

SECTION VII

...New industrial materials will produce new hazards requiring careful detective work before the exact agent or mode of action is incriminated, and to which the classical approach can be applied, but the principles are known, and the work can proceed along what are now fairly conventional lines.

*—The Committee on Environmental
Health Problems - 1962.
PHS Publication No. 908*

CHEMICAL HAZARDS

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Raw materials from many sources are converted by the chemical industry into the substances used by the industry itself to produce cosmetics, detergents and soaps, drugs, dyes, pigments, explosives, fertilizers, petrochemicals, inks, paints, pesticides, plastics, synthetic fibers, and many other products. Other industries use the substances in the production of durable and nondurable goods.

This section deals with the harmful health effects of some of these substances. Items discussed include the capacity of the substance to produce local and/or systemic effects, special diagnostic tests that may aid diagnosis of the illness by identification of the agent, potential occupational exposures, protection methods, and references.

HARMFUL EFFECTS. Under the heading Harmful Effects are given only the chief or dominant effects that characterize the usual responses to the toxic agent. Because of the lack of information on the mutagenic, teratogenic, or carcinogenic effects of many chemicals, consideration is given only in specific instances to these effects.

Local and systemic effects are given in an effort to categorize the effects of the toxic agent. It was arbitrarily decided to limit local effects to the skin and eyes and to the mucous membranes of the upper respiratory tract. Systemic effects include the manifestations elicited by the absorption of the toxic agent into the body and its distribution to the internal organs and particularly the effects of the agent on the tissues of the lower respiratory tract.

ROUTE OF ENTRY. The route of entry section is intended to supply information on the avenue by which the toxic agent is most likely to gain entrance into the body when encountered in the industrial environment.

SPECIAL DIAGNOSTIC TESTS. Ordinary tests such as complete blood counts, urinalyses, and chest roentgenograms are not included under the heading Special Diagnostic Tests. Similarly, liver and kidney function tests and cutaneous patch tests have not been included, even though they may be of considerable diagnostic importance. It is felt that the physician need not be reminded of the methods for determining abnormalities in the target organs which are mentioned under Systemic Effects.

It should be pointed out that many of these special diagnostic tests are difficult to carry out and should be performed only by qualified laboratories. In addition, the fact should be kept in mind that normal values may vary somewhat, even those from competent analytical laboratories.

Because of the absence of significant, interpretable information, no reference is made to behavioral patterns of response to toxic agents.

PERMISSIBLE EXPOSURE LIMITS. In the section on Permissible Exposure Limits, the standard as currently promulgated by the Secretary of the U. S. Department of Labor under the Occupational Safety and Health Act of 1970 (PL 91-596) is given. These standards contain the permissible exposure limit as found in 29 CFR 1910.1000 as of January 1, 1977. Where NIOSH has published a recommended revision to the OSHA regulation, the NIOSH recommended level is also noted. In addition in some instances the assigned Threshold Limit Value (TLV) appearing in the current (1976) list published by the American Conference of Governmental Industrial Hygienists (ACGIH) is given.

The Department of Labor promulgates standards that are mandatory in the United States; the TLVs issued by the ACGIH are guidelines and are to be considered as practical guides in the control of health hazards and should not be regarded as fine lines between safe and dangerous exposure levels. In 1971, most of the 1968 ACGIH TLV list was included in the standard for air contaminants (29 CFR 1910.93 amended to 1910.1000). United States standards are first published in the Federal Register (FR), which is available by subscription from the U. S. Government Printing Office. These regulations are then codified in the Code of Federal Regulations (CFR), generally in Title 29. This publication is also available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D. C. Since these regulations are mandatory and often stipulate medical requirements as to diagnostic tests, it would be wise to check this reference if there is any question about an illness resulting from occupational exposure.

POTENTIAL OCCUPATIONAL EXPOSURES. The list of occupations appended to a particular chemical substance lists occupations in which workers are potentially exposed to the toxic agent. Whether the exposure to the toxic agent constitutes a hazard depends upon such factors as concentration of the agent, how the agent is handled and used, duration of exposure, susceptibility of the worker to the agent, and the health protection practices that may be adopted by management. Thus, all hazardous situations imply an exposure, but all exposures are not hazardous.

SYMPTOMS AND EXPOSURE. In resolving the problem of the relationship between the signs and symptoms presented by the worker and the potential toxic exposure in his occupation, it is important to understand the ways by which a toxic chemical enters the body and to secure factual information as to the physical and chemical characteristics of the work environment and the personal hygiene of the worker. At the same time, it is essential to recognize that 1) chemical formulas offer, at most, only rough guides to the prediction of toxic response and 2) the forms of acute and chronic toxicity are so often dissimilar that prediction cannot be made of the nature of chronic toxicity from the acute manifestations.

SELECTION OF CHEMICALS. Most of the known occupational disease-producing chemicals are given; certain chemicals, however, are excluded because of insufficient data.

The chemicals given are arranged by chemical groups; for example, aliphatic hydrocarbons, alcohols, glycols. Some chemicals are discussed in the section on pesticides.

REFERENCES. A number of excellent secondary references are available on chemical hazards. These include the series of NIOSH Criteria Documents, the AIHA Hygienic Guides, and the ACGIH Documentation of the Threshold Limit Values for Substances in Workroom Air. An additional source is the Medical Surveillance Guidelines from the OSHA-NIOSH Standards Completion Program. These provide detailed information on toxicology, signs and symptoms, special tests, treatments, surveillance, and prevention. Specific references cited in a section are listed at the end of that section. Supplemental references covering some chemical groups are provided in bibliographies for those groups.

General texts of interest are listed in the following bibliography.

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ALIPHATIC HYDROCARBONS

Aliphatic hydrocarbons are saturated or unsaturated, branched or unbranched open carbon chains. Within this group there are three subgroups: alkanes (saturated hydrocarbons), alkenes (unsaturated hydrocarbons with one or more double bonds), and alkynes (unsaturated hydrocarbons with one or more triple bonds). Synonyms are paraffins, olefins, and acetylenes, respectively. Compounds of lower molecular weight containing fewer than 4 carbons are usually gases at room temperature, whereas larger molecules, containing from 5 to 16 carbons, are liquids, and those having more than 16 carbons are usually solids.

Aliphatic hydrocarbons are derived from petroleum by the cracking, distillation, and fractionation of crude oil. Most of these compounds are used industrially in mixtures, such as natural gas, petroleum naphtha, gasoline, kerosene, and mineral spirits. Aliphatic hydrocarbons are used principally as fuels, refrigerants, propellants, dry cleaning agents, lubricants, solvents, and chemical intermediates.

Aliphatic hydrocarbons are asphyxiants and central nervous system depressants. Lower members of the series, methane and ethane, are pharmacologically less active than higher members of the series, their main hazards resulting from the simple displacement of oxygen and from fire and from explosion. Higher members of the series cause narcosis. At least one member (hexane) has neurotoxic properties. Another common effect is irritation of the skin and mucous membranes of the upper respiratory tract. Repeated and prolonged skin contact may result in dermatitis, due to the defatting of skin. Due to its low viscosity, aspiration of liquid may result in diffuse chemical pneumonitis, pulmonary edema, and hemorrhage. Contamination of aliphatic hydrocarbons by benzene significantly increases the hazard. Therefore, it is important that benzene content, if suspected, be determined.

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ACETYLENE

DESCRIPTION

$\text{HC}\equiv\text{CH}$, acetylene, is a colorless gas with a faint ethereal odor.

SYNONYMS

Ethine, ethyne, narylene.

POTENTIAL OCCUPATIONAL EXPOSURES

Acetylene can be burned in air or oxygen and is used for brazing, welding, cutting, metallizing, hardening, flame scarfing, and local heating in metallurgy. The flame is also used in the glass industry. Chemically, acetylene is used in the manufacture of vinyl chloride, acrylonitrile, synthetic rubber, vinyl acetate, trichloroethylene, acrylate, butyrolactone, 1,4-butanediol, vinyl alkyl ethers, pyrrolidone, and other substances.

A partial list of occupations in which exposure may occur includes:

Acetaldehyde makers	Dye makers
Acetone makers	Foundry workers
Alcohol makers	Gougers
Braziers	Hardeners
Carbon black makers	Heat treaters
Ceramic makers	Lead burners
Copper purifiers	Rubber makers
Descalers	Scarfers
Drug makers	

PERMISSIBLE EXPOSURE LIMITS

No Federal standard has been established. NIOSH has recommended a ceiling limit of 2,500 ppm.

ROUTE OF ENTRY

Inhalation of gas.

HARMFUL EFFECTS

Local—

Acetylene is nonirritating to skin or mucous membranes.

Systemic—

At high concentrations pure acetylene may act as a mild narcotic and asphyxiant. Most accounted cases of illness or death can be attributed to acetylene containing impurities of arsine, hydrogen sulfide, phosphine, carbon disulfide, or carbon monoxide.

Initial signs and symptoms of exposure to harmful concentrations of impure acetylene are rapid respiration, air hunger, followed by im-

paired mental alertness and muscular incoordination. Other manifestations include cyanosis, weak and irregular pulse, nausea, vomiting, prostration, impairment of judgment and sensation, loss of consciousness, convulsions, and death. Low order sensitization of myocardium to epinephrine resulting in ventricular fibrillation may be possible.

MEDICAL SURVEILLANCE

No specific considerations are needed.

SPECIAL TESTS

None in common use.

PERSONAL PROTECTIVE METHODS

Acetylene poisoning can quite easily be prevented if 1) there is adequate ventilation and 2) impurities are removed when acetylene is used in poorly ventilated areas. General industrial hygiene practices for welding, brazing, and other metallurgical processes should also be observed.

BIBLIOGRAPHY

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ALICYCLIC HYDROCARBONS

DESCRIPTION

Cyclopropane: C_3H_6

Cyclohexane: C_6H_{12}

Cyclohexene: C_6H_{10}

Methylcyclohexane: C_7H_{14}

Alicyclic hydrocarbons are saturated or unsaturated molecules in which three or more carbon atoms are joined to form a ring structure. The saturated compounds are called cycloalkanes, cycloparaffins, or naphthenes. The cyclic hydrocarbons with one or more double bonds are called cycloalkenes or cyclo-olefins. These compounds are colorless liquids.

SYNONYMS

None.

POTENTIAL OCCUPATIONAL EXPOSURES

Uses vary with compounds. Cyclopropane is used as an anesthetic. Cyclohexane is used as a chemical intermediate, as a solvent for fats, oils, waxes, resins, and certain synthetic rubbers, and as an extractant of essential oils in the perfume industry. Cyclohexene is used in the manufacture of adipic, maleic, and cyclohexane carboxylic acid. Methylcyclohexane is used as a solvent for cellulose ethers and in the production of organic synthetics.

A partial list of occupations in which exposure may occur includes:

Adipic acid makers	Paint removers
Benzene makers	Plastic molders
Fat processors	Resin makers
Fungicide makers	Rubber makers
Lacquerers	Varnish removers
Nylon makers	Wax makers
Oil processors	

PERMISSIBLE EXPOSURE LIMITS

The Federal standards are:

Cyclohexane 300 ppm (1050 mg/m³);

Cyclohexene 300 ppm (1015 mg/m³);

Methylcyclohexane 500 ppm (2000 mg/m³).

Presently there is no standard for cyclopropane.

(Note: The 1976 ACGIH lists a TLV of 400 ppm (1,600 mg/m³) for methylcyclohexane.)

ROUTE OF ENTRY

Inhalation of gas or vapor.

HARMFUL EFFECTS

Local—

Repeated and prolonged contact with liquid may cause defatting of the skin and a dry, scaly, fissured dermatitis. Mild conjunctivitis may result from acute vapor exposure.

Systemic—

Alicyclic hydrocarbons are central nervous system depressants, although their acute toxicity is low. Symptoms of acute exposure are excitement, loss of equilibrium, stupor, coma, and, rarely, death as a result of respiratory failure. The concentration of cyclopropane required to produce surgical anesthesia is low, and there is a wide margin between anesthetic and toxic concentrations. The myocardium may become more sensitive to epinephrine during narcosis with cyclopropane. Severe diarrhea and vascular collapse resulting in heart, lung, liver, and brain degeneration have been reported in oral administration of alicyclic hydrocarbons to animals.

The danger of chronic poisoning is relatively slight because these compounds are almost completely eliminated from the body. Metabolism of cyclohexane, for example, results in cyclohexanone and cyclohexanol entering the bloodstream and does not include the metabolites of phenol, as with benzene. Damage to the hematopoietic system does not occur except when exposure is compounded with benzene, which may be a contaminant. Alicyclic hydrocarbons are excreted in the urine as sulfates or glucuronides, the particular content of each varying. Small quantities of these compounds are not metabolized and may be found in blood, urine, and expired breath.

MEDICAL SURVEILLANCE

Consider possible irritant effects to the skin and respiratory tract in any preplacement or periodic examination, as well as any renal or liver complications.

SPECIAL TESTS

None in common use. Some metabolites have been found in blood and urine.

PERSONAL PROTECTIVE METHODS

Skin protection with barrier creams or gloves.

Workers exposed to high concentrations of gas or vapor may need masks.

BIBLIOGRAPHY

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1,3-BUTADIENE

DESCRIPTION

$H_2C=CH-CH=CH_2$, 1,3-butadiene, is a colorless, flammable gas with a pungent, aromatic odor. Because of its low flash point, 1,3-butadiene's fire and explosion hazard may be more serious than its health hazard.

SYNONYMS

Biethylene, bivinyl, butadiene monomer, divinyl, erythrene, methylallene, pyrrolylene, vinylethylene.

POTENTIAL OCCUPATIONAL EXPOSURES

1,3-Butadiene is used chiefly as the principal monomer in the manufacture of many types of synthetic rubber. Presently, butadiene is finding increasing usage in the formation of rocket fuels, plastics, and resins.

A partial list of occupations in which exposure may occur includes:

Organic chemical synthesizers	Rocket fuel makers
Resin makers	Rubber makers
Rocket fuel handlers	

PERMISSIBLE EXPOSURE LIMITS

The Federal standard for 1,3-butadiene is 1,000 ppm (2,200 mg/m³).

ROUTE OF ENTRY

Inhalation of gas or vapor.

HARMFUL EFFECTS*Local—*

Butadiene gas is slightly irritating to the eyes, nose, and throat. Dermatitis and frostbite may result from exposure to liquid and evaporating gas.

Systemic—

In high concentrations, 1,3-butadiene gas can act as an irritant, producing cough, and as a narcotic, producing fatigue, drowsiness, headache, vertigo, loss of consciousness, respiratory paralysis, and death. One report states that chronic exposure may result in central nervous system disorders, diseases of the liver and biliary system, and tendencies toward hypotension, leukopenia, increase in ESR, and decreased hemoglobin content in the blood. These changes have not been seen by most observers in humans.

MEDICAL SURVEILLANCE

No specific considerations are needed.

SPECIAL TESTS

None in common use.

PERSONAL PROTECTIVE METHODS

Masks are recommended in contaminated areas with high concentrations of the gas.

BIBLIOGRAPHY

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GASOLINE**DESCRIPTION**

Gasoline is a highly flammable, mobile liquid with a characteristic odor.

SYNONYMS

Petrol, motor spirits, benzin.

POTENTIAL OCCUPATIONAL EXPOSURES

Gasoline is used as a fuel, diluent, and solvent throughout industry.

A partial list of occupations in which exposure may occur includes:

Filling station attendants	Pipeline workers
Garage mechanics	Refinery workers
Gasoline engine operators	Tank car cleaning crews
Motor transport drivers	

PERMISSIBLE EXPOSURE LIMITS

Presently, the composition of gasoline is so varied that a single Federal standard for all types of gasoline is not applicable. It is recommended, however, that atmospheric concentrations should be limited by the aromatic hydrocarbon content.

ROUTE OF ENTRY

Most cases of poisoning reported have resulted from inhalation of vapor and ingestion. It is not known whether gasoline poisoning may be compounded by percutaneous absorption.

HARMFUL EFFECTS

Local—

Gasoline is irritating to skin, conjunctiva, and mucous membranes. Dermatitis may result from repeated and prolonged contact with the liquid, which may defat the skin. Certain individuals may develop hypersensitivity.

Systemic—

Gasoline vapor acts as a central nervous system depressant. Exposure to low concentrations may produce flushing of the face, staggering gait, slurred speech, and mental confusion. In high concentrations, gasoline vapor may cause unconsciousness, coma, and possibly death resulting from respiratory failure.

Other signs also may develop following acute exposure. These signs are early acute hemorrhage of the pancreas, centrilobular cloudy swelling and fatty degeneration of the liver, fatty degeneration of the proximal convoluted tubules and glomeruli of the kidneys, and passive congestion of the spleen.

Ingestion and aspiration of the liquid gasoline usually occurs during siphoning.

Chemical pneumonitis, pulmonary edema, and hemorrhage may follow. Aromatic hydrocarbon content may also cause hematopoietic changes. Absorption of alkyl lead antiknock agents contained in many gasolines poses an additional problem especially where there is prolonged skin contact. The existence of chronic poisoning has not been established.

MEDICAL SURVEILLANCE

No special considerations are necessary.

SPECIAL TESTS

None in common use.

PERSONAL PROTECTIVE METHODS

Barrier creams and impervious gloves, protective clothing.
Masks in heavy exposure to vapors.

BIBLIOGRAPHY

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n-HEPTANE

DESCRIPTION

$\text{CH}_3(\text{CH}_2)_5\text{CH}_3$, *n*-heptane, is a clear liquid which is highly flammable and volatile.

SYNONYMS

None.

POTENTIAL OCCUPATIONAL EXPOSURES

n-Heptane is used as a solvent and as a standard in testing knock of gasoline engines.

A partial list of occupations in which exposure may occur includes:

- Process workers (where heptane is used as the solvent)
- Refinery laboratory workers
- Refinery workers

PERMISSIBLE EXPOSURE LIMITS

The Federal standard for *n*-heptane is 500 ppm (2000 mg/m³). (Note: The 1976 ACGIH lists a TLV of 400 ppm (1,600 mg/m³).

ROUTE OF ENTRY

Inhalation of the vapor.

HARMFUL EFFECTS

Local—

n-Heptane can cause dermatitis and mucous membrane irritation. Aspiration of the liquid may result in chemical pneumonitis, pulmonary edema, and hemorrhage.

Systemic—

Systemic effects may arise without complaints of mucous membrane irritation. Exposure to high concentrations causes narcosis producing vertigo, incoordination, intoxication characterized by hilarity, slight nausea, loss of appetite, and a persisting gasoline taste in the mouth. These effects may be first noticed on entering a contaminated area. *n*-Heptane may cause low order sensitization of the myocardium to epinephrine.

MEDICAL SURVEILLANCE

Preplacement examinations should evaluate the skin and general health, including respiratory, liver, and kidney function.

SPECIAL TESTS

None have been commonly used.

PERSONAL PROTECTIVE METHODS

Barrier creams and gloves. Masks where exposed to vapor.

n-HEXANE

DESCRIPTION

$\text{CH}_3(\text{CH}_2)_4\text{CH}_3$, *n*-hexane, is a colorless, volatile liquid and is highly flammable.

SYNONYMS

None.

POTENTIAL OCCUPATIONAL EXPOSURES

n-Hexane is used as a solvent, particularly in the extraction of edible fats and oils, as a laboratory reagent, and as the liquid in low temperature thermometers. Technical and commercial grades consist of 45 to 85% *n*-hexane, as well as cyclopentanes, isohexane, and from 1 to 6% benzene.

A partial list of occupations in which exposure may occur includes:

- Fat processors
- Oil processors
- Thermometer makers

PERMISSIBLE EXPOSURE LIMITS

The Federal standard is 500 ppm (1800 mg/m³) for workroom exposure to *n*-hexane. (Note: The 1976 ACGIH lists a TLV of 100 ppm (360 mg/m³).)

ROUTE OF ENTRY

Inhalation of vapor.

HARMFUL EFFECTS

Local—

Dermatitis and irritation of mucous membranes of the upper respiratory tract.

Systemic—

Asphyxia may be produced by high concentrations. Acute exposure may cause narcosis resulting in slight nausea, headache, and dizziness. Myocardial sensitization to epinephrine may occur but is of low order. Peripheral neuropathy has been reported resulting from exposure to *n*-hexane.

MEDICAL SURVEILLANCE

Consider the skin, respiratory system, central and peripheral nervous system, and general health in preplacement and periodic examinations.

SPECIAL TESTS

None in use.

PERSONAL PROTECTIVE METHODS

Barrier creams and gloves are recommended, as are masks where workers are exposed to vapors.

BIBLIOGRAPHY

Paulson, G. W., and G. W. Waylonis. 1976. Polyneuropathy due to n-hexane. *Arch. Intern. Med.* 136:880.

KEROSENE**DESCRIPTION**

Kerosene is a pale yellow or clear, mobile liquid, composed of a mixture of petroleum distillates, having a characteristic odor. Chemically, it is composed of aliphatic hydrocarbons with 10 to 16 carbons per molecule and benzene and naphthalene derivatives.

SYNONYMS

Kerosine, coal-oil, range-oil.

POTENTIAL OCCUPATIONAL EXPOSURES

Kerosene is used as a fuel for lamps, stoves, jets, and rockets. It is also used for degreasing and cleaning metals and as a vehicle for insecticides.

A partial list of occupations in which exposure may occur includes:

Farmers	Insecticide workers
Garage workers	Jet fuel handlers
Grease removers	Metal cleaners
Heating fuel handlers	Petroleum refinery workers

PERMISSIBLE EXPOSURE LIMITS

Presently there is no Federal standard for kerosene vapor in work-room air.

ROUTE OF ENTRY

Inhalation of vapor.

HARMFUL EFFECTS

Local—

The liquid may produce primary skin irritation as a result of de-

fating. Aspiration of liquid may cause extensive pulmonary injury. Because of its low surface tension, kerosene may spread over a large area, causing pulmonary hemorrhage and chemical pneumonitis. Kerosene mist may also cause mucous membrane irritation.

Systemic—

Inhalation of high concentrations may cause headache, nausea, confusion, drowsiness, convulsions, and coma. When kerosene is ingested, it may cause nausea, vomiting, and, in severe cases, drowsiness progressing to coma, and death by hemorrhagic pulmonary edema and renal involvement.

MEDICAL SURVEILLANCE

No specific considerations are needed.

SPECIAL TESTS

None in use.

PERSONAL PROTECTIVE METHODS

Barrier creams, gloves, and protective clothing are recommended. Where workers are exposed to vapors, masks are recommended.

BIBLIOGRAPHY

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NAPHTHA

DESCRIPTION

Naphthas derived from both petroleum and coal tar are included in this group. Petroleum naphthas composed principally of aliphatic hydrocarbons are termed "close-cut" fractions. "Medium-range" and "wide-range" fractions are made up of 40 to 80 per cent aliphatic hydrocarbons, 25 to 50 per cent naphthenic hydrocarbons, 0 to 10 per cent benzene, and 0 to 20 per cent other aromatic hydrocarbons.

Coal tar naphtha is a mixture of aromatic hydrocarbons, principally toluene, xylene, and cumene. Benzene, however, is present in appreciable amounts in those coal tar naphthas with low boiling points.

SYNONYMS

Petroleum naphtha: ligroin, benzine, petroleum ether, petroleum benzine.

POTENTIAL OCCUPATIONAL EXPOSURES

Naphthas are used as organic solvents for dissolving or softening rubber, oils, greases, bituminous paints, varnishes, and plastics. The less flammable fractions are used in dry cleaning, the heavy naphthas serving as bases for insecticides.

A partial list of occupations in which exposure may occur includes:

Chemical laboratory workers	Petroleum refinery workers
Detergent makers	Rubber coaters
Dry cleaners	Solvent workers
Fat processors	Stainers
Insecticide workers	Varnish makers
Metal degreasers	Wax makers
Oil processors	Wool processors
Painters	Xylene makers

PERMISSIBLE EXPOSURE LIMITS

The Federal standard for petroleum naphtha is 500 ppm (2,000 mg/m³); for coal tar naphtha it is 100 ppm (400 mg/m³).

ROUTE OF ENTRY

Inhalation of vapor. Percutaneous absorption of liquid is probably not important in development of systemic effects unless benzene is present.

HARMFUL EFFECTS

Local—

The naphthas are irritating to the skin, conjunctiva, and the mucous membranes of the upper respiratory tract. Skin "chapping" and photosensitivity may develop after repeated contact with the liquid. If confined against skin by clothing, the naphthas may cause skin burn.

Systemic—

Petroleum naphtha has a lower order of toxicity than that derived from coal tar, where the major hazard is brought about by the aromatic hydrocarbon content. Sufficient quantities of both naphthas cause central nervous system depression. Symptoms include inebriation, followed by headache and nausea. In severe cases, dizziness, convulsions, and unconsciousness occasionally result. Symptoms of anorexia and nervousness have been reported to persist for several months following an acute overexposure, but this appears to be rare. One fraction, hexane, has been reported to have been associated with peripheral neuropathy. (See Hexane.) If benzene is present, coal tar naphthas may produce blood changes such as leukopenia, aplastic anemia, or leukemia. The kidneys and spleen have also been affected in animal experiments. (See Benzene.)

MEDICAL SURVEILLANCE

Preplacement and periodic medical examinations should include the central nervous system. If benzene exposure is present, workers should have a periodic complete blood count (CBC) including hematocrit, hemoglobin, white blood cell count and differential count, mean corpuscular volume and platelet count, reticulocyte count, serum bilirubin determination, and urinary phenol in the preplacement examination and

at 3-month intervals. There are no specific diagnostic tests for naphtha exposure but urinary phenols may indicate exposure to aromatic hydrocarbons. It should be noted that benzene content of vapor may be higher than predicted by content in the liquid.

SPECIAL TESTS

None in common use.

PERSONAL PROTECTIVE METHODS

Workers should use barrier creams, protective clothing, gloves and masks where exposure to the vapor is likely.

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NATURAL GAS

DESCRIPTION

Natural gas consists primarily of methane (85%) with lesser amounts of ethane (9%), propane (3%), nitrogen (2%), and butane (1%). Methane is a colorless, odorless, flammable gas.

SYNONYMS

Marsh gas.

POTENTIAL OCCUPATIONAL EXPOSURES

Natural gas is used principally as a heating fuel. It is transported as a liquid under pressure. It is also used in the manufacture of various chemicals including acetaldehyde, acetylene, ammonia, carbon black, ethyl alcohol, formaldehyde, hydrocarbon fuels, hydrogenated oils, methyl alcohol, nitric acids, synthesis gas, and vinyl chloride. Helium can be extracted from certain types of natural gas.

A partial list of occupations in which exposure may occur includes:

Coal miners	Nitric acid makers
Electric power plant workers	Organic chemical synthesizers
Gas fuel users	Petroleum refinery workers
Helium extractors	Synthetic gas makers
Hydrogen makers	Vinyl chloride makers

PERMISSIBLE EXPOSURE LIMITS

There is no Federal standard for natural gas, methane, nitrogen, or butane. The Federal standard for propane is 1000 ppm (1,800 mg/m³). (Note: the 1974 ACGIH lists a TLV of 600 ppm (145 mg/m³) for butane as an intended change.)

ROUTE OF ENTRY

Inhalation of gas.

HARMFUL EFFECTS*Local—*

Upon escape from pressurized tanks, natural gas may cause frost-bite.

Systemic—

Natural gas is a simple asphyxiant. Displacement of air by the gas may lead to shortness of breath, unconsciousness, and death from hypoxemia. Incomplete combustion may produce carbon monoxide.

MEDICAL SURVEILLANCE

No specific considerations are needed.

SPECIAL TESTS

None are in use.

PERSONAL PROTECTIVE METHOD

Adequate ventilation should quite easily prevent any potential hazard.

PARAFFIN**DESCRIPTION**

Paraffin is a white, somewhat translucent solid and consists of a mixture of solid aliphatic hydrocarbons. It may be obtained from petroleum.

SYNONYMS

Paraffin wax, hard paraffin.

POTENTIAL OCCUPATIONAL EXPOSURES

Paraffin is used in the manufacture of paraffin paper, candles, food package materials, varnishes, floor polishes, and cosmetics. It is also used in waterproofing and extracting of essential oils from flowers for perfume.

A partial list of occupations in which exposure may occur includes:

Candle makers	Polish makers
Cosmetic makers	Varnish makers
Perfume makers	Waxpaper makers

PERMISSIBLE EXPOSURE LIMITS

Paraffin wax fume has no established Federal standard; however, in 1975 the ACGIH recommended a TLV of 0.2 mg/m³ for paraffin wax fume.

ROUTE OF ENTRY

Inhalation of fumes.

HARMFUL EFFECTS

Local—

Occasionally sensitivity reactions have been reported.

Chronic exposure can produce chronic dermatitis, wax boils, folliculitis, comedones, melanoderma, papules, and hyperkeratoses.

Systemic—

Carcinoma of the scrotum in wax pressmen exposed to crude petroleum wax has been documented. Other malignant lesions of an exposed area in employees working with finished paraffin are less well documented. Carcinoma of the scrotum, occurring in workmen exposed 10 years or more, began as a hyperkeratotic nevus-like lesion and developed into a squamous cell carcinoma. The lesions can metastasize to regional inguinal and pelvic lymph nodes. Paraffinoma has been reported from use of paraffin for cosmetic purposes.

MEDICAL SURVEILLANCE

Medical examinations should be concerned especially with the skin. Surveillance should be continued indefinitely.

SPECIAL TESTS

None appear useful.

PERSONAL PROTECTIVE METHODS

Strict personal hygienic measures and protective clothing form the basis of a protective program.

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TURPENTINE

DESCRIPTION

Turpentine is the oleoresin from species of *Pinus Pinacae* trees. The crude oleoresin (gum turpentine) is a yellowish, sticky, opaque mass and the distillate (oil of turpentine) is a colorless, volatile liquid. Chemically, it contains alpha pinene, beta pinene, camphene, mono-cyclic terpenes, and terpene alcohols.

SYNONYMS

Gum turpentine, oil of turpentine, spirit of turpentine, gum spirit, gum [derived from pine resin], wood turpentine [derived from pine stumps], sulfate wood pulp waste.

POTENTIAL OCCUPATIONAL EXPOSURES

Turpentine has found wide use as chemical feedstock for the manufacture of floor, furniture, shoe, and automobile polishes, camphor, cleaning materials, inks, putty, mastics, cutting and grinding fluids, paint thinners, resins, and degreasing solutions. Recently, alpha and beta pinenes, which can be extracted, have found use as volatile bases for various compounds.

A partial list of occupations in which exposure may occur includes:

Art glass workers	Oil additive makers
Belt dressing makers	Paint workers
Camphor makers	Pine oil makers
Drug makers	Resin makers
Furniture polish makers	Rubber workers
Ink makers	Solvent workers
Insecticide makers	Stain makers
Lacquer makers	Varnish workers
Lithographers	Wax makers

PERMISSIBLE EXPOSURE LIMITS

The Federal standard for turpentine is 100 ppm (560 mg/m³).

ROUTE OF ENTRY

Inhalation of vapor and percutaneous absorption of liquid are the usual paths of occupational exposure. However, symptoms have been reported to develop from percutaneous absorption alone.

HARMFUL EFFECTS

Local—

High vapor concentrations are irritating to the eyes, nose, and bronchi. Aspiration of liquid may cause direct lung irritation resulting in pulmonary edema and hemorrhage. Turpentine liquid may produce contact dermatitis. Eczema from turpentine is quite common and has been attributed to the auto-oxidation products of the terpenes (formic acid, formaldehyde, and phenols). This hypersensitivity usually develops in a small portion of the working population. Liquid turpentine splashed in the eyes may cause corneal burns and demands emergency treatment.

Systemic—

Turpentine vapor in acute concentrations may cause central nervous system depression. Symptoms include headache, anorexia, anxiety, excitement, mental confusion, and tinnitus. Convulsions, coma, and death have been reported in animal experiments.

Turpentine vapor also produces kidney and bladder damage. Chronic nephritis with albuminuria and hematuria has been reported as a result of repeated exposures to high concentrations. Predisposition to pneumonia may also occur from such exposures. Recovery usually takes from a few days to a few weeks. Several animal experiments of chronic

low level exposure have produced no ill effects to the central nervous system, kidneys, bladder, or blood.

MEDICAL SURVEILLANCE

Consideration should be given to skin disease or skin allergies in any preplacement or periodic examinations. Liver, renal, and respiratory disease should also be considered.

SPECIAL TESTS

None in common use.

PERSONAL PROTECTIVE METHODS

Rubber gloves, protective clothing, masks for high concentrations.

ALCOHOLS

The alcohols are hydrocarbons in which one or more hydrogen atoms are substituted by hydroxyl (-OH) groups. Compounds with one hydroxyl group are referred to as alcohol. Glycols have two, and glycerols have three, substituted hydroxyl groups. They are widely used as industrial solvents in a variety of products.

In general, alcohols are irritating to mucous membranes. Their toxicity varies, but usually they produce some narcotic effect. They have some disinfectant action and, because of their lipid solubility, most are absorbed to some extent through the skin.

ALLYL ALCOHOL

DESCRIPTION

$H_2C=CHCH_2OH$, allyl alcohol, is a colorless liquid with a pungent odor.

SYNONYMS

Vinyl carbinol, propenyl alcohol, 2-propenol-1, propenol-3.

POTENTIAL OCCUPATIONAL EXPOSURES

Allyl alcohol is primarily used in the production of allyl esters. These compounds are used as monomers and prepolymers in the manufacture of resins and plastics. Allyl alcohol is also used in the preparation of pharmaceuticals, in organic syntheses, and as a fungicide and herbicide.

A partial list of occupations in which exposure may occur includes:

- | | |
|--------------------|-------------------------------|
| Acrolein makers | Herbicide makers |
| Allyl ester makers | Organic chemical synthesizers |
| Drug makers | Plasticizer makers |
| Fungicide makers | Resin makers |
| Glycerine makers | |

PERMISSIBLE EXPOSURE LIMITS

The Federal standard is 2 ppm (5 mg/m³).

ROUTE OF ENTRY

Inhalation of vapor; percutaneous absorption of liquid.

HARMFUL EFFECTS*Local—*

Liquid and vapor are highly irritating to eyes and upper respiratory tract. Skin irritation and burns have occurred from contact with liquid but are usually delayed in onset and may be prolonged.

Systemic—

Local muscle spasms occur at sites of percutaneous absorption. Pulmonary edema, liver and kidney damage, diarrhea, delirium, convulsions, and death have been observed in laboratory animals, but have not been reported in man.

MEDICAL SURVEILLANCE

Preplacement and periodic examinations should include the eyes, skin, respiratory tract, and liver and kidney function.

SPECIAL TESTS

No specific test is available.

PERSONAL PROTECTIVE METHODS

Protective clothing to prevent skin contact should be made of neoprene; these must be discarded at the first sign of deterioration. The odor and irritant properties of allyl alcohol should be sufficient warning to prevent serious injury.

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AMYL ALCOHOL**DESCRIPTION**

$C_5H_{11}OH$, amyl alcohol, has eight isomers. All are colorless liquids, except the isomer 2-dimethyl-1-propanol, which is a crystalline solid.

Amyl alcohols are obtained from fusel oil which forms during the fermentation of grain, potatoes, or beets for ethyl alcohol. The fusel oil is a mixture of amyl alcohol isomers, and the composition is determined somewhat by the sugar source. Amyl alcohols may be prepared by acid hydrolysis of a petroleum fraction.

SYNONYMS

Pentanol, pentyl alcohols, fusel oil, grain oil, potato spirit, potato oil.

POTENTIAL OCCUPATIONAL EXPOSURES

Amyl alcohols are used in the manufacture of lacquers, paints, varnishes, paint removers, shoe cements, perfumes, pharmaceuticals, chemicals, rubber, plastics, fruit essences, explosives, hydraulic fluids, ore-floatation agents, in the preparation of other amyl derivatives, in the extraction of fats, and in the textile and petroleum refining industries.

A partial list of occupations in which exposure may occur includes:

Amyl acetate makers	Perfume makers
Amyl nitrite makers	Petroleum refiners
Explosive makers	Photographic chemical makers
Fat processors	Plastic makers
Flotation workers	Rubber makers
Lacquer makers	Shoe finishers
Mordanters	Textile workers
Oil processors	Wax processors
Painters	

PERMISSIBLE EXPOSURE LIMITS

The Federal standard for 3-methyl-1-butanol (isomyl alcohol) is 100 ppm (360 mg/m³). There are no standards for the other isomers.

ROUTE OF ENTRY

Inhalation of vapor, percutaneous absorption.

HARMFUL EFFECTS

Local—

The liquid and vapor are mild irritants to the membranes of the eyes and upper respiratory tract and skin.

Systemic—

In low concentrations, amyl alcohol may cause irritation of nose and throat, nausea, vomiting, flushing, headache, diplopia, vertigo, and muscular weakness. In higher dosage, it is a narcotic.

MEDICAL SURVEILLANCE

Consider possible irritant effects on skin and respiratory tract in any preplacement or periodic examinations.

SPECIAL TESTS

None in common use. Amyl alcohol can be determined in blood.

PERSONAL PROTECTIVE METHODS

Barrier creams and personal protective clothing should be used to prevent skin contact.

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n-BUTYL ALCOHOL

DESCRIPTION

$\text{CH}_3(\text{CH}_2)_3\text{OH}$, *n*-butyl alcohol, is a colorless volatile liquid with a pungent odor.

SYNONYMS

1-Butanol, butyl hydroxide, propylcarbinol, butyric alcohol, hydroxybutane, *n*-butanol, *n*-propylcarbinol.

POTENTIAL OCCUPATIONAL EXPOSURES

n-Butyl alcohol is used as a solvent for paints, lacquers, varnishes, natural and synthetic resins, gums, vegetable oils, dyes, camphor, and alkaloids. It is also used as an intermediate in the manufacture of pharmaceuticals and chemicals and in the manufacture of artificial leather, safety glass, rubber and plastic cements, shellac, raincoats, photographic films, perfumes, and in plastic fabrication.

A partial list of occupations in which exposure may occur includes:

Alkaloid makers	Photographic film makers
Detergent makers	Plasticizer makers
Drug makers	Stainers
Dye makers	Urea-formaldehyde resin makers
Lacquerers	Varnish makers

PERMISSIBLE EXPOSURE LIMITS

The Federal standard is 100 ppm (300 mg/m³). (Note: the 1976 ACGIH lists a TLV of 50 ppm (150 mg/m³).)

ROUTE OF ENTRY

Inhalation of vapor and percutaneous absorption.

HARMFUL EFFECTS

Local—

The liquid is a primary skin irritant. The vapor is an irritant to the conjunctiva and mucous membranes of the nose and throat. A mild keratitis characterized by corneal vacuoles has been noted at vapor concentrations over 200 ppm.

Systemic—

Inhalation of high concentrations, in addition to the local effects, have produced transitory and persistent dizziness with Meniere's syndrome. Slight headache and drowsiness may also occur.

MEDICAL SURVEILLANCE

Consider irritant effects on eyes, respiratory tract, and skin in any replacement or periodic examinations.

SPECIAL TESTS

None have been used. Blood levels can be determined.

PERSONAL PROTECTIVE METHODS

Barrier creams and protective clothing should be used where skin contact may occur.

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ETHYL ALCOHOL

DESCRIPTION

$\text{CH}_3\text{CH}_2\text{OH}$, ethyl alcohol, is a colorless, volatile, flammable liquid. Ethyl alcohol is produced by fermentation and distillation or by synthesis.

SYNONYMS

Ethanol, grain alcohol, spirit of wine, cologne spirit, ethyl hydroxide, ethyl hydrate.

POTENTIAL OCCUPATIONAL EXPOSURES

Ethyl alcohol is used in the chemical synthesis of a wide variety of compounds such as acetaldehyde, ethyl ether, ethyl chloride, and butadiene. It is a solvent or processing agent in the manufacture of pharmaceuticals, plastics, lacquers, polishes, plasticizers, perfumes, cosmetics, rubber accelerators, explosives, synthetic resins, nitrocellulose, adhesives, inks, and preservatives. It is also used as an antifreeze and as a fuel.

A partial list of occupations in which exposure may occur includes:

Acetaldehyde makers	Ink makers
Acetic anhydride makers	Lacquer makers
Adhesive makers	Motor fuel blenders
Beverage makers	Organic chemical synthesizers
Detergent makers	Rubber makers
Distillers	Shellac processors
Dye makers	Solvent workers
Ethyl ether makers	Stainers
Histology technicians	

PERMISSIBLE EXPOSURE LIMITS

The Federal standard is 1,000 ppm (1,900 mg/m³).

ROUTE OF ENTRY

Inhalation of vapor and percutaneous absorption.

HARMFUL EFFECTS

Local—

Mild irritation of eye and nose occurs at very high concentrations.

The liquid can defat the skin, producing a dermatitis characterized by drying and fissuring.

Systemic—

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

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

MEDICAL SURVEILLANCE

No special considerations needed.

SPECIAL TESTS

Ethyl alcohol can readily be determined in blood, urine, and expired air.

PERSONAL PROTECTIVE METHODS

Personal protective equipment is recommended where skin contact may occur.

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ETHYLENE CHLOROHYDRIN

DESCRIPTION

$\text{CH}_2\text{ClCH}_2\text{OH}$, ethylene chlorohydrin, is a colorless liquid with an ether-like odor.

SYNONYMS

Glycol chlorohydrin, 2-chloroethanol, β -chloroethyl alcohol.

POTENTIAL OCCUPATIONAL EXPOSURES

Ethylene chlorohydrin is used in the synthesis of ethylene glycol, ethylene oxide, amines, carbitols, indigo, malonic acid, novocaine, and in other reactions where the hydroxyethyl group ($-\text{CH}_2\text{CH}_2\text{OH}$) is introduced into organic compounds, for the separation of butadiene from hydrocarbon mixtures, in dewaxing and removing cycloalkanes from mineral oil, in the refining of rosin, in the manufacture of certain pesti-

cides, and in the extraction of pine lignin. In the lacquer industry, it is used as a solvent for cellulose acetate, cellulose esters, resins and waxes, and in the dyeing and cleaning industry, it is used to remove tar spots, as a cleaning agent for machines, and as a solvent in fabric dyeing. It has also found use in agriculture in speeding up sprouting of potatoes and in treating seeds to inhibit biological activity.

A partial list of occupations in which exposure may occur includes:

Cellulose acetate makers	Novocaine makers
Drug makers	Organic chemical synthesizers
Dye makers	Potato growers
Ethyl cellulose workers	Procaine makers
Indigo makers	Resin workers
Lacquer makers	Textile dyers and printers

PERMISSIBLE EXPOSURE LIMITS

The Federal standard is 5 ppm (16 mg/m³).

ROUTE OF ENTRY

Inhalation of vapor; percutaneous absorption of liquid.

HARMFUL EFFECTS

Local—

High vapor concentrations are irritating to the eyes, nose, throat, and skin.

Systemic—

Ethylene chlorohydrin is extremely toxic and in addition to local irritation of eyes, respiratory tract, and skin, inhalation of the vapor may produce nausea, vomiting, dizziness, headache, thirst, delirium, low blood pressure, collapse, and unconsciousness. The urine may show red cells, albumin, and casts. Death may occur in high concentrations with damage to the lung and brain. There is little margin of safety between early reversible symptoms and fatal intoxication. The toxic effects may be related to its metabolites, chloroacetaldehyde and chloroacetic acid.

MEDICAL SURVEILLANCE

Preplacement examination, including a complete history and physical should be performed. Examination of the respiratory system, liver, kidneys, and central nervous system should be stressed. The skin should be examined. A chest X-ray should be taken and pulmonary function tests performed (FVC-FEV).

The above procedures should be repeated on an annual basis, except that the X-ray is needed only when indicated by pulmonary function testing.

SPECIAL TESTS

None commonly used. Presence in blood can probably be determined by appropriate gas chromatographic methods.

PERSONAL PROTECTIVE METHODS

The liquid readily penetrates rubber. Protective clothing should be discarded at first sign of deterioration. Barrier creams may be used and scrupulous personal hygiene should be practiced.

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METHYL ALCOHOL

DESCRIPTION

CH_3OH , methyl alcohol, is a colorless, volatile liquid with a mild odor.

SYNONYMS

Methanol, carbinol, wood alcohol, wood spirit.

POTENTIAL OCCUPATIONAL EXPOSURES

Methyl alcohol is used as a starting material in organic synthesis of chemicals such as formaldehyde, methacrylates, methyl amines, methyl halides, and ethylene glycol, and as an industrial solvent for inks, resins, adhesives, and dyes for straw hats. It is an ingredient in paint and varnish removers, cleaning and dewaxing preparations, spirit duplicating fluids, embalming fluids, antifreeze mixtures, and enamels and is used in the manufacture of photographic film, plastics, celluloid, textile soaps, wood stains, coated fabrics, shatterproof glass, paper coating, water-proofing formulations, artificial leather, and synthetic indigo and other dyes. It has also found use as an extractant in many processes, an anti-detonant fuel-injection fluid for aircraft, a rubber accelerator, and a denaturant for ethyl alcohol.

A partial list of occupations in which exposures may occur includes:

Acetic acid makers	Foundry workers
Art glass workers	Gilders
Bookbinders	Ink makers
Bronzers	Lasters
Dyers	Leather workers
Enamel makers	Millinery workers
Ester makers	Painters
Feather workers	Photoengravers
Felt hat makers	

PERMISSIBLE EXPOSURE LIMITS

The Federal standard is 200 ppm (260 mg/m³).

ROUTE OF ENTRY

Inhalation of vapor; percutaneous absorption of liquid.

HARMFUL EFFECTS

Local—

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

Systemic—

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

MEDICAL SURVEILLANCE

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

SPECIAL TESTS

Determination of methyl alcohol in blood, and methyl alcohol and formic acid in urine. Estimation of alkali reserve which may be impaired because of acidosis following accidental ingestion.

PERSONAL PROTECTIVE METHODS

Barrier creams and protective clothing.

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PROPYL ALCOHOL

DESCRIPTION

There are two isomers of propyl alcohol, n-propyl alcohol ($\text{CH}_3\text{-CH}_2\text{CH}_2\text{OH}$) and isopropyl alcohol ($\text{CH}_3\text{CHOHCH}_3$). Both are colorless, volatile liquids.

SYNONYMS

n-Propyl alcohol: 1-Propanol, propylic alcohol. Isopropyl alcohol: Isopropanol, 2-propanol, secondary propyl alcohol, dimethylcarbinol.

POTENTIAL OCCUPATIONAL EXPOSURES

Isopropyl alcohol is the more widely used of the two isomers. In the pharmaceutical industry, it has replaced ethyl alcohol in liniments,

skin lotions, cosmetics, permanent wave preparations, hair tonics, mouth washes, and skin disinfectants and is widely used as a rubbing alcohol. Isopropyl alcohol is used in the manufacture of acetone, isopropyl derivatives, and safety glass, as a solvent in perfumes, resins and plastics, dye solutions, nitrocellulose lacquers, and in many extraction processes and is an ingredient of antifreezes, deicing agents, liquid soaps, and window cleaners. Further applications include use as a preservative and dehydrating agent, a coupling agent in oil emulsions, an extracting agent for sulfonic acids from petroleum oils, and for coatings in textiles. n-Propyl alcohol is used in lacquers, dopes, cosmetics, dental lotions, cleaners, polishes, and pharmaceuticals and as a surgical antiseptic. It is a solvent for vegetable oils, natural gums and resins, rosin, shellac, certain synthetic resins, ethyl cellulose, and butyral.

A partial list of occupations in which exposure may occur includes:

Disinfectant makers	Resin makers
Drug makers	Soap makers
Gum processors	Stainers
Metal degreasers	Vegetable oil processors
Nurses	Wax makers
Perfume makers	Window cleaning fluid makers
Polish makers	

PERMISSIBLE EXPOSURE LIMITS

The Federal standard for n-propyl alcohol is 200 ppm (500 mg/m³) and for isopropyl alcohol, 400 ppm (980 mg/m³).

ROUTE OF ENTRY

Isopropyl alcohol: Inhalation of vapor.

n-Propyl alcohol: Inhalation of vapor, percutaneous absorption.

HARMFUL EFFECTS

Local—

The two isomers are similar in physical and in most physiological properties. The vapors are mildly irritating to the conjunctiva and mucous membranes of the upper respiratory tract.

Systemic—

No cases of poisoning from industrial exposure have been recorded for either isomer. n-Propyl alcohol can produce mild central nervous system depression; isopropyl alcohol is potentially narcotic in high concentrations.

MEDICAL SURVEILLANCE

No specific considerations are needed.

SPECIAL TESTS

Isopropyl alcohol and its metabolite, acetone, may be detected in blood, urine, and body tissues.

PERSONAL PROTECTIVE METHODS

Clothing and barrier creams are recommended.

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GLYCOLS AND DERIVATIVES

Glycols are dihydric alcohols which are colorless, viscous liquids. Because these compounds are soluble in alcohol and water and have high boiling points and low freezing points, they are used as solvents and antifreeze. Ethylene glycol, like ethyl alcohol, is often called by the class name, i.e., glycol. These compounds have relatively low toxicity, and the major hazard appears when the liquids are heated during processing.

ETHYLENE GLYCOL

DESCRIPTION

$\text{HOCH}_2\text{CH}_2\text{OH}$, ethylene glycol, is a colorless, odorless, viscous liquid with a sweetish taste.

SYNONYMS

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

POTENTIAL OCCUPATIONAL EXPOSURES

Because of ethylene glycol's physical properties, it is used in anti-freeze, hydraulic fluids, electrolytic condensers, and heat exchangers. It is also used as a solvent and as a chemical intermediate for ethylene glycol dinitrate, glycol esters, and resins.

A partial list of occupations in which exposure may occur includes:

Antifreeze makers	Metal polishers
Brake fluid makers	Paint makers
Explosive makers	Resin makers
Glue makers	Textile makers
Hydraulic fluid makers	Tobacco workers
Ink makers	Wax makers
Metal cleaners	

PERMISSIBLE EXPOSURE LIMITS

There is no Federal standard; however, ACGIH in 1975 recommended a TLV of 10 mg/m³ for particulate ethylene glycol and 100 ppm (260 mg/m³) for the vapor form.

ROUTE OF ENTRY

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

HARMFUL EFFECTS

Local—

None.

Systemic—

Ethylene glycol's vapor pressure is such that at room temperature toxic concentrations are unlikely to occur. Poisoning resulting from vapor usually occurs only if ethylene glycol liquid is heated; therefore, occupational exposure is rare. Chronic symptoms and signs include: anorexia, oliguria, nystagmus, lymphocytosis, and loss of consciousness. Inhalation seems to primarily result in central nervous system depression and hematopoietic dysfunction, whereas, ingestion may result in depression followed by respiratory and cardiac failure, renal and brain damage.

MEDICAL SURVEILLANCE

No special considerations are needed.

SPECIAL TESTS

Urinalysis for oxalic acid, an ethylene glycol metabolite, may be useful in diagnosis of poisoning by oral ingestion.

PERSONAL PROTECTIVE METHODS

Masks should be worn in areas of vapor concentration.

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ETHYLENE GLYCOL ETHERS AND DERIVATIVES

DESCRIPTION

Ethylene glycol monoethyl ether: $\text{CH}_3\text{CH}_2\text{OCH}_2\text{CH}_2\text{OH}$.Ethylene glycol monoethyl ether acetate: $\text{CH}_3\text{CH}_2\text{OCH}_2\text{CH}_2\text{OO}-\text{CCH}_3$.Ethylene glycol monomethyl ether: $\text{CH}_3\text{OCH}_2\text{CH}_2\text{OH}$.Ethylene glycol monomethyl ether acetate: $\text{CH}_3\text{OCH}_2\text{CH}_2\text{OOC}-\text{CH}_3$.Ethylene glycol monobutyl ether: $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OCH}_2\text{CH}_2\text{OH}$.

These substances are colorless liquids with a slight odor.

SYNONYMS

Ethylene glycol monoethyl ether: cellosolve, 2-ethoxyethanol.

Ethylene glycol monoethyl ether acetate: cellosolve acetate, 2-ethoxyethyl acetate.

Ethylene glycol monomethyl ether: methyl cellosolve, 2-methoxyethanol.

Ethylene glycol monomethyl ether acetate: methyl cellosolve acetate, 2-methoxyethyl acetate.

Ethylene glycol monobutyl ether: butyl cellosolve, 2-butoxyethanol.

POTENTIAL OCCUPATIONAL EXPOSURES

Ethylene glycol ethers are used as solvents for resins, lacquers, paints, varnishes, gum, perfume, dyes and inks, and as a constituent of painting pastes, cleaning compounds, liquid soaps, cosmetics, nitrocellulose, and hydraulic fluids. Acetate derivatives are used as solvents for oils, greases and ink, in the preparation of lacquers, enamels, and adhesives, and to dissolve resins and plastics.

A partial list of occupations in which exposure may occur includes:

Cellophane sealers	Nail polish makers
Cleaning solution makers	Oil processors
Dry cleaners,	Plastic makers
Film makers	Printers
Hydraulic fluid makers	Stainers
Ink makers	Textile dyers
Lacquer makers	Wax processors

PERMISSIBLE EXPOSURE LIMITS

The Federal standards for these compounds are:

Ethylene glycol monoethyl ether	200 ppm	740 mg/m ³
Ethylene glycol monoethyl ether acetate	100 ppm	540 mg/m ³
Ethylene glycol monomethyl ether	25 ppm	80 mg/m ³
Ethylene glycol monomethyl ether acetate	25 ppm	120 mg/m ³
Ethylene glycol monobutyl ether	50 ppm	240 mg/m ³

ACGIH in 1975 recommended a TLV of 25 ppm (120 mg/m³) for ethylene glycol monomethyl ether acetate.

ROUTE OF ENTRY

Inhalation of vapor and percutaneous absorption of liquid.

HARMFUL EFFECTS

Local—

Ethylene glycol ethers are only mildly irritating to the skin. Vapor may cause conjunctivitis and upper respiratory tract irritation. Temporary corneal clouding may also result and may last several hours. Acetate derivatives cause greater eye irritation than the parent compounds. The butyl and methyl ethers may penetrate skin readily.

Systemic—

Acute exposure to these compounds results in narcosis, pulmonary

edema, and severe kidney and liver damage. Symptoms from repeated overexposure to vapors are fatigue and lethargy, headache, nausea, anorexia, and tremor. Anemia and encephalopathy have been reported with ethylene glycol monomethyl ether. Rats show increased hemolysis of erythrocytes from inhalation of ethylene glycol monobutyl ether. This has not been shown in man. Acute poisoning by ingestion resembles ethylene glycol toxicity, with death from renal failure.

MEDICAL SURVEILLANCE

Preplacement and periodic examinations should evaluate blood, central nervous system, renal and liver functions, as well as the skin and respiratory tract.

SPECIAL TESTS

None currently used.

PERSONAL PROTECTIVE METHODS

Use glasses and protective clothing to prevent skin absorption. Respiratory protection may be needed if ventilation is poor or if compounds are heated or atomized.

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ETHERS AND EPOXY COMPOUNDS

Ethers are organic molecules which contain a carbon-oxygen-carbon linkage. Colorless, volatile liquids, these compounds are generally used industrially as solvents and chemical feedstock for organic synthetics. Ethyl ether, the simplest ether, has been used as a general anesthetic and has been historically known as "ether." Occupationally, exposure to chlorinated ethers is much more significant. Two compounds, bis-(chloromethyl) ether and chloromethyl methyl ether, have produced carcinoma and, therefore, have received much attention recently. Dioxane, although it is not chlorinated, has also shown potential tumorigenic hazard. Skin, eye, and mucous membrane irritation is common to all the chemicals covered. Pulmonary edema, with the added hazard of delayed appearance, may also occur as a result of particular ether exposures.

Epoxy compounds are cyclic ethers with the structure $-C-O-C-$. The most important industrially are the alpha-epoxy compounds in which the epoxy group is in the 1-2 position. These are the most reactive and are used as chemical intermediates in the manufacture of surface-active agents, plasticizers, synthetic resins, solvents, etc.

BIS(CHLOROMETHYL) ETHER**DESCRIPTION**

$\text{ClCH}_2\text{OCH}_2\text{Cl}$, bis(chloromethyl) ether, is a colorless, volatile liquid with a suffocating odor. This substance may form spontaneously in warm moist air by the combination of formaldehyde and hydrogen chloride.

SYNONYMS

BCME, sym-dichloromethyl ether.

POTENTIAL OCCUPATIONAL EXPOSURES

Exposure to bis(chloromethyl) ether may occur in industry and in the laboratory. This compound is used as an alkylating agent in the manufacture of polymers, as a solvent for polymerization reactions, in the preparation of ion exchange resins, and as an intermediate for organic synthesis.

A partial list of occupations in which exposure may occur includes:

Ion exchange resin makers	Organic chemical synthesizers
Laboratory workers	Polymer makers

PERMISSIBLE EXPOSURE LIMITS

Bis(chloromethyl) ether is included in the Federal standard for carcinogens; all contact with it should be avoided.

ROUTE OF ENTRY

Inhalation of vapor and perhaps, but to a lesser extent, percutaneous absorption.

HARMFUL EFFECTS*Local—*

Vapor is severely irritating to the skin and mucous membranes and may cause corneal damage which may heal slowly.

Systemic—

Bis(chloromethyl) ether has an extremely suffocating odor even in minimal concentration so that experience with acute poisoning is not available. It is not considered a respiratory irritant at concentrations of 10 ppm. Bis(chloromethyl) ether is a known human carcinogen. Animal experiments have shown increases in lung adenoma incidence; olfactory esthesioneuroepitheliomas which invaded the sinuses, cranial vault, and brain; skin papillomas and carcinomas; and subcutaneous fibrosarcomas. There have been several reports of increased incidence of human lung carcinomas (primarily small cell undifferentiated) among ether workers exposed to bis(chloromethyl) ether as an impurity. The latency period is relatively short — 10 to 15 years. Smokers as well as non-smokers may be affected.

MEDICAL SURVEILLANCE

Replacement and periodic medical examinations should include an examination of the skin and respiratory tract, including chest X-ray. Sputum cytology has been suggested as helpful in detecting early malignant changes, and in this connection a smoking history is of importance. Possible effects on the fetus should be considered.

SPECIAL TESTS

None have been suggested.

PERSONAL PROTECTIVE METHODS

These are designed to supplement engineering controls and should be appropriate for protection of all skin or respiratory contact. Full body protective clothing and gloves should be used on entering areas of potential exposure. Those employed in handling operations should be provided with full face, supplied air respirators of continuous flow or pressure demand type. On exit from a regulated area, employees should remove and leave protective clothing and equipment at the point of exit, to be placed in impervious containers at the end of the work shift for decontamination or disposal. Showers should be taken before dressing in street clothes.

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CHLOROMETHYL METHYL ETHER**DESCRIPTION**

$\text{ClCH}_2\text{OCH}_3$, chloromethyl methyl ether, is a volatile, corrosive liquid. Commercial chloromethyl methyl ether contains from 1 to 7 per cent bis(chloromethyl) ether, a known carcinogen.

SYNONYMS

CMME, methyl chloromethyl ether, monochloromethyl ether, chloromethoxymethane.

POTENTIAL OCCUPATIONAL EXPOSURES

Chloromethyl methyl ether is a highly reactive methylating agent and is used in the chemical industry for synthesis of organic chemicals. Most industrial operations are carried out in closed process vessels so that exposure is minimized.

A partial list of occupations in which exposure may occur includes:
Organic chemical synthesizers

PERMISSIBLE EXPOSURE LIMITS

Chloromethyl methyl ether is included in the Federal standard for carcinogens; all contact with it should be avoided.

ROUTE OF ENTRY

Inhalation of vapor and possibly percutaneous absorption.

HARMFUL EFFECTS

Local—

Vapor exposure results in severe irritation of the skin, eyes, and nose. Rabbit skin tests using undiluted material resulted in skin necrosis.

Systemic—

Chloromethyl methyl ether is only moderately toxic given orally. Acute exposure to chloromethyl methyl ether vapor may result in pulmonary edema and pneumonia.

Several studies of workers with CMME manufacturing exposure have shown an excess of bronchiogenic cancer predominately of the small cell-undifferentiated type with relatively short latency period (typically 10-15 years). Therefore, commercial grade chloromethyl methyl ether must be considered a carcinogen. At present it is not known whether or not chloromethyl methyl ether's carcinogenic activity is due to bis(chloromethyl) ether (BCME) contamination, but this may be a moot question inasmuch as two of the hydrolysis products of CMME can combine to form BCME. Animal experiments to determine chloromethyl methyl ether's ability to produce skin cancer indicated marginal carcinogenic activity; highly pure CMME was used. Inhalation studies, using technical grade CMME showed only one bronchiogenic cancer and one esthesioneuroepithelioma out of 79 animals exposed.

MEDICAL SURVEILLANCE

Replacement and periodic medical examinations should include an examination of the skin and respiratory tract, including a chest X-ray. Sputum cytology has been suggested as helpful in detecting early malignant changes, and in this connection a detailed smoking history is of importance. Possible effects on the fetus should be considered.

SPECIAL TESTS

None have been suggested.

PERSONAL PROTECTIVE METHODS

These are designed to supplement engineering controls and to prevent all skin or respiratory contact. Full body protective clothing and gloves should be used on entering areas of partial exposure. Those employed in handling operations should be provided with fullface, sup-

plied air respirators of continuous flow or pressure demand type. On exit from a regulated area, employees should be required to remove and leave protective clothing and equipment at the point of exit, to be placed in impervious containers at the end of the work-shift for decontamination or disposal. Showers should be taken prior to dressing in street clothes.

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DICHLOROETHYL ETHER

DESCRIPTION

$\text{ClCH}_2\text{CH}_2\text{OCH}_2\text{CH}_2\text{Cl}$, dichloroethyl ether, is a clear, colorless liquid with a pungent, fruity odor.

SYNONYMS

Dichloroether, dichloroethyl oxide, sym-dichloroethyl ether, bis-(2-chloroethyl) ether, 2, 2-dichloroethyl ether.

POTENTIAL OCCUPATIONAL EXPOSURES

Dichloroethyl ether is used in the manufacture of paint, varnish, lacquer, soap, and finish remover. It is also used as a solvent for cellulose esters, naphthalenes, oils, fats, greases, pectin, tar, and gum; in dry-cleaning; in textile scouring; and in soil fumigation.

A partial list of occupations in which exposure may occur includes:

Cellulose ester makers	Oil processors
Degreasers	Paint makers
Drycleaners	Soap makers
Ethyl cellulose processors	Tar processors
Fat processors	Textile scourers
Gum processors	Varnish workers
Lacquer makers	

PERMISSIBLE EXPOSURE LIMITS

The Federal standard for dichloroethyl ether is 15 ppm (90 mg/m³); however, the ACGIH recommended TLV in 1975 was 5 ppm (30 mg/m³).

ROUTE OF ENTRY

Inhalation of vapor, percutaneous absorption.

HARMFUL EFFECTS

Local—

Irritation of the conjunctiva of the eyes with profuse lacrimation, irritation to mucous membranes of upper respiratory tract, coughing, and nausea may result from exposure to vapor. The liquid when placed in animal eyes has produced damage. Vapors in minimal concentrations (3 ppm) are distinctly irritating and serve as a warning property.

Systemic—

In animal experiments dichloroethyl ether has caused severe irritation of the respiratory tract and pulmonary edema. Animal experiments have also shown dichloroethyl ether to be capable of causing drowsiness, dizziness, and unconsciousness at high concentrations. Except for accidental inhalation of high concentrations, the chief hazard in industrial practice is a mild bronchitis which may be caused by repeated exposure to low concentrations.

MEDICAL SURVEILLANCE

Consideration should be given to the skin, eyes, and respiratory tract, and to the central nervous system in placement or periodic examinations.

SPECIAL TESTS

None have been proposed.

PERSONAL PROTECTIVE METHODS

In cases of vapor concentrations, protective clothing with full-face respirator with air supply should be worn. Skin protection (gloves, protective clothing) is needed to prevent skin absorption. Goggles should be used to prevent eye burns.

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DIOXANE

DESCRIPTION

$\text{OCH}_2\text{CH}_2\text{OCH}_2\text{CH}_2$, dioxane, is a volatile, colorless liquid that may form explosive peroxides during storage.

SYNONYMS

1,4-Diethylene dioxide, diethylethene ether, 1,4-dioxane, para-dioxane.

POTENTIAL OCCUPATIONAL EXPOSURES

Dioxane finds its primary use as a solvent for cellulose acetate,

dyes, fats, greases, lacquers, mineral oil, paints, polyvinyl polymers, resins, varnishes, and waxes. It finds particular usage in paint and varnish strippers, as a wetting agent and dispersing agent in textile processing, dye baths, stain and printing composition, and in the preparation of histological slides.

A partial list of occupations in which exposure may occur includes:

Adhesive workers	Histology technicians
Cellulose acetate workers	Lacquer makers
Cement workers	Metal cleaners
Degreasers	Oil processors
Deodorant makers	Paint makers
Detergent workers	Polish makers
Emulsion makers	Shoe cream makers
Fat processors	Varnish remover makers
Glue makers	Wax makers

PERMISSIBLE EXPOSURE LIMITS

The Federal standard is 100 ppm (360 mg/m³); however, the ACGIH 1975 recommended TLV was 50 ppm (180 mg/m³) of technical grade.

ROUTE OF ENTRY

Inhalation of vapor as well as percutaneous absorption.

HARMFUL EFFECTS

Local—

Liquid and vapor may be irritating to eyes, nose, and throat.

Systemic—

Exposure to dioxane vapor may cause drowsiness, dizziness, loss of appetite, headache, nausea, vomiting, stomach pain, and liver and kidney damage. Prolonged skin exposure to the liquid may cause drying and cracking.

MEDICAL SURVEILLANCE

Preplacement and periodic examinations should be directed to symptoms of headache and dizziness, as well as nausea and other gastrointestinal disturbances. The condition of the skin and of renal and liver function should be considered.

SPECIAL TESTS

No specific bio-monitoring tests are available.

PERSONAL PROTECTIVE METHODS

In areas of vapor concentration, protective clothing, barrier creams, gloves, and masks should be used.

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EPICHLOROHYDRIN

DESCRIPTION

$\text{CH}_2\text{OCHCH}_2\text{Cl}$, epichlorohydrin, is a colorless liquid with a chloroform-like odor.

SYNONYMS

Epi, chloropropylene oxide, 1-chloro-2,3-epoxypropane, chloromethyloxidrane, 2-epichlorohydrin.

POTENTIAL OCCUPATIONAL EXPOSURES

Epichlorohydrin is used in the manufacture of many glycerol and glycidol derivatives and epoxy resins, as a stabilizer in chlorine-containing materials, as an intermediate in the preparation of cellulose esters and ethers, paints, varnishes, nail enamels, and lacquers, and as a cement for celluloid.

A partial list of occupations in which exposure may occur includes:

Cellulose ether workers	Lacquer makers
Epoxy resin makers	Nail enamel makers
Glycerol derivative makers	Organic chemical synthesizers
Glycerophosphoric acid makers	Paint makers
Glycidol derivative makers	Resin makers
Gum processors	Solvent workers
Lacquerers	Varnish makers

PERMISSIBLE EXPOSURE LIMITS

The Federal standard is 5 ppm (19 mg/m³). NIOSH has recommended a time-weighted average limit of 2 mg/m³ with a ceiling concentration of 19 mg/m³ based on a 15-minute sampling period.

ROUTE OF ENTRY

Inhalation of vapor, percutaneous absorption of liquid.

HARMFUL EFFECTS

Local—

Epichlorohydrin is highly irritating to eyes, skin, and respiratory tract. Skin contact may result in delayed blistering and deep-seated pain. Allergic eczematous contact dermatitis occurs occasionally.

Systemic—

The earliest symptoms of intoxication may be referable to the gastrointestinal tract (nausea, vomiting, abdominal discomfort) or pain in the region of the liver. Labored breathing, cough, and cyanoses may be

evident and the onset of chemical pneumonitis may occur several hours after exposure. Animals exposed repeatedly to this chemical have developed lung, kidney, and liver injury.

MEDICAL SURVEILLANCE

Consider possible effects on the skin, eyes, lungs, liver, and kidney in replacement or periodic examinations.

SPECIAL TESTS

None currently used.

PERSONAL PROTECTIVE METHODS

Goggles and rubber, protective clothing should be worn. Epichlorohydrin slowly penetrates rubber, so all contaminated clothing should be thoroughly washed. Respirators are required in areas of vapor concentrations.

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ETHYLENE OXIDE

DESCRIPTION

H_2COCH_2 , ethylene oxide, is a colorless gas with a sweetish odor.

SYNONYMS

1,2-Epoxyethane, oxirane, dimethylene oxide, anprolene.

POTENTIAL OCCUPATIONAL EXPOSURES

Ethylene oxide is used as an intermediate in organic synthesis for ethylene glycol, polyglycols, glycol ethers esters, ethanolamines, acrylonitrile, plastics, and surface-active agents. It is also used as a fumigant for foodstuffs and textiles, an agricultural fungicide, and for sterilization, especially for surgical instruments.

A partial list of occupations in which exposure may occur includes:

Acrylonitrile makers	Fungicide workers
Butyl cellosolve makers	Gasoline sweeteners
Detergent makers	Grain elevator workers
Disinfectant makers	Organic chemical synthesizers
Ethanolamine makers	Polyglycol makers
Ethylene glycol makers	Polyoxirane makers
Exterminators	Rocket fuel handlers
Foodstuff fumigators	Surfactant makers
Fumigant makers	Textile fumigators

PERMISSIBLE EXPOSURE LIMITS

The Federal standard is 50 ppm (90 mg/m³).

ROUTE OF ENTRY

Inhalation of gas.

HARMFUL EFFECTS

Local—

Aqueous solutions of ethylene oxide or solutions formed when the anhydrous compound comes in contact with moist skin are irritating and may lead to a severe dermatitis with blisters, blebs, and burns. It is also absorbed by leather and rubber and may produce burns or irritation. Allergic eczematous dermatitis has also been reported. Exposure to the vapor in high concentrations leads to irritation of the eyes. Severe eye damage may result if the liquid is splashed in the eyes. Large amounts of ethylene oxide evaporating from the skin may cause frostbite.

Systemic—

Breathing high concentrations of ethylene oxide may cause nausea, vomiting, irritation of the nose, throat, and lungs. Pulmonary edema may occur. In addition, drowsiness and unconsciousness may occur. Ethylene oxide has been found to cause cancer in female mice exposed to it for prolonged periods.

Ethylene oxide is a well-known mutagen in commercial use in plants. No mutagenic effect has been demonstrated in man or animals.

MEDICAL SURVEILLANCE

Preplacement and periodic examinations should consider the skin and eyes, allergic history, the respiratory tract, blood, liver, and kidney function.

SPECIAL TESTS

None in common use.

PERSONAL PROTECTIVE METHODS

Eyes and skin should be protected and protective clothing changed when it is contaminated. In areas of high vapor concentration, respirators should be supplied to cover the face, including eyes. Shoes contaminated by this chemical should be discarded.

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ETHYL ETHER

DESCRIPTION

$\text{CH}_3\text{CH}_2\text{OCH}_2\text{CH}_3$, ethyl ether, is a colorless, mobile, highly flammable, volatile liquid with a characteristic pungent odor.

SYNONYMS

Anesthetic ether, diethyl ether, diethyl oxide, ether, ethoxyethane, ethyl oxide, sulfuric ether.

POTENTIAL OCCUPATIONAL EXPOSURES

Ethyl ether is used as a solvent for waxes, fats, oils, perfumes, alkaloids, dyes, gums, resins, nitrocellulose, hydrocarbons, raw rubber, and smokeless powder. It is also used as an inhalation anesthetic, a refrigerant, in diesel fuels, in dry cleaning, as an extractant, and as a chemical reagent for various organic reactions.

A partial list of occupations in which exposure may occur includes:

Acetic acid makers	Gum processors
Alcohol denaturers	Motor fuel makers
Collodion makers	Nitrocellulose makers
Diesel fuel blenders	Oil processors
Drug makers	Perfume makers
Explosive makers	Rayon makers
Fat processors	Rubber workers
Gasoline engine primers	Smokeless powder makers
Dye makers	Wax makers

PERMISSIBLE EXPOSURE LIMITS

The Federal standard is 400 ppm (1,200 mg/m³).

ROUTE OF ENTRY

Inhalation of vapor.

HARMFUL EFFECTS

Local—

Ethyl ether vapor is mildly irritating to the eyes, nose, and throat. Contact with liquid may produce a dry, scaly, fissured dermatitis.

Systemic—

Ethyl ether has predominantly narcotic properties. Overexposed individuals may experience drowsiness, vomiting, and unconsciousness. Death may result from severe overexposure. Chronic exposure results in some persons in anorexia, exhaustion, headache, drowsiness, dizziness, excitation, and psychic disturbances. Albuminuria has been reported. Chronic exposure may cause an increased susceptibility to alcohol.

MEDICAL SURVEILLANCE

Replacement or periodic examinations should evaluate the skin and respiratory tract, liver, and kidney function. Persons with a past history of alcoholism may be at some increased risk due to possibility of ethyl ether addiction (known as "ether habit").

SPECIAL TESTS

Tests for exposure may include expired breath for unmetabolized ethyl ether and blood for ethyl ether content by oxidation with chromate solution or by gas chromatographic methods.

PERSONAL PROTECTIVE METHODS

Barrier creams, gloves, protective clothing, and, in areas of vapor concentration, fullface respirator should be used.

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ESTERS

Esters are organic compounds with the structure $R-COOR'$. They are generally the result of the reaction between an organic or inorganic acid and alcohol with the elimination of water; however, other reactions, such as between an alcohol and an acid halide, will also form esters. The organic acid may be aliphatic or aromatic and may contain other substituents. Mono-, di-, or tricarboxylic esters may be formed.

Esters are an industrially important group of compounds. They are used in plastics and resins, as plasticizers, in lacquer solvents, in flavors and perfumes, in pharmaceuticals, and in industries such as automotive, aircraft, food processing, chemical, pharmaceutical, soap, cosmetic, surface coating, textiles, and leather.

There are four basic types of physiological effects of esters, and these can generally be related to structure. 1) Anesthesia and primary irritation are characteristic of most simple aliphatic esters. 2) Lacrimation, vesication, and lung irritation are due to the halogen atom in halogenated esters. 3) Cumulative organic damage to the nervous system or neuropathy can be caused by some, but not all, phosphate esters. 4) Most aliphatic and aromatic esters used as plasticizers are physiologically inert.

ACETATES

DESCRIPTION

- Methyl acetate: CH_3COOCH_3 .
 Ethyl acetate: $CH_3COOC_2H_5$.
 n-Propyl acetate: $CH_3COOC_3H_7$.
 Isopropyl acetate: $CH_3COOCH(CH_3)_2$.
 n-Butyl acetate: $CH_3COOC_4H_9$.
 Amyl acetate: $CH_3COOC_5H_{11}$.

The acetates are colorless, volatile, flammable liquids.

SYNONYMS

- Methyl acetate: none.
 Ethyl acetate: acetic ether, vinegar naphtha.
 n-Propyl acetate: acetic acid-propyl ester.
 Isopropyl acetate: none.
 n-Butyl acetate: butyl ethanoate, acetic acid butyl ester.
 Amyl acetate: isoamyl acetate, pear oil, banana oil, amyl acetate ester, pentyl acetate.

POTENTIAL OCCUPATIONAL EXPOSURES

The acetates are a group of solvents for cellulose nitrate, cellulose acetate, ethyl cellulose, resins, rosin, cumar, elemi, phenolics, oils, fats, and celluloid. They are also used in the manufacture of lacquers, paints, varnishes, enamel, perfumes, dyes, dopes, plastic and synthetic finishes (e.g., artificial leather), smokeless powder, photographic film, footwear, pharmaceuticals, food preservatives, artificial glass, artificial silk, furniture polish, odorants, and other organic syntheses.

A partial list of occupations in which exposure may occur includes:

Cellulose acetate makers	Nitrocellulose makers
Cumar makers	Paint makers
Dope makers	Perfume makers
Dye makers	Resin makers
Elemi makers	Rosin makers
Lacquer makers	Varnish makers

PERMISSIBLE EXPOSURE LIMITS

The Federal standards are:

Methyl acetate	200 ppm	610 mg/m ³
Ethyl acetate	400 ppm	1,400 mg/m ³
n-Propyl acetate	200 ppm	840 mg/m ³
Isopropyl acetate	250 ppm	950 mg/m ³
n-Butyl acetate	150 ppm	710 mg/m ³
Isoamyl acetate	100 ppm	525 mg/m ³
n-Amyl acetate	100 ppm	525 mg/m ³
sec-Amyl acetate	125 ppm	650 mg/m ³
sec-Butyl acetate	200 ppm	950 mg/m ³
tert-Butyl acetate	200 ppm	950 mg/m ³

ROUTE OF ENTRY

Inhalation and ingestion.

HARMFUL EFFECTS

Local—

In higher concentrations, acetates are irritants to the mucous membranes. All irritate eyes and nasal passages in varying degrees. Prolonged exposure can cause irritation of the intact skin. These local effects are the primary risk in industry.

Systemic—

All acetates may cause headache, drowsiness, and unconsciousness if concentrations are high enough. Those effects are relatively slow and gradual in onset and slow in recovery after exposure.

MEDICAL SURVEILLANCE

Consider initial effects on skin and respiratory tract in any pre-placement or periodical examinations, as well as liver and kidney function.

SPECIAL TESTS

None in common use.

PERSONAL PROTECTIVE METHODS

Barrier creams and protective clothing with gloves should be used, as well as fullface masks in areas of vapor concentration.

BIBLIOGRAPHY

Von Oettingen, W. F. 1960. The aliphatic acids and their esters: toxicity and potential dangers. The saturated monobasic acids and their esters: aliphatic acids with three to eighteen carbons and their esters. *AMA Arch. Ind. Health* 21:100.

ETHYL SILICATE

DESCRIPTION

$(\text{CH}_2\text{H}_5\text{O})_4\text{Si}$, ethyl silicate, is a colorless, flammable liquid with a sharp odor detectable at 85 ppm.

SYNONYMS

Tetraethyl orthosilicate, tetraethoxy silane.

POTENTIAL OCCUPATIONAL EXPOSURES

Ethyl silicate is used in production of cases and molds for casting of metals and as a hardener for water and weather-resistant concrete.

A partial list of occupations in which exposure may occur includes:

Acidproof cement makers	Heat resistant paint makers
Adhesive makers	Lacquer makers
Brick preserver makers	Metal casters
Building coaters	Plaster preserver makers
Cement preserver makers	Silicate paint makers

PERMISSIBLE EXPOSURE LIMITS

There is no Federal standard; however, the ACGIH recommended TLV is 100 ppm (approximately 850 mg/m³) determined as a time-weighted average. This TLV has not been confirmed in human exposure. At 3000 ppm, ethyl silicate vapors are intolerable.

ROUTE OF ENTRY

Inhalation of vapor.

HARMFUL EFFECTS

Local—

Ethyl silicate is a primary irritant to the eyes and the nose.

Systemic—

Damage to the lungs, liver, and kidneys, and anemia have been observed in animal experiments but have not been reported for human exposure.

MEDICAL SURVEILLANCE

Placement or periodic examinations should include the skin, eyes, respiratory tract, as well as liver and kidney functions.

SPECIAL TESTS

None currently used.

PERSONAL PROTECTIVE METHODS

Fullface masks in areas of vapor concentration.

BIBLIOGRAPHY

Pozzini, U. C., and C. P. Carpenter. 1951. Response of rodents to repeated inhalation of vapors of tetraethyl orthosilicate. *Arch. Ind. Hyg. Occup. Med.* 4:465.

FORMATES**DESCRIPTION**

Methyl formate: HCOOCH_3 .

Ethyl formate: HCOOC_2H_5 .

These are colorless, mobile, flammable liquids with agreeable odors.

SYNONYMS

Methyl formate: Methyl methanoate.

Ethyl formate: None.

POTENTIAL OCCUPATIONAL EXPOSURES

Formates are solvents for cellulose nitrate, oils, greases, fats, cellulose acetate, fatty acids, acetylcellulose, collodion, and celluloid. They are also used as larvicides, fumigants, flavoring agents in the production of lemonade, rum, arrack, and essences, and they are used in chemical synthesis.

A partial list of occupations in which exposure may occur includes:

Cellulose acetate workers	Nitrocellulose workers
Flavoring makers	Organic chemical synthesizers
Fumigant makers	Pesticide workers
Fumigators	Tobacco fumigators
Grain fumigators	

PERMISSIBLE EXPOSURE LIMITS

The Federal standards are:

Methyl formate	100 ppm	250 mg/m ³
Ethyl formate	100 ppm	300 mg/m ³

ROUTE OF ENTRY

Inhalation, ingestion, and skin absorption.

HARMFUL EFFECTS

Local—

Methyl formate is a mild irritant to mucous membranes, especially eyes and respiratory system. Ethyl formate may be irritating to skin and mucous membranes in high concentrations.

Systemic—

Methyl formate has an irritant and narcotic effect, and in high concentrations may cause drowsiness and unconsciousness. Systemic intoxication in industry is rare.

MEDICAL SURVEILLANCE

Consider eye and respiratory disease or symptoms in any placement or follow-up examinations.

SPECIAL TESTS

None in common use.

PERSONAL PROTECTIVE METHODS

Barrier creams should be used to protect the skin, and masks should be used in areas of vapor concentration.

BIBLIOGRAPHY

Von Oettingen, W. F. 1959. The aliphatic acids and their esters — toxicity and potential dangers. The saturated monobasic aliphatic acids and their esters. *AMA Arch. Ind. Health* 20:517.

CARBOXYLIC ACIDS AND ANHYDRIDES

The carboxylic acids and acid anhydrides have similar properties because of their acid characteristics. Carboxylic acids, and those compounds with the COOH moiety, may be aliphatic or aromatic and may have more than one carboxyl group. The acid anhydrides are derivatives of carboxylic acids.

These compounds have a primary irritant effect, the degree determined in part by acid dissociation and water solubility. Some may cause severe tissue damage similar to that seen with strong mineral acids. Sensitization may also occur, but is more common with the anhydrides than the acids.

ACETIC ACID

DESCRIPTION

CH₃COOH, acetic acid, is a colorless liquid with a pungent vinegar-like odor. Glacial acetic acid contains 99% acid.

SYNONYMS

Ethanoic acid, ethylic acid, methane carboxylic acid, pyroligneous acid, vinegar acid.

POTENTIAL OCCUPATIONAL EXPOSURES

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

A partial list of occupations in which exposure may occur includes:

Acetate ester makers	Plastic makers
Acetate fiber makers	Resin makers
Aspirin makers	Rubber makers
Dye makers	Stain removers
Food preservers	Textile printers
Insecticide makers	Tint rinse makers
Laundry workers	White lead makers
Photographic chemical makers	

PERMISSIBLE EXPOSURE LIMITS

The Federal standard is 10 ppm (25 mg/m³).

ROUTE OF ENTRY

Inhalation of vapor.

HARMFUL EFFECTS

Local—

Acetic acid vapor may produce irritation of the eyes, nose, throat, and lungs. Inhalation of concentrated vapors may cause serious damage to the lining membranes of the nose, throat, and lungs. Contact with concentrated acetic acid may cause severe damage to the skin and severe eye damage, which may result in loss of sight. Repeated or prolonged exposure to acetic acid may cause darkening, irritation of the skin, erosion of the exposed front teeth, and chronic inflammation of the nose, throat, and bronchi.

Systemic—

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

MEDICAL SURVEILLANCE

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

SPECIAL TESTS

None in common use.

PERSONAL PROTECTIVE METHODS

When working with glacial acetic acid, personal protective equipment, protective clothing, gloves, and goggles should be worn. Eye fountains and showers should be available in areas of potential exposure.

BIBLIOGRAPHY

- Capellini, A., and E. Sartorelli. 1967. Epidodio di intossicazione collettiva da anidride acetica ed acido acetica. *Med. Lav.* 58:108.
- Henson, E. V. 1959. Toxicology of the fatty acids. *J. Occup. Med.* 1:339.
- Von Oettingen, W. F. 1960. The aliphatic acids and their esters: toxicity and potential dangers. The saturated monobasic acids and their esters: aliphatic acids with three to eighteen carbons and their esters. *AMA Arch. Ind. Health* 21:100.

ACETIC ANHYDRIDE

DESCRIPTION

$\text{CH}_3\text{COOCOCH}_3$, acetic anhydride, is a colorless, strongly refractive liquid which has a strongly irritating odor.

SYNONYMS

Acetic oxide, acetyl oxide, ethanoic anhydride.

POTENTIAL OCCUPATIONAL EXPOSURES

Acetic anhydride is used as an acetylating agent or as a solvent in the manufacture of cellulose acetate, acetanilide, synthetic fibers, plastics, explosives, resins, pharmaceuticals, perfumes, and flavorings; and it is used in the textile dyeing industry.

A partial list of occupations in which exposure may occur includes:

Acetate fiber makers	Flavoring makers
Acetic acid makers	Perfume makers
Aspirin makers	Photographic film makers
Cellulose acetate fiber makers	Plastic makers
Drug makers	Resin makers
Dye makers	Textile makers
Explosive makers	

PERMISSIBLE EXPOSURE LIMITS

The Federal standard is 5 ppm (20 mg/m³).

ROUTE OF ENTRY

Inhalation of vapor.

HARMFUL EFFECTS

Local—

In high concentrations, vapor may cause conjunctivitis, photophobia, lacrimation, and severe irritation of the nose and throat. Liquid acetic anhydride does not cause a severe burning sensation when it comes in contact with the skin. If it is not removed, the skin may become white and wrinkled, and delayed severe burns may occur. Both liquid and vapor may cause conjunctival edema and corneal burns, which may develop into temporary or permanent interstitial keratitis with cor-

neal opacity due to progression of the infiltration. Contact and, occasionally, hypersensitivity dermatitis may develop.

Systemic—

Immediate complaints following concentrated vapor exposure include conjunctival and nasopharyngeal irritation, cough, and dyspnea. Necrotic areas of mucous membranes may be present following acute exposure.

MEDICAL SURVEILLANCE

Consideration should be given to the skin, eyes, and respiratory tract in any placement or periodic examinations.

SPECIAL TESTS

None currently used.

PERSONAL PROTECTIVE METHODS

Personal protective equipment (protective clothing, gloves, and goggles) should be used. Eye fountains and showers should be made available in areas where contact might occur.

BIBLIOGRAPHY

- Grant, W. M. 1962. *Toxicology of the Eye*. Charles C. Thomas Publishers, Springfield, Illinois.
- Takhirov, M. T. 1969. Hygienic standard for acetic acid and acetic anhydride. *Hyg. Sanit.* 34:122.

FORMIC ACID

DESCRIPTION

HCOOH, formic acid, is a colorless, flammable, fuming liquid, with a pungent odor.

SYNONYMS

Methanoic acid, formylic acid, hydrogen carboxylic acid.

POTENTIAL OCCUPATIONAL EXPOSURES

Formic acid is a strong reducing agent and is used as a decalcifier. It is used in dyeing color fast wool, electroplating, coagulating latex rubber, regenerating old rubber, and dehairing, plumping, and tanning leather. It is also used in the manufacture of acetic acid, airplane dope, allyl alcohol, cellulose formate, phenolic resins, and oxalate; and it is used in the laundry, textile, insecticide, refrigeration, and paper industries.

A partial list of occupations in which exposure may occur includes:

Airplane dope makers	Leather makers
Allyl alcohol makers	Paper makers
Dyers	Perfume makers
Electroplaters	Rubber workers
Insecticide makers	Textile makers
Lacquer makers	Wine makers
Laundry workers	

182 OCCUPATIONAL DISEASES

PERMISSIBLE EXPOSURE LIMITS

The Federal standard is 5 ppm (9 mg/m³).

ROUTE OF ENTRY

Inhalation of vapor and percutaneous absorption.

HARMFUL EFFECTS

Local—

The primary hazard of formic acid results from severe irritation of the skin, eyes, and mucous membranes. Lacrimation, increased nasal discharge, cough, throat discomfort, erythema, and blistering may occur depending upon solution concentrations.

Systemic—

These have not been reported from inhalation exposure and are unlikely due to its good warning properties.

Swallowing formic acid has caused a number of cases of severe poisoning and death. The symptoms found in this type of poisoning include salivation, vomiting, burning sensation in the mouth, bloody vomiting, diarrhea, and pain. In severe poisoning, shock may occur. Later, breathing difficulties may develop. Kidney damage may also be present.

MEDICAL SURVEILLANCE

Consideration should be given to possible irritant effects on the skin, eyes, and lungs in any placement or periodic examinations.

SPECIAL TESTS

None currently used.

PERSONAL PROTECTIVE METHODS

Workers should be supplied with protective clothing, gloves, and goggles. Respiratory protection will be needed in areas of high vapor exposure.

BIBLIOGRAPHY

- Henson, E. V. 1959. Toxicology of the fatty acids. *J. Occup. Med.* 1:339.
Malorny, G. 1969. Die akute und chronische Toxizität der Ameisensäure und ihrer Formiate. *Ernaehrungswiss.* 9:332.
Von Oettingen, W. F. 1959. The aliphatic acids and their esters — toxicity and potential dangers. The saturated monobasic aliphatic acids and their esters. *AMA Arch. Ind. Health* 20:517.

OXALIC ACID

DESCRIPTION

HOCCOOH. 2H₂O, oxalic acid in solution, is a colorless liquid. Anhydrous oxalic acid is monoclinic in form and is produced by careful drying of the crystalline dihydrate.

SYNONYMS

Dicarboxylic acid, ethane-di-acid, ethanedioic acid.

POTENTIAL OCCUPATIONAL EXPOSURES

Oxalic acid is used as an analytic reagent and in the manufacture of dyes, inks, bleaches, paint removers, varnishes, wood and metal cleansers, dextrin, cream of tartar, celluloid, oxalates, tartaric acid, purified methyl alcohol, glycerol, and stable hydrogen cyanide. It is also used in the photographic, ceramic, metallurgic, rubber, leather, engraving, pharmaceutical, paper, and lithographic industries.

A partial list of occupations in which exposure may occur includes:

Bleach makers	Laundry workers
Celluloid makers	Paper makers
Ceramic makers	Rubber makers
Cream of tartar makers	Tannery workers
Dye makers	Textile dyers
Glycerine makers	Printers
Ink makers	Wood bleachers

PERMISSIBLE EXPOSURE LIMITS

The Federal standard is 1 mg/m³.

ROUTE OF ENTRY

Inhalation of mist and, occasionally, dust.

HARMFUL EFFECTS*Local—*

Liquid has a corrosive action on the skin, eyes, and mucous membranes, which may result in ulceration. Local prolonged contact with extremities may result in localized pain, cyanosis, and even gangrenous changes probably resulting from localized vascular damage.

Systemic—

Chronic exposure to mist or dust has been reported to cause chronic inflammation of the upper respiratory tract. Ingestion is of lesser importance occupationally. Symptoms appear rapidly and include shock, collapse, and convulsive seizures. Such cases may also have marked kidney damage with deposition of calcium oxalate in the lumen of the renal tubules.

MEDICAL SURVEILLANCE

Evaluate skin, respiratory tract, and renal functions in placement or periodic examinations.

SPECIAL TESTS

The presence of increased urinary oxalate crystals may be helpful in evaluating oral poisoning. Determination of blood calcium and oxalate levels may also be used for this purpose.

PERSONAL PROTECTIVE METHODS

Protective clothing and goggles should be worn when working in areas where direct contact is possible. Respiratory protection from mist or dust may be needed.

BIBLIOGRAPHY

Klauder, J. V., L. Shelanski, and K. Gabriel. 1955. Industrial uses of fluorine and oxalic acid. *AMA Arch. Ind. Health* 12:412.

PHTHALIC ANHYDRIDE

DESCRIPTION

$C_8H_4O_3$, phthalic anhydride, is moderately flammable, white, lustrous, solid, with needle-like crystals.

SYNONYMS

Phthalic acid anhydride, benzene-o-dicarboxylic acid anhydride, phthalandione.

POTENTIAL OCCUPATIONAL EXPOSURES

Phthalic anhydride is used in the manufacture of phthaleins, benzoic acid, alkyd and polyester resins, synthetic indigo, and phthalic acid, which is used as a plasticizer for vinyl resins. To a lesser extent, it is used in the production of alizarin dye, anthranilic acid, anthraquinone, diethyl phthalate, dimethyl phthalate, erythrosin, isophthalic acid, methyl aniline, phenolphthalein, phthalamide, sulfathalidine, and terephthalic acid. It has also found use in pesticides and herbicides, as well as perfumes.

A partial list of occupations in which exposure may occur includes:

Alizarin dye makers	Mylar plastic makers
Alkyd resin makers	Organic chemical synthesizers
Automobile finish makers	Phthalein makers
Cellulose acetate plasticizer makers	Resin makers
Dacron fiber makers	Vat dye makers
Erythrosin makers	Vinyl plasticizer makers
Insecticide makers	

PERMISSIBLE EXPOSURE LIMITS

The Federal standard is 2 ppm (12 mg/m³).

ROUTE OF ENTRY

Inhalation of dust, fume, or vapor.

HARMFUL EFFECTS

Local—

Phthalic anhydride, in the form of a dust, fume, or vapor, is a potent irritant of the eyes, skin, and respiratory tract. The irritant effects are worse on moist surfaces. Conjunctivitis and skin erythema, burning, and contact dermatitis may occur. If the chemical is held in contact with the skin, as under clothes or shoes, skin burns may develop. Hypersensitivity may develop in some individuals. Inhalation of the dust or vapors may cause coughing, sneezing, and a bloody nasal discharge. Impurities, naphthoquinone, as well as maleic anhydride, may also contribute to eye, skin, and pulmonary irritation.

Systemic—

Repeated exposure may result in bronchitis, emphysema, allergic asthma, urticaria, and chronic eye irritation.

MEDICAL SURVEILLANCE

Emphasis should be given to a history of skin or pulmonary allergy, and preplacement and periodic examinations should evaluate the skin, eye, and lungs, as well as liver and kidney functions. The hydrolysis product, phthalic acid, is rapidly excreted in the urine, although this has not been used in biological monitoring. Diagnostic patch testing may be helpful in evaluating skin allergy.

SPECIAL TESTS

None in common use.

PERSONAL PROTECTIVE METHODS

Proper ventilation, rubber gloves, protective clothing, head coverings, and goggles are recommended when repeated or prolonged contact is possible. Respiratory protection may be needed in dusty areas or where fumes or vapors are present.

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- Ghezzi, I., and P. Scott. 1965. Clinical contribution on the pathology induced by phthalic and maleic anhydride. *Med. Lav.* 56:746.
- Merlevede, E., and J. Elskens. 1957. The toxicity of phthalic anhydride, maleic anhydride, and the phthalates. *Arch. Belg. Med. Soc.* 15:445.

ALDEHYDES AND KETONES

Aldehydes and ketones are aliphatic or aromatic organic compounds which contain the carbonyl group, $C=O$.

The aldehydes, $R-CH=O$, are used primarily as chemical feedstock because of their relatively high reactivity. They are volatile, colorless liquids, with the exception of formaldehyde, which is a gas, and can exhibit additional hazard due to its flammability. Typically, these compounds are strongly irritating to the skin, eyes, and respiratory tract. Acute exposure may result in pulmonary injuries such as edema, bronchitis, and bronchopneumonia. Skin and pulmonary sensitization may develop in some individuals and result in contact dermatitis and, more rarely, asthmatic attacks. After hypersensitivity develops, individuals may develop symptoms due to other aldehydes. For this reason, medical surveillance and industrial hygiene practices are of importance.

Ketones are characterized by the structure $R-O-R$. They are similar in their chemical and toxicological properties, and all are flammable, colorless liquids with a pungent odor similar to acetone. They are used as industrial solvents and raw materials or as intermediates in chemical synthesis. Prolonged exposure is usually precluded by the intense irritation of the eyes and respiratory tract.