to prevent any possibility of eye contact with liquids of >10% NH₃ content. Employees should wash immediately when skin is wet or contaminated with liquids of >10% content. Remove nonimpervious clothing immediately if wet or contaminated with liquids containing >10% and promptly remove if liquid contains <10% NH₃. Provide emergency showers and eyewash if liquids containing >10% NH₃ are involved.

Respirator Selection:

100 ppm: CCRS/SA/SCBA
300 ppm: CCRSF
500 ppm: GMS/SAF/SCBAF
Escape: GMS/SCBA

Disposal Method Suggested: Dilute with water, neutralize with HCl and discharge to sewer (A-38). Recovery is an option to disposal which should be considered for paper manufacture, textile treating, fertilizer manufacture and chemical process wastes (A-57).

References

- (1) National Institute for Occupational Safety and Health, *Criteria for a Recommended Standard: Occupational Exposure to Ammonia*, NIOSH Doc. No. 74-136, Washington, DC (1974).
- (2) U.S. Environmental Protection Agency, "Toxic Pollutant List: Proposal to Add Ammonia," *Federal Register*, 45, No. 2, 803-806 (January 3, 1980) Rescinded by *Federal Register*, 45, No. 232, 79692-79693 (December 1, 1980).
- (3) National Research Council, Committee on Medical and Biologic Effects of Environmental Pollutants, *Ammonia*, Baltimore, MD, University Park Press (1979).

57

AMMONIUM CHLORIDE

- Hazardous substance (EPA)

Description: NH₄Cl is a white crystalline solid which melts at 338°C with decomposition.

Code Numbers: CAS 12125-02-9 RTECS BP4550000 UN (NA 9085)

DOT Designation: ORM-E.

Synonyms: Sal ammoniac.

Potential Exposure: Ammonium chloride is used in galvanizing and soldering as a flux.

Permissible Exposure Limits in Air: There is no Federal standard but ACGIH has set a TWA of 10 mg/m³ for ammonium chloride fume. The tentative STEL value is 20 mg/m³.

Determination in Air: Collection on a filter and colorimetric analysis (A-1).

Permissible Concentration in Water: No criteria set.

Routes of Entry: Inhalation of fume, ingestion, skin and eye contact.

Harmful Effects and Symptoms: Ammonium chloride is a mild skin and respiratory system irritant with a low grade systemic toxicity by ingestion (A-34).

Personal Protective Methods: Employees should receive instruction in personal hygiene and the importance of not eating in work areas. Good housekeeping and adequate ventilation are essential. Dust masks, respirators, or goggles may be needed where amounts of significant soluble or alkaline forms are encountered, as well as protective clothing.

Respirator Selection:

2.5 mg/m³: DMXS
5 mg/m³: DMXSQ/FuHIEP/SA/SCBA
25 mg/m³: HIEPF/SAF/SCBAF
250 mg/m³: Sa:PD,PP,SAF:CF/PAPHE
Escape: HIEP/SCBA

Disposal Method Suggested: Barium fluoride—Precipitation with soda ash or slaked lime. The resulting sludge should be sent to a chemical waste landfill. Barium nitrate, barium sulfide—Chemical reaction with water, caustic soda, and slaked lime, resulting in precipitation of the metal sludge, which may be landfilled. Barite (barium sulfate) may be recovered from drilling muds for reuse (A-57) as an alternative to disposal.

References

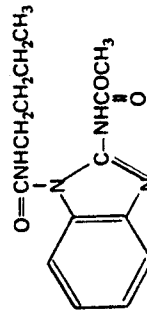
- (1) U.S. Environmental Protection Agency, *Toxicology of Metals, Vol. 2: Barium*, pp 71-84, Report EPA-600/1-77-022, Research Triangle Park, NC (May 1977).
- (2) U.S. Environmental Protection Agency, *Barium*, Health and Environmental Effects Profile No. 13, Wash., DC, Office of Solid Waste (April 30, 1980).

BAYGON®

Baygon® is a registered trademark name for the compound with the generic name of Propoxur (which see). ACGIH lists the compound under the trade-marked name rather than the generic name; hence it is cross-referenced here.

BENOMYL

Description: Methyl 1-[(butylamino)carbonyl]1H-benzimidazol-2-ylcarbamate, C₁₄H₁₈N₄O₃, with the structural formula



Benomyl is a colorless crystalline solid with a faint acrid odor which decomposes before melting.

Code Numbers: CAS 17804-35-2 RTECS DD6475000 UN 2588

DOT Designation: -

Synonyms: Benlate®.

Potential Exposure: Those involved in the manufacture (A-32), formulation and application of this fungicide.

Permissible Exposure Limits in Air: There is no Federal standard but ACGIH has set a TWA of 10 mg/m³ and a tentative STEL of 15 mg/m³.

Permissible Concentration in Water: No criteria set.

Harmful Effects and Symptoms: Benomyl is generally felt to have a low order of acute and chronic toxicity (A-34). However, a rebuttable presumption against registration for benomyl was issued on December 6, 1978 by U.S. EPA on the basis of reduction in nontarget species, mutagenicity, teratogenicity, reproductive effects, and hazard to wildlife.

BENZAL CHLORIDE

- Hazardous waste (EPA)

Description: C₆H₅CHCl₂ is a fuming colorless liquid which boils at 207°C.

Code Numbers: CAS 98-87-3 RTECS CZ5075000

DOT Designation: -

Synonyms: (Dichloromethyl)benzene; Benzylidene chloride

Potential Exposure: Benzal chloride is used almost exclusively for the manufacture of benzaldehyde. It can also be used to prepare cinnamic acid and benzoyl chloride.

Permissible Exposure Limits in Air: No standard set. (Inhaled benzal chloride will hydrolyze and probably produce effects similar to those of inhaled hydrochloric acid.)

Permissible Concentration in Water: No criteria set. (Benzal chloride hydrolyzes to benzaldehyde and HCl on contact with water.)

Harmful Effects and Symptoms: Benzal chloride is irritating to the skin. Benzal chloride was found to induce carcinomas, leukemia, and papillomas in mice. Benzal chloride was shown to possess a longer latency period than benzotrichloride before the onset of harmful effects (1).

Disposal Method Suggested: 1500°F, 0.5 second minimum for primary combustion; 2200°F, 1.0 second for secondary combustion; elemental chlorine formation may be alleviated through injection of steam or methane into the combustion process.

References

- (1) U.S. Environmental Protection Agency, *Benzal Chloride*, Health and Environmental Effects Profile No. 14, Wash., DC, Office of Solid Waste (April 30, 1980).

BENZENE

- Carcinogen (IARC) (5)
- Hazardous substance (EPA)
- Hazardous waste (EPA)
- Priority toxic pollutant (EPA)

Description: C₆H₆, benzene, is a clear, volatile, colorless, highly flammable liquid with a characteristic odor. The most common commercial grade contains

50 to 100% benzene, the remainder consisting of toluene, xylene, and other constituents which distill below 120°C.

Code Numbers: CAS 71-43-2 RTECS CY1400000 UN 1114

DOT Designation: Flammable liquid

Synonyms: Benzol, phenyl hydride, coal naphtha, phene, benzole, cyclohexatriene.

Potential Exposure: Benzene is used as a constituent in motor fuels, as a solvent for fats, inks, oils, paints, plastics, and rubber, in the extraction of oils from seeds and nuts, and in photogravure printing (1). It is also used as a chemical intermediate. By alkylation, chlorination, nitration, and sulfonation, chemicals such as styrene, phenols, and maleic anhydride are produced. Benzene is also used in the manufacture of detergents, explosives, pharmaceuticals, and dyes.

NIOSH estimates that approximately 2 million workers in the U.S. are potentially exposed to benzene. Increased concern for benzene as a significant environmental pollutant arises from public exposure to the presence of benzene in gasoline and the increased content in gasoline due to requirements for unleaded fuels for automobiles equipped with catalytic exhaust converters.

Incompatibilities: Strong oxidizers; chlorine, bromine with iron.

Permissible Exposure Limits in Air: In 1974 NIOSH published a criteria document (2) for occupational exposure to benzene which recommended adherence to an existing Federal standard of 10 ppm (30 mg/m³) as a time-weighted average with a ceiling of 25 ppm.

The Federal emergency standard for benzene effective May 21, 1977, is 1 ppm for an 8-hour TWA, with 5 ppm as a maximum peak above the acceptable ceiling for a maximum duration of 15 minutes.

OSHA again has amended its permanent standard as of mid-1978 limiting worker exposure to benzene to 1 ppm to exempt workplaces where benzene levels in liquids do not exceed 0.5%. After three years the minimum allowable level would be 0.1%. When OSHA first issued the standard no exemption for benzene mixtures was allowed. Later it amended the standard to exempt workplaces where the level of benzene in mixtures was less than 0.1%. In July 1980, the U.S. Supreme Court struck down the OSHA standard because it failed to show a cost/benefit analysis. In addition, ACGIH designated benzene as an "Industrial Substance Suspect of Carcinogenic Potential for Man," with a TLV of 10 ppm (30 mg/m³) and a tentative STEL of 25 ppm (75 mg/m³) as of 1980. The IDLH level is 2,000 ppm.

Determination in Air: Adsorption on charcoal, workups with CS₂, analysis by gas chromatography. See NIOSH Methods, Set U. See also reference (A-10). Benzene may also be determined with long duration detector tubes (A-11).

Permissible Concentration in Water: To protect freshwater aquatic life: 5,300 µg/l on an acute basis. To protect saltwater aquatic life: 5,100 µg/l on an acute basis. To protect human health: preferably zero. An additional lifetime cancer risk of 1 in 100,000 results from a concentration of 6.6 µg/l.

Determination in Water: Gas chromatography (EPA Method 602) or gas chromatography plus mass spectrometry (EPA Method 624).

Routes of Entry: Inhalation of vapor which may be supplemented by percutaneous absorption although benzene is poorly absorbed through intact skin; ingestion; skin and eye contact.

Harmful Effects and Symptoms: Local - Exposure to liquid and vapor may produce primary irritation to skin, eyes, and upper respiratory tract. If the liquid is aspirated into the lung, it may cause pulmonary edema and hemorrhage. Erythema, vesiculation, and dry, scaly dermatitis may also develop from defatting of the skin.

Systemic - Acute exposure to benzene results in central nervous system depression. Headache, dizziness, nausea, convulsions, coma, and death may result. Death has occurred from large acute exposure or as a result of ventricular fibrillation, probably caused by myocardial sensitization to endogenous epinephrine.

Early reported autopsies revealed hemorrhages (nonpathognomonic) in the brain, pericardium, urinary tract, mucous membranes, and skin. Chronic exposure to benzene is well documented to cause blood changes. Benzene is basically a myelotoxic agent. Erythrocyte, leukocyte, and thrombocyte counts may first increase, and then aplastic anemia may develop with anemia, leukopenia, and thrombocytopenia. The bone marrow may become hypo- or hyperactive and may not always correlate with peripheral blood.

Recent epidemiologic studies along with case reports of benzene related blood dyscrasias and chromosomal aberrations have led NIOSH to conclude that benzene is leukemogenic. The evidence is most convincing for acute myelogenous leukemia and for acute erythroleukemia, but a connection with chronic leukemia has been noted by a few investigators.

Recent work has shown increases in the rate of chromosomal aberrations associated with benzene myelotoxicity. These changes in the bone marrow are stable and may occur several years after exposure has ceased. "Stable" changes may give rise to leukemic clones and seem to involve chromosomes of the G group.

Points of Attack: Blood, central nervous system, skin, bone marrow, eyes, respiratory system.

Medical Surveillance: Preplacement and periodic examinations should be concerned especially with effects on the blood and bone marrow and with a history of exposure to other myelotoxic agents or drugs or of other diseases of the blood. Preplacement laboratory exams should include: (a) complete blood count (hematocrit, hemoglobin, mean corpuscular volume, white blood count, differential count, and platelet estimation); (b) reticulocyte count; (c) serum bilirubin; and (d) urinary phenol.

The type and frequency of periodic hematologic studies should be related to the data obtained from biologic monitoring and industrial hygiene studies, as well as any symptoms or signs of hematologic effects. Recommendations for proposed examinations have been made in the criteria for a recommended standard. Examinations should also be concerned with other possible effects such as those on the skin, central nervous system, and liver and kidney functions.

Biologic monitoring should be provided to all workers subject to benzene exposure. It consists of sampling and analysis of urine for total phenol content. The objective of such monitoring is to be certain that no worker absorbs an unacceptable amount of benzene. Unacceptable absorption of benzene, posing a risk of benzene poisoning, is considered to occur at levels of 75 mg phenol per liter of urine (with urine specific gravity corrected to 1.024), when determined by methods specified in the NIOSH "Criteria for Recommended Standard-Benzene." Alternative methods shown to be equivalent in accuracy and pre-

cision may also be useful. Biological monitoring should be done at quarterly intervals. If environmental sampling and analysis are equal to or exceed accepted safe limits, the urinary phenol analysis should be conducted every two weeks. This increased monitoring frequency should continue for at least 2 months after the high environmental level has been demonstrated.

Two follow-up urines should be obtained within one week after receipt of the original results, one at the beginning and the other at the end of the work week. If original elevated findings are confirmed, immediate steps should be taken to reduce the worker's absorption of benzene by improvement in environment control, personal protection, personal hygiene, and administrative control. See also reference (7).

First Aid: If this chemical gets into the eyes, irrigate immediately. If this chemical contacts the skin, wash with soap promptly. If a person breathes in large amounts of this chemical, move the exposed person to fresh air at once and perform artificial respiration. When this chemical has been swallowed, get medical attention. Do not induce vomiting.

Personal Protective Methods: Wear appropriate clothing to prevent repeated or prolonged skin contact. Wear eye protection to prevent any reasonable probability of eye contact. Employees should wash promptly with soap when skin is wet or contaminated. Remove clothing immediately if wet or contaminated to avoid flammability hazard.

Respirator Selection:

- 10 ppm: SA/SCBA
 - 50 ppm: SAF/SCBAF
 - 1,000 ppm: SA:PD,PP,CF
 - 2,000 ppm: SAF:PD,PP,CF
- Escape: GMS/SCBA

Disposal Method Suggested: Incineration.

References

- (1) National Academy of Sciences, *A Review of Health Effects of Benzene*, National Academy of Sciences, Washington, DC (June 1976).
- (2) National Institute for Occupational Safety and Health, *Criteria for a Recommended Standard: Occupational Exposure to Benzene*, NIOSH Doc. No. 74-137, Washington, DC (1974).
- (3) U.S. Environmental Protection Agency, *Benzene: Ambient Water Quality Criteria*, Wash., DC (1980).
- (4) U.S. Environmental Protection Agency, *Status Assessment of Toxic Chemicals: Benzene*, Report EPA-600/2-79-210D, Wash., DC (Dec. 1979).
- (5) International Agency for Research on Cancer, *IARC Monographs on the Carcinogenic Risk of Chemicals to Humans*, 7, 203, Lyon, France (1974) and 11, 295, Lyon, France (1976).
- (6) U.S. Environmental Protection Agency, *Benzene*, Health and Environmental Effects Profile No. 15, Wash., DC, Office of Solid Waste (April 30, 1980).
- (7) Nat. Inst. for Occup. Safety and Health, *A Guide to the Work Relatedness of Disease*, Revised Edition, DHEW (NIOSH) Publication No. 79-116, pp 63-72, Cincinnati, OH (Jan. 1979).

BENZIDINE

- Carcinogen (Human positive, IARC) (3)
- Hazardous waste (EPA)
- Priority toxic pollutant (EPA)

Description: $\text{NH}_2\text{C}_6\text{H}_4\text{C}_6\text{H}_4\text{NH}_2$, benzidine, is a crystalline solid with a significant vapor pressure. The salts are less volatile, but tend to be dusty.

Code Numbers: CAS 92-87-5 RTECS DC9625000 UN 1885

DOT Designation: Poison B

Synonyms: 4,4'-Biphenyldiamine, p-diaminodiphenyl, 4,4'-diaminobiphenyl, 4,4'-diphenylenediamine, benzidine base.

Potential Exposures: Benzidine is used primarily in the manufacture of azo dyestuffs; there are over 250 of these produced. Other uses, including some which may have been discontinued, are in the rubber industry as a hardener, in the manufacture of plastic films, for detection of occult blood in feces, urine, and body fluids, in the detection of H_2O_2 in milk, in the production of security paper, and as a laboratory reagent in determining HCN, sulfate, nicotine, and certain sugars. No substitute has been found for its use in dyes.

Free benzidine is present in the benzidine-derived azo dyes. According to industry, quality control specifications require that the level not exceed 20 ppm, and in practice the level is usually below 10 ppm. Industry has estimated a total environmental discharge at the 300 user facility sites of 450 pounds per year or about 1.5 pounds per year per facility, assuming all of the free benzidine is discharged in the liquid effluent.

No measurements for benzidine in ambient air, surface water, or drinking water have been reported. Further, no measurements for free benzidine in finished products containing azo dyes have been reported.

Estimates of the number of people exposed to benzidine and 3,3'-dichlorobenzidine are difficult to obtain. It has been suggested that 62 people in the U.S. are exposed to the former and between 250 and 2,500 to the latter.

Permissible Exposure Limits in Air: Benzidine and its salts are included in a Federal standard for carcinogens; all contact with them should be avoided. Cutaneous absorption is possible.

Determination in Air: Collection on a filter followed by colorimetric analysis (A-12). See also reference (A-10).

Permissible Concentration in Water: To protect freshwater aquatic life—2,500 $\mu\text{g}/\text{l}$ on an acute basis; insufficient data to yield a value for saltwater aquatic life. To protect human health—preferably zero. An additional lifetime cancer risk of 1 in 100,000 results from a concentration of 0.0012 $\mu\text{g}/\text{l}$.

Determination in Water: High performance liquid chromatography (EPA Method 605) or an oxidation/colorimetric method using Chloramine T (available from EPA) or a gas chromatography/mass spectrometric method (EPA Method 625).

Routes of Entry: Inhalation, percutaneous absorption, and ingestion of dust.

Harmful Effects and Symptoms: Local -- Contact dermatitis to primary irritation or sensitization has been reported.

Systemic -- Benzidine is a known human urinary tract carcinogen with an average latent period of 16 years. The first symptoms of bladder cancer usually are hematuria, frequency of urination, or pain.

Points of Attack: Skin, bladder.

Medical Surveillance: Placement and periodic examinations should include an evaluation of exposure to other carcinogens; use of alcohol, smoking, and medications; and family history. Special attention should be given on a regular

CHLORINATED PHENOLS

See also "2-Chlorophenol," "2,4-Dichlorophenol," "2,6-Dichlorophenol," "2,4,5-Trichlorophenol" and "Pentachlorophenol."

It is well known that the highly toxic polychlorinated dibenzo-p-dioxins may be formed during the chemical synthesis of some chlorophenols and that the amount of contaminant formed is dependent upon the temperature and precise control of the reaction. The toxicity of the dioxins varies with the position and number of substituted chlorine atoms and those containing chlorine in the 2, 3 and 7 positions are particularly toxic. The 2,3,7,8-tetrachlorodibenzop-dioxin (TCDD) is considered the most toxic of all the dioxins.

Evidence has accumulated that the various chlorophenols are formed as intermediate metabolites during the microbiological degradation of the herbicides 2,4-D and 2,4,5-T and pesticides silvex, ronnel, lindane and benzene hexachloride. In view of this, it is clear that chlorinated phenols represent important compounds with regard to potential point source and nonpoint source water contamination.

Chlorophenols may be produced inadvertently by chlorination reactions which take place during the disinfection of wastewater effluents or drinking water sources. Phenol has been reported to be highly reactive to chlorine in dilute aqueous solutions over a considerable pH range.

References

- (1) U.S. Environmental Protection Agency, *Chemical Hazard Information Profile: Mono/Dichlorophenols*, Washington, DC (1979).
- (2) U.S. Environmental Protection Agency, *Chlorinated Phenols: Ambient Water Quality Criteria*, Washington, DC (1980).
- (3) U.S. Environmental Protection Agency, *Reviews of the Environmental Effects of Pollutants, XI: Chlorophenols*, Report EPA-600/1-79-012, Cincinnati, OH (1979).
- (4) U.S. Environmental Protection Agency, *Chlorinated Phenols*, Health and Environmental Effects Profile No. 39, Office of Solid Waste, Washington, DC (April 30, 1980).

CHLORINE

● Hazardous substance (EPA)

Description: Cl₂, chlorine, is a greenish-yellow gas with a pungent odor. It is slightly soluble in water and is soluble in alkalis. It is the commonest of the four halogens which are among the most chemically reactive of all the elements.

Code Numbers: CAS 7782-50-5 RTECS FO2100000 UN 1017

DOT Designation: Nonflammable gas, poison and oxidizer.

Synonyms: None.

Potential Exposures: Gaseous chlorine is a bleaching agent in the paper and pulp and textile industries for bleaching cellulose for artificial fibers. It is used in the manufacture of chlorinated lime, inorganic and organic compounds such as metallic chlorides, chlorinated solvents, refrigerants, pesticides, and polymers, e.g., synthetic rubber and plastics; it is used as a disinfectant, particularly for water and refuse, and in detinning and dezincing iron. NIOSH estimated in 1973 that 15,000 workers had potential occupational exposure to chlorine.

Incompatibilities: Combustible substances and finely divided metals.

Permissible Exposure Limits in Air: Federal standard is 1 ppm (3 mg/m³). NIOSH has recommended a ceiling limit of 0.5 ppm for a 15-minute sampling period. The basis for the NIOSH-recommended environmental limit is the prevention of irritation of the skin, eyes, and respiratory tract. The tentative STEL is 3 ppm (9 mg/m³). The IDLH level is 25 ppm.

Determination in Air: Collection by fritted bubbler, colorimetric analysis using methyl orange which is bleached by free chlorine (A-11).

Permissible Concentration in Water: EPA (A-3) has suggested the following limits: Total residual chlorine: 2.0 µg/l for salmonid fish; 10.0 µg/l for other freshwater and marine organisms.

Routes of Entry: Inhalation, eye and skin contact.

Harmful Effects and Symptoms: *Local* - Chlorine reacts with body moisture to form acids. It is itself extremely irritating to skin, eyes, and mucous membranes, and it may cause corrosion of teeth. Prolonged exposure to low concentrations may produce chloracne.

Systemic - Chlorine in high concentrations acts as an asphyxiant by causing cramps in the muscles of the larynx (choking), swelling of the mucous membranes, nausea, vomiting, anxiety, and syncope. Acute respiratory distress including cough, hemoptysis, chest pain, dyspnea, and cyanosis develop, and later tracheobronchitis, pulmonary edema, and pneumonia may supervene.

Points of Attack: Lungs, respiratory system.

Medical Surveillance: Special emphasis should be given to the skin, eyes, teeth, cardiovascular status in placement and periodic examinations. Chest x-rays should be taken and pulmonary function followed.

First Aid: If this chemical gets into the eyes, irrigate immediately. If this chemical contacts the skin, flush with water immediately. If a person breathes in large amounts of this chemical, move the exposed person to fresh air at once and perform artificial respiration.

Personal Protective Methods: Whenever there is likelihood of excessive gas levels, workers should use respiratory protection in the form of fullface gas masks with proper canisters or supplied air respirators. The skin effects of chlorine can generally be controlled by good personal hygiene practices. Where very high gas concentrations or liquid chlorine may be present, full protective clothing, gloves, and eye protection should be used. Changing work clothes daily and showering following each shift where exposures exist are recommended.

Respirator Selection:

25 ppm: CCRSF/GMS/SAF/SCBAF

Escape: GMSF/SCBA

Note: Do not use oxidizable sorbents.

Disposal Method Suggested: Introduce into large volume and solution of reducing agent (bisulfite, ferrous salts or hypo), neutralize and flush to sewer with water (A-38). Recovery is an option to disposal for chlorine (A-57) in the case of gases from aluminum chloride electrolysis and chlorine in wastewaters.

References

- (1) National Institute for Occupational Safety and Health, *Criteria for a Recommended Standard: Occupational Exposure to Chlorine*, NIOSH Document No. 76-170 (1976).
- (2) National Academy of Sciences, *Medical and Biological Effects of Environmental Pollutants: Chlorine and Hydrogen Chloride*, Washington, DC (1976).

Determination in Air: Collection by charcoal tube, analysis by gas liquid chromatography (A-10).

Permissible Concentration in Water: No criteria set, but EPA (A-37) has suggested a permissible ambient goal of 26,000 $\mu\text{g}/\ell$ based on health effects.

Routes of Entry: Inhalation of vapor and percutaneous absorption, ingestion, eye and skin contact.

Harmful Effects and Symptoms: *Local* — Mild irritation of eye and nose occurs at very high concentrations. The liquid can defat the skin, producing a dermatitis characterized by drying and fissuring.

Systemic — Prolonged inhalation of high concentrations, besides the local effect on the eyes and upper respiratory tract, may produce headache, drowsiness, tremors, and fatigue. Tolerance may be a factor in individual response to a given air concentration.

Bizarre symptoms (other than typical manifestations of intoxication) may result from the denaturants often present in industrial ethyl alcohol. Ethyl alcohol may act as an adjuvant, increasing the toxicity of other inhaled, absorbed, or ingested chemical agents. An exception is methanol where ethyl alcohol counteracts methanol toxicity.

Medical Surveillance: Look for chronic irritation of mucous membranes and signs of chronic alcoholism in regular physical examinations. Ethyl alcohol can readily be determined in blood, urine, and expired air.

First Aid: Irrigate eyes with water.

Personal Protective Methods: Personal protective equipment is recommended where skin contact may occur.

Disposal Method Suggested: Incineration.

ETHYLAMINE

- Hazardous substance (EPA)

Description: $\text{C}_2\text{H}_5\text{NH}_2$ is a colorless liquid or gas with a strong ammonia-like odor. It boils at 15° to 16°C.

Code Numbers: CAS 75-04-7 RTECS KH2100000 UN 1036

DOT Designation: Flammable gas.

Synonyms: Ethylamine (anhydrous), aminoethane, monoethylamine.

Potential Exposure: Monoethylamine (MEA) is used as an intermediate in the manufacture of the following chemicals: triazine herbicides (A-32), 1,3-diethylthiourea (a corrosion inhibitor), ethylaminoethanol, 4-ethylmorpholine (urethane foam catalyst), ethyl isocyanate, and dimethylolmethylethyltriazone (agent used in wash-and-wear fabrics). The cuprous chloride salts of MEA are used in the refining of petroleum and vegetable oil.

Incompatibilities: Strong acids, strong oxidizers.

Permissible Exposure Limits in Air: The Federal standard is 10 ppm (18 mg/m^3). There are no STEL values proposed. The IDLH level is 4,000 ppm.

Determination in Air: Adsorption on silica, workup with H_2SO_4 using ultrasonics, analysis by gas chromatography. See NIOSH Methods, Set K. See also reference (A-10).

Permissible Concentration in Water: No criteria set, but EPA (A-37) has suggested an ambient environmental goal of 248 $\mu\text{g}/\ell$ on a health basis.

Routes of Entry: Inhalation, skin absorption, ingestion, eye and skin contact. **Harmful Effects and Symptoms:** Eye irritation, skin burns, dermatitis, respiratory irritation.

Points of Attack: Respiratory system, eyes, skin.

Medical Surveillance: Consider the points of attack in preplacement and periodic physical examinations.

First Aid: If this chemical gets into the eyes, irrigate immediately. If this chemical contacts the skin, flush with water immediately. If a person breathes in large amounts of this chemical, move the exposed person to fresh air at once and perform artificial respiration. When this chemical has been swallowed, get medical attention. Give large quantities of water and induce vomiting. Do not make an unconscious person vomit.

Personal Protective Methods: Wear appropriate clothing to prevent any reasonable probability of skin contact. Wear eye protection to prevent any possibility of eye contact. Employees should wash immediately when skin is wet or contaminated. Remove nonimpervious clothing immediately if wet or contaminated. Provide emergency showers and eyewash.

Respirator Selection:

500 ppm: SAF/SCBAF

4,000 ppm: SAF:PD,PP,CF

Escape: GMS/SCBA

Disposal Method Suggested: Controlled incineration; incinerator is equipped with a scrubber or thermal unit to reduce NO_x emissions.

References

- (1) U.S. Environmental Protection Agency, *Chemical Hazard Information Profile: Ethylamines*, Washington, DC (April 1, 1978).

ETHYLBENZENE

- Hazardous substance (EPA)
- Priority toxic pollutant (EPA)

Description: $\text{C}_6\text{H}_5\text{CH}_2\text{CH}_3$ is a colorless liquid with a pungent aromatic odor. It boils at 136°C.

Code Numbers: CAS 100-41-4 RTECS DA0700000 UN 1175

DOT Designation: Flammable liquid.

Synonyms: Ethylbenzol, phenylethane, EB.

Potential Exposure: Ethyl benzene is used in the manufacture of cellulose acetate, styrene, and synthetic rubber. It is also used as a solvent or diluent and as a component of automotive and aviation gasoline.

Significant quantities of EB are present in mixed xylenes. These are used as diluents in the paint industry, in agricultural sprays for insecticides and in gasoline blends (which may contain as much as 20% EB). In light of the large quantities of EB produced and the diversity of products in which it is found, there

Handbook of Toxic and Hazardous Chemicals

304

exist many environmental sources for ethylbenzene, e.g., vaporization during solvent use, pyrolysis of gasoline and emitted vapors at filling stations.

Groups of individuals who are exposed to EB to the greatest extent and could represent potential pools for the expression of EB toxicity include: (1) individuals in commercial situations where petroleum products or by-products are manufactured (e.g., rubber or plastics industry); (2) individuals residing in areas with high atmospheric smog generated by motor vehicle emissions.

Incompatibilities: Strong oxidizers.

Permissible Exposure Limits in Air: The Federal standard is 100 ppm (435 mg/m³). The tentative STEL is 125 ppm (545 mg/m³). The IDLH level is 2,000 ppm. The USSR standards are eight times lower than in the United States.

Determination in Air: Charcoal adsorption, workup with CS₂, analysis by gas chromatography. See NIOSH Methods, Set C. See also reference (A-10).

Permissible Concentration in Water: To protect freshwater aquatic life—32,000 µg/l, on an acute toxicity basis. To protect saltwater aquatic life—430 µg/l, on an acute toxicity basis. For the protection of human health—1.4 µg/l.

Determination in Water: Inert gas purge followed by gas chromatography and photoionization detection (EPA Method 602) or gas chromatography plus mass spectrometry (EPA Method 624).

Routes of Entry: Inhalation, ingestion, eye and skin contact.

Harmful Effects and Symptoms: Kidney disease, liver disease, chronic respiratory disease, skin disease—and the facts in brief are as follows: EB is not nephrotoxic. Concern is expressed because the kidney is the primary route of excretion of EB and its metabolites. EB is not hepatotoxic. Since EB is metabolized by the liver, concern is expressed for this tissue. Exacerbation of pulmonary pathology might occur following exposure to EB. Individuals with impaired pulmonary function might be at risk. EB is a defatting agent and may cause dermatitis following prolonged exposure. Individuals with preexisting skin problems may be more sensitive to EB.

Irritation of eyes and mucous membranes; headaches, dermatitis; narcosis, coma.

Points of Attack: Eyes, upper respiratory system, skin, central nervous system.

Medical Surveillance: Consider the points of attack in preplacement and periodic physical examinations.

First Aid: If this chemical gets into the eyes, irrigate immediately. If this chemical contacts the skin, flush with water promptly. If a person breathes in large amounts of this chemical, move the exposed person to fresh air at once and perform artificial respiration. When this chemical has been swallowed, get medical attention. Do not induce vomiting.

Personal Protective Methods: Wear appropriate clothing to prevent repeated or prolonged skin contact. Wear eye protection to prevent any reasonable probability of eye contact. Employees should wash promptly when skin is wet or contaminated. Remove clothing immediately if wet or contaminated to avoid flammability hazard.

Respirator Selection:

1,000 ppm: CCROVF
2,000 ppm: GMOV/SAF/SCBAF
Escape: GMOV/SCBA

Disposal Method Suggested: Incineration.

References

- (1) U.S. Environmental Protection Agency, *Ethylbenzene: Ambient Water Quality Criteria*, Washington, DC (1980).

ETHYL BROMIDE

Description: C₂H₅Br is a colorless to yellow liquid with an ether-like odor. It boils at 37° to 38°C. It has a burning taste and becomes yellowish on exposure to air.

Code Numbers: CAS 74-96-4 RTECS KH6475000 UN 1891

Dot Designation: None.

Synonyms: Bromoethane, monobromoethane.

Potential Exposure: This chemical is used as an ethylating agent in organic synthesis and gasoline, as a refrigerant, and as an extraction solvent. It has limited use as a local anesthetic.

Incompatibilities: Chemically active metals: sodium, potassium, calcium, powdered aluminum, zinc, magnesium.

Permissible Exposure Limits in Air: The Federal standard is 200 ppm (890 mg/m³). The tentative STEL is 250 ppm (1,110 mg/m³). The IDLH level is 3,500 ppm.

Determination in Air: Charcoal adsorption, workup with isopropanol, gas chromatography. See NIOSH Methods, Set H. See also reference (A-10).

Permissible Concentration in Water: No criteria set.

Routes of Entry: Inhalation, ingestion, eye and skin contact.

Harmful Effects and Symptoms: Irritation of skin, eyes and respiratory system; central nervous system depression; pulmonary edema; liver, kidney disease; cardiac arrhythmias; cardiac arrest; dizziness.

Points of Attack: Skin, liver, kidneys, respiratory system, lungs, cardiovascular system, central nervous system.

Medical Surveillance: No specific considerations needed according to NIOSH.

First Aid: If this chemical gets into the eyes, irrigate immediately. If this chemical contacts the skin, flush with soap promptly. If a person breathes in large amounts of this chemical, move the exposed person to fresh air at once and perform artificial respiration. When this chemical has been swallowed, get medical attention. Give large quantities of salt water and induce vomiting. Do not make an unconscious person vomit.

Personal Protective Methods: Wear appropriate (rubber, not leather) clothing to prevent repeated or prolonged skin contact. Wear eye protection to prevent any reasonable probability of eye contact. Employees should wash promptly when skin is wet. Remove clothing immediately if wet or contaminated to avoid flammability hazard.

- (2) Occupational Health and Safety Administration, *Criteria for a Recommended Standard: Occupational Exposure to Ethylene Dibromide*, NIOSH Doc. No. 77-221 (1977).
- (3) Nat. Inst. for Occup. Safety and Health, *Current Intelligence Bulletin No. 3: Ethylene Dibromide*, Rockville, MD (July 7, 1975).
- (4) International Agency for Research on Cancer, *IARC Monographs on the Carcinogenic Risks of Chemicals to Humans*, Lyon, France 15, 195 (1977).

ETHYLENE DICHLORIDE

- Carcinogen (positive, NCI) (7)
- Hazardous substance (EPA)
- Hazardous waste (EPA)
- Priority toxic pollutant (EPA)

Description: $\text{CICH}_2\text{CH}_2\text{Cl}$, 1,2-dichloroethane, is a colorless, flammable liquid which has a pleasant odor, sweetish taste. It boils at 84°C .

Code Numbers: CAS 107-06-2 RTECS K10525000 UN 1184

DOT Designation: Flammable liquid.

Synonyms: 1,2-Dichloroethane, sym-dichloroethane, ethylene chloride, glycol dichloride.

Potential Exposures: In recent years, 1,2-dichloroethane has found wide use in the manufacture of ethylene glycol, diaminoethylene, polyvinyl chloride, nylon, viscose rayon, styrene-butadiene rubber, and various plastics. It is a solvent for resins, asphalt, bitumen, rubber, cellulose acetate, cellulose ester, and paint; a degreaser in the engineering, textile and petroleum industries; and an extracting agent for soybean oil and caffeine. It is also used as an antiknock agent in gasoline, a pickling agent, a fumigant, and a drycleaning agent. It has found use in photography, xerography, water softening, and also in the production of adhesives, cosmetics, pharmaceuticals, and varnishes.

In an early document (1) issued in 1976 NIOSH estimated that 18,000 workers were potentially exposed to ethylene dichloride. In a subsequent document issued in 1978 (2) NIOSH estimates that as many as 2 million workers may have occupational exposure to ethylene dichloride. Of these workers, an estimated 34,000 are exposed to ethylene dichloride 4 hours or more per day.

Incompatibilities: Strong oxidizers, strong caustics, chemically active metals, such as aluminum or magnesium powder, sodium, potassium.

Permissible Exposure Limits in Air: The current Federal standard for ethylene dichloride is 50 parts of ethylene dichloride per million parts of air (ppm) averaged over an eight-hour work shift, with a ceiling level of 100 ppm and a maximum acceptable peak of 200 ppm for 5 minutes in any three-hour period. NIOSH has recommended that the permissible exposure limit be reduced to 5 ppm averaged over a work shift of 10 hours per day, 40 hours per week, with a ceiling level of 15 ppm averaged over a 15-minute period. The NIOSH Criteria Document for Ethylene Dichloride (1) should be consulted for more detailed information.

Neither of these levels may provide adequate protection from potential carcinogenic effects because they were selected to prevent toxic effects other than cancer.

As an interim and prudent measure while the carcinogenicity of ethylene dichloride is being further evaluated, NIOSH recommends (2) that occupational

utes duration. NIOSH has recommended as of 1977 that the employer shall control workplace concentrations of ethylene dibromide so that no employee is exposed in his workplace to concentrations greater than 1.0 mg/m^3 (0.13 ppm) as a ceiling limit, as determined by a sampling period of 15 minutes. ACGIH has cited ethylene dibromide as a "substance with recognized carcinogenic potential awaiting reassignment of TLV pending further data acquisition." In November 1978, NCI called EDB "the most potent cancer-causing substance ever found in the animal test program of NCI." Industry sources rebutted this and a decision by EPA on use restriction was pending.

A rebuttable presumption against registration for EDB for pesticide uses was issued on December 14, 1977 by EPA on the basis of oncogenicity, mutagenicity and reproductive effects (A-32).

Determination in Air: Charcoal adsorption, workup with CS_2 , analysis by gas chromatography. See NIOSH Methods, Set H. See also reference (A-10).

Permissible Concentration in Water: No criteria set.

Routes of Entry: Inhalation of the vapor, absorption through the skin, ingestion and eye and skin contact.

Harmful Effects and Symptoms: *Local* — Prolonged contact of the liquid with the skin may cause erythema, blistering, and skin ulcers. These reactions may be delayed 24 to 48 hours. Dermal sensitization to the liquid may develop. The vapor is irritating to the eyes and to the mucous membranes of the respiratory tract.

Systemic — Inhalation of the vapor may result in severe acute respiratory injury, central nervous system depression, and severe vomiting. Animal experiments have produced injury to the liver and kidneys.

Points of Attack: Respiratory system, liver, kidneys, skin, eyes.

Medical Surveillance: Preemployment and periodic examinations should evaluate the skin and eyes, respiratory tract, and liver and kidney functions.

First Aid: If this chemical gets into the eyes, irrigate immediately. If this chemical contacts the skin, wash with soap immediately. If a person breathes in large amounts of this chemical, move the exposed person to fresh air at once and perform artificial respiration. When this chemical has been swallowed, get medical attention. Give large quantities of salt water and induce vomiting. Do not make an unconscious person vomit.

Personal Protective Methods: Wear appropriate clothing to prevent repeated or prolonged skin contact. Wear eye protection to prevent any reasonable probability of eye contact. Employees should wash immediately when skin is wet or contaminated. Remove nonimpervious clothing immediately if wet or contaminated. Provide emergency showers.

Respirator Selection:

10 mg/m^3 : SA/SCBA
 50 mg/m^3 : SAF/SCBAF
 2,000 mg/m^3 : SAF:PD,PP,CF
 Escape: GMOV/SCBA

Disposal Method Suggested: Controlled incineration with adequate scrubbing and ash disposal facilities.

References

- (1) Environmental Protection Agency, *Sampling and Analysis of Selected Toxic Substances, Task 1—Ethylene Dibromide*, Final Report. Office of Toxic Substances, EPA, Washington, DC (September 1975).

Disposal Method Suggested: Incineration, preferably after mixing with another combustible fuel. Care must be exercised to assure complete combustion to prevent the formation of phosgene. An acid scrubber is necessary to remove the halo acids produced. Alternatively, ethylene dichloride may be recovered from process off gases (A-58).

References

- (1) National Institute for Occupational Safety and Health, *Criteria for a Recommended Standard: Occupational Exposure to Ethylene Dichloride*, NIOSH Doc. No. 76-139 (1976).
- (2) National Institute for Occupational Safety and Health, *Ethylene Dichloride*, NIOSH Current Intelligence Bulletin No. 25, Washington, DC (April 19, 1978).
- (3) National Institute for Occupational Safety and Health, *Chloroethanes: Review of Toxicity*, Current Intelligence Bulletin No. 27, Washington, DC (August 21, 1978).
- (4) U.S. Environmental Protection Agency, *Chemical Hazard Information Profile: 1,2-Dichloroethane*, Washington, DC (September 1, 1977).
- (5) U.S. Environmental Protection Agency, *Chlorinated Ethanes: Ambient Water Quality Criteria*, Washington, DC (1980).
- (6) U.S. Environmental Protection Agency, *1,2-Dichloroethane*, Health and Environmental Effects Profile No. 70, Washington, DC, Office of Solid Waste (April 30, 1980).
- (7) National Cancer Institute, *Bioassay of 1,2-Dichloroethane for Possible Carcinogenicity* Technical Report Series No. 55, Bethesda, MD (1978).

ETHYLENE GLYCOL

51

Description: HOCH₂CH₂OH, ethylene glycol, is a colorless, odorless, viscous liquid with a sweetish taste.

Code Numbers: CAS 107-21-1 RTECS KW2975000

DOT Designation: —

Synonyms: 1,2-Ethanediol, glycol alcohol, glycol, EG.

Potential Exposures: Because of ethylene glycol's physical properties, it is used in antifreeze, hydraulic fluids, electrolytic condensers, and heat exchangers. It is also used as a solvent and as a chemical intermediate for ethylene glycol dinitrate, glycol esters, resins, and for pharmaceuticals (A-41).

Permissible Exposure Limits in Air: There is no Federal standard; however ACGIH in 1980 has recommended a TLV of 10 mg/m³ for particulate ethylene glycol and a ceiling value of 55 ppm (125 mg/m³) for the vapor. There was no tentative STEL set.

Permissible Concentration in Water: No criteria set, but EPA (A-37) has suggested a permissible ambient goal of 140 µg/l based on health effects.

Routes of Entry: Inhalation of particulate or vapor. Percutaneous absorption may also contribute to intoxication.

Harmful Effects and Symptoms: Local — None.

Systemic — Ethylene glycol's vapor pressure is such that at room temperature toxic concentrations are unlikely to occur. Poisoning resulting from vapor usually occurs only if ethylene glycol liquid is heated; therefore, occupational exposure is rare. Chronic symptoms and signs include: anorexia, oliguria, myoglobinuria, lymphocytosis, and loss of consciousness. Inhalation seems to primarily result in central nervous system depression and hematopoietic dysfunction.

exposure be minimized. Exposures should be limited to as few employees as possible, while minimizing workplace exposure levels with engineering and work practice controls.

The ACGIH has recommended a TWA value of 10 ppm (40 mg/m³) and a tentative STEL value of 15 ppm (60 mg/m³). The IDLH level is 1,000 ppm.

Determination in Air: Charcoal adsorption, workup with CS₂, analysis by gas chromatography. See NIOSH Methods, Set J. See also reference (A-10).

Permissible Concentration in Water: To protect freshwater aquatic life—118,000 µg/l on an acute toxicity basis and 20,000 µg/l on a chronic basis. To protect saltwater aquatic life—113,000 µg/l on an acute toxicity basis. To protect human health—preferably zero. An additional lifetime cancer risk of 1 in 100,000 occurs at a concentration of 9.4 µg/l.

Determination in Water: Inert gas purge followed by gas chromatography with halide specific detection (EPA Method 601) or gas chromatography plus mass spectrometry (EPA Method 624).

Routes of Entry: Inhalation of vapor, skin absorption of liquid, ingestion, eye and skin contact.

Harmful Effects and Symptoms: Local — Repeated contact with liquid can produce a dry, scaly, fissured dermatitis. Liquid and vapor may also cause eye damage, including corneal opacity.

Systemic — Inhalation of high concentrations may cause nausea, vomiting, mental confusion, dizziness, and pulmonary edema. Chronic exposure has been associated with liver and kidney damage.

Acute exposures can lead to death from respiratory and circulatory failure. Autopsies in such situations have revealed widespread bleeding and damage in most internal organs. Repeated long-term exposures to ethylene dichloride has resulted in neurologic changes, loss of appetite and other gastrointestinal problems, irritation of the mucous membranes, liver and kidney impairment, and death (1).

Points of Attack: Kidneys, liver, eyes, skin, central nervous system.

Medical Surveillance: Preplacement and periodic examinations should include an evaluation of the skin and liver and kidney functions.

First Aid: If this chemical gets into the eyes, irrigate immediately. If this chemical contacts the skin, wash with soap promptly. If a person breathes in large amounts of this chemical, move the exposed person to fresh air at once and perform artificial respiration. When this chemical has been swallowed, get medical attention. Give large quantities of salt water and induce vomiting. Do not make an unconscious person vomit.

Personal Protective Methods: Wear appropriate clothing to prevent repeated or prolonged skin contact. Wear eye protection to prevent any reasonable probability of eye contact. Employees should wash promptly when skin is wet or contaminated. Remove clothing immediately if wet or contaminated to avoid flammability hazard.

Respirator Selection: —

50 ppm: SA/SCBA
250 ppm: SAF/SCBAF
Escape: GMOV/SCBA

Note: For eye irritation, use full facepiece

Harmful Effects and Symptoms: Potential acute hazards consist of damage to the lungs and damage to the skin and eyes from burns from the hot coolant; potential chronic hazards comprise damage to liver, kidney and blood-forming organs with the possibility of induction of metabolic disorders and cancer (A-34).

HYDROGEN BROMIDE

Description: HBr, hydrogen bromide, is a corrosive colorless gas.

Code Numbers: CAS 10035-10-6 RTECS MW3850000 UN 1048

DOT Designation: Nonflammable gas.

Synonyms: Anhydrous hydrobromic acid.

Potential Exposure: Hydrogen bromide and its aqueous solutions are used in the manufacture of organic and inorganic bromides, as a reducing agent and catalyst in controlled oxidations, in the alkylation of aromatic compounds, and in the isomerization of conjugated diolefins. It is used in the production of many drugs (A-41).

Incompatibilities: Strong oxidizers, strong caustics, metals, moisture.

Permissible Exposure Limits in Air: The Federal standard for hydrogen bromide is 3.0 ppm (10 mg/m³). There is no STEL proposed. The IDLH level is 50 ppm.

Determination in Air: Absorption in a bubbler with sodium hydroxide, analysis by ion-specific electrode. See NIOSH Methods, Set L. See also reference (A-10).

Allowable Concentration in Water: No criteria set.

Routes of Entry: Inhalation, ingestion, eye and skin contact.

Harmful Effects and Symptoms: Hydrogen bromide (hydrobromic acid) is less toxic than bromine, but is an irritant to the mucous membranes of the upper respiratory tract. Long term exposures can cause chronic nasal and bronchial discharge and dyspepsia. Skin contact may cause burns. Eye irritation, eye burns and temporary blindness can result from HBr exposure.

Points of Attack: Respiratory system, eyes, skin.

Medical Surveillance: Consider the points of attack in preplacement and periodic physical examinations.

First Aid: If this chemical gets into the eyes, irrigate immediately. If this chemical contacts the skin, flush with water immediately. If a person breathes in large amounts of this chemical, move the exposed person to fresh air at once and perform artificial respiration. When this chemical has been swallowed, get medical attention. Give large quantities of water and do not induce vomiting.

Personal Protective Methods: Wear appropriate clothing to prevent any possibility of skin contact. Wear eye protection to prevent any possibility of eye contact. Employees should wash immediately when skin is wet or contaminated. Remove nonimpervious clothing immediately if wet or contaminated. Provide emergency showers and eyewash if contaminants are involved.

Respirator Selection:

50 ppm: CCRAFG/GMAG/SAF/SCBAF

Escape: GMAG/SCBA

Disposal Method Suggested: Soda ash/slaked lime is added to give a neutral bromide solution which is discharged to sewers or streams with water dilution.

References

(1) U.S. Environmental Protection Agency, *Chemical Hazard Information Profile: Bromine and Bromine Compounds*, Washington, DC (November 1, 1976).

HYDROGEN CHLORIDE

- Hazardous substance (EPA)

Description: HCl, hydrogen chloride, is a colorless, nonflammable gas, soluble in water. The aqueous solution is known as hydrochloric acid or muriatic acid and may contain as much as 38% HCl.

Code Numbers: CAS 7647-01-0 RTECS MW9610000 UN 1050

DOT Designation: Nonflammable gas.

Synonyms: Anhydrous hydrochloric acid, chlorohydric acid.

Potential Exposure: Hydrogen chloride itself is used in the manufacture of pharmaceutical hydrochlorides (A-41), chlorine, vinyl chloride from acetylene, alkyl chlorides from olefins, arsenic trichloride from arsenic trioxide; in the chlorination of rubber; as a gaseous flux for babbitting operations; and in organic synthesis involving isomerization, polymerization, alkylation, and nitration reactions.

The acid is used in the production of fertilizers, dyes, dyestuffs, artificial silk, and paint pigments; in refining edible oils and fats; in electroplating, leather tanning, ore refining, soap refining, petroleum extraction, pickling of metals, and in the photographic, textile, and rubber industries.

Incompatibilities: Most metals, alkali or active metals.

Permissible Exposure Limits in Air: The Federal standard for hydrogen chloride is 5 ppm (7 mg/m³) as a ceiling value. There is no tentative STEL value. The IDLH level is 100 ppm.

Determination in Air: Collection in a bubbler using sodium acetate, analysis by ion-specific electrode. See NIOSH Methods, Set R. See also reference (A-10).

Permissible Concentration in Water: No criteria set.

Route of Entry: Inhalation of gas or mist, ingestion, eye and skin contact.

Harmful Effects and Symptoms: Local - Hydrochloric acid and high concentrations of hydrogen chloride gas are highly corrosive to eyes, skin, and mucous membranes. The acid may produce burns, ulceration, and scarring on skin and mucous membranes, and it may produce dermatitis on repeated exposure. Eye contact may result in reduced vision or blindness. Dental discoloration and erosion of exposed incisors occur on prolonged exposure to low concentrations. Ingestion may produce fatal effects, from esophageal or gastric necrosis.

Systemic - The irritant effect of vapors on the respiratory tract may produce laryngitis, glottal edema, bronchitis, pulmonary edema, and death.

Points of Attack: Respiratory system, lungs, skin, eyes.

Medical Surveillance: Special consideration should be given to the skin, eyes, teeth, and respiratory system. Pulmonary function studies and chest x-rays may be helpful in following recovery from acute overexposure.

First Aid: If this chemical gets into the eyes, irrigate immediately. If this chemical contacts the skin, flush with water immediately. If a person breathes in large amounts of this chemical, move the exposed person to fresh air at once and perform artificial respiration. When this chemical has been swallowed, get medical attention. Give large quantities of water and do not induce vomiting.

Personal Protective Methods: Wear appropriate clothing to prevent any possibility of skin contact with liquids of pH <3 or repeated or prolonged contact with liquids of pH >3. Wear eye protection to prevent any possibility of eye contact. Employees should wash immediately when skin is wet or contaminated with liquids of pH <3. Remove nonimpervious clothing immediately if wet or contaminated with liquids of pH <3. Provide emergency showers and eyewash if liquids of pH <3 are involved.

Respirator Selection:

50 ppm: CCRAG/SA/SCBA
100 ppm: CCRABF/GMAG/SAF/SCBAF
Escape: GMAG/SCBA

Disposal Method Suggested: Soda ash-slaked lime is added to form the neutral solution of chloride of sodium and calcium. This solution can be discharged after dilution with water. Alternatively, hydrogen chloride can be recovered from a variety of process waste streams (A-57).

References

(1) National Institute for Occupational Safety and Health, *Information Profiles on Potential Occupational Hazards: Hydrogen Chloride (Gas)*, pp. 23-28, Report PB-276,678, Rockville, Maryland (1977).

HYDROGEN CYANIDE

- Hazardous substance (EPA)
- Hazardous waste (EPA)

Description: Hydrogen cyanide, a colorless gas or liquid which boils at 26°C, is intensely poisonous with the odor of bitter almonds. It is highly flammable and explosive and is a very weak acid. Hydrogen cyanide, HCN (together with its soluble salts), owes its toxicity to the -CN moiety and not to its acid properties. HCN vapor is released when cyanide salts come in contact with any acid.

Code Numbers: CAS 74-90-8 RTECS MW6825000 UN 1051

DOT Designation: Poison gas and flammable gas.

Synonyms: Hydrocyanic acid, prussic acid.

Potential Exposure: Hydrogen cyanide is used as a fumigant, in electroplating, and in chemical synthesis of acrylates and nitriles, particularly acrylonitrile. It may be generated in blast furnaces, gas works, and coke ovens. Cyanide salts have a wide variety of uses, including electroplating, steel hardening, fuming, gold and silver extraction from ores, and chemical synthesis. The number of workers with potential exposure to HCN has been estimated by NIOSH to be approximately 1,000.

Incompatibilities: Bases such as caustics, amines.

Permissible Exposure Limits in Air: The Federal standard for hydrogen cyanide is 10 ppm (11 mg/m³). NIOSH has recommended 5 mg/m³ expressed as cyanide and determined as a ceiling concentration based on a 10 minute sampling period. The ACGIH recommended TWA is 10 ppm (10 mg/m³). The notation "skin" is added to indicate the possibility of cutaneous absorption. There is no tentative STEL value. The IDLH level is 50 ppm.

Determination in Air: Sample is filtered, then drawn through a KOH bubbler. Analysis is by ion-specific electrode (A-10). Long duration detector tubes may be used (A-11).

Permissible Concentration in Water: A USPHS drinking water criterion for alternate source selection is 100 µg/l (A-37).

Routes of Entry: Inhalation of vapor, percutaneous absorption of liquid and concentrated vapor, ingestion and eye and skin contact.

Harmful Effects and Symptoms: *Local* - Hydrogen cyanide is a mild upper respiratory irritant and may cause slight irritation of the nose and throat. There may also be irritation from skin and eye contact with the liquid. Hydrogen cyanide liquid may cause eye irritation.

Systemic - Hydrogen cyanide is an asphyxiant. It inactivates certain enzyme systems, the most important being cytochrome oxidase, which occupies a fundamental position in the respiratory process and is involved in the ultimate electron transfer to molecular oxygen. Inhalation, ingestion, or skin absorption of hydrogen cyanide may be rapidly fatal. Larger doses may cause loss of consciousness, cessation of respiration, and death. Lower levels of exposure may cause weakness, headache, confusion, nausea, and vomiting. These symptoms may be followed by unconsciousness and death.

Points of Attack: Liver, kidneys, cardiovascular system, central nervous system.

Medical Surveillance: Preplacement and periodic examinations should include the cardiovascular and central nervous systems, liver and kidney function, blood, history of fainting or dizzy spells. Blood CN levels may be useful during acute intoxication. Urinary thiocyanate levels have been used but are nonspecific and are elevated in smokers.

First Aid: If this chemical gets into the eyes, irrigate immediately. If this chemical contacts the skin, flush with water immediately. If a person breathes in large amounts of this chemical, move the exposed person to fresh air at once and perform artificial respiration. When this chemical has been swallowed, get medical attention. Give large quantities of water and induce vomiting. Do not make an unconscious person vomit.

Personal Protective Methods: Wear appropriate clothing to prevent any possibility of skin contact. Wear eye protection to prevent any possibility of eye contact. Employees should wash immediately if wet or contaminated to avoid flammability hazard. Provide emergency showers and eyewash.

Respirator Selection:

50 ppm: SA/SCBA
Escape: GMS/SCBA

Synonyms: Dimethyloxymethane; Methyl formal; Formal; Dimethylacetal formaldehyde.

Potential Exposure: Methylal is used as a specialty fuel and as a solvent in adhesives and protective coatings.

Incompatibilities: Strong oxidizers, acids.

Permissible Exposure Limits in Air: The Federal standard is 1,000 ppm (3,100 mg/m³). The tentative STEL value is 1,250 ppm (3,875 mg/m³). The IDLH level is 10,000 ppm.

Determination in Air: Charcoal adsorption, workup in hexane, analysis by gas chromatography. See NIOSH Methods, Set F. See also reference (A-10).

Permissible Concentration in Water: No criteria set.

Routes of Entry: Inhalation, ingestion, skin and eye contact.

Harmful Effects and Symptoms: Mild irritation of the eyes and upper respiratory system; skin irritation; anaesthesia.

Points of Attack: Skin, respiratory system, central nervous system.

Medical Surveillance: Consider the points of attack in preplacement and periodic physical examinations.

First Aid: If this chemical gets into the eyes, irrigate immediately. If this chemical contacts the skin, flush with water promptly. If a person breathes in large amounts of this chemical, move the exposed person to fresh air at once and perform artificial respiration. When this chemical has been swallowed, get medical attention. Give large quantities of salt water and induce vomiting. Do not make an unconscious person vomit.

Personal Protective Methods: Wear appropriate clothing to prevent repeated or prolonged skin contact. Wear eye protection to prevent any reasonable probability of eye contact. Employees should wash promptly when skin is wet or contaminated. Remove clothing immediately if wet or contaminated to avoid flammability hazard.

Respirator Selection:

10,000 ppm: SA/SCBA
Escape: GMOV/SCBA

Disposal Method Suggested: Concentrated waste containing no peroxides: discharges liquid at a controlled rate near a pilot flame. Concentrated waste containing peroxides: perforation of a container of the waste from a safe distance followed by open burning.

METHYL ALCOHOL

● Hazardous waste (EPA)

Description: CH₃OH, methyl alcohol, is a colorless, volatile liquid with a mild odor. It boils at 64°-65°C.

Code Numbers: CAS 67-56-1 RTECS PC1400000 UN 1230

DOT Designation: Flammable liquid

Synonyms: Methanol, carbinol, wood alcohol, wood spirit.

Potential Exposure: Methyl alcohol is used as a starting material in organic synthesis of chemicals such as formaldehyde, methacrylates, methyl amines, methyl halides, ethylene glycol and pesticides (A-32) and as an industrial solvent for inks, resins, adhesives, and dyes for straw hats. It is an ingredient in paint and varnish removers, cleaning and dewaxing preparations, spirit duplicating fluids, embalming fluids, antifreeze mixtures, and enamels and is used in the manufacture of photographic film, plastics, celluloid, textile soaps, wood stains, coated fabrics, shatterproof glass, paper coating, waterproofing formulations, artificial leather, and synthetic indigo and other dyes.

It has also found use as an extractant in many processes, an antidetonant fuel-injection fluid for aircraft, a rubber accelerator, and a denaturant for ethyl alcohol.

NIOSH estimates that approximately 175,000 workers in the United States are potentially exposed to methyl alcohol.

Incompatibilities: Strong oxidizers.

Permissible Exposure Limits in Air: The Federal standard is 200 ppm (260 mg/m³). NIOSH recommends adherence to the present Federal standard of 200 ppm, 262 mg of methyl alcohol per cubic meter of air as a time-weighted average for up to a 10-hour workday, 40 hour workweek. In addition NIOSH recommends a ceiling of 800 ppm, 1,048 mg of methyl alcohol per cubic meter of air as determined by a sampling time of 15 minutes. The notation "skin" indicates the possibility of cutaneous absorption. Methanol's international hygienic standards are as follows: West Germany and Sweden, 260 mg/m³ (8-hr TWA); East Germany and Czechoslovakia, 100 mg/m³ (8-hr TWA); U.S.S.R. 5 mg/m³ (acceptable ceiling concentration).

The tentative STEL is 250 ppm (310 mg/m³). The IDLH level is 25,000 ppm.

Determination in Air: Adsorption on silica, workup with water, analysis by gas chromatography. See NIOSH Methods, Set E. See also reference (A-10).

Permissible Concentration in Water: No criteria set, but EPA (A-37) has suggested a permissible ambient goal of 3,600 µg/l based on health effects.

Routes of Entry: Inhalation of vapor, percutaneous absorption of liquid, ingestion, eye and skin contact.

Harmful Effects and Symptoms: *Local* - Contact with liquid can produce defatting and a mild dermatitis. Methyl alcohol is virtually nonirritating to the eyes or upper respiratory tract below 2,000 ppm, and it is difficult to detect by odor at less than this level.

Systemic - Methyl alcohol may cause optic nerve damage and blindness. Its toxic effect is thought to be mediated through metabolic oxidation products, such as formaldehyde or formic acid, and may result in blurring of vision, pain in eyes, loss of central vision, or blindness. Other central nervous system effects result from narcosis and include headache, nausea, giddiness, and loss of consciousness. Formic acid may produce acidosis. These symptoms occur principally after oral ingestion and are very rare after inhalation.

Points of Attack: Eyes, skin, central nervous system, gastrointestinal system.

Medical Surveillance: Consider eye disease and visual acuity in any periodic or placement examinations, as well as skin and liver and kidney functions.

Special tests which may be used include: Determination of methyl alcohol in blood, and methyl alcohol and formic acid in urine; estimation of alkali reserve which may be impaired because of acidosis following accidental ingestion.

Permissible Concentration in Water: No criteria set.

Routes of Entry: Inhalation, ingestion, skin absorption, eye and skin contact.

Harmful Effects and Symptoms: Irritation of eyes and respiratory system; coughs; burns; dermatitis; conjunctivitis.

Points of Attack: Respiratory system, eyes, skin.

Medical Surveillance: Consider the points of attack in preplacement and periodic physical examinations.

First Aid: If this chemical gets into the eyes, irrigate immediately. If this chemical contacts the skin, flush with water immediately. If a person breathes in large amounts of this chemical, move the exposed person to fresh air at once and perform artificial respiration. When this chemical has been swallowed, get medical attention. Give large quantities of water and induce vomiting. Do not make an unconscious person vomit.

Personal Protective Methods: Wear appropriate clothing to prevent any possibility of skin contact with liquid methylamine. Wear eye protection to prevent any possibility of eye contact. Employees should wash immediately when skin is wet or contaminated. Remove clothing immediately if wet or contaminated to avoid flammability hazard. Provide emergency showers and eye wash.

Respirator Selection:

100 ppm: SAF/SCBAF
Escape: GMSF/SCBAF

Disposal Method Suggested: Controlled incineration (incinerator is equipped with a scrubber or thermal unit to reduce NO_x emissions).

References

(10) U.S. Environmental Protection Agency, *Chemical Hazard Information Profile: Methylamines*, Wash., DC (May 1, 1978).

METHYL n-AMYL KETONE

Description: CH₃COC₅H₁₁ is a clear colorless liquid with a mild, banana-like odor which boils at 151°C.

Code Numbers: CAS 110-43-0 RTECS MJ507500 UN 1110

DOT Designation: Combustible liquid.

Synonyms: n-Amyl methyl ketone; 2-heptanone.

Potential Exposure: Methyl amyl ketone is used as a solvent for nitrocellulose in lacquers and as a relatively inert reaction medium.

NIOSH has estimated annual worker exposure at 67,000.

Incompatibilities: Strong acids, alkalis, oxidizers.

Permissible Exposure Limits in Air: The Federal standard is 100 ppm (465 mg/m³). The ACGIH has recommended as of 1980 a TWA of 50 ppm (235 mg/m³) and a tentative STEL of 100 ppm (465 mg/m³). The IDLH level is 4,000 ppm.

First Aid: If this chemical gets into the eyes, irrigate immediately. If this chemical contacts the skin, flush with water promptly. If a person breathes in large amounts of this chemical, move the exposed person to fresh air at once and perform artificial respiration. When this chemical has been swallowed, get medical attention. Give large quantities of salt water and induce vomiting. Do not make an unconscious person vomit.

Personal Protective Methods: Wear appropriate clothing to prevent repeated or prolonged skin contact. Wear eye protection to prevent any reasonable probability of eye contact. Employees should wash promptly when skin is wet. Remove clothing immediately if wet or contaminated to avoid flammability hazard.

Respirator Selection:

2,000 ppm: SA/SCBA
10,000 ppm: SAF/SCBAF
25,000 ppm: SAF:PD,PP,CF
Escape: SCBA

Disposal Method Suggested: Incineration.

References

- (1) National Institute for Occupational Safety and Health, *Criteria for a Recommended Standard: Occupational Exposure to Methyl Alcohol*, NIOSH Doc. No. 76-148, Wash., DC (1976).
- (2) U.S. Environmental Protection Agency, *Chemical Hazard Information Profile: Methanol*, Wash., DC (July 11, 1977) (Revised 1979).
- (3) U.S. Environmental Protection Agency, *Methyl Alcohol*, Health and Environmental Effects Profile No. 126, Wash., DC, Office of Solid Waste (April 30, 1980).

METHYLAMINE

- Hazardous substance (EPA)

Description: CH₃NH₂ is a colorless gas with an ammonialike odor, at low concentrations fishy odor, liquid under pressure. It boils at -6°C.

Code Numbers: CAS 74-89-5 RTECS PF6300000 UN 1061

DOT Designation: Flammable gas.

Synonyms: Monomethylamine, anhydrous methylamine.

Potential Exposure: Monomethylamine is a starting material for N-oleyl-taurine, a surfactant, and p-N-methylaminophenol sulfate, a photographic developer. It has possible uses in solvent extraction systems in the separation of aromatics from aliphatic hydrocarbons. It is also used in the synthesis of many different pharmaceuticals (A-41), pesticides (A-32) and rubber chemicals.

Incompatibilities: Mercury, strong oxidizers.

Permissible Exposure Limits in Air: The Federal standard is 10 ppm (12 mg/m³). There is no STEL value proposed. The IDLH level is 100 ppm.

Determination in Air: Collection by impinger or fritted bubbler, colorimetric analysis (A-18). Alternatively, silica gel adsorption, elution with methanoic acid, derivatization with benzaldehyde and gas chromatographic analysis (A-10).

Points of Attack: Eyes, respiratory system, skin, lungs.

Medical Surveillance: The skin, eyes, and respiratory tract should receive special attention in any placement or periodic examination. NIOSH recommends that workers subject to sodium hydroxide exposure have comprehensive preplacement medical examinations. Medical examinations shall be made available promptly to all workers with signs or symptoms of skin, eye, or upper respiratory tract irritation resulting from exposure to sodium hydroxide.

First Aid: If this chemical gets into the eyes, irrigate immediately. If this chemical contacts the skin, flush with water immediately. If a person breathes in large amounts of this chemical, move the exposed person to fresh air at once and perform artificial respiration. When this chemical has been swallowed, get medical attention. Give large quantities of water and do not induce vomiting.

Personal Protective Methods: Wear appropriate clothing to prevent any possibility of skin contact. Wear eye protection to prevent any possibility of eye contact. Employees should wash immediately when skin is wet or contaminated. Work clothing should be changed daily if it is possible that clothing is contaminated. Remove nonimpervious clothing immediately if wet or contaminated. Provide emergency showers and eyewash.

Respirator Selection:

100 mg/m³: HIEPF/SAF/SCBAF

200 mg/m³: PAPHIEF/SAF:PD,PP,CF

Escape: DMXSF/SCBAF

Disposal Method Suggested: Discharge into tank containing water, neutralize, then flush to sewer with water.

References

- (1) National Institute for Occupational Safety and Health, *Criteria for a Recommended Standard: Occupational Exposure to Sodium Hydroxide*, NIOSH Doc. No. 76-105, Washington, DC (1976).

70

SODIUM METABISULFITE

Description: Na₂S₂O₅ is a white crystalline powder with a sulfur dioxide odor. It may be considered the anhydride of 2 molecules of sodium disulfite.

Code Numbers: CAS 7681-57-4 RTECS UX8225000 UN (NA2693)

DOT Designation: ORM-B

Synonyms: Sodium pyrosulfite, pyrosulfurous acid disodium salt.

Potential Exposure: Sodium metabisulfite is used as an antioxidant in pharmaceutical preparations and as a preservative in foods.

Permissible Exposure Limits in Air: There is no Federal standard but ACGIH as of 1980 has adopted a TWA value of 5 mg/m³. There is no tentative STEL value given.

Permissible Concentration in Water: No criteria set.

Routes of Entry: Inhalation, skin and eye contact, ingestion.

Harmful Effects and Symptoms: Irritation of the eyes, skin and mucous membranes.

Points of Attack: Skin, eyes, mucous membranes.

SODIUM HYDROXIDE

- Hazardous substance (EPA)

Description: NaOH, sodium hydroxide, is a white, deliquescent material sold as pellets, flakes, lumps, or sticks. Aqueous solutions are known as soda lye.

Code Numbers: CAS 1310-73-2 RTECS WB4900000 UN 1823

DOT Designation: "Corrosive material."

Synonyms: Caustic soda, caustic alkali, caustic flake, sodium hydrate, soda lye, white caustic.

Potential Exposure: Sodium hydroxide is utilized to neutralize acids and make sodium salts in petroleum refining, viscose rayon, cellophane, and plastic production, and in the reclamation of rubber. It hydrolyzes fats to form soaps, and it precipitates alkalooids and most metals from aqueous solutions of their salts. It is used in the manufacture of mercerized cotton, paper, explosives, and dyestuffs, in metal cleaning, electrolytic extraction of zinc, tin plating, oxide coating, laundering, bleaching, and dishwashing, and it is used in the chemical industries. NIOSH estimates that 150,000 workers are potentially exposed to the alkali.

Incompatibilities: Water, acids, flammable liquids, organic halogens; metals: aluminum, tin, zinc; nitromethane and nitro compounds.

Permissible Exposure Limits in Air: The Federal standard for sodium hydroxide is 2 mg/m³. NIOSH recommends a ceiling concentration of 2.0 mg sodium hydroxide/m³ as determined by a sampling period of 15 min. There is no STEL value set.

The recommendation for a limit on airborne workplace sodium hydroxide concentrations serves to protect against the irritation of the respiratory tract from sodium hydroxide aerosols.

The IDLH level is 200 mg/m³.

Determination in Air: Bubbler collection and electrometric titration (A-10) or filter collection, and extraction and back titration (A-10).

Permissible Concentration in Water: There are no criteria for NaOH as such. The EPA has, however, recommended criteria for pH as follows: to protect freshwater aquatic life—pH 6.5 to 9.0; to protect saltwater aquatic life—pH 6.5 to 8.5; and to protect humans drinking water—pH 5 to 9.

Route of Entry: Inhalation of dust or mist, ingestion, skin and eye contact.

Harmful Effects and Symptoms: *Local*—This compound is extremely alkaline in nature and is very corrosive to body tissues. Dermatitis may result from repeated exposure to dilute solutions in the form of liquids, dusts, or mists.

Extensive work practices are recommended to protect workers from local contact with sodium hydroxide. Local contact of sodium hydroxide with eyes, skin, and the alimentary tract has resulted in extensive damage to tissues, with resultant blindness, cutaneous burns, and perforations of the alimentary tract.

Systemic—Systemic effects are due entirely to local tissue injury. Extreme pulmonary irritation may result from inhalation of dust or mist. During the tissue regeneration process in the alimentary tract, some squamous cell carcinomas have developed.

Respirator Selection:

1,000 ppm: CCR0VF
 5,000 ppm: GMOV/SAF/SCBAF
 Escape: GMOV/SCBA

Disposal Method Suggested: Incineration.

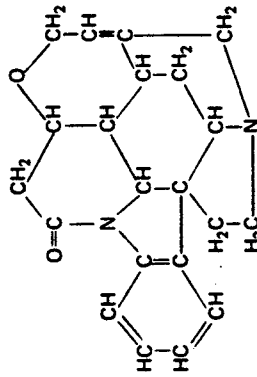
References:

- (1) National Institute for Occupational Safety and Health, *Criteria for a Recommended Standard: Occupational Exposure to Refined Petroleum*, NIOSH Doc. No. 77-192, Washington, DC (1977).

STRYCHNINE

- Hazardous substance (EPA)
- Hazardous waste (EPA)

Description: $C_{21}H_{22}N_2O_2$, with the structural formula:



Strychnine is a colorless crystalline powder which melts at 270° to 280°C with decomposition.

Code Numbers: CAS 57-24-9 RTECS WL2275000 UN 1692

DOT Designation: Poison B.

Synonyms: Mole Death®, Mouse-Nots®.

Potential Exposure: Those involved in the extraction (from *Strychnos* seeds), formulation or application of this rodent poison.

Incompatibilities: Strong oxidizers.

Permissible Exposure Limits in Air: The Federal standard is 0.15 mg/m³. The tentative STEL is 0.45 mg/m³. The IDLH value is 3.0 mg/m³.

Determination in Air: Filter collection, analysis by ultraviolet spectroscopy (A-28).

Permissible Concentration in Water: No criteria set.

Routes of Entry: Inhalation of dust, ingestion, skin and eye contact.

Harmful Effects and Symptoms: Stiffness of neck and facial muscles, restlessness, apprehension, lessened acuity of perception, reflex excitability, cyanosis, tetanic convulsions, opisthotonos.

A rebuttable presumption against registration of strychnine for pesticide uses was issued by EPA on December 1, 1976 on the basis of reductions in nontarget and endangered species (A-32).

Points of Attack: Central nervous system.

Medical Surveillance: Consider the points of attack in preplacement and periodic physical examinations.

First Aid: If this chemical gets into the eyes, irrigate immediately. If this chemical contacts the skin, wash with soap promptly. If a person breathes in large amounts of this chemical, move the exposed person to fresh air at once and perform artificial respiration. When this chemical has been swallowed, get medical attention. Give large quantities of water and induce vomiting. Do not make an unconscious person vomit.

Personal Protective Methods: Wear appropriate clothing to prevent repeated or prolonged skin contact. Employees should wash promptly when skin is wet or contaminated.

Respirator Selection:

0.75 mg/m³: DMXS
 1.5 mg/m³: DMXSO/HIEP/SA/SCBA
 3 mg/m³: HIEPF/PAPHIE/SAF/SA:PD,PP,CF/SCBAF
 Escape: DMXS/SCBA

Disposal Method Suggested: Careful incineration has been recommended for disposal. Two procedures are suggested (A-32). (1) Pour or sift onto a thick layer of sand and soda ash mixture (90-10). Mix and shovel into a heavy paper box with much paper packing. Burn in incinerator. Fire may be augmented by adding excelsior and scrap wood. Stay on the upwind side. (2) Waste may be dissolved in flammable solvent (alcohols, benzene, etc.) and sprayed into fire box of an incinerator with afterburner and scrubber.

References

- (1) U.S. Environmental Protection Agency, "Preliminary Notice of Determination Concluding the Rebuttable Presumption Against Registration of Pesticide Products: Notice of Availability of Position Document," *Federal Register*, 45, No. 216 73602-8 (November 5, 1980).

STYRENE

- Hazardous substance (EPA)

Description: $C_6H_5CH=CH_2$, is a colorless to yellowish, very refractive, oily liquid with a penetrating odor. It boils at 145°C.

Code Numbers: CAS 100-42-5 RTECS WL3675000 UN 2055

DOT Designation: Flammable liquid.

Synonyms: Cinnamene, cinnamol, phenethylene, phenylethylene, styrene monomer, styrol, styrolene, vinylbenzene.

Potential Exposure: Upon heating to 200°C, styrene polymerizes to form polystyrene, a plastic. It is also used in combination with 1,3-butadiene or acrylonitrile to form copolymer elastomers, butadiene-styrene rubber, an acrylonitrile-butadiene-styrene (ABS). It is also used in the manufacture of resins, polyesters, and insulators and in drug manufacture (A-41).

Incompatibilities: Oxidizers, catalysts for vinyl polymers, peroxides, strong acids, aluminum chloride.

Permissible Exposure Limits in Air: The Federal standard for styrene for an 8-hour TWA is 100 ppm (420 mg/m³). The acceptable ceiling concentration is 200 ppm with an acceptable maximum peak of 600 ppm for a maximum duration of 5 minutes in any 3 hours. The ACGIH as of 1980 has recommended a TWA of 50 ppm (215 mg/m³) and a tentative STEL of 100 ppm (425 mg/m³). The IDLH is 5,000 ppm.

Determination in Air: Charcoal adsorption, workup with CS₂, analysis by gas chromatography. See NIOSH Methods, Set C. See also reference (A-10).

Permissible Concentration in Water: A no-adverse effect level in drinking water has been calculated to be 0.9 mg/l by NAS/NRC.

Routes of Entry: Inhalation, ingestion, skin and eye contact.

Harmful Effects and Symptoms: *Local* - Liquid and vapor are irritating to the eyes, nose, throat, and skin. The liquids are low-grade cutaneous irritants, and repeated contact may produce a dry, scaly, and fissured dermatitis.

Systemic - Acute exposure to high concentrations may produce irritation of the mucous membranes of the upper respiratory tract, nose, and mouth, followed by symptoms of narcosis, cramps, and death due to respiratory center paralysis. Effects of short-term exposure to styrene under laboratory conditions include prolonged reaction time and decreased manual dexterity.

Points of Attack: Central nervous system, respiratory system, lungs, eyes, skin.

Medical Surveillance: Consider possible irritant effects on the skin, eyes, and respiratory tract in any preplacement or periodic examinations, as well as blood, liver, and kidney function.

Mandelic acid in urine has been used as a measure of the intensity of styrene exposure.

First Aid: If this chemical gets into the eyes, irrigate immediately. If this chemical contacts the skin, flush with water. If a person breathes in large amounts of this chemical, move the exposed person to fresh air at once and perform artificial respiration. When this chemical has been swallowed, get medical attention. Do not induce vomiting.

Personal Protective Methods: Wear appropriate clothing to prevent repeated or prolonged skin contact. Wear eye protection to prevent any reasonable probability of eye contact. Employees should wash promptly when skin is wet or contaminated. Remove clothing immediately if wet or contaminated to avoid flammability hazard.

Respirator Selection:

400 ppm: CCROV/SA/SCBA
 1,000 ppm: CCROVF
 5,000 ppm: GMOV/SAF/SCBAF
 Escape: GMOV/SCBA

Disposal Method Suggested: Incineration. In some cases, recovery and re-cycle of styrene monomer is economic and technology is available (A-58).

SUBTILISINS

Description: These are proteolytic enzymes which take the form of light-colored, free-flowing powders.

Code Numbers: none

DOT Designation: -

Synonyms: Maxatase®, Alcalase®, Alk®, Protease 150®.

Potential Exposure: These materials are used as enzyme agents in laundry detergent formulations.

Permissible Exposure Limits in Air: There are no Federal standards but ACGIH (1980) has set a ceiling value of 0.00006 mg/m³, based on "high volume" sampling. There is no tentative STEL value.

Permissible Concentration in Water: No criteria set.

Routes of Entry: Inhalation of dust.

Harmful Effects and Symptoms: Irritation of skin and respiratory tract, bronchoconstriction and respiratory allergies, breathlessness, wheezing, sore throat, congested nares, headache, persistent cough (A-34).

Points of Attack: Skin and respiratory system.

Medical Surveillance: Attention to points of attack is indicated in preplacement and regular physical examinations.

Personal Protective Methods: Maximum skin protection should be provided by protective clothing.

Respirator Selection: Dust respirators are necessary.

SULFOTEP

S S
 || ||

Description: (C₂H₅O)₂POPOP(C₂H₅)₂ is a yellow mobile liquid with a garlic like odor.

Code Numbers: CAS 3689-24-5 RTECS XN4375000 UN 1704

DOT Designation: Poison B.

Synonyms: Thiopyrophosphoric acid, tetraethyl ester; thiodiphosphoric acid, tetraethyl ester; sulfotep; Dithio; Dithione; Thiotepe; ENT 16273; Blada fum®; TEDP.

Potential Exposure: Those involved in the manufacture (A-32), formulation and application of this insecticide.

Incompatibilities: Strong oxidizers.

Permissible Exposure Limits in Air: The Federal standard is 0.2 mg/m³. The ACGIH has set a TWA of 0.2 mg/m³ and a tentative STEL of 0.6 mg/m³. The notation "skin" is added to indicate the possibility of cutaneous absorption. The IDLH level is 35 mg/m³.

Determination in Air: Collection on impinger or fritted bubbler, analysis by gas liquid chromatography (A-1).

Permissible Concentration in Water: No criteria set.

Routes of Entry: Inhalation, skin absorption, ingestion, skin and eye contact.

VINYL ACETATE

- Hazardous substance (EPA)

Description: $\text{CH}_3\text{COOCH}=\text{CH}_2$ is a colorless, flammable liquid which boils at 73°C.

Code Numbers: CAS 108-05-4 RTECS AK0875000 UN 1301

DOT Designation: Flammable liquid.

Synonyms: Acetic acid vinyl ester, vinyl acetate monomer, ethenyl ethanoate.

Potential Exposure: Vinyl acetate is used primarily in polymerization processes to produce polyvinyl acetate, polyvinyl alcohol and vinyl acetate copolymer. The polymers, usually made as emulsions, suspensions, solutions or resins are used to prepare adhesives, paints, paper coatings and textile finishes. Low molecular weight vinyl acetate is used as a chewing gum base. NIOSH estimates that 70,000 workers annually are exposed to vinyl acetate in the U.S.

Permissible Exposure Limits in Air: There is no Federal standard for vinyl acetate. NIOSH (1) recommends a ceiling value of 4 ppm (15 mg/m³) measured over a 15-minute period. The ACGIH (1980) has set a TWA value of 10 ppm (30 mg/m³) and a tentative STEL value of 20 ppm (60 mg/m³). There is no IDLH level set.

Determination in Air: Adsorption on Chromosorb 107, thermal desorption, analysis by gas chromatograph with a flame ionization detector (1). See also reference (A-10).

Permissible Concentration in Water: No criteria set.

Routes of Entry: Inhalation, ingestion, skin and eye contact.

Harmful Effects and Symptoms: Vinyl acetate vapor at concentrations below 250 mg/m³ is a primary irritant to the upper respiratory tract and eyes and the liquid may irritate the skin to the point of vesiculation. The irritations reported have all been reversible, however, and there are no known residual systemic effects (1).

Points of Attack: Eyes, skin, upper respiratory system.

Medical Surveillance: Particular attention should be paid to upper respiratory tract, eyes and skin in preplacement and periodic physical examinations.

First Aid: Flush skin or eyes with water after contact.

Personal Protective Measures: For eye protection: chemical safety goggles or face shields with goggles. For skin protection: gloves, aprons, suits and boots to prevent contact with liquid vinyl acetate.

Respirator Selection: Priority should be given to engineering controls to reduce exposure, but details of respirator selection are given by NIOSH (1).

Disposal Method Suggested: Incineration.

References

- (1) National Institute for Occupational Safety and Health, *Criteria for a Recommended Standard: Occupational Exposure to Vinyl Acetate*, NIOSH Publication No. 78-205, Washington, DC (1978).

VINYL BROMIDE

- Carcinogen (Animal Positive) (3)

Description: $\text{CH}_2=\text{CHBr}$ is a colorless gas which boils at about 16°C.

Code Numbers: CAS 593-60-2 RTECS KU8400000 UN 1085

DOT Designation: Flammable gas.

Synonyms: Bromoethylene, bromoethene.

Potential Exposure: It is used as an intermediate in organic synthesis and for the preparation of plastics by polymerization and copolymerization. The major use of vinyl bromide is in the production of flame-retardant synthetic fibers. An example of this is SEF, a modacrylic fiber produced by Monsanto. The formula for SEF is 79 to 81% acrylonitrile, 9% vinyl bromide, 8% vinylidene chloride and 2 to 4% other. SEF is used primarily in children's sleepwear. It is produced in a batch polymerization operation with a suspension polymerization medium and a wet spinning process. This method of production would probably produce residual vinyl bromide monomer in the finished product. NIOSH has estimated worker exposure at 26,000 annually.

Permissible Exposure Limits in Air: There is no Federal standard. The ACGIH as of 1980 has set a TWA value of 5 ppm (20 mg/m³) with the notation that vinyl bromide is "suspect of carcinogenic potential in man." NIOSH (1971) has recommended an exposure standard of 1 ppm.

Permissible Concentration in Water: No criteria set.

Harmful Effects and Symptoms: Vinyl bromide is considered a moderate toxic substance. In high concentrations, vinyl bromide may produce dizziness, disorientation, and sleepiness in humans. As noted above, ACGIH has designated vinyl bromide as "suspect of carcinogenic potential for man."

Points of Attack: In animals: liver, lung, breast, zymbal gland, lymphatic system (2).

References

- (1) U.S. Environmental Protection Agency, *Chemical Hazard Information Profile: Vinyl Bromide*, Washington, DC (January 30, 1978).
- (2) National Institute for Occupational Safety and Health, *Vinyl Halides: Carcinogenicity*, Current Intelligence Bulletin No. 28, Washington, DC (September 21, 1978).
- (3) Huntingdon Research Center, *HRC Project 7511-253; 18-Month Sacrifice Pathology Report (Vinyl Bromide)*, New York (June 26, 1978).

VINYL CHLORIDE

- Carcinogen (Human Positive, IARC)(5)
- Hazardous waste (EPA)
- Priority toxic pollutant (EPA)

Description: $\text{CH}_2=\text{CHCl}$, vinyl chloride, is a flammable gas at room temperature (boils at -14°C), and is usually encountered as a cooled liquid. The colorless liquid forms a vapor which has a pleasant, ethereal odor.

Code Numbers: CAS 75-01-4 RTECS KU9625000 UN 1086

DOT Designation: Flammable gas.

Potential Exposures: Vinyl chloride is used as a vinyl monomer in the manufacture of polyvinyl chloride and other resins. It is also used as a chemical intermediate and as a solvent (1).

The hazard of vinyl chloride was originally believed to primarily concern workers employed in the conversion of VCM to PVC who may receive a particularly high exposure of VCM in certain operations (e.g., cleaning of polymerization kettles) or a long-term exposure to relatively low concentrations of VCM in the air at different factory sites. Much larger populations are now believed to be potentially at risk, including: producers of VCM; people living in close proximity to VCM or PVC producing industries; users of VCM as propellant in aerosol sprays; persons in contact with resins made from VCM; consumers of food and beverage products containing leachable amounts of unreacted VCM from PVC packaged materials; and ingestion of water containing unreacted VCM leached from PVC pipes.

NIOSH (2) estimates definite worker exposure to vinyl chloride at 27,000 and probable worker exposure at 2,200,000. About 1,500 workers were employed in monomer synthesis and an additional 5,000 in polymerization operations. As many as 350,000 workers were estimated to be associated with fabrication plants. By 1976 it was estimated that nearly one million persons were associated with manufacturing goods derived from PVC.

Vinyl chloride levels ranging from barely detectable to high concentrations have been found in drinking water, beverages, food, cosmetics, and other consumer products. Aerosol products containing vinyl chloride as a propellant have been discontinued. However, incinerators may be an additional source of vinyl chloride emissions since the entrapped monomer escapes following incomplete combustion of PVC products. Insufficient published data are available on exposure levels of persons living in the vicinity of PVC fabricating plants, or on the release of the monomer from various plastic products. However, all of these routes represent additional potential sources of population exposure (1).

Permissible Exposure Limits in Air: The Federal standard for exposure to vinyl chloride sets a limit of 1 ppm over an 8-hour period, and a ceiling of 5 ppm averaged over a period not exceeding 15 minutes. ACGIH (1980) lists vinyl chloride as a human carcinogen and NIOSH has documented the designation of vinyl chloride as a demonstrated carcinogen in humans, and gives a proposed TWA value of 5 ppm (10 mg/m³) but no tentative STEL value.

Determination in Air: Adsorption on activated carbon, desorption with carbon bisulfide, analysis by gas chromatograph with flame ionization detector (A-10). See also reference (7).

Permissible Concentration in Water: No criteria have been determined for the protection of freshwater or saltwater aquatic life due to insufficient data. For the protection of human health: preferably zero. An additional lifetime cancer risk of 1 in 100,000 is posed by a concentration of 20 µg/l.

Determination in Water: Inert gas purge followed by gas chromatography with halide specific detection (EPA Method 601) or gas chromatography plus mass spectrometry (EPA Method 624).

Routes of Entry: Vinyl chloride gas is absorbed by inhalation, skin absorption has been suggested, but experimental evidence is presently lacking.

Harmful Effects and Symptoms: Local - Vinyl chloride is a skin irritant, and contact with the liquid may cause frostbite upon evaporation. The eyes may be immediately and severely irritated.

Systemic - Vinyl chloride depresses the central nervous system causing symptoms which resemble mild alcohol intoxication. Lightheadedness, somnolence, and dulling of visual and auditory responses may develop in acute exposures. Death from severe vinyl chloride exposure has been reported.

Chronic exposure of workers involved in reactor vessel entry and handling may result in the triad of acroosteolysis, Raynaud's phenomenon, and sclerodermatous skin changes. Chronic exposure may also cause hepatic damage. Vinyl chloride is regarded as a human carcinogen (2) and a cause of angiosarcoma of the liver. Excess cancer of the lung and lymphatic and nervous systems has also been reported. Experimental evidence of tumor induction in a variety of organs, including liver, lung, brain and kidneys, as well as nonmalignant alterations such as fibrosis and connective tissue deterioration indicate the multisystem oncogenic and toxicologic effects of vinyl chloride.

Medical Surveillance: Preplacement and periodic examinations should emphasize liver function and palpation. Liver scans and grey-scale ultrasonography have been useful in detecting liver tumors. Medical histories should include alcoholic intake, past hepatitis, exposure to hepatotoxic agents, drugs and chemicals, past blood transfusions, past hospitalizations. Radiographic examinations of the hands may be helpful if acroosteolysis is suspected. Long term follow-up of exposed persons is essential as in the case of other carcinogens.

First Aid: Irrigate eyes with running water. Wash contaminated areas of body with soap and water.

Personal Protective Methods: Where vinyl chloride levels cannot meet the standard, workers should be required to wear respiratory protection, either an supplied respirator or, if the level does not exceed 25 ppm, a chemical-cartridge or canister-type gas mask. In hazard areas, proper protective clothing to prevent skin contact with the vinyl chloride or polyvinyl chloride residue should be worn.

Respirator Selection: Use of self-contained breathing apparatus is recommended (A-38).

Disposal Method Suggested: Incineration, preferably after mixing with another combustible fuel. Care must be exercised to assure complete combustion to prevent the formation of phosgene. An acid scrubber is necessary to remove the halo acids produced. A variety of techniques have been described for vinyl chloride recovery from PVC latexes (A-58)(6).

References

- (1) U.S. Environmental Protection Agency, *Scientific and Technical Assessment Report on Vinyl Chloride and Polyvinyl Chloride*, Office of Research and Development, Washington, DC (June 1975).
- (2) National Institute for Occupational Safety and Health, *Vinyl Halides—Carcinogenicity* Current Intelligence Bulletin No. 28, Washington, DC (September 21, 1978).
- (3) U.S. Environmental Protection Agency, *Vinyl Chloride: Ambient Water Quality Criteria*, Washington, DC (1980).
- (4) U.S. Environmental Protection Agency, *Chloroethene*, Health and Environmental Effects Profile No. 45, Office of Solid Waste, Washington, DC (April 30, 1980).
- (5) International Agency for Research on Cancer, *IARC Monographs on the Carcinogenic Risks of Chemicals to Humans*, 7, 291 (1974) and 19, 377 (1979), Lyon, France.
- (6) Sittig, M., *Vinyl Chloride and PVC Manufacture: Process and Environmental Aspects* Noyes Data Corp., Park Ridge, NJ (1978).
- (7) U.S. Environmental Protection Agency, "National Emission Standards for Hazardous Air Pollutants," *Federal Register*, 45, No. 224, 76346-54 (November 18, 1980).