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Lawrence Livermore Laboratory

ENVIRONMENTAL TECHNOLOGY APPLICATIONS:
FACT FILE ON TOXIC CONTAMINANTS IN INDUSTRIAL
WASTE PROCESS STREAMS

H. W. Newkirk

May 11, 1977

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ENVIRONMENTAL TECHNOLOGY APPLICATIONS:

FACT FILE ON TOXIC CONTAMINANTS IN INDUSTRIAL WASTE PROCESS STREAMS

INTRODUCTION

Every year our industrially complex society exposes human beings and the environment to a large number and variety of chemical substances and mixtures. Fortunately, of the 3.5 million known chemical compounds and the hundreds of new compounds introduced into commerce each year, relatively few are highly toxic as they are currently used. This report is a compendium of facts related to chemical materials present in industrial waste process streams which have already been declared or are being evaluated as hazardous under the Toxic Substances Control Act.

Since some 400 chemicals are presently covered by consensus standards, the substances reviewed are only those considered to be a major threat to public health and welfare by Federal and State regulatory agencies. For each hazardous material cited, the facts relate, where possible, to an identification of the stationary industrial sources, the kind of waste stream impacted, proposed regulations and established effluent standards, the volume of emissions produced each year, the volume of emissions per unit of industrial product produced, present clean-up capabilities, limitations and costs. These data should be helpful in providing information for the assessment of potential problems, should be of use to the manufacturers of pollution control equipment or of chemicals for pollution control, should be of use to the operators or potential operators of processes which produce pollutants, and should help to define industry-wide emission practices and magnitudes.

Much of the material outlined is tentative, rapidly changing, and highly variable in time and place. It is anticipated that this fact file will be updated as more information is reported and additional hazardous chemical materials are cited in the literature.

TOXIC CONTAMINANTS IN INDUSTRIAL WASTE PROCESS STREAMS

CONTAMINANT - Ammonia

KIND OF WASTE - Air and Water

SOURCES - Refineries, fertilizer plants, chemical process plants, power plants, (combustion of fossil fuels), poultry processing plants, meat product plants, glass container manufacturing plants, ferroalloys manufacturing plants.

STANDARDS

AIR

EPA and OSHA - On November 25, 1975 the Occupational Safety and Health Administration (OSHA) proposed a standard which contains a requirement limiting employee exposure to ammonia to a ceiling concentration of 50 parts per million (ppm) of air.

OTHER - The maximum allowable concentration (MAC) for ammonia established by the U.S. Public Health Service in 1943 was time-weighted-average (TWA) of 100 ppm. This level was adopted by the American Conference of Governmental Industrial Hygienists (ACGIH) as their MAC for ammonia in 1946. This became the Threshold Limit Value (TLV) for ammonia in 1948. The following year the TLV was lowered to 50 ppm to protect against respiratory irritation and eliminate most complaints of discomfort.

In 1969, ACGIH published a notice of intent to change the 50 ppm TWA to a 50 ppm ceiling limit. This proposed change was not adopted by ACGIH, rather, the 50 ppm TWA was changed to a 25 ppm TWA ($18 \mu\text{g}/\text{m}^3$) in 1973. ACGIH stated that this would minimize discomfort among uninsured workers.

STANDARDS

WATER

National Water Quality Standards for NPS

The U. S. Public Health Service has published guidelines for drinking water which include recommended limits for nitrate, sulfate, and a threshold odor number. These guidelines have been periodically reissued over the past fifty years to reflect changes in recommended limits. The drinking water standards have been revised four times. The EPA issued interim drinking water standards in March 1975 which are expected to form the basis for the National Standards.

Similar guidelines also are available for water used for recreation; fish and wildlife, agricultural uses; and various industries.

National Discharge Standards for NPS

Point source effluent discharge standards related to the discharge of nitrogen, phosphorus, or sulfur, into waters are currently being promulgated.

STANDARDS

WATER

Typical Rules and Regulations on Point Source Discharges of Ammonia

<u>Point Source Category</u>	<u>Pollutant</u>	<u>a</u> <u>Maximum</u>	<u>b</u> <u>Average</u>
Poultry Processing Products	Ammonia	8.0 mg/l	4.0 mg/l
Poultry Processing Products (new sources)	Ammonia	0.40 mg/k kg of LWK	0.20 mg/k kg of LWK
Inorganic Chemical Manufacturing	Ammonia	No discharge of process water to navigable waters	
	Ammonia	8.8 kg/khg of product	4.4 kg/khg of product
Meat Products (Meat Cutter subcategory)	Ammonia (as N)	8.0 mg/l	4.0 mg/l
Fertilizer (Ammonium Sulfate subcategory)	Ammonia (as N)	^c 30 mg/l	
Meat Products and Rendering Processing	Ammonia	0.04 kg/hkg of raw material	0.02 kh/hkg of raw material
Glass Container Manufacturing (new sources)	Ammonia	104.0 g/hkg of product frosted	52.0 g/hkg of product frosted
Ferroalloys Manufacturing electrolytic manganese	Ammonia	40.667 hg/hkg of product	20.334 kg/hkg of product
electrolytic manganese dioxide	Ammonia	10.574 hg/hkg of product	5.287 hg/hkg of product

^aMaximum for any one day.

^bAverage of daily values for 30 consecutive days shall not exceed this number.

^cPretreatment Standard.

Source: LBL-1, Volume 2, University of California, 1973.

VOLUMES AND EMISSION FACTORS

AIR
RELEASED FROM OIL REFINERIES

<u>Source</u>	<u>Lb/100 Barrels Fresh Feed</u>
Compressor-internal combustion	0.2
Fluid-bed catalytic cracking units	54.0
Thermoform catalytic cracking units	5.0

Source: Report PB 188,082

FROM CATALYTIC CRACKING

<u>Unit Type</u>	<u>$\mu\text{g}/\text{m}^3$</u>	<u>Tons/Day</u>
Fluid bed	47,000-470,000	4.2
Thermoform	20,000-72,000	0.2

Source: Report PB 188,082

FROM METALLURGICAL AND CERAMIC PLANTS

Nonferrous foundries: per plant producing 50 tons of castings per day	0.002 tons of ammonia
Gray iron foundries: per plant producing 200 tons of castings per day	0.023 tons of ammonia
Stone, clay, and glass plants: per cement plant producing 4,830 barrels per day	0.17 manufacturing tons

Source: Report PB 188,082

FROM COMBUSTION

<u>Combustion Source</u>	<u>Amount of Emission</u>
Coal	2 lb/ton
Fuel oil	1 lb/1,000 gal
Natural gas	0.3 to 0.56 lb/10 ⁶ ft ³
Bottled gas (butane)	1.7 lb/10 ⁶ ft ³
Propane	1.3 lb/10 ⁶ ft ³
Wood	2.4 lb/ton
Forest fires	0.3 lb/ton

Source: Report PB 188,082

WATER

No data found

LEVEL OF CONTROL

AIR

Removal by oxidation and absorption or filtration of air through activated carbon. Methods used to abate pollutants with which it is associated also reduce the quantity of ammonia that reaches the atmosphere. For example, in smokeless charging of coke ovens (that is, collecting the bulk of escaping coke oven gas, coal dust, and tar by vacuum during coke oven charging), the ammonia emissions to the atmosphere are cut in half.

In incineration systems where wet scrubbers are used to remove fly ash, the ammonia in the gas stream leaving the incinerator should also be reduced. However, no specific information was found on this subject.

In the chemical industry, where ammonia is used as a raw material, its recovery is a matter of fundamental economic importance; methods have therefore been designed to minimize its loss. For high concentrations of ammonia, gas wet scrubbers can be used. For ammonia concentrations in air between approximately 16 to 27% (flammable range) the gas can be flared. Where the ammonia occurs as a solid (as ammonium sulfate in the fertilizer industry for instance) conventional methods for solids removal can be used such as bag filters, electrostatic precipitators, and wet scrubbers.

WATER

One process involves the destruction of ammonia contained in waters resulting from the operation of coke ovens based on the principle of expelling the gas from the water, which comprises heating the water to be treated, with lean gas at an elevated temperatures of such a degree that the temperature of the water after treatment thereof is at least 60°C., conveying the lean gas charged with ammonia to regenerators of industrial furnaces, and heating the same therein to such a temperature that the ammonia will become dissociated to nitrogen and hydrogen. By this treatment, ammonia and other harmful gases will be completely eliminated from the water which are then safe for discharge into the sewers.

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TOXIC CONTAMINANTS IN INDUSTRIAL WASTE PROCESS STREAMS

CONTAMINANT - Arsenic

KIND OF WASTE - Air and Water

AIR

STATIONARY SOURCES - Metallurgical smelters, agricultural activities using pesticides, power plants (combustion of coal and oil)

WATER

Metallurgical industries, glassware and ceramic production facilities, tannery operations, dye, chemical and pesticide manufacturing activities.

STANDARDS - The 1962 U.S. Public Health Service drinking water standards have a suggested limit that should not be exceeded of 0.01 mg/l arsenic (10 µg/l), with 0.05 mg/l or greater (50 µg/l) constituting grounds for rejection of the water supply. EPA is expected to issue revised standards in 1973. McKee and Wolf list the following limits for arsenic for these beneficial uses:

Domestic water supplies	0.05 mg/l
Irrigation.	1.0 mg/l
Stock and wildlife watering	1.0 mg/l
Fish and other aquatic life	1.0 mg/l

The Food and Drug Administration has set a limit of 3.5 mg/kg of arsenic residue on sprayed fruits and vegetables.

Criteria for arsenic in water intended for purposes other than human consumption include the following:

Irrigation waters, used continuously on all soils . .	1.0 mg/l
Irrigation waters, short term use on fine-textured soil only	20 mg/l

The recommended maximum atmospheric concentration of arsenic in dusts, fumes or mists during an 8-hour daily exposure is 0.5 mg/m³; for arsine it is 0.05 ppm.

Threshold Limit Value (TLV) - 0.5 µg/m³

<u>AIR</u>		
<u>Source</u>	<u>Amount in Tons</u>	<u>Pollutant, %</u>
Mining	<1	neg
Phosphate rock	neg	neg
Primary Copper		
Roasting	900	10.07
Reverberatory furnaces	400	4.48
Converters	1,150	12.87
Material handling	250	2.80
Primary zinc		
Roasting	1,390	15.55
Primary lead		
Sintering	285	3.19
Blast furnace	80	0.90
Reverberatory furnace	11	0.12
Gray iron foundry	97	1.09
Cotton ginning	19	0.21
Nonferrous alloys	neg	neg
Phosphoric acid	neg	neg
Glass manufacture	638	7.14
Wood preservatives	neg	neg
Miscellaneous arsenic chemicals	3.3	0.04
Arsenic pesticide production	197	2.20
Pesticide, herbicide, fungicide use	2,925	32.72
Power plant boilers		
Pulverized coal	429	4.80
Stoker coal	49	0.55
Cyclone coal	15	0.17
Industrial boilers		
Pulverized coal	19	0.21
Stoker coal	67	0.75
Cyclone coal	9	0.10
All oil	neg	neg
Residential/commercial coal	6	0.07
Total	8,939	100

Source: The MITRE Corporation, Preliminary Results, EPA Contract # 68-01-0438

VOLUME OF EMISSIONS

WATER

No data found

EMISSION FACTORS

AIR

PROCESSING ARSENIC AND ITS COMPOUNDS

<u>Source</u>	<u>Emission Factor</u>
Pesticide production for agricultural uses *	20 lb/ton of arsenic processed
Glass production	0.2 lb/ton of glass produced
Wood preservatives	Negligible
Others (paint pigments, pyrotechnics, pharmaceutical, semiconductors, etc.	3 lb/ton of arsenic processed

* Controlled emission factor

Source: PB 230,894

CONSUMPTIVE USES OF ARSENIC

<u>Source</u>	<u>Emission Factor</u>
Cotton ginning processing	4 lb/10 ³ bales of cotton ginned
Detergents	Negligible

Source: PB 230,894

VOLUME OF EMISSIONS

MINING AND INDUSTRIAL SOURCES OF ARSENIC

<u>Source</u>	<u>Emission Factor</u>
Mining	0.2 lb/ton of arsenic in ore
Copper smelter	5 lb/ton of copper
Lead smelter	0.8 lb/ton of lead
Zinc smelter	1 lb/ton of zinc
Cast iron	0.01 to 0.02 lb/ton of metal charged
Nonferrous alloys	1 lb/ton of arsenic processed

Source: Report PB 230,894

FUEL COMBUSTION

<u>Fuel and Source</u>	<u>Arsenic Content, ppm</u>	<u>Emission Factor lb/10³ gallons</u>
Coal, domestic, controlled	5.44	3
Average for foreign residual oil	0.14	0.001
Average for foreign crude oils	0.13	0.0009
Average for U.S. crude oils	0.15	0.001

Source: Report PB 230,894

SOLID WASTE INCINERATION

<u>Source</u>	<u>Emission Factor</u>
Cotton ginning waste burned	17 lb/10 ³ bales of cotton ginned
Sewage and sludge	0.02 lb/ton sewage and sludge

Source: Report PB 230,894

VOLUME OF EMISSIONS

WATER

Very little information could be found.

LEVEL OF CONTROL

AIR

The removal of particulate material will control arsenic emissions if the control equipment operates at a temperature low enough (~100°C.) to condense the arsenic fumes. An electrostatic precipitator has been reported to reduce the arsenic from 5 to 17 ppb to 0 to 4 ppb. Cooling flues, bag houses, and electrostatic precipitators have been used in the smelting industry. No data have been reported in the United States on their removal efficiency for arsenic.

WATER

Only limited information was encountered on current levels of arsenic in industrial wastes, and on current treatment processes. Most of the literature describing industrial sources and treatment of arsenic is 30 years or more old. More recent industrial literature, while referring to arsenical wastes and to the severe pollution resulting from their discharge, presents no specific treatment processes or industrial waste values. More up-to-date information is available on the removal of arsenic from drinking water, and in fact the methods for arsenic treatment of both drinking water and industrial wastes are similar. No treatment costs directly related to wastewaters were encountered.

WATER TREATMENT METHODS AND REMOVALS ACHIEVED

Treatment	Initial Arsenic (mg./l.)	Final Arsenic (mg./l.)	Percent Removal
Lime Softening	0.2	0.03	85
Charcoal Filtration	0.2	0.06	70
Ferric Sulfide Filter Bed	0.8	0.05	94
Coagulation with Ferric Sulfate	25.0	5 or less	80 or more
Coagulation with Ferric Chloride	3.0	0.05	98
Precipitation with Ferric Hydroxide	---	0.6	--
Precipitation with Ferric Hydroxide	362.0*	15-20*	94-96

* As arsenious oxide.

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Coagulation with Ferric Sulfate	25.0	5 or less	80 or more
Coagulation with Ferric Chloride	3.0	0.05	98
Precipitation with Ferric Hydroxide	---	0.6	--
Precipitation with Ferric Hydroxide	362.0*	15-20*	94-96

* As arsenious oxide.

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PATENTS

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TOXIC CONTAMINANTS IN INDUSTRIAL WASTE PROCESS STREAMS

CONTAMINANT - Asbestos

KIND OF WASTE - Air and Water

AIR

SOURCES - Mining and Milling sites, manufacturing facilities, and certain segments of the construction industry (demolition sites).

WATER

Precipitation and runoff to receiving waters.

AIR

STANDARDS -

EPA - On April 6, 1973, under Section 112 of the Clean Air Act, as amended, the Administrator promulgated the national emission standard for asbestos. Amendments to this standard were promulgated on May 3, 1974 (39 FR 15396) and on October 14, 1975 (40 FR 48292). One of the provisions of the standard limits asbestos emissions from the spraying of materials to insulate or fireproof buildings, structures, pipes and conduits. The standard prohibits the use of such materials which contain more than one percent asbestos on a dry weight basis. Proposed amendments (Federal Register March 2, 1977, Part II and III, p. 12122) would extend coverage of the demolition and renovation provisions to all materials which are friable and contain more than one percent asbestos by weight. The proposed amendments similarly would extend the coverage of the asbestos spraying provisions by prohibiting all materials sprayed on buildings, structures, structural members, pipes and conduits which contain more than one percent asbestos by weight. The proposed amendments specify that materials sprayed on structural members are covered.

OSHA - The present standard was promulgated on 7 June 1972 established an 8-hour time weighted average (TWA) concentration exposure limit of five fibers longer than 5 micrometers per cubic centimeter of air, and a ceiling limitation against any exposure in excess of ten such fibers per cubic centimeter. The present standard further provided that, effective 1 July 1976, the 8-hour TWA is to be reduced to two fibers. On October 9, 1975 a proposed change in the standard was published by OSHA. The proposed standard would, among other things, lower the permissible exposure to 500,000 fibers per cubic meter (0.5 asbestos fibers per cubic centimeter) for an 8-hour time-weighted average exposure, and likewise reduce the permissible ceiling exposure to 5 million asbestos fibers per cubic meter (5 asbestos fibers per cubic centimeter) for any period not exceeding 15 minutes.

STANDARDS -

OTHER - No data found

WATER

No data found

VOLUME OF EMISSIONS

AIR

ASBESTOS EMISSIONS

<u>Source</u>	<u>Amount, tons</u>	<u>Pollutant, %</u>
Asbestos mining	5,610	89.6
Kraft pulp mill recovery furnace	15	0.24
Sulfite pulp mill	neg	neg
Asbestos products		
Brake lining production	312	4.98
Shingle and siding production	205	3.27
Asbestos textile production	18	0.29
Installation of asbestos construction material	61	0.97
Spray on steel fire proofing	15	0.24
Insulating cement application	25	0.40
Total	6,261	99.99

Source: The MITRE Corporation, Preliminary Results, EPA Contract No. 08-01-0458.

WATER

Asbestiform amphibole minerals, have been detected in substantial quantities in municipal water supplies taken from western Lake Superior water. The total concentration of amphibole minerals in the Duluth, Minnesota, water supply, averages 0.19 milligram per liter with large fluctuations due to seasonal and climatological effects on lake circulation. A conservative estimate of the fiber count for 1973 Duluth water supply samples is $(1 \text{ to } 30) \times 10^6$ amphibole fibers identifiable by electron diffraction per liter of water with a mass concentration of 1 to 30 micrograms per liter.

EMISSION FACTORS

AIR

ASBESTOS FROM MINING AND MILLING

<u>Source</u>	<u>Emission factor, lb/ton of asbestos produced</u>
Mining, total	10
Mining	3
Loading	2
Hauling	2
Unloading	2
Mining, total, 50% control	5
Milling	100
Milling, 50% control	80
Milling, 80% control	20

^aUncontrolled unless otherwise specified.

Source: Report PB 230,894

EMISSION FACTORS

PROCESSING OF ASBESTOS

<u>Source</u>	<u>Emission factor, lb/ton of asbestos produced</u>
Friction material, controlled	6
Asbestos cement products, controlled	1
Textiles	40
Textiles, controlled	2
Asbestos paper	4
Asbestos paper, controlled	1
Floor tile	4
Floor tile, controlled	1

^aUncontrolled unless otherwise specified.

Source: Report PB 230,894

WATER

No data found.

LEVEL OF CONTROL

AIR

MINING-OPEN PIT

Control methods in certain mining operations leave much to be desired. Methods for controlling emissions from blasting are virtually non-existent. Dust controls in material handling still need considerable development.

<u>Operation</u>	<u>Control method</u>
Drilling	Small bag collectors Water
Blasting	No known method for efficiently controlling emissions to ambient air
Material handling	Filtered air cab (protects worker only)
Shoveling	The use of water to soak piles of ore is sometimes used.
Material handling	Filtered air cab (protects worker only)
Handling	Covered load-canvas
Roadways	Road stabilization program-oil chemical water
Waste disposal	Tailings are covered with earth- reforestation

Source: W. B. Reitze, D.A. Haladay, H. Romer and E. M. Fenner, Second International Clean Air Congress, p. 101, (1972).

LEVEL OF CONTROL

MILLING

The technology to effectively control asbestos milling emissions is on the shelf. Bag filters with an efficiency in excess of 99% are readily available. Recent discussions regarding the relationship of bag house efficiency and fiber size have pointed up the need for more data from the medical community regarding the biologic activity of the sub-micron asbestos fibers.

<u>Operation</u>	<u>Control method</u>
Crushing	Bag Filter ^a —a cyclone may be used as a primary collector
Ore drying	Bag Filter—a cyclone may be used as a primary collector
Milling	Bag Filter
Classification air separation	Bag Filter
Packaging	Bag Filter
Solid waste	Tailings are covered with earth—reforestation

a) Filters usually enclosed in a negative pressure bag house.

CONSTRUCTION

Asbestos containing building materials

Calcium silicate products	Cutting with hand saw	No control device available for the hand saw
Pipe covering	Cutting with band saw	Bag collectors are available for fabrication shop or on site use.
Block	table saw saber saw	
Asbestos cement	Dry mixing in pail quantities	Asbestos cement now marketed in plastic bags suitable for use as a mixing container.
	Dry mixing in tub quantities	
Asbestos cement products	Cutting, with bandsaw	Bag collectors are available both types of saw.
(Tightly bound) Pipe	Rotary saw	
Board		

The above operations are customarily performed in confined areas. The air pollution usually arises from efforts to reduce dust in the work place.

Solid waste disposal	Scrap from cutting and fitting of pipe covering, and block discarded asbestos cement.	Material enclosed in tightly closed bags or containers and moved in covered trucks to a sanitary land fill.
All asbestos containing waste.	Demolition.	
Spray application	Enclosure of spray area perimeter, stair wells, elevator shafts and hopper charging areas with canvas plastic or solid board.	
	After completion of spray operation, the area is shoveled, swept and vacuumed clean.	

Source: W.B. Reitze, D.A. Holaday, H.Romer and E.M. Fenner, 2nd Intl Clean Air Cong. 101 (1972).

LEVEL OF CONTROL

ASBESTOS TEXTILE

<i>Operation</i>	<i>Control methods</i>
Carding	Enclosures, hoods or pick-ups vented to bag house
Willowing	
Weaving	Certain operations may be per- formed while the fiber is moist thereby reducing dust.
Spinning	
Twisting	
Material handling	Enclosure or hood to bag house
Bag opening	
Bag emptying	
Bag disposal	
Bins	
Bobbins	
Spools	

ASBESTOS CEMENT PRODUCTS—FLOOR TILE—FRICTION MATERIAL, PLASTICS, ETC.

	<i>Operation</i>	<i>Control methods</i>
Dry and/or wet mix	Bag opening	Enclosure or hood to bag house. Wet scrubbers are also used for dry mix
	Bag dumping	
	Bag disposal	
Pressing—	Wet stock	No dust
Moulding—	Wet furnish	Slurry—no dust
Forming—	Wet furnish	Slurry—no dust
Drying and curing	Little or no dust generated during operation	
Finishing	cutting grinding sawing, planing routing	Enclosure or hood—to bag house Primary cyclone may be used
Packaging and shipping	Bagging Boxing	Pickup point to bag house
Warehousing	Raw material Finish product	Vacuum sweeper to disposable bag

Source: W. B. Reitze, D. A. Holaday, H. Romer and E. M. Fenner, 2nd International Clean Air Congress, 101 (1972).

WATER

No data found.

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TOXIC CONTAMINANTS IN INDUSTRIAL WASTE PROCESS STREAMS

CONTAMINANT - Beryllium

KIND OF WASTE - Air

SOURCES - Industrial plants producing or using beryllium products; (extraction plants, metal and alloy machine shops, foundries and ceramic plants) mining and smelting operations, and power plants (fossil fuel combustion).

STANDARDS -

EPA - The emission standards were set so that ambient concentrations would not exceed 10 ng/m^3 for a 30 day average.

The 10 ng/m^3 standard was based on a study of "neighborhood cases" of chronic beryllium disease that was made in 1948.

The types of facilities which are required to abide by the standard are:

Beryllium Extraction Plants

Beryllium Metal and Alloy Machine Shops

Beryllium Foundries

Beryllium Ceramic Plants

A very different type of standard is required to regulate the emissions during the firing of rocket motors. In this case large quantities are emitted for short time periods. In 1966 the National Research Council of the National Academy of Sciences developed two separate standards to be applied to rocket motor emissions. One applied to soluble and low-fired compounds and the other is to high-fired oxides. The EPA has applied the more restrictive of these two standards to rocket motor test facilities. The standard states that emissions from intermittent beryllium sources shall not exceed a time weighted concentration of $75 \text{ } \mu\text{g-minutes/m}^3$ within the limits of 10 to 60 minute intervals during any consecutive two week period.

STANDARDS -

OSHA - The present Occupational Safety and Health Administration (OSHA) standard for beryllium, was adopted from the American National Standards Institute's (ANSI) prescribes an 8-hour time-weighted average of $2.0 \mu\text{g}/\text{m}^3$ with a ceiling concentration of $5.0 \mu\text{g}/\text{m}^3$. In addition, the present standard allows a peak concentration above the acceptable ceiling concentration for an 8-hour shift of $25 \mu\text{g}/\text{m}^3$, for a maximum duration of 30 minutes.

On October 17, 1975, OSHA proposed a new standard that reduces the current permissible employee exposure for an 8-hour time-weighted average concentration, based on a 40-hour work week, to 1.0 microgram of beryllium per cubic meter of air ($1.0 \mu\text{g}/\text{m}^3$), sets a 5 microgram per cubic meter of air ($5 \mu\text{g}/\text{m}^3$) ceiling limit for exposures to airborne concentrations of beryllium, eliminates the peak concentration level and proposes a dermal exposure limit.

OTHER - In 1949, a guideline limit for beryllium concentrations in community air was developed by the Atomic Energy Commission (AEC). The concentration selected was an average of 0.01 microgram of beryllium per cubic meter of air for 30 days. In the period since the implementation of this guideline, no reported cases of chronic beryllium disease have occurred as a result of community exposure. Consequently, the Committee on Toxicology of the National Academy of Sciences has concluded that the average concentration $0.01 \mu\text{g}/\text{m}^3$ for 30 days has proved to be a safe level of exposure.

The recommended occupational standard states that no worker shall be exposed to more than $2 \mu\text{g Be}/\text{m}^3$ determined as a time weighted average exposure for an 8 hour work day and no peak concentration shall exceed $25 \mu\text{g}/\text{m}^3$ as determined by a minimum sampling time of 30 minutes.

VOLUME OF EMISSIONS

<u>Source</u>	<u>Amount, tons</u>	<u>Pollutant, %</u>
Mica, feldspar mining	neg	neg
Gray iron foundry		
Cupola	4	2.77
Ceramic coatings	neg	neg
Beryllium alloys and compounds	5	3.64
Beryllium fabrication	neg	neg
Power plant boilers		
Pulverized coal	86	59.62
Stoker coal	10	6.93
Cyclone coal	3	2.08
All oil	2	1.39
Industrial boilers		
Pulverized coal	8	5.55
Stoker coal	13	9.01
Cyclone coal	2	1.39
All oil	2	1.39
Residential/commercial boilers		
Coal	1	0.69
Oil	8	5.55
Total	144	100.01

Source: The MITRE Corporation, Preliminary Results, EPA Contract No. 68-01-0458.

EMISSION FACTORS

<u>Source</u> ¹	<u>Emission Factor</u>
Mining	0.2 lb/ton of Be produced
Production of beryllium metal and its compounds, overall value ²	30 lb/ton of Be produced
Cement plants ²	
Dry process	
Feed to raw mill ³	0.00003 lb/1,000 tons of feed
Wet process	
Kiln ⁴⁻⁵	0.002 lb/1,000 tons of feed
Clinker cooler ⁴	0.0008 lb/1,000 tons of feed
Clinker cooler ⁶	0.0009 lb/1,000 tons of feed
Processing or uses of beryllium and its compounds	
Beryllium alloys (stamped and drawn) ⁷	0.1 lb/ton of Be processed
Beryllium alloys (molding)	
Uncontrolled	0.01 lb/ton of alloy melted
After a baghouse	0.0004 lb/ton of alloy melted
Ceramics ²	1 lb/ton of Be processed
Rocket propellants	Negligible
Beryllium metal fabrication ²	0.1 lb/ton of Be processed

¹Uncontrolled unless otherwise specified.

²Controlled emission factor.

³Exit from baghouse.

⁴Exit from electrostatic precipitator.

⁵At another plant, beryllium emissions from the kiln were below the detection limit of the analytical technique.

⁶Exit from two baghouse collectors in parallel.

⁷It is not known whether this estimate is based on controlled or uncontrolled emissions.

Source: Report PB 230,894

FUEL COMBUSTION, COAL

<u>Source</u> ¹	<u>Beryllium Content, ppm</u>	<u>lb/ton</u>
Power plants		
Kansas ²	2	0.00004
South Carolina ³	4	0.00002
Illinois ³	1	0.00003
Michigan ³	1	0.00002
Coal beds		
Maryland	2.4	0.003
Ohio	2.6	0.0046
Pennsylvania	2.8	0.0026
Alabama	2.2	0.0033
Georgia	1.6	0.002
Kentucky-east	4.4	0.0069
Kentucky-west	2.4	0.0044
Tennessee	2.8	0.0023
Virginia	1.2	0.001
West Virginia	1.3	0.0023
Illinois	2.0	0.0036
Indiana	4.5	0.0091
Arkansas	1.8	0.0020
Iowa	3.6	0.0049
Missouri	3.8	0.0078
Oklahoma	1.6	0.0022
Montana	2.4	0.0054
North Dakota	0.8	0.0011
Wyoming	1.4	0.0046
Colorado	0.6	0.0033
Utah	0.3	0.0006
U.S. Average	2.2	0.0037

¹Uncontrolled unless otherwise specified.

²Exit from limestone wet scrubber.

³Exit from electrostatic precipitator.

⁴Not reported.

Source: Report PB 230,894.

FUEL COMBUSTION, OIL

<u>Source</u>	<u>Beryllium Content, ppm</u>	<u>lb/10³ gallons</u>
Residual oil	0.08	0.0007
Power plant, Connecticut ¹	0.024	0.0002
Residual No. 6	0.1	0.0008

¹Exit from electrostatic precipitator.

Source: Report PB 230,894.

WASTE INCINERATION

<u>Source</u>	<u>lb/10³ tons of waste burned</u>
Sewage sludge incinerator Multiple hearth, after wet scrubber	0.002
Fluidized bed, after wet scrubber	0.002
Municipal incinerator, uncontrolled	0.03
Municipal incinerator, after electrostatic precipitator	0.03

Source: Report PB 230,894.

LEVEL OF CONTROL

Cleaning of residual gases by particulate control techniques. This type of equipment is usually 95-99% effective in removing particulates greater than one micrometer ($1\mu\text{m}$). For wet chemical processes, scrubbers, packed towers, organic wet collectors, and wet cyclones have been found to be effective. For dry processes, conventional bag collectors, reverse-jet bag collectors electrostatic precipitators, cyclones and unit filters have been used.

The effectiveness of abatement activities can be appreciated by comparing present-day industrial exposure concentrations with concentrations existing prior to recognition of the significance of beryllium air pollution to industrial health. Current practices limit employees' exposure to beryllium to about $2\mu\text{g./m.}^3$ or less, with out-of-plant neighborhood concentrations limited to $0.01\mu\text{g./m.}^3$. By comparison, samples of beryllium concentration in a Cleveland factory revealed concentrations as high as $4,710\mu\text{g./m.}^3$.

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TOXIC CONTAMINANTS IN INDUSTRIAL WASTE PROCESS STREAMS

CONTAMINANTS - Cadmium

KIND OF WASTE - Air and Water

AIR

STATIONARY SOURCES - Metallurgical industry (extraction, refining and processing of lead, copper and Zinc), electroplating, alloying, pigments and plastic industries.

WATER

Metallurgical industry (alloying), ceramics, electroplating photography, pigment works, textile printing, activities, chemical industries and lead mine drainage.

STANDARDS -

AIR

EPA - No data found

OSHA - No data found

OTHER - Threshold Limit Values;

(TLV) metal dust and soluble salts - $0.2 \mu\text{g}/\text{m}^3$
Cadmium oxide fume (as Cd) - $0.1 \mu\text{g}/\text{m}^3$

WATER

The 1962 U.S. Public Health Drinking Water Standards list $10 \mu\text{g}/\text{l}$ cadmium as a cause for rejection of a water source. Water Quality Criteria, 1968, suggests a tolerance limit of $5 \mu\text{g}/\text{l}$ for irrigation waters used continuously on all soils, and $50 \mu\text{g}/\text{l}$ for short-term use on fine textured soils only. The EPA is expected to issue updated drinking water standards in the near future.

VOLUME OF EMISSIONS

AIR

<u>Source</u>	<u>Amount in Tons</u>	<u>% This Pollutant</u>
Copper Mining	NEG	NEG
Zinc Mining	<1	0.01
Lead Mining	NEG	NEG
Primary Copper		
Roasting	229	7.59
Reverberatory Furnace	94	3.12
Converters	270	8.95
Material Handling	59	1.96
Primary Zinc		
Roasting	666	22.07
Sintering	284	9.41
Distillation	90	2.98
Material Handling	NEG	NEG
Primary Nickel	NEG	NEG
Primary Lead		
Sintering	66	2.19
Blast Furnace	19	0.63
Reverberatory	3	0.10
Material Handling	NEG	NEG
Secondary Copper		
Sweating Furnace	70	2.32
Blast Furnace	55	1.82
Iron & Steel		
Blast Furnace	1,000	33.14
Non-Ferrous Alloys		
Furnaces	3	0.10
Material Handling	NEG	NEG
Cadmium Paint Pigments	11	0.36
Cadmium-Barium Plastic Stabilizers	3	0.10
Cadmium-Nickel Batteries	<1	0.01
Miscellaneous Cadmium Products	<1	0.02
Use of Pesticides, Herbicides and Fungicides	<1	0.01
Fertilizer Application	<1	0.02
Incinerators	95	3.15
TOTAL	3,018	100.06

Source: The MITRE Corporation, Preliminary Results, EPA Contract No. 68-01-0438.

VOLUME OF EMISSIONS

WATER

Regional Summary of Cadmium in Surface Waters of the U.S.

Region	Maximum ($\mu\text{g/l}$)	Minimum ($\mu\text{g/l}$)	Median ($\mu\text{g/l}$)	Not Detected (%)	Detected (%)
New England and Northeast	32	<1	2	36	64
Southeast	90	<1	<1	55	45
Central	40	<1	<1	55	45
Southwest	130	<1	<1	65	35
Northwest	21	<1	<1	78	22

Source: W. H. Durum & J. D. Heim, Am. N. Y. Acad. Science 199 26 (1972).

EMISSION FACTORSAIRINDUSTRIAL SOURCES

<u>Source^a</u>	<u>Emission Factor</u>
Mining of zinc-bearing ore ^b	0.001 lb/ton of Zn or 0.2 lb/ton of Cd mined
Zinc smelters	300 lb/ton of Cd charged or 2.0 lb/ton of Zn produced
Copper smelters	1300 lb/ton of Cd charged or 0.07 lb/ton of Cu produced
Lead smelters	1300 lb/ton of Cd charged or 0.02 lb/ton of Pb produced
Cadmium refining units	25 lb/ton of Cd produced
Secondary copper ^b	4 lb/ton of Cu scrap
Secondary lead	
Reverberatory furnace	0.1 lb/10 ³ tons of Pb
Reverberatory furnace	0.4 lb/10 ³ tons of Pb
Steel scrap (galvanized metal) ^b	0.003 lb/ton of steel
Cement plants	
Dry process	
Kiln	0.3 lb/10 ³ tons of feed
Raw mill	0.0001 lb/10 ³ tons of feed
Air separator after raw mill	0.0009 lb/10 ³ tons of feed
Feed to raw mill	0.0003 lb/10 ³ tons of feed
Feed to finish mill	0.0005 lb/10 ³ tons of feed
Wet process	
Kiln	0.2 lb/10 ³ tons of feed
Raw mill	0.02 lb/10 ³ tons of feed
Clinker cooler	0.0001 lb/10 ³ tons of feed

^aIn this table, sources are controlled unless otherwise specified.

^bUncontrolled emission factors.

Source: Report PB 230,894

PROCESSES INVOLVING CADMIUM

<u>Source</u> ^a	<u>Emission factor, (lb/ton) of cadmium charged</u>
Pigments ^b	15
Plastic stabilizers ^b	6
Alloys and solders ^c	10
Batteries (Ni-Cd)	2
Miscellaneous (x-ray screens, cathode ray tubes, nuclear reactor components, etc.)	2

^aEmission are uncontrolled unless otherwise specified.

^bControlled emissions (bag filters).

^cControlled emissions.

Source : Report PB 230,894.

CONSUMPTION USES OF CADMIUM

<u>Source</u> ^a	<u>Emission factors</u>
Rubber tire wear	0.01 lb/10 ⁸ vehicle miles
Fungicides	0.05 lb/10 ³ gal. of spray
Superphosphate fertilizers	0.0002 lb/ton of fertilizer
Motor oil consumption (in vehicle)	0.002 lb/10 ⁶ vehicle miles
Cigarettes	16.0 µg/20 cigarettes

^aAll sources are uncontrolled.

Source: Report PB 230,894.

FUEL COMBUSTION

<u>Source</u> ^a	<u>Cadmium content ppm</u>	<u>Emission factor</u>
Heating oil (residual assumed)	0.4 to 0.5	0.003 to 0.004 lb/10 ³ gal. of oil
Diesel oil	0.07 to 0.1	0.0006 to 0.0008 lb/10 ³ gal. of oil
Foreign No. 6 residual fuel oil		
Virgin islands	5	0.04 lb/10 ³ gal. of oil
Virgin islands (different oil field)	<0.4	-
Curacao, N.A.	4	0.03 lb/10 ³ gal. of oil
Trinidad	3	0.02 lb/10 ³ gal. of oil
Venezuela	<0.4	-
Coal, power plant, Kansas	-	0.2 lb/10 ³ tons of coal burned
Coal, power plant, Michigan	-	1 lb/10 ³ tons of coal burned

^aUncontrolled emissions unless otherwise specified.

Source: Report PB 230,894

WASTE INCINERATION

<u>Source</u> ^a	<u>Emission factor</u>
Sewage sludge incinerators	
Multiple hearth ^b	0.007 lb/ton of solid waste incinerated
Fluidized bed	0.003 lb/10 ³ tons of solid waste incinerated
Municipal incinerator	
Refuse only	0.8 lb/10 ³ tons waste incinerated
Refuse and sludge	0.6 lb/10 ³ tons waste incinerated
Overall value for uncontrolled solid waste incineration (municipal) ^c	0.003 lb/ton of solid waste incinerated
Lubricating oil ^d	0.002 lb/10 ³ gal. of oil

^aIn this table, emissions are controlled unless otherwise specified.

^bCadmium ratio of metal in particulate to metal in sludge was 2.6.

^cThis emission factor is presented for comparison only; it should not be used for emission estimates.

^dEmissions of cadmium oxides.

Source: Report PB 230,894

WATER

INDUSTRIAL WASTE WATERS

<u>Process</u>	<u>Cadmium Concentration, mg/l</u>
Automobile Heating Control Manufacturing	14-22
Plating Rinse Waters Automatic Barrel Zn & Cd Plant	10-15
Mixed Manual Barrel and Rack	7-12
Plating Rinse Waters (large installations)	15 ave, 50 max.
Plating Rinse Waters 0.5 gph dragout	48
2.5 " "	240
Plating Bath	23,000
Bright Dip and Passivation Baths	2,000 - 5,000
Lead Mine Acid Drainage	1,000

Source: Report PB 216,162

LEVEL OF CONTROL

AIR

Electrostatic precipitators, baghouses, and cyclones are effectively used for abatement. However, little information has been found on the specific application of these procedures for the purpose of controlling cadmium air pollution.

WATER

Methods of cadmium wastewater treatment currently in use are essentially those employed for most heavy metal wastes encountered in the plating and metal processing industries. These methods include precipitation and ion exchange. Precipitation is accomplished as the hydroxide at elevated pH, but values of pH 10 or greater are necessary for effective removal. Removal solely on a solubility basis is restricted to 0.1 mg./l. residual cadmium at pH 10. Organic or inorganic complexing agents in the waste stream will reduce the effectiveness of precipitative removal.

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TOXIC CONTAMINANTS IN INDUSTRIAL WASTE PROCESS STREAMS

CONTAMINANT - Carbon Monoxide

KIND OF WASTE - Air

STATIONARY SOURCES - Power plants (fossil fuel combustion), solid waste disposal sites, process industries (metallurgical foundries and petroleum refineries).

STANDARDS -

EPA - The national primary and secondary air quality standard - $10 \mu\text{g}/\text{m}^3$ (9 ppm) maximum 8-hour average; $40 \mu\text{g}/\text{m}^3$ (35 ppm) maximum 1-hour average.

OSHA - No data found

OTHER - Threshold Limiting Value (TLV) - 50 ppm ($55 \mu\text{g}/\text{m}^3$)

VOLUME OF EMISSIONS (1972)

<u>Source</u>	<u>Quantity (10⁶ tons)</u>
Stationary fuel combustion	0.3
Miscellaneous	0.9
Industrial processes	17.5
Solid waste disposal	11.2
Total	29.9

*[1972 National Emissions Report, Environmental Protection Agency, Research Triangle Park, NC, Publ. EPA-450/2-74-012 (1974).]

EMISSION FACTORS

<u>Source</u>	<u>Emission factor^a</u>
Stationary fuel combustion	
Coal	
Less than 10 x 10 ⁶ Btu/hr capacity	50 lb/ton of coal burned
10 to 100 x 10 ⁶ Btu/hr capacity	3 lb/ton of coal burned
Greater than 100 x 10 ⁶ Btu/hr capacity	0.5 lb/ton of coal burned
Fuel oil	
Less than 100 x 10 ⁶ Btu/hr capacity	2 lb/1,000 gal of oil burned
More than 100 x 10 ⁶ Btu/hr capacity	0.04 lb/1,000 gal of oil burned
Natural gas	
Less than 100 x 10 ⁶ Btu/hr capacity	0.4 lb/10 ⁶ ft ³ of gas burned
More than 100 x 10 ⁶ Btu/hr capacity	Negligible lb/10 ⁶ ft ³ of gas burned
Wood	30-65 lb/ton of wood burned
Solid waste disposal	
Open burning onsite of leaves, brush, paper, etc.	60 lb/ton of waste burned
Open-burning dump	85 lb/ton of waste burned
Municipal incinerator	1 lb/ton of waste burned ^b
Commercial and industrial multiple chamber incinerator	10 lb/ton of waste burned
Commercial and industrial single chamber incinerator	44 lb/ton of waste burned
Flue-fed incinerator	27 lb/ton of waste burned
Domestic incinerator	200 lb/ton of waste burned
Process industries (specific examples)	
Gray iron foundry	
Cupola	
Uncontrolled	250 lb/ton of charge
Controlled with afterburner	8 lb/ton of charge
Iron and steel manufacture	
Blast furnace	1,700-250 lb/ton of pig iron produced ^c
Basic oxygen furnace	124-152 lb/ton of steel produced ^d
Petroleum refinery	
Fluid catalytic unit	13,700 lb/1,000 bbl fresh feed ^e
Moving-bed catalytic cracking unit	3,800 lb/1,000 bbl fresh feed ^e

^aThese emissions are from uncontrolled sources, unless otherwise noted.

^bThis represents excellent design and operation.

^cPractically all of the CO is burned for heating purposes or in waste gas flares.

^dGases emitted from a basic oxygen furnace during the blowing period contain 87 percent CO. After ignition of the gases above the furnace, the CO amounts to 0.0-0.3 percent.

^eThese emissions are completely controlled when CO waste heat boilers are utilized.

Source: EPA Report AP-65

LEVELS OF CONTROL

The control of carbon monoxide emissions from stationary combustion sources can be accomplished by the following methods: good operating procedures, employing alternative fuel sources, changing the waste disposal method, using afterburners on cupolas in the iron and steel industry, and by using waste heat boilers in the chemical and petroleum industry. Some alternatives to other fuels for stationary sources include changing to gas from oil or coal; substituting nuclear or hydroelectric power; and replacing industrial, commercial, and household thermal requirements with central power.

SUMMARY OF METHODS FOR CONTROLLING CARBON MONOXIDE EMISSIONS FROM STATIONARY COMBUSTION SOURCES

Control Method	Remarks
Change of fuel or energy source: Change to gas from oil and coal	Accepted emission factors for burning of coal, oil, and gas show decreasing CO emissions for these three fuels, in the order given. But CO emissions from boilers and furnaces are so low a fraction of total CO emissions that fuel change is not justified.
Change to nuclear power or hydroelectric generation	Use of nuclear power is expected to grow; hydroelectric generation will grow slowly. Nuclear power involves generation of some CO due to the periodic test operation of standby power-generating units employing conventional fuels.
Replace industrial, commercial, and household thermal requirements with central power	Generation of electric power is increasing. CO emissions are easier to control at a central power plant than at small installations and households. Efficiency is lower for indirect use of fuel through electricity than for direct burning. Reduction in local CO concentrations may result in increased oxides of nitrogen (NO _x) emissions at distant power plants.
Combustion control: Air supply	A well-adjusted gas-fired boiler may emit less than 1 ppm of CO, but may emit more than 50,000 ppm if insufficient combustion air is supplied. Insufficient air always causes CO formation; too much air may do the same by flame quench.
Residence time	Short residence times tend to cause more CO in exit gases. Proper residence time allows the use of less excess air.
Temperature	High temperature is desirable, but dissociation of CO ₂ into CO becomes noticeable at 2800°F. Rapid cooling and low oxygen concentration tend to hinder recombination of CO ₂ . Flame temperatures above 3000°F. are conducive to formation of oxides of nitrogen (NO _x).
Mixing	Good mixing is very important for burning of CO; appliance and burner design should facilitate mixing.
Flame contact	Contact of flame with cold surfaces tends to form CO by quenching, i.e., it reduces residence time at effective oxidation temperature.
Change of waste disposal method: Sanitary landfill	Replaces open-burning and incineration.
Various treatments for coal-waste piles	These are not deliberately burned, but ignite by spontaneous combustion or accident.

Source: National Air Pollution Control Administration Publ. No. AP-65 (1970)

SUMMARY OF METHODS FOR CONTROLLING CARBON MONOXIDE EMISSIONS FROM STATIONARY PROCESS SOURCES

Source	Control Method	Remarks
Iron and steel industry:		
Blast furnace	CO generated is burned as fuel.	Emissions can be produced by faulty equipment and accidents.
Grey iron cupola	Flame afterburner.	Not all controlled.
Basic oxygen steel furnace	Burned inside hood and dispersed by stack.	Collection for use as fuel not common in United States.
Sintering furnace	None	
Coke oven	Proper design, scheduling, operation and maintenance.	Controls are same as those to control particulates and SO ₂ . See AP-52, <i>Control Techniques for Sulfur Oxide Air Pollutants</i> .
Petroleum industry:		
Petroleum catalytic cracking unit	Burned as fuel in CO boiler.	CO produced during regeneration of catalyst. Burning as fuel usually requires supplementary fuel for stability.
Petroleum fluid coker	Burned as fuel in CO boiler.	Gas produced in coker burning section of coking unit is rich in CO.
Chemical industry:	Most commonly burned as waste.	Moderate amounts generated in chemical industry as a whole, but this actually occurs only in specified segments of the industry. Emissions are from gas purging, leaks, abnormal operations such as startup, upsets and shutdown, or relief of overpressure.

Source: National Air Pollution Control Administration Publ. No. AP-65 (1970)

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TOXIC CONTAMINANTS IN INDUSTRIAL WASTE PROCESS STREAMS

CONTAMINANTS - Chromium

KIND OF WASTE - Air and Water

AIR

STATIONARY SOURCES - Ferrochromium and chrome steel production, refractory production, coal and fuel oil combustion, cement production.

WATER

Painting industry, dyeing and tanning industry, metal cleaning, plating and anodizing operations, glass, ceramics, photography industry.

STANDARDS -

EPA - No data found

OSHA - No data found

OTHER -

Threshold Limiting Value (TLV)

Chromic Acid and Chromates	0.1 mg/m ³
Chromous Salts	0.5 mg/m ³
Metal and Insoluble Salts	1 mg/m ³

VOLUME OF EMISSIONS, EMISSION FACTORS AND LEVELS OF CONTROL FOR IMPACTS TO AIR
(1970)

Source	Uncontrolled Emission Factor lb/ton	Production Level (tons/yr)	Percent Cr in Emissions	Emissions of Cr Before Controls (tons/yr)	Estimated Level of Emission Control	Emissions of Cr After Controls (tons/yr)
				0		
Refining						
Ferrochromium						
Electric furnace	(200-330)					
Material handling	500 ^a	375,500	22	20,600	40%	12,360
Electrolytic chromium	0	375,500	65	1,220	32%	830
	0.048	9,000	51	neg	95%	neg
Refractory						
Noneast	150	60,300	b	4,500	64%	1,630
Electric cast	225	6,700	b	754	77%	173
Chemical Processing						
Dichromate	30	61,000	b	920	90%	92
Other chemicals	-	-	-	-	-	24
Steel and Alloys						
Chromium steels	15	189,000	b	2,362	78%	520
Cast iron	15	5,000	b	188	99%	2
Super alloys and alloys	15	12,000	b	150	78%	33
General steel making	N.A.	N.A.	N.A.	N.A.	N.A.	100 ^c
Inadvertent Sources						
Coal combustion	N.A.	33,800,000 ^e	0.026	8,700	82%	1,564
Oil combustion	N.A.	287,000 ^d	0.13	370	0	370
Cement production	N.A.	934,000 ^d	0.03	N.A.	N.A.	280
Incineration	N.A.	931,000 ^d	0.017	N.A.	N.A.	158
Asbestos	N.A.	6,579	0.15	10	99%	0
Total				39,774	54%	18,136

^aIntermediate value

^bEmission factor multiplier equal to tons of Cr processed or handled annually.

^cNeeds further investigation.

^dEmissions, after control

^eEmissions, before control.

Source: Report PB 230,034

EMISSION FACTORS FOR WATER

HEXAVALENT CHROMIUM WASTEWATER SOURCES AND TYPICAL CONCENTRATIONS

Industrial Source	Chromium (VI) Concentration mg/l	
	Average	Range
Leather Tanning	40	
Wood Preserving		0.23 - 1.5
Cooling Tower Blowdown	31.4	
Cooling Tower Blowdown		8 - 10.7
Cooling Tower Blowdown		10 - 60
Bright Dip Rinse		1 - 6
Bright Dip Bath		10,000 - 50,000
Bright Dip Bath		20,000 - 75,000
Bright Dip Bath		200 - 600
Anodizing Bath	173	
Anodizing Bath		15,000 - 52,000
Anodizing Rinse	49	
Anodizing Rinse		30 - 100
Plating	1,300	
Plating	600	
Plating		100,000 - 270,000
Plating		60 - 80
Electroplating	140	
Electroplating	41	15 - 70

Source: Report PB 216,162

In addition to the hexavalent form, some few mg./l. of trivalent chromium may be encountered in raw plating wastes, even prior to chemical reduction of Cr^{+6} . For example, in one process waste a hexavalent chromium concentration was reported ranging from 0.0 to 18.0 mg./l. and a total chromium concentration of 2.9 to 31.8 milligrams per liter. By difference, their data indicate a trivalent chromium concentration in this one waste stream of 2.9 to 13.9 mg./l.

An acid bath waste stream contained a hexavalent content of 122 to 270 mg./l. and trivalent chromium levels of 37 to 282 mg./l. Thus, trivalent chromium represents a major component of this acid waste, even before reduction of hexavalent chromium. After reduction the trivalent content of this latter waste stream would be approximately 160 to 550 mg./l.

LEVEL OF CONTROL

AIR

Chromium air pollution usually occurs as particulate emissions, which may be controlled by the usual dust-handling equipment, such as bag filters, precipitators, and scrubbers. Chromium poses no peculiar control problems except when it is emitted as aerosols (e.g., sprays and chromic acid mists).

Some chrome-plating facilities have installed methods of preventing air pollution. Moisture-extractor vanes in the hood-duct system have been used to break up bubbles in the exhaust gases. Most exhaust systems use slot hoods to capture the discharged mists.

WATER

HEXAVALENT CHROMIUM

Removal of hexavalent chromium ions from a waste stream may be accomplished by reduction and precipitation, ion exchange, or evaporative recovery. Ion exchange and evaporative recovery have the advantage that the chromium may be recovered for reuse. Whether ion exchange is used to recover chemicals, or to concentrate them for further treatment, it always has the advantage of producing reusable water.

Water vapor from the evaporative recovery process may be recondensed, and also reused. If waste flow rates and chromium concentrations are low (less than 50 mg./l.), the total water volume reuse, and the amount of chromium involved does not warrant reclamation. In such a case, reduction to trivalent chromium and precipitation appears most feasible.

TRIVALENT CHROMIUM

Most trivalent chromium in industrial waste results from reduction of hexavalent chromium as a preliminary step in waste treatment. This trivalent chromium is most often treated with lime to precipitate chromic hydroxide. The chromic hydroxide sludge is dewatered by vacuum filtration, or disposed of directly to landfill or otherwise. Treated effluent trivalent chromium concentrations to 0.06 mg./l. have been reported.

Under special circumstances, ion exchange removal of trivalent chromium have been employed. Ion exchange is characterized by effecting complete Cr^{+3} removal, until the exchange capacity of the resin is exhausted. This exchange capacity may be recovered by regenerating the resin.

WASTE SLUDGES

One process reported permits recovering the chromium content from waste sludge produced from the separation of the sludge as precipitated solids from the waste effluent streams of metal finishing processes, the chromium content of the sludge being in the form of barium chromate.

The above is achieved by forming an aqueous slurry of the sludge, adding sulfuric acid thereto, agitating the resulting admixture for a period of time at ambient temperature, separating the insolubles therefrom, adding to the filtrate from the separation an amount of a carbonate selected from the group consisting of Ca^{+2} , Sr^{+2} , Ba^{+2} and Pb^{+2} to precipitate out a substantial portion of the sulfate ion from the reacting environment, adding to the filtrate of the second separation step strontium carbonate to precipitate out the remaining sulfate ion, and separating the insolubles from the reacting environment to obtain a solution containing all the CrO_3 content from the initial extraction.

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TOXIC CONTAMINANTS IN INDUSTRIAL WASTE PROCESS STREAMS

CONTAMINANT - Coke Oven Emissions (Particulates, sulfur monoxide, hydrocarbons, nitrogen oxides, ammonia).

KIND OF WASTE - Air and Water

AIR

SOURCES - Oven-charging, coke pushing and quenching operations, leakage around open doors and lids, and material handling operations.

WATER

Excess ammonia liquor, cooling and quenching water overflow, light oil recovery wastes, wharf drainage and coal pile runoff.

STANDARDS

EPA - No data found

OSHA - Proposed standards limit employee exposure to an 8-hour time-weighted average concentration based on a 40-hour week of respirable particulates of 0.3 milligrams per cubic meter of air (0.3 mg/m³).

OTHER - A value of 0.2 milligrams per cubic meter of air (0.2 mg/m³) for coal tar pitch volatiles (CTPV) was adopted by the American Conference of Governmental Industrial Hygienists (ACGIH) in 1967. The Standards advisory committee on Coke Oven Emissions (SACCOE) recommended in 1975 that employees not be exposed to benzo (a) pyrene (B (a) P) in excess of 0.2 micrograms per cubic meter of air (0.2 ug/m³) calculated on an eight-hour time weighted average basis.

VOLUME OF EMISSIONS

AIR

No data found

WATER

No data found

AIR

Volume/Unit of Product

Type of Operation	Particulates	Sulfur Dioxide	Carbon Monoxide	Hydrocarbons ^b	Nitrogen oxides (NO ₂)	Ammonia
	lb/ton	lb/ton	lb/ton	lb/ton	lb/ton	lb/ton
By-product coking						
Unloading	0.4	-	-	-	-	-
Charging	1.5	0.02	0.6	2.5	0.03	0.02
Coking cycle	0.1	-	0.6	1.5	0.01	0.06
Discharging	0.6	-	0.07	0.2	-	0.1
Quenching	0.9	-	-	-	-	-
Underfiring	-	4	-	-	-	-
Beehive Ovens	200	-	1	8	-	2

^aEmission factors expressed as units per unit weight of coal charged.

^bExpressed as methane.

The sulfur dioxide factor is based on the following representative conditions; (1) sulfur content of coal charged to oven is 0.8 percent by weight; (2) about 33 percent by weight of total sulfur in the coal charged to oven is transferred to the coke-oven gas; (3) about 40 percent of coke-oven gas is burned during the underfiring operation and the remainder is used in other parts of the steel operation where the rest of the sulfur dioxide is discharge-about 6 lb/ton (3 kg/MT) of coal charged; and (4) gas used in underfiring has not been desulfurized.

Source: Report EPA-42, 2nd Edition

MISSION FACTORSWATER

By-Product Coke Plant Wastes

Characteristics	Plants			
	A	B	C	D
Flow, l/kg	580	530	154	19,200
Ammonia, mg/l	1,900	1,380	7,330	39
BOD ₅ mg/l	1,550	1,280	1,120	12
Cyanide, mg/l	102	110	91	7.7
Oil and grease, mg/l	-	240	101	2.1
Phenol, mg/l	450	350	910	6.1
Sulfide, mg/l	-	629	197	4.2
Suspended solids, mg/l	-	36	421	23

Source: Report 440/1-73/024

MISSION FACTORS

WATER

BEEHIVE COKE PLANT WASTES

Characteristics	Plants		
	A	B	C
Flow, l/kg	2,040	2,040	513
Ammonia, mg/l	0.33	0	0
BOD ₅ mg/l	3.00	0	0
Cyanide, mg/l	0.002	0	0
Phenol, mg/l	0.011	0	0
Suspended solids, mg/l	-	29	722

Source: Report EPA 440/1-73/024

LEVEL OF CONTROL

AIR

Existing equipment removes particulate matter, ammonia vapor and tar materials.

WATER

Organic compounds most difficult to remove (Phenols); utilizes an adsorbent bed of charcoal.

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TOXIC CONTAMINANTS IN INDUSTRIAL WASTE PROCESS STREAMS

CONTAMINANT - Hydrocarbons

KIND OF WASTE - Air and Water

AIR

STATIONARY SOURCES - Coke and charcoal production, petroleum refining, fossil fuel combustion, solid waste incineration, and solvent manufacturing and storage.

WATER

Spills from pipelines, tankers, oil wells and refineries

STANDARDS -

EPA - National Primary and Secondary Air Quality Standard -
160 $\mu\text{g}/\text{m}^3$ (0.24 ppm)

OSHA - No data found

OTHER - The Federal Water Pollution Control Act of 1956 as amended by the Water Quality Improvement Act of 1970 provides for national effluent standards for oil.

VOLUME OF EMISSIONS (1972)

<u>AIR</u>	
Source	10 ⁶ tons/y
Stationary Fuel Combustion	0.2
Industrial Processes	6.5
Solid Waste Disposal	4.5
Miscellaneous Combustion	0.4
Total	11.6

Source: 1972 National Emissions Report,
Environmental Protection Agency,
Research Triangle Park, NC,
Publ. EPA-450/2-74-012 (1974).

WATER

Estimated annual oil discharges into the oceans, all sources

Input	MTA
Transportation	2.133
Tankers, dry docking, terminal operation, bilges, accidents	
Coastal refineries, municipal and industrial warehouses	0.8
Offshore oil productions	0.08
River and urban runoff	1.9
Atmospheric fallout	0.6
Natural seeps	0.6
Total	6.133

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EMISSION FACTORS

AIR

Source	Hydrocarbon emissions, lb/unit given	Unit
Fuel combustion—stationary sources		
Coal combustion unit		
<10 x 10 ⁶ Btu/hr capacity	10	ton of coal
10 to 100 x 10 ⁶ Btu/hr capacity	1	ton of coal
Greater than 100 x 10 ⁶ Btu/hr capacity	0.2	ton of coal
Fuel Oil		
<10 x 10 ⁶ Btu/hr capacity	3	1,000 gal of oil
10 to 100 x 10 ⁶ Btu/hr capacity	2	1,000 gal of oil
Greater than 100 x 10 ⁶ Btu/hr capacity	0.8	1,000 gal of oil
Solid waste disposal		
Open burning on site of leaves, brush, paper, etc.	12	ton of waste
Open burning dump	30	ton of waste
Municipal incinerator	0.3	ton of waste
Multiple-chamber incinerator	0.5	ton of waste
Single-chamber incinerator	0.8	ton of waste
Flue-fed incinerator	2	ton of waste
Domestic incinerator		
No control	2	ton of waste
Afterburner	1	ton of waste
Process industries		
Phthalic anhydride plant		
Oxidation of naphthalene vapors with excess air over catalyst	32	ton of product
Petroleum refinery (as total hydrocarbons)		
Boilers and process heaters	140	1,000 bbl oil
Fluid catalytic unit	220	1,000 bbl fresh feed
Moving-bed catalytic cracking unit	37	1,000 bbl fresh feed
Compressor internal combustion engines	1.2	1,000 ft ³ fuel gas
Blowdown system		
With control	5	1,000 bbl refinery capacity
Without control	300	1,000 bbl refinery capacity
Process drains		
With control	8	1,000 bbl waste water
Without control	210	1,000 bbl waste water
Vacuum jets		
With control	Negligible	1,000 bbl vacuum distillation capacity
Without control	130	1,000 bbl vacuum distillation capacity
Cooling towers	6	10 ⁶ gal cooling water capacity
Pipeline valves and flanges	28	1,000 bbl refinery capacity
Vessel relief valves	11	1,000 bbl refinery capacity
Pump seals	17	1,000 bbl refinery capacity
Compressor seals	5	1,000 bbl refinery capacity
Air blowing, blend changing, and sampling	10	1,000 bbl refinery capacity
Storage		
V.P. ≥ 1.5 psia—fixed roof	47	1,000 bbl refinery capacity
V.P. ≥ 1.5 psia—floating roof	4.8	1,000 bbl storage capacity
V.P. < 1.5 psia—fixed roof	1.6	1,000 bbl storage capacity
Commercial operations		
Dry cleaning		
Chlor-hydrocarbons	1.7	per capita per year
Hydrocarbon vapors	2.2	per capita per year
Gasoline handling (evaporation)		
Filling tank vehicles		
Splash filling	8.2	1,000 gal throughput
Submerge filling	4.9	1,000 gal throughput
Filling service station tanks		
Splash filling	11.5	1,000 gal throughput
Submerge filling	7.3	1,000 gal throughput
Filling automobile tanks	11.6	1,000 gal throughput

LEVELS OF CONTROL

AIR

Hydrocarbon emissions from fuel combustion in stationary sources can be reduced or eliminated by essentially three techniques: improved operating practices, improved equipment design, and fuel substitution.

Good operating practice is the most practical technique for reducing hydrocarbon emissions from existing stationary combustion sources. Even the best equipment will perform poorly if improperly applied, installed, operated, or maintained. Hydrocarbon emissions are directly related to the three common combustion parameters of time, temperature, and turbulence. A high degree of fuel and air turbulence will greatly reduce hydrocarbon emissions, increase combustion efficiency, and reduce fuel consumption.

Hydrocarbon emissions may be reduced by upgrading combustion processes through improving equipment designs to reduce emissions or through redesign to reduce the quantity of fuel required for a given energy output.

Improvements in the combustion of pulverized coal and better mixing of highly turbulent secondary air into the primary combustion zone have improved combustion efficiencies and reduced emissions of hydrocarbons from steam-electric generating plants. The trend toward better steam utilization in these plants has also improved the efficiency of conversion of thermal energy from fossil fuels into electrical energy.

WATER

Just as with hydrocarbons in air, the removal of hydrocarbons from water involve separation techniques or destruction techniques.

Practices to remove oil spills include: mechanical containment and removal, absorption, chemical dispersants, physical sinking and biological degradation.

Mechanical containment and removal by floating booms and other barrier devices, and physical removal by absorption on chopped straw, are effective means to avoid damage. Unfortunately, they operate at low recovery rates and winds, waves, and currents often combine to make the methods very ineffective in open water.

Absorbents such as straw, manufactured fibers, and absorbent clays are spread on a slick, mixed with the oil, and collected. Straw is considered the most cost-effective sorbent because it holds five times its weight in oil and is less expensive than alternative absorbents.

Chemical dispersants reduce the fouling of beaches, boats, marine structures, birds and other sea life, and render the oil more susceptible to biodegradation. It may also increase the availability of the oil to the marine environment with greater resulting damage to life.

Physically sinking oil with various materials for large spills has been recommended. The possible rapid destruction of bottom fauna may lead to the destruction of the sea life dependent on the fauna for food and protection.

Biological degradation helps hydrocarbons in the sea to be naturally degraded by marine microorganisms and bacteria strains. Acceleration of biological degradation may cause additional ecological damage through oxygen depletion. Additional research is needed to develop effective and rapid acting biological methods.

Practices to minimize oil spills include: using simple and inexpensive control measures, such as load-on-top in conjunction with alarm systems, improved operating techniques, improved training for tanker crews, establishment of shipping lanes, improved navigation aids, and shorter ship turning radii.

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TOXIC CONTAMINANTS IN INDUSTRIAL WASTE PROCESS STREAMS

CONTAMINANT - Lead

KIND OF WASTE - Air and Water

AIR

STATIONARY SOURCES - Mining and milling activities, metallurgical processes, consumer product manufacturing, power plants (fossil fuel combustion).

WATER

Battery manufacturing plants, plating factories, television tube manufacturing and tetraethyl lead manufacturing activities.

STANDARDS -

AIR

There are no federal standards restricting lead emissions but some states have adopted local standards. For example, the Air Resources Board of the State of California in 1971 adopted a regulation which limits both stationary source emissions and ground level concentrations. This regulation forbids any source from emitting more than 15 pounds of lead per day or a quantity which results in a ground level concentration of $1 \mu\text{g}/\text{m}^3$ greater than the background level.

EPA - The Natural Resources Defense Council (NRDC) won a suit in March 1976 to compel EPA to establish ambient air quality standards for lead.

OSHA - Proposed standard (10/3/75) permits employees an exposure limit to an 8-hour time-weighted average concentration, based on a 40-hour week of 100 micrograms of lead per cubic meter of air ($100 \text{ mg}/\text{m}^3$). The present Occupational Safety and Health standard for "lead and its inorganic compounds" was adopted in 1971 and is $200 \text{ mg}/\text{m}^3$ as determined on the basis of an 8-hour time-weighted average. In 1973 the National Institute of Occupational Safety and Health (NIOSH) recommended lowering the existing standard to $150 \text{ mg}/\text{m}^3$.

Threshold Limiting Value (TLV) - $0.15 \text{ mg}/\text{m}^3$

STANDARDS -

WATER

The 1962 U.S. Public Health Drinking Water Standards and the 1975 Interim Drinking Water Standards list 50 $\mu\text{g/l}$ as constituting grounds for rejection of the water supply as unsuitable for use in drinking. The third edition of the International Standards for Drinking-water lists a tentative level of 100 $\mu\text{g/l}$ of lead in water which is used for drinking purposes and the maximum acceptable load of lead from food and beverages has been tentatively placed at 5 $\mu\text{g/kg/day}$. The permissible concentration of lead in domestic water supplies is below 0.05 ppm and it is desirable that it be totally absent. The permissible lead-concentration in irrigation water for continuous use is 5.0 mg/l and for short term use in fine textured soil is 20.0 mg/l. The maximum allowable concentration of lead in effluents being discharged to a storm sewer or stream is 0.1 ppm.

VOLUME OF EMISSIONS (1970 Data)

AIR

Source Category	Source Group	Emissions - Tons	Emissions %
Mining and Milling		60	0.3
Metallurgical Industries		3,860	21.4
	Primary Lead	1,700	
	Primary Copper	1,700	
	Primary Zinc	240	
	Secondary Lead	220	
Lead Oxide		140	0.8
Consumer Product Manufacturing		3,080	17.0
	Storage Batteries	480	
	Gasoline Additives	1,900	
	Pigments	210	
	Solder	110	
	Cable Covering	50	
	Type Metal	200	
	Brass and Bronze	40	
	Metallic Lead Products	90	
Other Emission Sources		10,910	60.5
	Waste Incineration		
	Waste Oil	3,200	
	Municipal Incineration	2,400	
	Sewage & Sludge Incineration	200	
	Coal	650	
	Oil	90	
	Iron & Steel	1,500	
	Grey Iron Foundries	2,300	
	Ferroalloys	70	
	Cement	500	
		18,050	100.0

VOLUME OF EMISSIONS

WATER

No quantitative data available. About two-thirds of the urban fallout of lead alkyls, which are soluble salts, find their way into storm sewers. This contribution amounts to 8,800 tons per year but is mostly from mobile sources.

The quantity of lead discharged per day from a single lead-plating bath is reported to be 112 pounds.

EMISSION FACTORSAIR

<u>Source</u>	<u>Factor</u>
Mining and Milling	0.2 lb/ton lead mined (controlled)
Metallurgical Industries	
Primary Lead Production	5.0 lb/ton of product (controlled)
Primary Copper Production	0.6 lb/ton of Cu concentrates (controlled)
Primary Zinc Production	0.3 lb/ton of Zn concentrates (controlled)
Secondary Lead Production	0.7 lb/ton of product (controlled)
Lead Oxide Processing	0.7 lb/ton of lead oxide (controlled)
Consumer Product Manufacturing	
Storage Batteries	8.0 lb/ton of lead processed (uncontrolled)
Storage Batteries	1.3 lb/ton of lead processed (controlled)
Gasoline Additives	14.0 lb/ton of lead processed (controlled)
Solder	3.0 lb/ton of lead processed (controlled)
Cable Covering	2.0 lb/ton of lead processed (controlled)
Type Metal	17.0 lb/ton of lead processed (controlled)
Brass and Bronze	4.0 lb/ton of lead processed (controlled)
Other Emission Sources	
Waste Oil Combustion	0.04 lb/bbl of oil burned (controlled)
Municipal Incineration	0.2 lb/ton of charge (uncontrolled)
Sewage and Sludge Incineration	0.6 lb/ton of charge (uncontrolled)
Coal Combustion	2.2 lb/1,000 tons of coal burned (controlled)
Distillate Oil Combustion	0.1 lb/1,000 bbls of oil burned (uncontrolled)
Residual Oil Combustion	0.04 lb/bbl of oil burned (uncontrolled)
Steel Production	
Open-Hearth	0.14 lb/ton of steel (uncontrolled)
Basic Oxygen	0.18 lb/ton of steel (uncontrolled)
Electric Arc	0.18 lb/ton of steel (uncontrolled)
Grey Iron Foundries	0.3 lb/ton of iron (uncontrolled)
Cement Production	25 lb/1,000 bbl of cement production (uncontrolled)
Pigments	10 lb/ton of lead processed (uncontrolled)
Ferroalloys	
Silicomanganese	
Electric Furnace	0.9 lb/ton of product (uncontrolled)
Ferromanganese	
Electric Furnace	0.4 lb/ton of product (uncontrolled)
Blast Furnace	4 lb/ton of product (uncontrolled)

EMISSION FACTORS

WATER

<u>Industry</u>	<u>Lead, mg/l</u>
Battery Manufacture	
Particulate	5-48
Soluble	0.5-25
Plating	2-140
Plating	0-30
Television Tube Manufacture	400
Mine Drainage	0.02-2.5
Mining Process Water	0.018-0.098
Tetraethyl Lead Manufacture	
Organic	126.7-144.8
Inorganic	66.1-84.9
Tetraethyl Lead Manufacture	45

Source: Report PB 216,162

REGIONAL SUMMARY OF LEAD IN SURFACE WATERS OF THE U.S.

Region	Concentration, $\mu\text{g/l}$			Not Detected	Detected
	Maximum	Minimum	Median	%	%
New England and Northeast	890	1	6	8	92
Southeast	44	1	4	27	73
Central	84	1	1	51	49
Southwest	34	1	1	61	39
Northwest	23	1	1	62	38

Source: W. H. Durum and J. D. Hem, Ann. N.Y. Acad. Sci. 199, 26 (1972).

LEVEL OF CONTROL

AIR

Emissions of gaseous lead compounds appears to have been adequately controlled. The main efforts in the control of lead emissions have been carried out in order to achieve an economic advantage for the industry rather than to protect the environment. This is perhaps justified since there have been few established cases of nonoccupational death or disease from the inhalation of airborne lead.

Electrostatic precipitators and fabric filters (baghouses) are the devices most commonly used to trap particulate emissions which would otherwise become airborne.

WATER

Control is usually accomplished by precipitation techniques using lime or dolomite. However, little data on effluent lead values after treatment and little cost data could be found. Precipitated lead compounds are very insoluble so recovery is expected to be efficient. Capital and operating costs should be similar to those reported for other heavy metals (e.g., copper, zinc, nickel).

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TOXIC CONTAMINANTS IN INDUSTRIAL WASTE PROCESS STREAMS

CONTAMINANT - Mercury

KIND OF WASTE - Air and Water

AIR

STATIONARY SOURCES - Coal-fired power plants, paint, primary nonferrous smelters, incinerators, mercury-cell chlor-alkali plants, primary and secondary mercury-processing plants, laboratories and hospitals.

WATER

Waste discharges from the chlor-alkali industry, electrical and electronics industry, explosives manufacturing industry, photographic industry, the pesticide and preservative industry, chemical and petrochemical industry, paint and pharmaceutical-cosmetic industry, pulp and paper operations, research, dental and hospital laboratories, see preservative operations, and mining and processing.

STANDARDS

Threshold Limit Value (TLV) - Alkyl Compounds
(ACGIH for 1974)

On Skin - 0.001 ppm and 0.01 mg/m³

All Forms - 0.05 mg/m³

In 1969, the Department of Agriculture and later EPA suspended most seed treatments, and FDA set a 0.5 parts per million mercury tolerance in fish. Because mercury is readily absorbed through the skin, FDA also banned its use in cosmetics. By late 1971, EPA has suspended mercurial fungicides and slimicides for use in swimming pools, cooling towers, and laundering and issued a notice of intent to cancel all other uses of mercury compounds as biocides. Cancellation hearings on uses in paints and in fungicides for golf courses and other turf and for several minor uses are continuing.

In 1970, under the permit authority of the Refuse Act of 1899, major mercury dischargers were requested immediately to reduce effluents to water to less than one-half pound per day. The permit program identified 50 companies as mercury dischargers, 10 of which were formally charged by the Justice Department with polluting the nation's waterways. Federal, state, and industry actions reportedly reduced total discharges to water from 287 pounds per day in July 1970 to about 40 pounds in September. By 1971, 9 of the 10 facilities prosecuted were operating under interim stipulations and were discharging one-half pound per day or less; the tenth plant was shut down. The total discharge from three of these facilities dropped from 139 pounds per day to 2 pounds. Pending promulgation of national effluent standards for toxic pollutants (under section 307 of the Federal Water Pollution Control Act), effluents are now subject to permit requirements administered by EPA or to regulation by the states. Almost all firms are now reporting compliance with permit requirements. Standards governing emissions to the air from chlor-alkali and mercury ore processing plants have also been in effect since July 1973.

National Emission Standards for Mercury - 2.3 kg/day or 1 µg/m³

The standards are applicable to mercury ore processing facilities, and mercury-cell chlor-alkali plants.

VOLUME OF EMISSIONS

AIR

Source	Emissions - 1971 (Short Tons)
Mining	2.5
Processing	
Primary mercury	33.5
Secondary mercury	0.5
Nonferrous: Copper	35.0
Zinc	11.0
Lead	5.0
Reprocessing	
Paint	0.8
Electrical apparatus	2.6
Consumptive uses	
Paint	229.0
Agricultural	8.1
Pharmaceuticals	4.2
Electrolytic chlorine (mercury cell)	150.0
Instruments	2.6
Dental preparations	0.9
General laboratory use	6.9
Other	
Coal: Power plants	59.3
Other	31.8
Oil: Power plants	10.2
Incineration and other disposal	
Incineration	10.8
Sewage and sludge	4.4
Other	77.5
TOTAL	686.6

Source: Report PB 222,802

WATER

Prior to July 1970, fifty plants were dumping 287 lbs. of mercury per day into U.S. waterways; by September 1970 this was reduced to 4 lbs. of mercury per day.

EMISSION FACTORS

PROCESSING AND UTILIZATION OF MERCURY AND ITS COMPOUNDS

Source ^a	Emission Factor
Instruments	17 lb/ton of contained Hg
Electrolytic production of chlorine	
Hydrogen stream	
Uncontrolled	0.002 to 0.01 lb/ton of Cl ₂ produced
After one carbon adsorber unit	0.001 lb/ton of Cl ₂ produced
End-box ventilation	0.01 lb/ton of Cl ₂ produced
Cell room ventilation	
Ridge vent	0.003 to 0.004 lb/ton of Cl ₂ produced
Fan ventilation (1 fan)	0.0005 lb/ton of Cl ₂ produced
Loss in hydrogen stream	0.02 lb/ton of Cl ₂ produced
Loss in ventilation	0.04 lb/ton of Cl ₂ produced
Comparative data	
Loss in hydrogen stream	0.2 lb/ton of Cl ₂ produced
End-box ventilation	0.075 lb/ton of Cl ₂ produced
Cell room ventilation	0.03 lb/ton of Cl ₂ produced
Electrical apparatus	8 lb/ton of Hg used

^a Uncontrolled unless otherwise specified

Source: Report PB 230,894

SOLID WASTE INCINERATION

Source	Emission Factor
Solid waste incineration	1 lb/10 ³ tons of refuse burned
Sewage sludge incineration	
Uncontrolled	0.03 lb/ton sewage and sludge burned

Source: Report PB 230,894

MINING, PRIMARY AND SECONDARY SOURCES

Source ^a	Emission Factor
Mining	0.01 lb/ton of ore mined
Primary ore processing	
Smelter Stack	0.031 lb/ton of ore processed
Hoeing operations	0.02 lb/ton of ore processed
Retort operations	0.002 lb/ton of ore processed
Secondary production	40 lb/ton Hg processed

^a All sources are uncontrolled

Source: Report PB 230,894

CONSUMPTIVE USES OF MERCURY AND ITS COMPOUNDS

Source	Emission Factor
Paint	1300 lb/ton of contained Hg
Agricultural spraying	1000 lb/ton of contained Hg
Pharmaceuticals	400 lb/ton of Hg applied
Dental preparations	20 lb/ton of Hg handled
General laboratory handling	80 lb/ton of Hg used

Source: Report PB 230,894

COAL COMBUSTION

<u>Source</u> ^a	<u>Mercury content, ppm</u>	<u>Emission factor lb/10³ tons</u>
Eastern states coals		
Ohio	0.13	0.3
West Virginia		
Kanawha County	0.07±0.02	0.14
Pennsylvania		
Washington County	0.12±0.04	0.24
Missouri		
Henry County	0.31 to 0.37±0.06	0.16
Kentucky		
Muhlenberg County	0.19±0.03	0.38
Indiana		
Clay County	0.08±0.02	0.16
Illinois	0.18	0.36
New York	0.13	0.3
Western states coals		
Montana	0.08	0.2
Colorado	0.02	0.04
Arizona	0.02	0.04
Utah	0.04	0.08
Average U.S. Coals	0.20	0.40

^aAll sources uncontrolled.

Source: Report PB 230,894

COMBUSTION OF OIL

Source ^a	Mercury content, ppm	Emission Factor lb/10 ³ gal.
Average value for imported residual oils	0.13	0.001
Average value for imported low-sulfur fuel oils	0.009	0.00007
Average value for foreign crude oils	0.05	0.0004
Average value for U.S. crude oils	0.05	0.0004

^a All sources uncontrolled

Source: Report PB 230,894

WATER

MERCURY IN INDUSTRIAL EFFLUENTS

Waste	Dissolved Mercury, mg/l	Suspended Solids Mercury, mg/Kg dry weight of solids
Paper Mill Settling Pond	.00008	10
Paper Mill Effluent	.002-.0034	5.6
Fertilizer Mill	.00026-.004	32.0
Smelting Plant	.002-.004	-
Chlor-Alkali Plant	.080-2.0	14.0

Source: R. E. Cranston and D. E. Buckley

OTHER DATA

Chlor-Alkali Plant - Losses to waste discharge without process modification or wastewater.

Treatment - 0.1 to 0.5 pound mercury per ton of chlorine produced.

Acetaldehyde Production Unit - 20 $\mu\text{g}/\text{l}$ of mercury

Commercial bleach preparations - 0.200 $\mu\text{g}/\text{l}$ of mercury

Minomata Bay - 0.36 to 1.6 $\mu\text{g}/\text{l}$, 600 tons of mercury in the Bay

LEVEL OF CONTROL

AIR

Few industries currently control atmospheric mercury emissions solely for the sake of protecting public health. In general, economic reasons have dictated the use of those mercury emission controls that are employed. The basic control method employs condensation to remove mercury from a gas stream. The amount of cooling accomplished depends on the temperature of the ambient air and available cooling water. In the mercury-cell chlor-alkali industry, the hydrogen stream is cooled to collect valuable mercury that must be replaced if atmospheric losses occur.

In certain cases, the hydrogen stream is either treated further with impregnated activated carbon or cooled to very low temperatures and sold as a by-product to the chemical industry. The mercury concentration in the chlor-alkali cell room is controlled to less than 100 $\mu\text{g}/\text{m}^3$, as recommended by the National Conference of Governmental Industrial Hygienists (NCGIH), to protect operating personnel from mercury poisoning. The control is maintained by dilution of the cell-room air with large ventilation flow rates, resulting in sizable atmospheric emissions from the cell rooms.

WATER

One process recovers mercury from the brine of the mercury cathode electrolytic cells by adding a soluble sulfide to the solution. The reacted mercury in the brine is converted to a mercury sulfide dispersion and then separated by flocculation techniques. Since mercury sulfide is rather insoluble, good recovery is expected.

In another process, soluble mercury salts are reduced by aldehydes added to the brine solution and metallic mercury is recovered by settling techniques. In other processes, liquid alkali amalgamation, zinc, bismuth, tin, nickel, copper, etc., are used as reducing agents. Most of these processes are capable of removing at least 99% of the mercury present in the solution.

WATER SEDIMENTS AND SLUDGES

Techniques for removing mercury from sludge are not well developed. Sulfur-based getter systems are most commonly used.

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TOXIC CONTAMINANTS IN INDUSTRIAL WASTE PROCESS STREAMS

CONTAMINANT - Nickel

KIND OF WASTE - Air and Water

AIR

STATIONARY SOURCE - Metallurgical plants using nickel, plating plants, power plants (coal and oil combustion), and incineration activities.

WATER

Metal industries (plating and processing operations), basic steel works and foundries, and printing plants.

STANDARDS -

EPA - No data found

OSHA - No data found

OTHER - Threshold Limiting Value (TLV)

Nickel carbonyl - 0.001 ppm or 0.007 $\mu\text{g}/\text{m}^3$

Nickel metal and soluble compounds - 1 $\mu\text{g}/\text{m}^3$

Tolerances for irrigation waters:

Continuous water use - 0.5 $\mu\text{g}/\ell$

Short-term water use - 2.0 $\mu\text{g}/\ell$

VOLUME OF EMISSIONSAIR

<u>Source</u>	<u>Amount in Tons</u>	<u>% This Pollutant</u>
Nickel Mining	2	0.03
Iron and Steel Blast Furnace	100	1.67
Gray Iron Foundry Cupola	79	1.32
Ferro-Alloys Blast Furnace	491	8.20
Electric Furnace	98	1.64
Non-Ferrous Alloys Furnaces	64	1.07
Material Handling	NEG	NEG
Power plant Boilers		
Pulverized Coal	87	1.45
Stoker Coal	10	0.17
Cyclone Coal	3	0.05
All oil	1,441	24.08
Industrial Boilers		
Pulverized Coal	7	0.12
Stoker Coal	23	0.38
Cyclone Coal	3	0.05
All oil	1,139	19.03
Residential/Commercial		
Coal	3	0.05
Oil	2,435	40.69
<hr/>		
Total	5,985	100.00

Source: The MITRE Corporation, Preliminary Results, EPA Contract No. 68-01-0438.

WATER

No data found

EMISSION FACTORS

AIR

COAL COMBUSTION

<u>Source</u> ^a	<u>Nickel content, ppm</u>	<u>Emission factor lb/ton</u>
Coal-fired boilers	-d	0.003
Power plant study		
South Carolina ^b	-d	0.007
Michigan ^b	10	0.0006
Illinois ^b	10 to 20	0.0003
Average ^b	12	0.0006
Kansas ^c	30	0.0006

^aUncontrolled unless otherwise specified.

^bExit from an electrostatic precipitator.

^cExit from wet scrubber.

^dNot reported.

Source: Report PB 230,894

EMISSION FACTORS

OIL COMBUSTION

<u>Source</u> ^a	<u>Nickel content, ppm</u>	<u>Emission factor lb/10³ gal.</u>
Average for U.S. crude oils	15	0.1
Average for imported crude oils	10	0.07
Average for foreign crude oils	25.6	0.2
Average for foreign fuel oils	36.3	0.3
U.S. boilers Residential units (distillate)	-d	0.0004 to 0.0005
Commercial units (residual No. 6)	48.5	0.08
Commercial units (residual No. 5)	31	0.06
Commercial units (residual No. 4)	18	0.05

^aUncontrolled unless otherwise specified.

^bNumbers in parentheses indicate number of samples analyzed.

^cParticle size distribution (particulate collected with a cascade impactor):
25 percent (by weight) less than 0.21 micron, -80 percent less than
7.4 microns, mass mean particle size approximately 1.2 microns.

^dNot reported.

Source: Report PB 230,894

INDUSTRIAL SOURCES

<u>Source</u> ^a	<u>Emission factor</u>
Mining and metallurgical	17 lb/ton of Ni produced
Processing of nickel and its compounds	
Stainless steel	10 lb/ton of Ni charged or 0.6 lb/ton of stainless steel produced
Nickel alloy steels ^b	10 lb/ton of Ni charged
Iron and steel scrap	0.0015 lb/ton of steel and iron
Nickel alloys (other) ^c	2 lb/ton of Ni charged
Copper base alloys ^c	2 lb/ton of Ni charged
Electrical alloys ^c	2 lb/ton of Ni charged
Cast iron	20 lb/ton of Ni charged
Electroplating	Negligible
Batteries	8 lb/ton of Ni processed
Catalysts	Negligible
Cement plants	
Dry process	
Kiln ^c	0.3 lb/10 ³ tons of feed
Feed to raw mill ^c	0.01 lb/10 ³ tons of feed
Air separator after raw mill ^c	0.001 lb/10 ³ tons of feed
Raw mill ^c	0.0006 lb/10 ³ tons of feed
Air separator after finish mill ^c	0.003 lb/10 ³ tons of feed
Feed to finish mill ^c	0.01 lb/10 ³ tons of feed
Wet Process	
Kiln ^d (2 different plants)	0.2 to 2 lb/10 ³ tons of feed
Clinker cooler ^c	0.004 lb/10 ³ tons of feed
Clinker cooler ^d	0.1 lb/10 ³ tons of feed
Clinker cooler ^e	0.2 lb/10 ³ tons of feed
Finishing mill after air separator ^c	0.004 lb/10 ³ tons of feed

^aUncontrolled unless otherwise specified.

^bConsidered controlled.

^cExit from baghouse.

^dExit from electrostatic precipitator.

^eExit from baghouses (in parallel).

WASTE INCINERATION

<u>Source</u> ^a	<u>Emission factor</u>
Sewage sludge incinerators	
Multiple hearth ^b	0.0003 lb/ton of solid waste incinerated ^c
Fluidized bed ^b	0.0003 lb/ton of solid waste incinerated ^d
Municipal incinerator	
Refuse only ^b	0.003 lb/ton of solid waste incinerated
Refuse and sludge ^b	0.005 lb/ton of solid waste incinerated
Lubricating oil	0.07 lb/10 ³ gal. of lubricating oil ^e

^aIn this table, all sources except lubricating oil are controlled.

^bEmission from wet scrubber.

^cEmission factor for nickel oxides.

Source: Report PB 230,894

WATER

CONCENTRATIONS IN METAL PROCESSING AND PLATING WASTEWATERS

Industry	Nickel Concentration, mg/l	
	Range	Average
<u>Tableware Plating</u>		
Silver bearing waste	0-30	5
Acid Waste	10-130	33
Alkaline waste	0.4-3.2	1.9
<u>Metal Finishing</u>		
Mixed wastes	17-51	-
Acid wastes	12-48	-
Alkaline wastes	2-21	-
Small parts fabrication	179-184	181
Combined degreasing, pickling and Ni dipping of sheet steel	3-5	-
<u>Business Machine Manufacture</u>		
Plating wastes	5-35	11
Pickling wastes	6-32	17
<u>Plating Plants</u>		
4 different plants	2-205	-
Rinse waters	2-900	-
Large plants	up to 200	25
5 different plants	5-58	24
Large plating plant	88 (single waste stream)	-
	46 (combined flow)	-
Automatic plating of Zinc base castings	45-55	-
Automatic plating of ABS type plastics	30-40	-
Manual barrel and rack	15-25	-

Source: Report PB 216,162

LEVELS OF CONTROL

AIR

Nickel air pollution usually occurs as particulate emissions and may be controlled with the particulate by the usual dust handling equipment such as bag filters, precipitators, and scrubbers. Nickel poses no unique control problems except with gaseous nickel carbonyl. Control of nickel carbonyl may be accomplished by taking advantage of the fact that nickel carbonyl decomposes at temperatures above 60°C.

Gases containing nickel carbonyl may be passed through a furnace, where the nickel carbonyl decomposes into its two components, nickel and carbon monoxide. The resulting nickel metal can then be removed as particulate.

WATER

Nickel waste water treatment is frequently combined with treatment for other contaminants, and specific costs of nickel removal are difficult to isolate. Destructive treatment for nickel by lime precipitation is capable of reducing residual nickel concentrations to less than 1 mg./l.

Implementation of process modifications also makes nickel recovery an attractive proposition when waste stream separation is practiced, as nickel is a relatively expensive metal. Several recovery systems have been demonstrated to be economically feasible, including precipitate recovery after ion exchange, and evaporative recovery. For hot nickel plating baths, process modifications have led to direct nickel recovery, by return of rinse water to the plating bath.

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TOXIC CONTAMINANTS IN INDUSTRIAL WASTE PROCESS STREAMS

CONTAMINANT - Nitrogen Oxides (NO₂) and other Nitrogen Compounds

KIND OF WASTE - Air and Water

AIR

STATIONARY SOURCE - Fuel combustion in power plants; chemical processes (nitric acid manufacture, nitrations, etc.)

WATER

Agricultural production activities, food and kindred product industries, chemical and allied products and sanitary service sites, solid waste disposal sites.

STANDARDS -

AIR (NO₂)

EPA - The primary and secondary national air quality standard - 100 $\mu\text{g}/\text{m}^3$ (0.05 ppm) annual arithmetic mean.

OSHA - No data found

OTHER - Threshold Limit Values (TLV) Nitrogen Dioxide - 5 ppm (9 $\mu\text{g}/\text{m}^3$)

Nitric acid - 25 ppm (30 $\mu\text{g}/\text{m}^3$)

WATER (Other Nitrogen Compounds)

Threshold Limiting Value (TLV) -

Nitric Acid - 2 ppm (5 $\mu\text{g}/\text{m}^3$)

Domestic Water Supplies -

Nitrates plus nitrites (as mg/lN) - <10

Permissible Criteria

VOLUME OF EMISSIONS (1972)

<u>AIR (NO₂)</u>	
<u>Source</u>	<u>Quantity (10⁶ tons)</u>
Stationary fuel combustion	6.3
Industrial processes	2.9
Solid waste disposal	0.4
Miscellaneous combustion	6.4
Total	16.0

Source:

[1972 National Emissions Report, Environmental Protection Agency, Research Triangle Park, NC, Publ. EPA-450/2-74-012 (1974)]

WATER (Nitrites, Nitrates)

<u>Source</u>	<u>Quantity of Nitrogen Compounds (as N) (Millions of Pounds/Year)</u>
Agriculture - Crops	8,250
Agriculture - Livestock	1,000
Nitrogenous	
Fertilizers	4
Petroleum Refining	70
Sanitary System -	2,400
Sewers	
Totals	11,724
Totals Without Domestic	
Sewage	9,324

Source: [1972 National Emissions Report, Environmental Protection Agency, Research Triangle Park, N.C., Publ. EPA-450/2-74-012 (1974).]

EMISSION FACTORS

AIR

NITROGEN OXIDES DURING COMBUSTION OF FUELS AND OTHER MATERIALS

Source	Average emission factor
Fuels	
Coal	
Household and commercial	8 lb/ton
Industry	20 lb/ton
Utility	20 lb/ton
Fuel oil	
Household and commercial	12.22 lb/10 ³ gal
Industry	22 lb/10 ³ gal
Utility	104 lb/10 ³ gal
Natural gas	
Household and commercial	116 lb/10 ³ ft ³
Industry	214 lb/10 ³ ft ³
Utility	390 lb/10 ³ ft ³
Wood	11 lb/ton
Combustion sources	
Gas Engines	
Oil and gas production	320 lb/10 ⁶ ft ³
Gas plant	4,300 lb/10 ⁶ ft ³
Pipeline	7,300 lb/10 ⁶ ft ³
Refinery	4,400 lb/10 ⁶ ft ³
Gas Turbines	
Gas plant	200 lb/10 ⁶ ft ³
Pipeline	200 lb/10 ⁶ ft ³
Refinery	200 lb/10 ⁶ ft ³
Waste Disposal	
Open burning	11 lb/ton
Conical incinerator	0.65 lb/ton
Municipal incinerator	2 lb/ton
On-site incinerator	2.5 lb/ton
Other combustion	
Coal refuse banks	8 lb/ton
Forest burning	11 lb/ton
Agricultural burning	2 lb/ton
Structural fires	11 lb/ton
Chemical industries	
Nitric acid manufacture	57 lb/ton HNO ₃ product
Adipic acid	12 lb/ton product
Terephthalic acid	13 lb/ton product
Nitrations	
large operations	0.2-14 lb/ton HNO ₃ used
small batches	3-240 lb/ton HNO ₃ used

Source: EPA Publication No. AP-67

WATER (Nitrites, Nitrates)

Nitrogen is present in domestic waste waters in the range of 15-25 µg/ℓ.

LEVEL OF CONTROL

AIR (Nitrogen Oxides)

The primary strategies for reducing nitrogen oxide emissions from stationary sources include staged combustion, low excess air operation, and flue gas recirculation.

Staged combustion is effective for controlling both thermal nitrogen oxides (nitric oxide fixation by high temperature) and fuel nitrogen oxide (oxidation of nitrogen chemically bound in the fuel). The method consists of initially contacting fuel with less than the amount of air (oxygen) required for complete combustion, then subsequently adding more air after a time delay in one or more steps or stages.

Low excess air operation involves minimizing oxygen availability for combination with either thermally activated or cracked fuel activated nitrogen atoms.

Flue gas recirculation lowers the concentration of nitric oxide by recirculating exhaust gases to the flame regions thereby reducing peak temperatures and oxygen availability. This method requires much greater capital investment and significantly increases operating control requirements.

Other methods include burner redesign, water/steam injection, wet scrubbing with aqueous ammonia, load reduction, remixed fuel/oxidizer, removal of nitrogen from fuels, catalytic reduction in stack processes, fuel substitution and fluidized bed combustion. In a practical study conducted by KVB, Inc. and funded by the Electric Power Research Institute, a promising technique for the control of NO_x emissions from utility boilers has been successfully demonstrated. The experiments involved the injection of reducing agents into combustion product streams. Decreases in NO_x concentrations by as much as 90 percent were achieved under certain conditions, the most successful additives

LEVEL OF CONTROL (Continued)

being ammonia and RA-2, a proprietary chemical. Exxon originally conceived the idea of homogeneous selective gas phase decomposition of NO_x , and the process will now be subjected to detailed studies which will hopefully lead to field application.

WATER (Nitrites, Nitrates)

The important control methods for abatement of nitrogen-compound pollution are process-centered rather than treatment-centered.

The most successful nitrogen removal processes for nitrates include biological denitrification, ammonia stripping and ion exchange. Biological denitrification, both columnar and suspended growth, proved to be a reliable and economic process in achieving a high degree of nitrogen removal. Control of the nitrification step is a must in providing an effective reduction. Any reduced form of nitrogen reaching the denitrification step would leak through and reduce the efficiency of the process. Methanol appears to be the most practicable and economical source of carbon. Optimum methanol to nitrate-nitrogen ratio seems to range between 2:1 and 3:1. The three-stage system appears to be the best approach to control nitrification.

The processes for the detoxification of nitrate containing aqueous solutions are usually accomplished by oxidation to nitrates and subsequent treatment as nitrate containing solutions.

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TOXIC CONTAMINANTS IN INDUSTRIAL WASTE PROCESS STREAMS

CONTAMINANT - Total Suspended Particulates (TSP)
(Solid and liquid particles including smoke, mists, fumes and spray)

KIND OF WASTE - Air

STATIONARY SOURCES - Metallurgical furnaces, fossil fuel combustion, crushed stone, forest products processes, agricultural operations.

STANDARDS -

EPA - The national primary ambient air quality standard for total suspended particulate matter is $75 \mu\text{g}/\text{m}^3$ of air annual geometric mean near $260 \mu\text{g}/\text{m}^3$ daily average level. The secondary standard is $60 \mu\text{g}/\text{m}^3$ annual geometric mean; $0.150 \mu\text{g}/\text{m}^3$ maximum 24-hour average. As a result of a Sierra Club lawsuit, EPA promulgated the no significant deterioration of air quality regulations based on air quality in the U. S. as of January 1, 1975. Under these regulations the desired ambient concentrations of TSP are: annual - $10 \mu\text{g}/\text{m}^3$; 24-hour - $30 \mu\text{g}/\text{m}^3$.

OSHA - No data found

OTHER - California Ambient Air Quality Standards -
 $60 \mu\text{g}/\text{m}^3$ annual geometric mean
 $100 \mu\text{g}/\text{m}^3$ 24 hours

EMISSION FACTORS

PARTICULATE EMISSIONS FROM STATIONARY INDUSTRIAL SOURCES (1972)

<u>Process</u>	<u>Volume (tons/year)</u>
Fuel Combustion	5,953,000
Crushed Stone, Sand and Gravel	4,600,000
Agricultural Operations (grain elevators, feed mills and cotton gins)	1,817,000
Iron and Steel	1,442,000
Cement	934,000
Forest Products	580,000
Lime	573,000
Clay	467,000
Primary Nonferrous (copper, aluminum, zinc and lead)	476,000
Fertilizer and Phosphate Rock	328,000
Asphalt (batch plants and roofing)	218,000
Ferroalloy	160,000
Iron Foundries	143,000
Secondary Nonferrous (copper, aluminum, zinc and lead)	127,000
Coal Cleaning	94,000
Carbon Black	93,000
Petroleum	45,000
Acids (sulfuric and phosphoric)	16,000
Total	18,066,000

Source: Report PB 203,128

EMISSION FACTORS

FOSSIL FUEL COMBUSTION BITUMINOUS COAL

<u>Furnace size, 10⁶ Btu/hr heat input</u>	<u>lb/ton coal burned</u>
Greater than 100 (Utility and large industrial boilers)	
Pulverized	
General	16A
Wet bottom	13A
Dry bottom	17A
Cyclone	2A
10 to 100 (large commercial and general industrial boilers)	
Spreader stoker ^b	13A
Less than 10 (commercial and domestic furnaces)	
Spreader stoker	2A
Hand-fired units	20

^aThe letter A on all units other than hand-fired equipment indicates that the weight percentage of ash in the coal should be multiplied by the value given. Example: If the factor is 16 and the ash content is 10 percent, the particulate emissions before the control equipment would be 10 times 16, or 160 pounds of particulate per ton of coal (10 times 8, or 80 kg of particulates per MT of coal).

^bFor all other stokers, use 5A (2.5A) for particulate emission factor.

Source: EPA Publication, AP-42, 2nd Edition

ANTHRACITE COAL

Type of furnace	lb/ton ^(a)
Pulverized (dry bottom), no fly-ash reinjection	17A
Overfeed stokers, no fly-ash reinjection	2A
Hand-fired units	10

^aA is the ash content expressed as weight percent.

Source: EPA Publication, AP-42, 2nd Edition

FUEL OIL

Type of Unit			
Power plant	Industrial and commercial		Domestic
	Residual	Distillate	
1b/10 ³ gal	1b/10 ³ gal	1b/10 ³ gal	1b/10 ³ gal
8	23	15	10

Source: EPA Publication, AP-42, 2nd Edition

NATURAL GAS

Type of Unit				
Power plant	Industrial process boilers	Domestic and commercial heating units	Gas turbines	Gas engines
1b/10 ⁶ ft ³	1b/10 ⁶ ft ³	1b/10 ⁶ ft ³	1b/10 ⁶ ft ³	1b/10 ⁶ ft ³
15	18	19	-	-

Source: EPA Publication, AP-42, 2nd Edition

LIQUIFIED PETROLEUM GAS

Industrial process furnaces		Domestic and commercial furnaces	
Butane	Propane	Butane	Propane
1b/10 ³ gal	1b/10 ³ gal	1b/10 ³ gal	1b/10 ³ gal
1.8	1.7	1.9	1.8

Source: EPA Publication, AP-42, 2nd Edition

LEVELS OF CONTROL

Particulate matter in air is collected and controlled by a variety of equipment of varying efficiency: cyclone, scrubbers, electrostatic precipitators, and fabric filters.

Advantages and disadvantages of various collection devices.*

Collector	Advantages	Disadvantages
Gravitational	Low pressure loss, simplicity of design and maintenance.	Much space required. Low collection efficiency.
Cyclone	Simplicity of design and maintenance. Little floor space required. Dry continuous disposal of collected dusts. Low-to-moderate pressure loss. Handles large particles. Handles high dust loadings. Temperature independent.	Much head room required. Low collection efficiency of small particles. Sensitive to variable dust loadings and flow rates.

Advantages and disadvantages of various collection devices.*
(continued)

Collector	Advantages	Disadvantages
Wet collectors	<p>Simultaneous gas absorption and particle removal.</p> <p>Ability to cool and clean high-temperature, moisture-laden gases.</p> <p>Corrosive gases and mists can be recovered and neutralized.</p> <p>Reduced dust explosion risk.</p> <p>Efficiency can be varied.</p>	<p>Corrosion, erosion problems. Added cost of wastewater treatment and reclamation.</p> <p>Low efficiency on submicrometer particles.</p> <p>Contamination of effluent stream by liquid entrainment.</p> <p>Freezing problems in cold weather.</p> <p>Reduction in buoyancy and plume rise.</p> <p>Water vapor contributes to visible plume under some atmospheric conditions.</p>
Electrostatic precipitator	<p>99+ percent efficiency obtainable.</p> <p>Very small particles can be collected.</p> <p>Particles may be collected wet or dry.</p> <p>Pressure drops and power requirements are small compared to other high-efficiency collectors.</p> <p>Maintenance is nominal unless corrosive or adhesive materials are handled.</p> <p>Few moving parts.</p> <p>Can be operated at high temperatures (550 to 850°F.)</p>	<p>Relatively high initial cost.</p> <p>Precipitators are sensitive to variable dust loadings or flow rates.</p> <p>Resistivity causes some material to be economically uncollectable.</p> <p>Precautions are required to safeguard personnel from high voltage.</p> <p>Collection efficiencies can deteriorate gradually and imperceptibly.</p>
Fabric filtration	<p>Dry collection possible.</p> <p>Decrease of performance is noticeable.</p> <p>Collection of small particles possible.</p> <p>High efficiencies possible.</p>	<p>Sensitivity to filtering velocity.</p> <p>High-temperature gases must be cooled to 200 to 550°F.</p> <p>Affected by relative humidity (condensation).</p> <p>Susceptibility of fabric to chemical attack.</p>

Advantages and disadvantages of various collection devices.*

(continued)

Collector	Advantages	Disadvantages
Afterburner, direct flame.	High removal efficiency of submicrometer odor-causing particulate matter. Simultaneous disposal of combustible gaseous and particulate matter. Direct disposal of nontoxic gases and wastes to the atmosphere after combustion. Possible heat recovery. Relatively small space requirement. Simple construction. Low maintenance.	High operational cost. Fire hazard. Removes only combustibles.
Afterburner, catalytic.	Same as direct flame afterburner. Compared to direct flame: reduced fuel requirements, reduced temperature, insulation requirements, and fire hazard.	High initial cost. Catalysts subject to poisoning. Catalysts require reactivation.

Source: Control Techniques for Particulate Air Pollutants, Department of Health, Education, and Welfare, National Air Pollution Control Administration, Washington, D.C., Publ. AP-51 (1969).

Range of Collection Efficiencies for Common Types of Equipment

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TOXIC CONTAMINANTS IN INDUSTRIAL PROCESS WASTE STREAMS

CONTAMINANT - Pesticides

KIND OF WASTES - Solid, Air and Water

AIR

STATIONARY SOURCES - Pesticide production processes (manufacture, formulation and packaging), direct application techniques, storage and handling operations, food processing industries.

WATER

Direct application techniques, percolation and runoff from agricultural lands, airborne drift from aerial and land applications, discharge of industrial waste waters, discharge of waste waters from cleanup of equipment, atmosphere co-precipitation of vapors or particles with rain, food processing industries

SOLID

Direct application, and food treatment processes from the pesticide and food processing industries (lime slurries and filtered solids).

STANDARDSAIRTHRESHOLD LIMIT VALUES FOR AIRBORNE PESTICIDES

<u>Pesticide</u>	<u>TLV</u>	
	<u>ppm</u>	<u>Mg/m³</u>
Aldrin-skin	—	0.25
Carbonyl (Sevin)	—	5
Chlordane - Skin	—	0.5
Dieldrin - Skin	—	0.25
DDT - Skin	—	1
Endrin - Skin	—	0.1
2,4-D	—	10
2,4,5-T	—	10
Heptachlor - Skin	—	0.5
Lindane - Skin	—	0.5
Methyl biomed - Skin	15	60
Methyl Parathion - Skin	—	10
Methoxychlor	—	10
Parathion - Skin	—	0.1
Pyrethrin	—	5
Toxaphene - Skin	—	0.5

Source: LBL-1 Volume 4 (1973).

STANDARDS

WATER

In 1968 the National Technical Advisory Committee on Water Quality Criteria published maximum permissible levels for pesticides in the aquatic environment. Different sets of criteria were recommended by Subcommittees for:

- a) Public Water Supplies
- b) Agricultural Uses
- c) Fish, Other Aquatic Life, and Wildlife.

DRINKING WATER CRITERIA

The Subcommittee on Public Water Supplies adopted drinking water criteria for three pesticide groups: chlorinated hydrocarbon insecticides (DDT, dieldrin, etc.), organophosphate/carbamate cholinergic insecticides (parathion, carbaryl, etc.), and phenoxyalkanoic acid herbicides (2,4-D, 2,4,5-T, etc.).

Permissible Concentrations for Organic Pesticides in Public Water Supplies.

Pesticide	Permissible Concentrations, $\mu\text{g/l}$
Aldrin	17.0
Chlordane	3.0
DDT	42.0
Dieldrin	17.0
Endrin	1.0
Heptachlor	18.0
Heptachlor epoxide	18.0
Lindane	56.0
Methoxychlor	35.0
Organic phosphates and carbamates	100.0*
Toxaphene	5.0
2,4-D; 2,4,5-T; and 2,4,5-TP	100.0

**As parathion equivalents in cholinesterase inhibition.*

Source: Water Quality Criteria, Report of the National Technical Advisory Committee to the Secretary of the Interior, U.S. GPO, Washington, D.C. (1968).

STANDARDS (Continued)

Four pesticides were named recently by EPA in the proposed toxic pollutant effluent standards as published in the Federal Register for December 27, 1973. For discharge into streams having a flow rate of less than 10 cu. ft./sec. or into lakes having an area of less than 500 acres, it is proposed that there be no discharge of aldrin-dieldrin, DDT (or DDD or TDE), endrin or toxaphene. The limitations on discharges to faster flowing streams, larger lakes or salt water are tabulated below.

	Fresh Water	Salt Water
Aldrin-Dieldrin	0.5 $\mu\text{g./l.}$	5.5 $\mu\text{g./l.}$
DDT (and DDD and TDE)	0.2 $\mu\text{g./l.}$	0.6 $\mu\text{g./l.}$
Endrin	0.2 $\mu\text{g./l.}$	0.6 $\mu\text{g./l.}$
Toxaphene	1.0 $\mu\text{g./l.}$	1.0 $\mu\text{g./l.}$

With the above, there is stipulated a condition that when the receiving stream flow is less than 10 times the waste stream flow, these concentrations are reduced by a factor of 10.

AGRICULTURAL WATER CRITERIA

The Subcommittee for Agricultural Uses also recommend that pesticides not exceed levels for chlorinated hydrocarbons in general farmstead uses. The Subcommittee endorsed the concept of fish in livestock source water as a safety indicator, citing evidence of lower tolerance levels for pesticide residues with fish than with livestock. Accordingly, presence of living fish in agricultural water supplies should indicate their safety for livestock.

ESTUARINE CRITERIA

The Subcommittee on Fish, other Aquatic Life and Wildlife separated estuarine and marine organisms from freshwater life, choosing shrimp as a sensitive indicator life form. They recommend a maximum permissible concentration of 50 ng/l for 13 chlorinated hydrocarbon and 6 organophosphorus pesticides acutely toxic to shrimp at 5 $\mu\text{g./l}$ or less.

Group B contained pesticides not acutely toxic to shrimp below 1 mg/l:

Arsenicals	2,4,5-T compounds
Botanicals	Phthalic acid compounds
Carbamates	Triazine compounds
2,4-D compounds	Substituted urea compounds

For these compounds a maximum permissible concentration of 10 $\mu\text{g./l}$ was recommended. Acute toxicity data were available for approximately 100 other pesticides but it was believed that these chemicals were unlikely to reach the estuarine environment at toxic levels. Criteria established for these chemicals in fresh water should be adequate protection for estuaries.

FRESHWATER CRITERIA

In general, the Subcommittee held that "reasonably safe concentrations" in receiving waters of the pesticides could be assured by permitting their levels to rise no higher than 1 to 10% of the 48 hr TL_m values.

SOLID

No data found

VOLUME OF EMISSIONS

AIR

No quantitative data found.

DDT residues in precipitation were found in Great Britain at seven stations in 1966 to 1967. The mean concentration was 80 ng/l, about twice that reported for melt-waters of recent antarctic snow. DDT residues in South Florida precipitation averaged 1 ng/l in 18 samples taken at four sites in 1968 to 1969.

If the total annual precipitation of water over the oceans, estimated as 3×10^{17} liters, averaged 80 ng/l DDT, 24,000 metric tons of DDT residues would be precipitated each year into the oceans.

WATER

A typical waste stream carbamate manufacture will contain:

COD	10,000 mg/l
BOD ₅	Nil
Total solids	40,000
pH	7 to 10
Suspended solids	Nil
Sodium	8,000
Chlorides	100
Phosphates	Nil
Organic nitrogen	500
Sulfates	20,000
Product	Nil
Toxicity	Low
Flow per pound of product	Not available

Source: EPA Report 12020 FYE 01/72.

PARATHION MANUFACTURE

COD	3,000 mg/l
BOD ₅	700
Total solids	27,000
pH	2.0
Acidity	3,000
Sodium	6,000
Chlorides	7,000
Phosphates	250
Nitrates	20
Sulfates	3,000
Parathion	20
Calcium	High

Source: EPA Report 12020 FYE 01/72

CHLORINATED HYDROCARBON HERBICIDES MANUFACTURE

COD	8,300 mg/l
BOD ₅	6,300
Total solids	104,000
Suspended solids	2,500
pH	0.5
Chlorides	52,000
Chlorophenols	112
Chlorophenoxy acids	235
Nitrogen	Low
Phosphorus	Low
Flow	30 lb COD/ lb product

Source: EPA Report 12020 FYE 01/72

A diolefin based chlorinated hydrocarbon pesticide manufacture.

COD	500 mg/l
BOD ₅	50
Total solids	1,000
Suspended solids	100
pH	2
Chlorides	High
Nitrates	?
Phosphates	?
Product	100 to 300 ppb as Endrin
Toxicity	High
Flow	0.375 gallons treated waste-water/ lb product

Source: EPA Report 12020 FYE 01/72

One report states that 329,000 tons of pesticide wastes were disposed at sea in 1968.

SOLID

No data found

EMISSION FACTORS - No data found

LEVELS OF CONTROL

AIR

The abatement of pesticidal contamination of the ambient air is a complex problem but it is being attempted. It appears that the contamination arising from the production processes can be controlled. Although incidences of occupational poisonings have been reported, proper protective measures are available. Precautions similar to those used in general chemical industries are taken to prevent the dusts and fumes from leaving the production plant into the outside environment.

Volatilization of pesticides into the air from soil, water, plants, and other treated surfaces is known to occur. However, the control of this is complicated by the fact that the extent to which volatilization occurs is not known. Some control over volatilization from soil can be effected by the use of cover crops.

WATER AND SOLID

Pesticide adsorption by activated carbon has been shown to be most effective treatment for reducing high concentrations of pesticides from water. The removal of low level pesticide contamination is much more difficult to control, and evidence indicates that current conventional water treatment methods are not effective.

CONTROL TECHNIQUES FOR PESTICIDES WASTE STREAMS

Pesticide	Liquid Wastes		Solid or Other Wastes	
	Source	Disposal	Source	Disposal
DDT	Processing solutions	Evaporative basin	Reactor solutions	County Dump
Aldrin	Floor washings, etc.	Evaporation basin	Lime slurry	Lime pit
Dieldrin	Process solutions	Evaporation basin	Filter solids	Incinerate
Chlordane	Process solutions	Deep well	Filter solids	Clay pit
Toxaphene	Pinene-Camphene plant	Bio-treatment plant		
	Process solutions	Neutralize, hold, discharge	Filter solids	Solid waste
Disulfoton	Process solutions	Secondary treatment plant	Filter solids, etc.	Commercial landfill
			H ₂ S	Flare
Malathion	Process solutions	Barge to deep sea	Filter solids	Landfill (with lye)
Phorate	Process solutions	Barge to deep sea	Filter solids	Landfill
			Mercaptan losses	Flare
Parathion	Process solutions	Waste treatment plant	H ₂ S; S	Flare; incinerate
Carbaryl	Process solutions	Secondary waste treatment	H ₂ , COCl ₂ , amine	Flare
			Heavy residues	Incinerate
Aldicarb	Process solutions	Neutralize, secondary waste treatment	Process vents	Flare
2,4-D (Dow)	Process solutions	Trickling filter; biological waste treatment plant	Filter solids and still bottoms	Incinerate, Scrub
2,4-D (Chipman)	Process solutions	Charcoal absorption/ filtration treatment		
2,4,5-T (Dow)	As per 2,4-D			
2,4,5-T (Thompson-Hayward)	Process solutions	Oxidation pond, discharge	Solids	Landfill
Atrazine	Process solutions	Host to river; some to deep well		
Trifluralin	Process solutions	Biological waste treatment	NO _x	Scrubber
Alachlor	Process solutions	Discharge	Solvent	Fuel
Caplan	Process solutions	Hold, discharge	Gas streams	Scrub, vent
Methyl Bromide			Caseous wastes	Scrub, waste treatment plant
Pyrethrin	Aqueous still bottoms	Sewer	Process solids	Storage
<u>Bacillus</u> <u>l.</u> (Abbott)	Process solutions	Sterilized; biological waste treatment	Filter solids	Landfill
<u>Bacillus</u> <u>l.</u> (Nutrilite)	Process solutions	Evaporation pond	Process air	Incinerate or filter
HgCl ₂ -Hg ₂ Cl ₂	Process solution	Hg-recovery; discharge to sewer	Filter solids	Hg recovery
			NO _x , H ₂ S	Recovery

Source: Report PB 213,782

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TOXIC CONTAMINANTS IN INDUSTRIAL WASTE PROCESS STREAMS

CONTAMINANT - Phosphates

KIND OF WASTE - Air and Water

AIR

SOURCES - Mining and rock processing; fertilizer manufacturing.

WATER

Detergent laden wastes from food process industries; agricultural runoff; miscellaneous industrial and municipal wastewaters.

STANDARDS -

Typical Rules and Regulations on Point Source Discharges of Phosphates.

<u>Point Source Category</u>	<u>Pollutant</u>	<u>^a Maximum</u>	<u>^b Average</u>
Steam Electric Power Cooling tower blowdown	Phosphorus	5.0 mg/l	5.0 mg/l
Electroplating (existing source)	Phosphorus	320 mg per m ² per operation	160 mg/m ² per operation
Electroplating (new source)	Phosphorous	160 mg/m ² per operation	80 mg/m ² per operation
Phosphate Manufacturing	Total Phos- phorous	70 mg/l	35 mg/l

^aMaximum for any one day.

^bAverage of daily values for 30 consecutive days shall not exceed this number.

^cPretreatment Standard.

Source: LBL-1, Volume 2, Berkeley, University of California (February 1, 1973).

VOLUME OF EMISSIONS: No Data found

EMISSION FACTORSAIR (PARTICULATE)

<u>Process</u>	<u>Volume/Unit Product (lb/ton)</u>	<u>Volume (lbs/yr)</u> ^{10⁸}	<u>Estimated Level of Control</u>
Phosphate Mining	0.8	0.08	None
Phosphate Rock Processing	76	86.00	94%
Phosphoric Acid (Wet Process)	22.25	6.2	91%
Fertilizers (General)	12	3.3	15%
Fertilizers (Normal Superphosphate)	195.5	8.0	90%
Fertilizers (Triple Superphosphate)	195.5	19.0	90%
Fertilizers (Ammonium Phosphate)	110	12.0	85%
Fertilizer Applications	5.0	0.3	10%
Elemental Phosphorus	26.1	8.4	68%
Phosphoric Acid (Thermal)	2.6	0.03	None
Sodium Phosphate	83	2.7	88%
Soaps and Detergents	40	0.24	98%
Calcium Phosphate	85	8.5	86%
Plating, Polishing and Miscellaneous	0.25	0.0006	None
Inadvertent Sources	175	756	84%
<hr/>			
TOTALS	1,029.00	910.75	—

Source: Report PB 231,670

WATER

<u>Process</u>	<u>Volume/Unit Product (lb/ton)</u>	<u>Volume 10^6 lbs/yr)</u>	<u>Estimated Level of Control</u>
Sanitary Sewer Systems	Not Available	540	Not Available
Industrial Inorganic Chemicals	" "	11	" "
Phosphate Fertilizers	" "	41	" "
Petroleum Refining	" "	6	" "
TOTALS		598	

Source: Report PB 231,670

SUMMARY OF RAW WASTES FROM PHOSPHATE PLANTS

	Sodium Triphosphate	Food Grade Calcium Phosphates		Animal Feed Calcium Phosphates	
		Dewatering	Solids Scrubbing	Acid Defluorination	Solids Scrubbing
Process water wasted:					
l/kg pdt	0	2,100	2,100	6,300	420
gal/ton pdt	0	500	500	1,500	100
Raw waste load, kg/kg pdt:					
TSS	-	50	50	-	22.5
Dissolved PO ₄	-	15	15	-	4
HF, H ₂ SiF ₆ , H ₂ SiO ₃	-	-	-	12	-
Raw waste load, lb/ton pdt:					
TSS	-	100	100	-	45
Dissolved P ₄	-	30	30	-	8
HF, H ₂ SiF ₆ , H ₂ SiO ₃	-	-	-	24	-
Concentrations, mg/l:					
TSS	-	24,000	24,000	-	54,000
Dissolved PO ₄	-	7,000	7,000	-	7,000
HF, H ₂ SiF ₆ , H ₂ SiO ₃	-	-	-	1,900	-
TDS, mg/l	-	7,000	7,000	1,900	7,000
Solid wastes:					
kg/kg pdt	0		10	-	-
lb/ton pdt	0		20	-	-

Source: EPA 440/1-73/006

EMISSION FACTORS FOR THE PRODUCTION OF PHOSPHATE FERTILIZERS

Type of product	Particulates ^a	Fluorides ^b
	lb/ton	lb/ton
Normal superphosphate		
Grinding, drying	9	-
Main stack	-	0.15
Triple superphosphate		
Run-of-pile (ROP)	-	0.03
Granular	-	0.10
Diammonium phosphate		
Dryer, cooler	80	c
Ammoniator-granulator	2	0.04

^aControl efficiencies of 99 percent can be obtained with fabric filters.

^bTotal fluorides, including particulate fluorides. Factors all represent outlet emissions following control devices, and should be used as typical only in the absence of specific plant information.

^cIncluded in ammoniator-granulator total.

Source: EPA Publication AP-42, 2nd Edition

PHOSPHATE FERTILIZER

Manufacturing - Contaminants in Cooling water blowdown systems

Contaminant	Concentration, mg/l
Chromate	0 to 250
Sulfate	500 to 3,000
Chloride	35 to 160
Phosphate	10 to 50
Zinc	0 to 30
TDS	500 to 10,000
SS	0 to 50
Biocides	0 to 100

Source: Report EPA 440/1-73/011

Phosphate Fertilizer Manufacturing - Contaminants in Boiler Blowdown

Contaminant	Concentration, mg/l
Phosphate	5 to 50
Sulfite	0 to 100
TDS	500 to 3,500
Zinc	0 to 10
Alkalinity	50 to 700
Hardness	50 to 500
Silica (SiO_2)	25 to 80

Source: Report EPA-440/1-73/011

Phosphoric Acid Manufacturing - Typical Equilibrium Composition of Gypsum Pond Water

Contaminant	Concentration, mg/l
P_2O_5	6,000 to 12,000
Fluoride	3,000 to 5,000
Sulfate	2,000 to 4,000
Calcium	350 to 1,200
Ammonia	0 to 100
Nitrate	0 to 100
pH	1.0 to 1.5

Source: Report 12020 FPD 09/71

PARTICULATE EMISSION FACTORS FOR PHOSPHATE ROCK

PROCESSING WITHOUT CONTROLS^a

<u>Type of Source</u>	<u>Emissions</u> <u>lb/ton</u>
Drying ^b	15
Grinding ^c	20
Transfer and storage ^c	2
Open storage piles	40

^aEmission factors expressed as units per unit weight of phosphate rock.

^bDry cyclones followed by wet scrubbers can reduce emissions by 95 to 99 percent.

Source: EPA Publication AP-42, 2nd Edition

EMISSION FACTORS FOR PHOSPHORIC ACID PRODUCTION

<u>Source</u>	<u>Particulates</u> <u>lb/ton</u>	<u>Fluorides</u> <u>lb/ton</u>
Wet process (phosphate rock)		
Reactor, uncontrolled	-	18
Gypsum pond	-	1 ^a
Condenser, uncontrolled	-	20
Thermal process (phosphorus burned)		
Packed tower	4.6	-
Venturi scrubber	5.6	-
Glass-fiber mist eliminator	3.0	-
Wire-mesh mist eliminator	2.7	-
High-pressure-drop mist eliminator	0.2	-
Electrostatic precipitator	1.8	-

^aPounds per acre per day (kg/hectare-day); approximately 0.5 acre (0.213 hectare) is required to produce 1 ton of P₂O₅ daily.

Source: EPA Publication AP-42, 2nd Edition.

Phosphoric Acid Manufacturing -

TYPICAL PHOSSY WATER COMPOSITION AND VOLUME *

Contaminant	mg/l
Phosphorus	1,000 to 2,000
Phosphate	50 to 500
Fluoride	100 to 1,000
Suspended solids	2,000 to 4,000

* 1,000 to 2,000 gal/ton P_2O_5 , pH 3 to 6

Source: Report 12020 FPD 09/71

Phosphoric Acid Manufacturing -

COMPOSITION OF FURNACE GRADE PHOSPHORIC ACID PLANT COOLING WATER BLOWDOWN*

Impurity	mg/l
Fluoride	10 to 500
Phosphate	10 to 1,000
Sulfate	500 to 5,000
Chromate	0 to 100
Heavy metals	0 to 20
NH_3	0 to 5
Nitrates	0 to 5
SO_2	10 to 100
TDS	500 to 10,000
Oil	0 to 10
Other organics	0 to 100
Suspended solids	50 to 200
pH	5.5 to 6.0

* Cooling water blowdown volume 250 to
1,000 gal/ton P_2O_5

Source: Report 12020 FPD 09/71

SUMMARY OF RAW WASTE FROM PHOSPHORIC ACID MANUFACTURE

	H ₃ PO ₄ (75%)
Phospy water:	
P ₄ concentration, ppm	1,700
l/kg P ₄ consumed	580
kg P ₄ /kg P ₄ consumed	1
gal/ton P ₄ consumed	140
lb/ton P ₄ consumed	2
Process water wasted:	
l/kg pdt	-
gal/ton pdt	-
Raw waste load, kg/kg pdt:	
HCl	-
H ₂ SO ₃	-
H ₃ PO ₃ + H ₃ PO ₄	1
Raw waste load, lb/ton pdt:	
HCl	-
H ₂ SO ₃	-
H ₃ PO ₃ + H ₃ PO ₄	2
Concentrations, mg/l:	
HCl	-
H ₂ SO ₃	-
H ₃ PO ₃ + H ₃ PO ₄	High
Process water consumed:	
l/kg pdt	380
gal/ton pdt	92
Cooling water used:	
l/kg pdt	91,000
gal/ton pdt	22,000
Solid wastes, kg/kg pdt:	
As compounds	0.1
Total residues	-
Solid wastes, lb/ton pdt:	
As compounds	0.2
Total residues	-

Source: Report EPA 440/1-73/006

LEVEL OF CONTROL

AIR

Phosphate mists are usually removed and controlled by scrubbers, cyclones, fiber mist eliminators, high energy wire mesh contactors and electrostatic precipitators. This type of equipment provides collection efficiencies of 96 to 99.9% of mists with sizes greater than 1.0 micron.

WATER

Phosphate is usually removed by chemically treating wastewater to form an insoluble phosphate precipitate which is removed by filtering techniques.

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TOXIC CONTAMINANTS IN INDUSTRIAL WASTE PROCESS STREAMS

CONTAMINANT - Polychlorinated Biphenyls (PCB)

KIND OF WASTE - Air and Water

STATIONARY SOURCES - Vaporization of paints, coatings and plasticizers, vaporization during open burning, leaks and disposal of industrial fluids, disposal in dumps and landfills.

STANDARDS -

EPA - Streams having a flow less than 10 cu. ft/sec or lakes having an area less than 500 acres shall receive no discharges. Faster flowing streams and larger lakes may receive a maximum of 280 µg/liter (salt water bodies only 10 µg/l) unless the low flow of the stream is less than ten times the waste flow in which case the 280 is reduced to 28 µg/liter.

On January 19, 1977, EPA ruled that PCB may not be discharged into waterways by industrial plants.

OSHA - No data found.

OTHER - In the absence of broad federal authority to restrict the use of PCB's, such as the proposed Toxic Substances Control Act, the only U.S. producer, the Monsanto Industrial Chemicals Co., voluntarily limited PCB sales to use in closed-system capacitors and transformers. Because PCB accumulation in fish and aquatic invertebrates could reach levels thousands of times higher than that in the ambient water, EPA recommended revising water quality standards to reduce PCB levels in lakes and rivers below 0.01 parts per billion.

In 1973, the Food and Drug Administration adopted stringent limits for PCB's in food and food packaging and issued regulations designed to prevent accidental contamination of foods in food plants (5 ppm). In February 1973, the Organization for Economic Cooperation and Development, which consists of Japan, Australia, and nations of Western Europe and North America, adopted a directive limiting worldwide use of PCB's. Member countries agreed to restrict use to transformers, capacitors, heat transfer fluids, and hydraulic fluids for mining equipment and to control the manufacture, import, and export of products containing PCB's.

In August 1975, as a result of discoveries of continuing high levels of PCB's, EPA reinforced its efforts to identify uses, distribution, and effluent levels. EPA has also accelerated its timetable for developing a national effluent standard pursuant to section 307(a) of the Federal Water Pollution Control Act. Other activities scheduled for the near future include publication of final water quality criteria and proposals for regulations governing liability in spills involving PCB's.

Threshold Limit Value - 42% Chlorine (skin) 1 mg/m^3
 54% Chlorine (skin) 0.5 mg/m^3

VOLUME OF EMISSIONS

ESTIMATED PCB INPUT RATES, NORTH AMERICA

(In millions of pounds)

SOURCE	1974	QUANTITY
Vaporization of plasticizers		Negligible
Vaporization during open burning		¹ 0.38
Leaks and disposal of industrial fluids		² 0.99
Disposal in dumps and landfills		<u>15.40</u>
Total		16.72

¹ Assuming 20 percent annual decrease in PCB's reaching open burning.

² Assumed to have decreased an order of magnitude, partially due to collection by Monsanto and partially due to greater awareness and many fewer firms handling the material.

Source: David P. Peakall, "PCB's and Their Environmental Effects," CRC Critical Environment Review (in press).

WATER

Fresh water is an important repository and transport mechanism for PCB's. Use patterns and measurements in industrial outfalls, receiving waters, downstream waterways, and fish demonstrate that this statement is true. Likely sources of continuing releases to fresh waters are PCB wastes leached from landfills and deposits of airborne residues.

Source: Environmental Protection Agency, STORET.

The total input of PCB's into the oceans of North America has been calculated at about 3.3 million pounds.

PCB CONCENTRATIONS IN NORTH ATLANTIC SURFACE WATERS

1971 - 1974

(In parts per million)

Date	Mean PCB	Area
August 1971	25	Iceland-Newfoundland
July 1972	41	Newfoundland-Portugal
August 1972	36	Portugal-Norwegian Sea
September 1972	30	Massachusetts-Bermuda
April 1973	1	Sargasso Sea
September 1973	2	Azores to Barbados
September 1973	0.8	Sargasso Sea-New York
February 1974	0.8	New England continental shelf

Source: David B. Peakall, "PCB's and Their Environmental Effects," CRC Critical Environment Review (in press).

EMISSION FACTORS - No data found

LEVELS OF CONTROL - No data found

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TOXIC CONTAMINANTS IN INDUSTRIAL PROCESS WASTE STREAMS

CONTAMINANTS - Sulfur Oxides (SO_2) and Other Sulfur Compounds

KIND OF WASTE - Air and Water

AIR

STATIONARY SOURCES - Combustion of coal and oil by power plants and industrial processes industries (refrigeration, bleaching, fumigation, etc.).

WATER

Water scrubbing of gaseous exhausts, acid mine drainage leaching and runoff from residues deposited on land, incineration of sulfur-containing sludges, chemical and allied products, textile mill products, gas manufacturing, paper and allied products industries.

STANDARDS -

AIR (SO_2)

EPA - The national primary air quality standard - $80 \mu\text{g}/\text{m}^3$ (0.03 ppm) annual arithmetic mean, $365 \mu\text{g}/\text{m}^3$ (0.14 ppm) maximum 24-hour average. The secondary standard - $1300 \mu\text{g}/\text{m}^3$ (0.5 ppm) maximum 3-hour average. The NO Significant Deterioration of Air Quality Regulations are:

$15 \mu\text{g}/\text{m}^3$ Annual

$100 \mu\text{g}/\text{m}^3$ 24-hour

$700 \mu\text{g}/\text{m}^3$ 3-hour

OSHA - In 1945, Cook compiled a summary of standards which listed the maximum allowable concentration (MAC) of sulfur definite discomfort in exposed workers. The tentative TLV of 5 ppm was adopted in 1958.

In 1968, the ACGIH further documented the 5 ppm TLV and included Greenwald's human and animal studies and information of acute upper respiratory irritation and nosebleeding which had occurred in workers exposed to 10 ppm sulfur dioxide, but not at a level of 5 ppm.

In June 1974, NIOSH published the document entitled "Criteria for a Recommended Standard . . . Occupational Exposure to Sulfur Dioxide." In this document, NIOSH recommended a permissible exposure limit of 2 ppm time-weighted average (TWA) to control the effects of exposure of sulfur dioxide. This recommendation was based on reports of irritant effects, pulmonary function reduction, and also the possible cancer "promoting effects" of sulfur dioxide in workers. Although not itself a carcinogen, sulfur dioxide may promote cancer by lowering the body's defenses in the respiratory system to the penetration and retention of certain carcinogens.

STANDARDS - (continued)

- OSHA - On November 24, 1975, OSHA proposed a requirement limiting employee exposure to an 8-hour time-weighted average exposure concentration of 2 parts sulfur dioxide per million parts air (5.23 mg/m^3), together with a ceiling limit of 10 ppm (26.12 mg/m^3) as measured over a sampling period of 15 minutes.
- OTHER - Threshold Limiting Value (TLV) - 5 ppm or 13 mg/m^3 (other sulfur compounds)
- WATER
- Threshold Limiting Value (TLV)
- Sulfuric acid - $1 \text{ } \mu\text{g/m}^3$
- Recommended maximum sulfate - $250 \text{ } \mu\text{g/l}$ concentration for drinking water
- Toxic concentration of sodium sulfide for fish - $3.2 \text{ } \mu\text{g/l}$
- Toxic concentration of dissolved hydrogen sulfide - $0.5 - 1.0 \text{ } \mu\text{g/l}$.
- Hydrogen sulfide - $0.5 - 1.0 \text{ } \mu\text{g/l}$.
- Undesirable for irrigational use - More than $700 \text{ } \mu\text{g/l}$ sulfur compounds
- Undesirable for cattle - More than $500 \text{ } \mu\text{g/l}$ sulfur compounds

VOLUME OF EMISSIONS (1972)

<u>Source</u>	<u>AIR (SO_2)</u>	
	<u>Quantity (10^6 tons)</u>	
Fuel combustion stationary	18.4	
Miscellaneous combustion	7.2	
Industrial processes	6.8	
Solid waste disposal	0.2	
	<hr/>	
Total	32.6	

[1972 National Emissions Report, Environmental Protection Agency, Research Triangle Park, NC, Publ. EPA-450/2-74-012 (1974).]

VOLUME OF EMISSIONS (1972)

WATER (Sulfates, Sulfides)

Pollutants (Millions of Pounds/Year)

<u>Name</u>	<u>Sulfur Compounds (as S)</u>
Anthracite Mining	2,200
Nitrogenous Fertilizers	1
Petroleum Refining	39
Sanitary Systems - Sewers	960
<hr/>	
Totals	3,200
Totals Without Domestic Sewage	2,240
<hr/>	

Source: Report EPA-450/2-74-012 (1974)

EMISSION FACTORS

AIR

EMISSION FACTORS FOR MODIFIED-CLAUS SULFUR PLANTS

Number of catalytic stages	Recovery of sulfur, %	SO ₂ emissions ^a
		lb/ton 100% sulfur
Two, uncontrolled	92 to 95	211 to 348
Three, uncontrolled	95 to 96	167 to 211
Four, uncontrolled	96 to 97	124 to 167
Sulfur removal process	99.9	4.0

^aThe range in emission factors corresponds to the range in the percentage recovery of sulfur.

Source: EPA Publication AP-42, 2nd Edition

EMISSION FACTORS FOR SULFURIC ACID PLANTS^a

Conversion of SO ₂ to SO ₃ , %	SO ₂ emissions
	lb/ton of 100 % H ₂ SO ₄
93	96
94	82
95	70
96	55
97	40
98	27
99	14
99.5	7
99.7	4
100	0

^aThe following linear interpolation formula can be used for calculating emission factors for conversion efficiencies between 93 and 100 percent: emission factor (lb/ton acid) = 13.65 (percent conversion efficiency) + 1365.

Source: EPA Publication AP-42, 2nd Edition.

EMISSION FACTORS (continued)

ACID MIST EMISSION FACTORS FOR SULFURIC ACID PLANTS WITHOUT CONTROLS

Raw material	Oleum produced % total output	Emissions ^a lb/ton acid
Recovered sulfur	0 to 43	0.35 to 0.08
Bright virgin sulfur	0	1.7
Dark virgin sulfur	33 to 100	0.32 to 6.3
Sulfide ores	0 to 25	1.2 to 7.4
Spent acid	0 to 77	2.2 to 2.7

^aEmissions are proportional to the percentage of oleum in the total product. Use the low end of ranges for low oleum percentage and high end of ranges for high oleum percentage.

WATER

Mine drainage affects, continuously or intermittently, the water quality of 10,500 mi of streams in portions of eight Appalachian States, although primarily in Pennsylvania, Maryland, Ohio, Kentucky, and West Virginia. In Appalachia during 1966 more than 6000 tons/d of acidity were discharged to streams and over 10,000 mi of streams were effected by all coal mining operations. A typical acid discharge may have pH levels of 3.5 to 6.6, acidity content of 0 to 1000 ppm, sulfate content of 500 to 1000 ppm, and an iron content of 0 to 500 ppm.

The estimated current rate of pollution is 3.5×10^6 tons/y to all U.S. streams. The flow pattern of surface and subsurface waters is being seriously disturbed in over 11×10^6 acres of land mined for coal in the U.S.

LEVEL OF CONTROL

AIR

Techniques to reduce sulfur oxide emissions.*

Methods	Advantages	Disadvantages
Dispersal of emissions and curtailment	Curtailment and tall stacks have been shown to reduce or eliminate occurrences of significant ground-level concentrations in the vicinity of large plants. Can be implemented immediately for some degree of emission control.	Curtailment interferes with plant operation. Methods are only an interim measure until reliable removal processes are available. Effective tall stacks are dependent upon meteorological and geographic conditions and do not provide a reduction in the amount of material released into the atmosphere.
Substitution of energy sources - hydroelectric and nuclear power	Causes no sulfur oxide emissions. Provides large sources of electrical energy at competitive cost.	Limited availability of suitable sites restricts expansion of hydroelectric power. Nuclear power substitution presents the possibility of introducing other emission problems.
Desulfurize high sulfur fuels		
<u>Coal</u>		
a. Coal Gasification	Sulfur oxide reduction is directly proportional to reduction of sulfur in the fuel. Readily abundant high-sulfur coal can be used as feed stock. Reduction of particulate emissions is another benefit. Sulfur removal is accomplished prior to combustion when the volume of gases to be treated is less than that of stack gases: techniques for removing the sulfur from the product gas are readily available; the clean gas permits the use	Economically feasible techniques are still in the development stage.

Desulfurize high
sulfur fuels

Coal (continued)

of more efficient power cycles than are presently used. Potentiality cheapest way of controlling sulfur emissions.

b. Partial Coal
Liquefaction

Obtaining a sulfur- and ash-free extract through partial liquefaction is reasonable in cost.

Complete liquefaction requires a large amount of hydrogen, which is very expensive but obtaining a sulfur- and ash-free extract through partial liquefaction is reasonable in cost.

Fuel oil

Sulfur oxide reduction is directly proportional to reduction of sulfur in the fuel. Reduction of particulate emission is another benefit. Proven refinery processes can produce a residual fuel oil with sulfur content of 0.3%.

Heavy capital investment. Interference by heavy metals in oil.

Gas

Technologically well developed. High degree of sulfur removal. Reduction of emissions is another benefit. Methods for desulfurization are readily available.

Heavy capital investment.

Sulfur oxide reduction is directly proportional to reduction of sulfur in the fuel. Reduction of particulate emissions is another benefit.

High price and unreliability of supply would require sulfur oxide abatement anyway. Exploitation of low-sulfur coal reserves in the west imposes severe environmental costs.

Combustion process
modification to
increase efficiency

Small improvements in the efficiency of
a large power plant create large fuel
savings and decrease sulfur oxide
emissions.

Changes in basic techniques used to
generate electricity may require a
considerable R&D effort and an
extensive capital investment. Long
phase-in time.

Desulfurize flue gases
(Dry scrubbing, wet
scrubbing, or
attached chemical
plant)

Research to develop this technology is
over 40 years old. Permits use of
high-sulfur fuel feedstock. An
alternative approach where a switch
to low-sulfur fuel presents technical
and economic problems. Processes that
permit burning of high-sulfur fuels are
approaching full development. Some
solubled products, feasible technology.

Reliability of units 100 MW or
larger has not been demonstrated.
Processes considered most advanced
have only been tested in a limited
number of large-scale demonstrated
projects. Enormous disposal problem
attendant with throwaway control
systems (nonregenerative alkaline and
furnace injection) - products have no
market value and must be disposed of
in permanent impounding areas.
Soluble magnesium salts will leach and
contaminate water at the surface
or underground. Lack of buoyancy of
the plumes of all wet scrubber systems.

Source:

Lawrence Livermore Laboratory, staff compilation.

AIR

Economic evaluation of sulfur dioxide control process systems.*

Processor method	Reactant input requirements	Throw-away or recovery	Investment costs (dollars/kW for coal boilers)	Operating costs (mills/kWh)		Sulfur dioxide removal efficiency	Comments
				No credit for sulfur recovery	Credit for sulfur recovery		
Low-sulfur fuel	NA	NA	0	2.0-5.0	NA	NA	Costs dependent on location and fuel type
Dry limestone injection	Limestone, 200°, Stoich	Throw away	12-14 (200 MW new)	0.6-0.8	NA	22-45°	Costs dependent on solids removal, variables removal dependent on limestone type, and boiler load limited in applicability
Wet line limestone scrubbing	Lime, 100-1200°, stock limestone 120-150°, Stoich	Throw away	27-46 (200-1000 MW new or retro)	1.1-2.2	NA	80-90°	Costs dependent on solids removal considerations, new or retrofit scrubber type, lime or limestone, size of unit, etc. Considered most advanced technology. Several commercial units in operation testing on EPA prototype initiated
Magnesium oxide scrubbing	MgO alkali water fuel for regeneration and drying	Recovery of conc. H ₂ SO ₄	33-58 (200-1000 MW new or retro)	1.5-3.0	0.9-2.6	80-90°	Costs dependent on same factors for wet limestone. Boston electric unit to start up in March 1972. H ₂ SO ₄ assumed marketed at \$18/ton on-site acid production
Monsanto catalytic oxidation (add-on)	Vanadium pentoxide catalyst (periodic replacement)	Recovery of dilute H ₂ SO ₄	45-50 (1000 MW new)	2.1-2.5	1.8-2.2	80-90°	Costs dependent on same factors as for wet limestone. Boston electric unit to start up in March 1972. H ₂ SO ₄ assumed marketed at \$9/ton (conc. basis)

Source:

[Princiotta, F. T., Environmental Protection Agency, Research Triangle Park, NC, Publ. PB-228706 (1972).]

EMISSION COMPARISON AND COLLECTION EFFICIENCY OF TYPICAL ELECTROSTATIC PRECIPITATOR AND FIBER MIST ELIMINATORS

Control device	Particle size collection efficiency, %		Acid mist emissions	
	>3 μ m	$\leq$ 3 μ m	98% acid plants lb/ton	oleum plants lb/ton
Electrostatic precipitator	99	100	0.10	0.12
Fiber mist eliminator				
Tubular	100	95 to 99	0.02	0.02
Panel	100	90 to 98	0.10	0.10
Dual pad	100	93 to 99	0.11	0.11

^aBased on manufacturers' generally expected results; calculated for 8 percent sulfur dioxide concentration in gas converter.

Source: EPA Publication AP-42, 2nd Edition.

WATER (Sulfates, Sulfides)

The processes related to the removal of sulfates and sulfides from acid wastewaters usually involve neutralization followed by clarification techniques.

Cost and effectiveness of some techniques for controlling acid mine drainage.*

Technique	Effectiveness (%)	Cost (1969 dollars)
<u>Treatment</u>		
Neutralization	80-90	0.10-1.30/1,000 gal
Distillation	97-99	0.40-3.25/1,000 gal
Reverse osmosis	90-97	0.68-2.57/1,000 gal
Ion exchange	90-92	0.61-2.53/1,000 gal
Freezing	90-99	0.67-3.23/1,000 gal
Electrodialysis	25-95	0.58-2.52/1,000 gal
<u>At the source</u>		
Water diversion	25-75	300-2,000/acre
Mine sealing	10-80	1,000-20,000/seal
Surface restoration	25-75	300-3,000/acre
Revegetation	5-25	70-350/acre

* [Dials, G. E., and E. C. Moore, Environment 16, No. 7, 21 (1974).]

Mine drainage control techniques.*

Technique	Procedure	Mine type ^a	
		Surface	Underground
Surface land reclamation	The grading of earth, the construction of water ditches, and the revegetation of ground disturbed by excavation of the surface.	A I	- -
Mine entry sealing	The placement of barriers in openings from underground mines exposed to the surface to constrain the movement of air or water.	- -	- I
Drainage diversion	The channeling of surface waters or mine waters to control volume, direction, and contact time.	A I	A I
Impoundment	The physical restriction of waters within an isolated area of an underground or surface mine.	- I	- I
Refuse pile reclamation	The burial or covering and revegetation of the discarded waste rock from mining.	A I	A I
Underground grouting	The placement of a sealant on the surface or into the subsurface to constrain the movement of air and water in an underground mine, e.g., the pouring of concrete which would seal after reaching subsurface.	- -	- I
Revegetation	The planting of grasses, legumes, or trees upon the surface of areas disturbed or altered by excavation or dumping during mining.	A I	- -
Inert gas blanket	The placement and retention within an underground mine of a gas that is not reactive in the acid-mine-drainage forming process.	- -	- I

(continued)

Technique	Procedure	Mine type ^a	
		Surface	Underground
Microbiologic iron and sulfate removal	The use of living organisms to actively reduce mine drainage contaminants.	- I	A I
Sterilization	The use of toxic materials to destroy or retard living organisms active in the acid-mine-drainage forming process.	- -	A I
Microbiological control	The use of living organisms against each other to retard the action of those which are active in the acid-mine-drainage process.	- -	- I
Internal sealing	The isolation or constraint of underground mine waters by the placement of barriers well within the depths of underground mines.	- -	A -
Resource removal	The extraction of all coal, and the burying and sealing of toxic producing strata.	A I	- -
Neutralization	The process of chemically counteracting the effects of acid mine drainage.	A I	A I
Flash distillation	The rapid evaporation of acid mine drainage and the reliquefaction of the remaining fluid, free of residual contaminants.	A I	A I
Reverse osmosis	The passage through a selective membrane of the liquid portion of acid mine drainage thereby freeing it from a major portion of the residual contaminants.	A I	A I
Ion exchange	The passage of acid mine drainage among reactive particles that selectively retain residual contaminants while the remaining liquid passes through.	A I	A I

(continued)

Technique	Procedure	Mine type ^a	
		Surface	Underground
Desulfating	The use of living organisms that thrive on metabolic processes that destroy sulfate, which is a major residual contaminant of mine drainage.	A I	A I
Sulfide iron removal	The precipitation of iron from acid mine drainage with the addition of selectively reactive sulfide compounds.	A I	A I
Electrodialysis	The passage of acid mine drainage through an electrically charged selective membrane allowing the passage of liquid thus freeing it from residual contaminants with the appropriate electrical resistance to passage.	A I	A I
Permanganate iron removal	The precipitation of iron from acid mine drainage with the addition of an agent that oxidizes the iron.	A I	A I
Regulated pumping	The discharge of acid mine drainage at volumes, rates, times, and locations so that the contaminating effects will be minimized.	A I	A I
Stream flow regulation	The containment and release of stream waters at volumes, rates, times, and locations so that the contaminating effect will be minimized.	A I	A I
Deep well injection	The placement of acid mine drainage or its altered product into the subsurface through a vertical drilled hole.	A I	A I

^aA = Active; mines and areas in use for mining.

I = Inactive; closed or abandoned mines or portions of active mines not in use.

* [Lawrence Livermore Laboratory, staff compilation.]

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TOXIC CONTAMINANTS IN INDUSTRIAL WASTE PROCESS STREAMS

CONTAMINANT - Trichloroethylene (TCE)

KIND OF WASTE - Air and Water

SOURCES - Vapor degreasing operations, dry cleaning establishments, chemical production facilities.

STANDARDS -

EPA - No data found

OSHA - In 1972, OSHA adopted the ANSI standard for exposure to TCE of 100 ppm as averaged over an eight-hour workday, a 200 ppm acceptable ceiling concentration and allowance for peak exposures of 300 ppm occurring not more frequently than five minutes in any two hours. This is the current OSHA standard for occupational exposure. On October 20, 1975, OSHA proposed a new standard which would retain the current eight-hour time-weighted average limit for exposure to airborne concentrations of TCE of 100 parts per million (ppm) and would reduce the ceiling limit from 200 ppm to 150 ppm. In addition, the acceptable maximum peak of 300 ppm for five minutes in any two hour period would be deleted.

OTHER - German Engineering Society
Air Quality Standard - 15.0 ppm max once in 4 hours;
5.0 ppm long term
Threshold Limiting Value (TLV) - 100 ppm (535 mg/m³)

VOLUME OF EMISSIONS

U. S. production - 234,000 metric tons of trichloroethylene

U. S. chlorinated hydrocarbon residue wastes - 350,000 tons/yr

EMISSION FACTORS

AIR

HYDROCARBON EMISSION FACTORS FOR DRY-CLEANING OPERATIONS

Control	Trichloroethylene Solvent
Uncontrolled	210
Average Control	95
Good Control	35

Source: EPA Publication AP-42, 2nd Edition

WATER

Not Available

LEVEL OF CONTROL

Devices for recovery of trichloroethylene from air usually involve condensation of the vapors or absorption onto activated charcoal. No data found on the efficiency of these processes. The primary control element in use in synthetic solvent plants is a water-cooled condenser that is an integral part of the closed cycle in a tumbler or drying system. Up to 95% of the solvent that is evaporated from the clothing is recovered here. About half of the remaining solvent is then recovered in an activated-carbon adsorber, giving an overall control efficiency of 97 to 98%. There are no commercially available control units for solvent recovery in petroleum-based plants because it is not at present economical to recover the vapors.

Steam stripping processes are usually used for remaining trichloroethylene from wastewater streams.

REFERENCES

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TOXIC CONTAMINANTS IN INDUSTRIAL WASTE PROCESS STREAMS

CONTAMINANT - Vinyl Chloride

KIND OF WASTE - Air and Water

STATIONARY SOURCES -

AIR AND WATER

Plastic manufacturing plants (raw materials, solvents, etc.)

STANDARDS -

EPA - In 1974 the U.S. Department of Labor established an occupational exposure limit of 1 ppm for vinyl chloride over any 8-hour period and a ceiling of 5 ppm average over any period not exceeding 15 minutes. EPA classified it as a hazardous pollutant under the Clean Air Act on December 24, 1975.

EPA proposed a best available control technology strategy, designed to reduce aggregate national emissions by at least 90 percent.

Such action would limit to 10 ppm the source strength of vinyl chloride emissions. This limit, together with atmospheric dilution, is intended to protect anyone living near a vinyl chloride or polyvinyl chloride plant.

The standards apply to 58 existing plants around the country and also to new plants. The vinyl chloride emissions from the 58 plants account for 95 percent of the present nationwide total. The rest occur at about 8,000 plastic product fabricating plants, where emissions are generally much lower.

OSHA - No data found

OTHER - In September 1975, FDA proposed to ban the use of rigid and semi-rigid, generally clear, vinyl chloride plastics that come in contact with food. Because pliable wraps, cap liners, package coatings, etc., have undergone more heating and plasticizing, unreacted vinyl chloride residues are expected to be much lower in these products, and therefore less likely to migrate into food. Use of these products would not be affected under the FDA proposal.

The Threshold Limiting Value (TLV) is 200 ppm (770 $\mu\text{g}/\text{m}^3$).

VOLUME OF EMISSIONS

AIR

An estimated 220 million pounds of vinyl chloride was released into the atmosphere by U. S. plants in 1974. Monitoring data in the populated areas around plants producing ethylene dichloride, vinyl chloride, and polyvinyl chloride indicate that average exposures are less than 1 ppm; however, peak exposures of 33 ppm have been observed. Most plants that emit those pollutants are not isolated from surrounding populations. About 4.6 million persons live within 5 miles of the production facilities.

WATER

No data found

EMISSION FACTORS

AIR

PLASTICS MANUFACTURING WITHOUT CONTROLS

<u>Type of plastic</u>	<u>Particulate lb/ton</u>	<u>Gases lb/ton</u>
Polyvinyl chloride	35 ^a	17

^aUsually controlled with a fabric filter efficiency of 98 to 99 percent.

Source: EPA Publication AP-42, 2nd edition.

WATER

WASTEWATER LOADING FOR THE PLASTICS AND SYNTHETICS INDUSTRY

<u>Product</u>	Wastewater Loading (gal/1000 lb.)	
	<u>Observed Flow</u>	<u>Reported Range</u>
Polyvinyl Chloride--Suspension		
Polyvinyl Chloride--Emulsion	1800	(300-5000)
Polyvinyl Chloride--Bulk		

Source: Report EPA 440/1-73/010

PLASTICS AND SYNTHETICS INDUSTRY RAW WASTE LOADS

(1b/1000 lb of Production)

<u>PRODUCT</u>	<u>BOD₅</u>		<u>COD</u>		<u>SS</u>	
	<u>Reported Range</u>	<u>Observed Value</u>	<u>Reported Range</u>	<u>Observed Value</u>	<u>Reported Range</u>	<u>Observed Value</u>
Polyvinyl Chloride	0.1 - 48	5.7	0.2-100	25	1 - 30	30

Source: Report EPA 440/1-73/010.

LEVEL OF CONTROL

AIR

Much of the control equipment used in the plastics industry is a basic part of the system and serves to recover a reactant or product. These controls include floating roof tanks or vapor recovery systems on volatile material, storage units, vapor recovery systems (adsorption or condensers), purge lines that vent to a flare system, and recovery systems on vacuum exhaust lines.

WATER

No data found.

ADDITIONAL READING REFERENCES

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