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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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.

ACETALDEHYDE

DESCRIPTION

CH_3CHO, acetaldehyde, is a flammable, volatile, colorless liquid with a characteristic odor. It is produced by oxidation of alcohol with a metallic catalyst, by hydration of acetylene, or, usually, by direct oxidation of ethylene.

SYNONYMS

Acetic aldehyde, aldehyde, ethanol, ethyl aldehyde.

POTENTIAL OCCUPATIONAL EXPOSURES

Acetaldehyde can be reduced or oxidized to form acetic acid, acetic anhydride, acrolein, aldol, buranol, chloral, 2-methyl-5-ethyl pyridine, paraldehyde, and pentaerythritol. It is also used in the manufacture of disinfectants, drugs, dyes, explosives, flavorings, lacquers, mirrors (silvering), perfume, photographic chemicals, phenolic and urea resins, rubber accelerators and antioxidants, varnishes, vinegar, and yeast.

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

- Acetic acid makers
- Antioxidant makers
- Disinfectant makers
- Explosives workers
- Flavoring makers
- Mirror silverers
- Paraldehyde makers
- Urea resin makers
- Rubber makers
- Vinegar makers
- Yeast makers

PERMISSIBLE EXPOSURE LIMITS

The Federal standard is 200 ppm (360 mg/m^3); however, the ACGIH 1976 recommended TLV is 100 ppm (180 mg/m^3).

ROUTE OF ENTRY

Inhalation of vapor.

HARMFUL EFFECTS

Local—

The liquid and the fairly low levels of the vapor are irritating to the eyes, skin, upper respiratory passages, and bronchi. Repeated exposure may result in dermatitis, rarely, and skin sensitization.

Systemic—

Acute involuntary exposure to high levels of acetaldehyde vapors may result in pulmonary edema, preceded by excitement, followed by narcosis. It has been postulated that these symptoms may have been similar to those of alcohol, which is converted to acetaldehyde and acetic acid. Chronic effects have not been documented, and seem unlikely, since voluntary inhalation of toxicologically significant levels of acetaldehyde are precluded by its irritant properties at levels as low as 200 ppm (360 mg/m^3 of air).

MEDICAL SURVEILLANCE

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

SPECIAL TESTS

None appear needed, but effects of exposure can be determined from blood results by gas chromatographic methods, if desired.

PERSONAL PROTECTIVE METHODS

Protective clothing, gloves, goggles, and respiratory protective equipment where high concentrations of the gas or vapor are expected.

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ACROLEIN

DESCRIPTION

$H_2C=CHCHO$, acrolein, is a clear, yellowish liquid which is a petroleum byproduct. It is commercially produced by the oxidation of propylene.

SYNONYMS

Acraldehyde, acrylic aldehyde, allyl aldehyde, propenal.

POTENTIAL OCCUPATIONAL EXPOSURES

Acrolein is the feedstock for several types of plastics, plasticizers, acrylates, textile finishes, synthetic fibers, and methionines. It is also used in the manufacture of colloidal forms of metals, in perfumes, and, due to its pungent odor, as a warning agent in methyl chloride refrigerants. Other potential exposures may arise when acrolein vapor is given off when oils and fats containing glycerol are heated.

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

- Acrylate makers
- Fat processors
- Methionine makers
- Perfume makers
- Plastic makers
- Refrigerant makers
- Renderers
- Rubber makers
- Textile resin makers

PERMISSIBLE EXPOSURE LIMITS

The Federal standard for exposure to acrolein is 0.1 ppm (0.25 mg/m^3).

ROUTE OF ENTRY

Inhalation of vapor and percutaneous absorption.

HARMFUL EFFECTS

Local—

In the liquid or pungent vapor form, acrolein produces intense irritation to the eye and mucous membranes of the respiratory tract. Skin burns and dermatitis may result from prolonged or repeated exposure. Sensitization in a few individuals may also occur.

Systemic—

Because of acrolein's pungent, offensive odor and the intense irritation of the conjunctiva and upper respiratory tract, severe toxic effects from acute exposure are rare, as workmen will not tolerate the vapor even in minimal concentrations. Acute exposure to acrolein may cause bronchial inflammation, resulting in bronchitis or pulmonary edema.

MEDICAL SURVEILLANCE

Preplacement and periodic medical examinations should consider respiratory, skin, and eye disease. Pulmonary function tests may be helpful.

SPECIAL TESTS

None in common use.

PERSONAL PROTECTIVE METHODS

Protection in handling and transporting is advocated. Suitable ventilation and protective clothing should be provided for employees working in areas of possible exposure. Protective respiratory equipment in areas of vapor concentration.

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FORMALDEHYDE

DESCRIPTION

HCHO, formaldehyde, is a colorless, pungent gas. It is produced commercially by the catalytic oxidation of methyl alcohol and sold in aqueous solution containing 30-50% formaldehyde and from 0-15% methanol, which is added to prevent polymerization. Formaldehyde solution is called formalin, formol, or morbicid.

SYNONYMS

Oxomethane, oxymethylene, methylene oxide, formic aldehyde, methyl aldehyde.

POTENTIAL OCCUPATIONAL EXPOSURES

Formaldehyde has found wide industrial usage as a fungicide, germicide, and in disinfectants and embalming fluids. It is also used in the manufacture of artificial silk and textiles, latex, phenol, urea, thiourea and melamine resins, dyes, and inks, cellulose esters and other organic molecules, mirrors, and explosives. It is also used in the paper, photographic, and furniture industries.

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

Anatomists	Hide preservers
Biologists	Ink makers
Deodorant makers	Latex makers
Disinfectant makers	Photographic film makers
Embalming fluid makers	Textile printers
Formaldehyde resin makers	Wood preservers

PERMISSIBLE EXPOSURE LIMITS

The Federal standard is 3 ppm determined as a TWA. The acceptable ceiling concentration is 5 ppm with an acceptable maximum peak above this value of 10 ppm for a maximum duration of 30 minutes. ACGIH in 1975 recommended a TLV of 2 ppm (3 mg/m^3) as a ceiling value. NIOSH has recommended a ceiling of 1 ppm (1.2 mg/m^3) for any 30-minute sampling period.

ROUTE OF ENTRY

Inhalation of gas.

HARMFUL EFFECTS

Local—

Formaldehyde gas may cause severe irritation to the mucous membranes of the respiratory tract and eyes. The aqueous solution splashed in the eyes may cause eye burns. Urticaria has been reported following inhalation of gas. Repeated exposure to formaldehyde may cause dermatitis either from irritation or allergy.

Systemic—

Systemic intoxication is unlikely to occur since intense irritation of upper respiratory passages compels workers to leave areas of exposure. If workers do inhale high concentrations of formaldehyde, coughing, difficulty in breathing, and pulmonary edema may occur. Ingestion, though usually not occurring in industrial experience, may cause severe irritation of the mouth, throat, and stomach.

MEDICAL SURVEILLANCE

Consider the skin, eyes, and respiratory tract in any preplacement or periodic examination, especially if the patient has a history of allergies.

SPECIAL TESTS

None in common use.

PERSONAL PROTECTIVE METHODS

Prevention of intoxication may be easily accomplished by supplying adequate ventilation and protective clothing. Barrier creams may also be helpful. In areas of high vapor concentrations, full protective face masks with air supply is needed, as well as protective clothing.

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FURFURAL

DESCRIPTION

$C_5H_4O_2$, furfural, is an aromatic heterocyclic aldehyde with an amber color and aromatic odor. This liquid is obtained from cereal straws and brans containing pentosans by hydrolysis and dehydration with sulfuric acid.

SYNONYMS

Furfurol (a misnomer), furfuraldahyde, artificial ant oil, pyromucic aldehyde, furol, 2-furaldehyde.

POTENTIAL OCCUPATIONAL EXPOSURES

Furfural is used as a solvent for wood resin, nitrated cotton, cellulose acetate, and gums. It is used in the production of phenolic plastics, thermosetting resins, refined petroleum oils, dyes, and varnishes. It is also utilized in the manufacture of pyromucic acid, vulcanized rubber, insecticides, fungicides, herbicides, germicides, furan derivatives, polymers, and other organic chemicals.

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

Adipic acid makers	Lysine makers
Butadiene refiners	Metal refiners
Cellulose acetate makers	Nylon makers
Disinfectant workers	Organic chemical synthesizers
Dye makers	Pyromucic acid makers
Herbicide makers	Road builders

PERMISSIBLE EXPOSURE LIMITS

The Federal standard is 5 ppm (20 mg/m^3).

ROUTES OF ENTRY

Inhalation of vapor, percutaneous absorption.

HARMFUL EFFECTS

Local—

Liquid and concentrated vapor are irritating to the eyes, skin, and mucous membranes of the upper respiratory tract. Eczematous dermatitis as well as skin sensitization, resulting in allergic contact dermatitis and photosensitivity, may develop following repeated exposure.

Systemic—

Workers chronically exposed to the vapor have had complaints of headache, fatigue, itching of the throat, lacrimation, loss of the sense of taste, numbness of the tongue, and tremor. Occupational overexposure is relatively rare due to the liquid's low vapor pressure, and symptoms usually disappear rapidly after removal from exposure.

MEDICAL SURVEILLANCE

Consider skin irritation and skin allergies (especially to aldehydes) in preplacement or periodic examinations. Also consider possible respiratory irritant effects.

SPECIAL TESTS

None commonly used.

PERSONAL PROTECTIVE METHODS

Protective clothing and adequate ventilation should be provided in areas where toxic exposure may occur. In areas of vapor concentrations, fullface masks may be required.

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KETONES

DESCRIPTION

The ketone family includes:

Acetone: CH_3COCH_3
Diacetone: $(CH_3)_2COHCH_2COCH_3$
Methyl ethyl ketone: $CH_3COCH_2CH_3$
Methyl n-propyl ketone: $CH_3CH_2CH_2COCH_3$
Methyl n-butyl ketone: $CH_3COCH_2CH_2CH_2CH_3$
Methyl isobutyl ketone: $(CH_3)_2CHCH_2COCH_3$

SYNONYMS

Acetone: 2-Propanone, dimethyl ketone, beta-ketopropane, pyroacetic ether.

Diacetone: Diacetone alcohol, diacetonyl alcohol, dimethylacetonyl

carbinol, 4-hydroxy-4 methyl-2-pentanone, 2-methyl-2-pentanol-4-one.

Methyl ethyl ketone: Butanone, 2-butanone, MEK, ethyl methyl ketone,

Methyl n-propyl ketone: Ethyl acetone, 2-pentanone, MPK.

Methyl n-butyl ketone: n-Butyl methyl ketone, propyl acetone, 2-hexanone, MBK.

Methyl isobutyl ketone: Hexone, isopropylacetone, 4-methyl-2-pentanone, MIBK.

POTENTIAL OCCUPATIONAL EXPOSURES

This group of ketone solvents has many uses in common. They are low-cost solvents for resins, lacquers, oils, fats, collodion, cotton, cellulose acetate, nitrocellulose, cellulose esters, epoxy resins, gums, pigments, dyes, vinyl polymers, and copolymers. They are used as chemical intermediates, in the manufacture of smokeless powder and explosives, and in the paint, lacquer, varnish, plastics, dyeing, celluloid, photographic, cement, rubber, artificial silk and leather, synthetic rubber, and lubricating oil industries. They are also used in hydraulic fluids, metal cleaning compounds, quick drying inks, airplane dopes, compositions for paper and textiles, pharmaceuticals, cosmetics, and as paint removers and dewaxers.

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

Adhesive makers	Lacquer and oil processors
Celluloid makers	Shoe makers
Dope workers	Solvent workers
Dye makers	Varnish and stain makers
Explosive makers	Wax makers
Garage mechanics	

PERMISSIBLE EXPOSURE LIMITS

The Federal standards are:

Acetone	1,000 ppm	2,400 mg/m^3
Diacetone	50 ppm	240 mg/m^3
Methyl ethyl ketone	200 ppm	590 mg/m^3
Methyl n-propyl ketone	200 ppm	700 mg/m^3
Methyl n-butyl ketone	100 ppm	410 mg/m^3
Methyl isobutyl ketone	100 ppm	410 mg/m^3

ROUTES OF ENTRY

Inhalation of vapor, percutaneous absorption.

HARMFUL EFFECTS

Local—

These solvents may produce a dry, scaly, and fissured dermatitis after repeated exposure. High vapor concentrations may irritate the conjunctiva and mucous membranes of the nose and throat, producing eye and throat symptoms.

Systemic—

In high concentrations, narcosis is produced, with symptoms of headache, nausea, light headedness, vomiting, dizziness, incoordination, and unconsciousness.

Recent reports indicate that exposure of workers to methyl n-butyl ketone has been associated with the development of peripheral neuropathy. Rat experiments have also shown nerve changes characteristic of peripheral neuropathy after exposure to 1,300 ppm.

MEDICAL SURVEILLANCE

Preplacement examinations should evaluate skin and respiratory conditions. In the case of methyl n-butyl ketone, special attention should be given to the central and peripheral nervous systems.

SPECIAL TESTS

Acetone can be determined in the blood, urine, and expired air, and has been used as an index of exposure. A neurotoxic metabolite of methyl n-butyl ketone has been found in the rat. This is not present with methyl isobutyl ketone.

PERSONAL PROTECTIVE METHODS

Contact with skin and eyes should be avoided by the use of protective clothing. In areas of high vapor concentration, masks should be used.

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ALIPHATIC HALOGENATED HYDROCARBONS

Halogenated hydrocarbons typically are colorless, volatile liquids with excellent organic solvent properties. Chemically, they consist of saturated or unsaturated carbon chains in which one hydrogen atom or more have been replaced by one or more halogens (fluorine, chlorine, bromine, or iodine). Hydrocarbons having only one or two halogens are usually flammable and less toxic than similar hydrocarbons with complete halogen substitution. Hydrocarbons containing fluorine tend to be less toxic, while hydrocarbons containing bromine or iodine are generally more toxic than hydrocarbons containing chlorine. The latter, chlorinated hydrocarbons, are widely used because of their low cost.

Halogenated hydrocarbons have found wide use as solvents in degreasing, dewaxing, drycleaning, and extracting processes. Other uses are as aerosol propellants, fumigants, insecticides, refrigerants, and

chemical intermediates for drugs, plastics, and synthetic rubber. Some of these compounds have been used medically as anesthetics and anthelmintics. The toxicologic effects of halogenated hydrocarbons vary from one compound to another but, generally, most cause central nervous system depression. Also common to most is the defatting of the skin which may lead to dermatitis. Upon inhalation of high concentrations of vapor, liver or kidney injury may occur, but it should be noted that while some compounds may have no effect, others may affect only one of these two organs, and still others may affect both. Pulmonary irritation and damage to the hematopoietic system may also occur after exposure to certain compounds.

Medical surveillance of workers exposed to halogenated hydrocarbons should include periodic examinations, including urinalysis to check for renal damage and appropriate tests for liver dysfunction. Evidence of acute exposure to chlorinated compounds may be obtained in some cases by analysis of expired air obtained soon after exposure. If acute poisoning is suspected, epinephrine should not be used in treatment as it has been noted that epinephrine injected during narcosis caused by exposure to certain halogenated solvents may lead to cardiac arrhythmia.

CARBON TETRACHLORIDE

DESCRIPTION

CCl_4, carbon tetrachloride, is a colorless, nonflammable liquid with a characteristic odor. Oxidative decomposition by flame causes phosgene and hydrogen chloride to form.

SYNONYMS

Tetrachloromethane, perchloromethane.

POTENTIAL OCCUPATIONAL EXPOSURES

Carbon tetrachloride is used as a solvent for oils, fats, lacquers, varnishes, rubber, waxes, and resins. Fluorocarbons are chemically synthesized from it. It is also used as an azeotropic drying agent for spark plugs, a dry cleaning agent, a fire extinguishing agent, a fumigant, and an anthelmintic agent. The use of this solvent is widespread, and substitution of less toxic solvents when technically possible is recommended.

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

- Chemists
- Degreasers
- Fat processors
- Firemen
- Fluorocarbon makers
- Grain fumigators
- Ink makers
- Insecticide makers
- Lacquer makers
- Metal cleaners
- Propellant makers
- Refrigerant makers
- Rubber makers
- Solvent workers
- Wax makers

PERMISSIBLE EXPOSURE LIMITS

The Federal standard is 10 ppm (65 mg/m^3) as an 8-hour TWA

with an acceptable ceiling concentration of 25 ppm; acceptable maximum peaks above the ceiling of 200 ppm are allowed for one 5-minute duration in any 4-hour period. NIOSH has recommended a ceiling limit of 2 ppm based on a 1-hour sampling period at a rate of 750 ml/min.

ROUTES OF ENTRY

Inhalation of vapor. Percutaneous absorption has been demonstrated in animals.

HARMFUL EFFECTS

Local—

Carbon tetrachloride solvent removes the natural lipid cover of the skin. Repeated contact may lead to a dry, scaly, fissured dermatitis. Eye contact is slightly irritating, but this condition is transient.

Systemic—

Excessive exposure may result in central nervous system depression, and gastrointestinal symptoms may also occur. Following acute exposure, signs and symptoms of liver and kidney damage may develop. Nausea, vomiting, abdominal pain, diarrhea, enlarged and tender liver, and jaundice result from toxic hepatitis. Diminished urinary volume, red and white blood cells in the urine, albuminuria, coma, and death may be consequences of acute renal failure. The hazard of systemic effects is increased when carbon tetrachloride is used in conjunction with ingested alcohol.

MEDICAL SURVEILLANCE

Preplacement and periodic examinations should include an evaluation of alcohol intake and appropriate tests for liver and kidney functions. Special attention should be given to the central and peripheral nervous system, the skin, and blood.

SPECIAL TESTS

Expired air and blood levels may be useful as indicators of exposure.

PERSONAL PROTECTIVE METHODS

Barrier creams, gloves, protective clothing, and masks should be used as appropriate where exposure occurs.

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CHLOROFORM

DESCRIPTION

$CHCl_3$, chloroform, is a clear, colorless liquid with a characteristic odor. Though nonflammable, chloroform decomposes to form hydrochloric acid, phosgene, and chlorine upon contact with a flame.

SYNONYMS

Trichloromethane, methenyl chloride.

POTENTIAL OCCUPATIONAL EXPOSURES

Chloroform was one of the earliest general anesthetics, but its use for this purpose has been abandoned because of toxic effects. Chloroform is widely used as a solvent (especially in the lacquer industry); in the extraction and purification of penicillin and other pharmaceuticals; in the manufacture of artificial silk, plastics, floor polishes, and fluorocarbons; and in sterilization of catgut.

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

- Chemists
- Drug makers
- Fluorocarbon makers
- Lacquer workers
- Polish makers
- Silk synthesizers
- Solvent workers

PERMISSIBLE EXPOSURE LIMITS

The Federal standard is 50 ppm (240 mg/m^3). The ACGIH recommended 1976 TLV is 25 ppm. NIOSH's recommended limit is a ceiling of 2 ppm based on a 1-hour sample collected at 750 1/min.

ROUTE OF ENTRY

Inhalation of vapors.

HARMFUL EFFECTS

Local—

Chloroform may produce burns if left in contact with the skin.

Systemic—

Chloroform is a relatively potent anesthetic at high concentrations. Death from its use as an anesthetic has resulted from liver damage and from cardiac arrest. Exposure may cause lassitude, digestive disturbance, dizziness, mental dullness, and coma. Chronic overexposure has been shown to cause enlargement of the liver and kidney damage. Alcoholics seem to be affected sooner and more severely from chloroform exposure. Disturbance of the liver is more characteristic of exposure than central nervous system depression or renal injury. There is some animal experimental evidence that suggests chloroform may be a carcinogen.

MEDICAL SURVEILLANCE

Preplacement and periodic examinations should include appropriate

tests for liver and kidney functions, and special attention should be given to the nervous system, the skin, and to the history of alcoholism.

SPECIAL TESTS

Expired air and blood levels may be useful in estimating levels of acute exposure.

PERSONAL PROTECTIVE METHODS

Protective clothing and gloves should be worn to protect the skin, and masks should be worn in areas of high vapor concentration.

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CHLOROPRENE

DESCRIPTION

$H_2C=CC_1-CH=CH_2$, chloroprene, is a colorless, flammable liquid posessing a pungent odor.

SYNONYMS

2-chloro-1,3-butadiene.

POTENTIAL OCCUPATIONAL EXPOSURES

The only major use of chloroprene is in the production of artificial rubber (neoprene, duprene).

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

Duprene makers
Neoprene makers
Rubber makers

PERMISSIBLE EXPOSURE LIMITS

The Federal standard is 25 ppm (90 mg/m^3). Because of suspected carcinogenic and/or mutagenic potential, the limit may be lowered.

ROUTES OF ENTRY

Inhalation of vapor and skin absorption.

HARMFUL EFFECTS

Local—

Chloroprene acts as a primary irritant on contact with skin, conjunctiva, and mucous membranes and may result in dermatitis, conjunctivitis, and circumscribed necrosis of the cornea. Temporary hair loss has been reported during the manufacture of polymers.

Systemic—

Inhalation of high concentrations may result in anesthesia and respiratory paralysis. Chronic exposure may produce damage to the lungs,

nervous system, liver, kidneys, spleen, and myocardium. Russian studies suggest that chloroprene exposure is associated with an increased incidence of cancer of the skin and lungs, but this has not been confirmed. Fetal effects have been noted in rodents.

MEDICAL SURVEILLANCE

Preplacement and periodic examinations should include an evaluation of the skin, eyes, respiratory tract, and central nervous system. Liver and kidney function should be evaluated.

SPECIAL TESTS

None commonly used.

PERSONAL PROTECTIVE METHODS

Protective clothing, chemical safety goggles, air-supplied or self-contained respirators, and safety harnesses should be worn where there is exposure to the liquid or high concentrations of the vapor.

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1,2-DIBROMOETHANE

DESCRIPTION

$BrCH_2CH_2Br$, 1,2-dibromoethane, is a colorless nonflammable liquid with a chloroformlike odor.

SYNONYMS

Ethylene dibromide, ethylene bromide, sym-dibromoethane.

POTENTIAL OCCUPATIONAL EXPOSURES

1,2-Dibromoethane is used principally as a fumigant for ground pest control and as a constituent of ethyl gasoline. It is also used in fire extinguishers, gauge fluids, and waterproofing preparations; and it is used as a solvent for celluloid, fats, oils, and waxes.

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

- Antiknock compound makers
- Cabbage growers
- Drug makers
- Farmers
- Fat processors
- Fire extinguisher makers
- Fumigant workers
- Gum processors
- Lead scavenger makers
- Resin makers
- Termite controllers
- Tetraethyl lead makers
- Wool reclaimers

PERMISSIBLE EXPOSURE LIMITS

The Federal standard is 20 ppm (145 mg/m^3) as an 8-hour TWA with an acceptable ceiling concentration of 300 ppm; acceptable maximum peaks above the ceiling of 50 ppm are allowed for 5 minutes duration.

ROUTES OF ENTRY

Inhalation of the vapor and absorption through the skin.

HARMFUL EFFECTS

Local—

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

Systemic—

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

MEDICAL SURVEILLANCE

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

SPECIAL TESTS

None commonly used.

PERSONAL PROTECTIVE METHODS

1,2-Dibromoethane can penetrate most types of rubber and leather protective clothing, and, therefore, protective clothing made from other materials should be provided. Masks must be worn in areas with excessive vapor concentrations.

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1,2-DICHLOROETHANE

DESCRIPTION

$Cl_1CH_2CH_2Cl$, 1,2-dichloroethane, is a colorless, flammable liquid which has a pleasant odor, sweetish taste.

SYNONYMS

Ethylene dichloride, sym-dichloroethane, ethylene chloride, glycol dichloride, β-dichloroethane.

POTENTIAL OCCUPATIONAL EXPOSURES

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

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

Adhesive makers	Insecticide makers
Bakelite processors	Metal degreasers
Camphor workers	Ore upgraders
Drycleaners	Solvent workers
Exterminators	Textile cleaners
Gasoline blenders	Vinyl chloride makers

PERMISSIBLE EXPOSURE LIMITS

The Federal standard is 50 ppm (200 mg/m^3) as an 8-hour TWA with an acceptable ceiling concentration of 100 ppm. Acceptable maximum peaks above the ceiling of 200 ppm are allowed for 5 minutes duration in any 3-hour period.

ROUTES OF ENTRY

Inhalation of vapor and skin absorption of liquid.

HARMFUL EFFECTS

Local—

Repeated contact with liquid can produce a dry, scaly, fissured dermatitis. Liquid and vapor may also cause eye damage.

Systemic—

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

MEDICAL SURVEILLANCE

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

SPECIAL TESTS

None commonly used; can be determined in expired air.

PERSONAL PROTECTIVE METHODS

Protective clothing, goggles, and gloves are to be worn. In high vapor concentrations,use fullface masks and supplied air respirators.

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1,2-DICHLOROETHYLENE

DESCRIPTION

ClCH=CHCl, 1,2-dichloroethylene, exists in two isomers, cis 60% and trans 40%. There are variations in toxicity between these two forms. At room temperature, it is a liquid with a slight acrid, ethereal odor. Gradual decomposition results in hydrochloric acid formation in the presence of ultraviolet light or upon contact wth hot metal.

SYNONYMS

Acetylene dichloride, sym-dichloroethylene, 1,2-dichloroethene.

POTENTIAL OCCUPATIONAL EXPOSURES

1,2-Dichloroethylene is used as a solvent for waxes, resins, and acetyl cellulose. It is also used in the extraction of rubber, as a refrigerant, in the manufacture of pharmaceuticals and artificial pearls, and in the extraction of oils and fats from fish and meat.

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

Carbolic acid processors
Drug makers
Drycleaners
Solvent workers
Wax makers

PERMISSIBLE EXPOSURE LIMITS

The Federal standard is 200 ppm (790 mg/m^3).

ROUTE OF ENTRY

Inhalation of the vapor.

HARMFUL EFFECTS

Local—

This liquid can act as a primary irritant producing dermatitis and irritation of mucous membranes.

Systemic—

1,2-Dichloroethylene acts principally as a narcotic, causing central nervous system depression. Symptoms of acute exposure include dizzi-

ness, nausea and frequent vomiting, and central nervous system intoxication similar to that caused by alcohol. Renal effects, when they do occur, are transient.

MEDICAL SURVEILLANCE

Consider possible irritant effects on skin or respiratory tract as well as liver and renal function in preplacement or periodic examinations.

SPECIAL TESTS

None commonly used; expired air analyses may be useful in detecting exposure.

PERSONAL PROTECTIVE METHODS

Barrier creams and gloves are needed to protect the skin. In high vapor concentrations, masks and protective clothing are required.

BIBLIOGRAPHY

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ETHYL CHLORIDE

DESCRIPTION

CH_3CH_2Cl, ethyl chloride, is a flammable gas with an ethereal odor, burning taste. It is flammable, and the products of combustion include phosgene and hydrogen chloride.

SYNONYMS

Monochloroethane, hydrochloric ether, chloroethane, chlorethyl.

POTENTIAL OCCUPATIONAL EXPOSURES

Ethyl chloride is used as an ethylating agent in the manufacture of tetraethyl lead, dyes, drugs, and ethyl cellulose. It can be used as a refrigerant and as a local anesthetic (freezing).

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

Anesthetists	Phosphorus and sulfur processors
Dentists	Physicians
Drug makers	Refrigeration workers
Ethylation workers	Resin makers
Fat and oil processors	Sulfur processors
Nurses	Tetraethyl lead makers
Perfume makers	Wax makers

PERMISSIBLE EXPOSURE LIMITS

The Federal standard is 1000 ppm (2600 mg/m^3).

ROUTES OF ENTRY

Inhalation of gas and slight percutaneous absorption.

HARMFUL EFFECTS

Local—

The liquid form of ethyl chloride is mildly irritating to skin and eyes. Frostbite can occur due to rapid liquid evaporation.

Systemic—

Ethyl chloride exposure may produce headache, dizziness, incoordination, stomach cramps, and eventual loss of consciousness. In high concentrations, it is a respiratory tract irritant, and death due to cardiac arrest has been recorded. Renal damage has been reported in animals. Effects from chronic exposure have not been reported.

MEDICAL SURVEILLANCE

Consider possible acute cardiac effects in any preplacement or periodic examination.

SPECIAL TESTS

None commonly used. Ethyl chloride is excreted in expired air.

PERSONAL PROTECTIVE METHODS

In high vapor concentrations, use mask with full face protection, gloves, and protective clothing.

BIBLIOGRAPHY

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FLUOROCARBONS

DESCRIPTION

Chemically, fluorocarbons are hydrocarbons containing fluorine and include compounds that may contain other halogens in addition to fluorine. Generally, these compounds are colorless, nonflammable gases, though a few are liquids at room temperature. Decomposition of chlorine-containing fluoromethanes caused by contact with an open flame or hot metal produces hydrogen chloride, hydrogen fluoride, phosgene, carbon dioxide, and chlorine.

SYNONYMS

See listing of economically important fluorocarbons under "Permissible Exposure Limits." Also, Freon® is a trademark for a number of fluorocarbons used particularly in refrigeration products and equipment.

POTENTIAL OCCUPATIONAL EXPOSURES

The fluorocarbons are used primarily as refrigerants and polymer intermediates. They are also used as aerosol propellants, anesthetics, fire extinguishers, foam blowing agents, in drycleaning, and in degreasing of electronic equipment. The fluorocarbons have found wide use due to their relatively low toxicity.

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

Aerosol bomb workers	Metal conditioners
Ceramic mold makers	Plastic makers
Drycleaners	Pressurized food makers
Drug makers	Refrigeration makers
Fire extinguisher workers	Rocket fuel makers
Heat transfer workers	Solvent workers

PERMISSIBLE EXPOSURE LIMITS

Federal standards for selected fluorocarbons of economic importance are listed as follows:

Compound	Federal Standards	
	ppm	mg/m³
Bromotrifluoromethane Fluorocarbon 13B1	1,000	6,100
Dibromodifluoromethane Fluorocarbon 12B2	100	860
Dichlorodifluoromethane Fluorocarbon 12	1,000	4,950
Dichloromonofluoromethane Fluorocarbon 21	1,000	4,200
Dichlorotetrafluoroethane Fluorocarbon 114	1,000	7,000
Fluorotrichloromethane Fluorocarbon 11	1,000	5,600
1,1,1,2-Tetrachloro-2,2-difluoroethane Fluorocarbon 112	500	4,170
1,1,2,2-Tetrachloro-1,2-difluoroethane Fluorocarbon 112	500	4,170
1,1,2-Trichloro-1,2,2-trifluoroethane Fluorocarbon 113	1,000	7,600
Bromochlorotrifluoroethane Fluorocarbon 123B1	No Standard	
Chlorodifluoromethane Fluorocarbon 22	No Standard (ACGIH TLV of 1,000 ppm)	
Chloropentafluoroethane Fluorocarbon 115	No Standard	
Chlorotrifluoroethylene Fluorocarbon 1113	No Standard	
Chlorotrifluoromethane Fluorocarbon 13	No Standard	
Difluoroethylene Fluorocarbon 1131	No Standard	
Fluoroethylene Fluorocarbon 1141	No Standard	
Hexafluoropropylene Fluorocarbon 1216	No Standard	
Octafluorocyclobutane Fluorocarbon C-318	No Standard	
Tetrafluoroethylene Fluorocarbon 1114	No Standard	

ROUTE OF ENTRY

Inhalation of vapor or gas.

HARMFUL EFFECTS

Local—

These compounds may produce mild irritation to the upper respiratory tract. Dermatitis occurs only rarely. Decomposition products may also be the cause of these effects.

Systemic—

Mild central nervous system depression may occur in cases of exposure to very high concentrations of fluorocarbons. Symptoms from acute exposure may manifest themselves in occasional tremor and incoordination. It has been reported that dizziness has resulted from an exposure to 5% dichlorodifluoromethane and unconsciousness from exposure to 15%. Cardiac arrhythmias, with sudden death, have occurred from breathing some of these chemicals. Typically, fluorocarbons have very low levels of toxicity, and their predominant hazard is from simple asphyxia.

Fluoroalkenes are more toxic than fluoroalkanes. Liver and kidney damage has been reported to occur from chronic exposure to fluoroalkenes, whereas no chronic effects have been reported from fluoroalkanes.

MEDICAL SURVEILLANCE

Though these compounds are of a low level of toxicity, they should not be considered inert. There are no specific diagnostic tests for the toxic effects occurring at very high concentrations. Preplacement and periodic examinations should consider possible cardiac effects from acute exposure.

SPECIAL TESTS

None commonly used. Compounds are usually excreted rapidly in expired air.

PERSONAL PROTECTIVE METHODS

Simple ventilation can avert acute poisoning. Masks are rarely needed.

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METHYL AND ETHYL BROMIDE

DESCRIPTION

CH_3Br, methyl bromide, is a colorless, nearly odorless gas. It is synthesized from sodium bromide, methyl alcohol, and sulfuric acid.

C_2H_5Br, ethyl bromide, is a colorless, volatile, flammable liquid possessing an etherlike odor, burning taste. It becomes yellowish on exposure to air. It is produced from potassium bromide, ethyl alcohol, and sulfuric acid.

SYNONYMS

Methyl bromide: bromomethane.

Ethyl bromide: bromoethane, monobromoethane, monobromomethane.

POTENTIAL OCCUPATIONAL EXPOSURES

Methyl Bromide: The primary use of methyl bromide is as an insect fumigant for soil, grain, warehouses, mills, ships, etc. It is also used as a chemical intermediate and a methylating agent, a refrigerant, a herbicide, a fire extinguishing agent, a low-boiling solvent in aniline dye manufacture; for degreasing wool; for extracting oils from nuts, seeds, and flowers; and in ionization chambers.

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

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

Anesthetists	Grain fumigators
Color makers	Refrigerant makers
Dye makers	Soil fumigators
Fire extinguisher workers	Solvent workers
Fruit fumigators	Wool degreasers

PERMISSIBLE EXPOSURE LIMITS

The Federal standard for methyl bromide is 20 ppm (80 mg/m^3) as a ceiling value. The Federal standard for ethyl bromide is 200 ppm (890 mg/m^3) as a TWA. The ACGIH recommended TLV for methyl bromide is 15 ppm (60 mg/m^3) as a TWA.

ROUTES OF ENTRY

Inhalation and percutaneous absorption.

HARMFUL EFFECTS

Local—

Methyl bromide is irritating to the eyes, skin, and mucous membranes of the upper respiratory tract. In cases of moderate skin exposure, there may be an itching dermatitis, and in severe cases, vesicles and second-degree burns. Methyl bromide may be absorbed by leather, resulting in prolonged skin contact. Repeated or prolonged skin contact with ethyl bromide may cause irritation.

Systemic—

High concentrations of either methyl or ethyl bromide may cause lung irritation which may result in pulmonary edema and death. Acute exposure to methyl bromide may produce delayed effects. Onset of symptoms is usually delayed from 30 minutes to 6 hours; the first to appear are malaise, visual disturbances, headaches, nausea, vomiting, somnolence, vertigo, and tremor in the hands. The tremor may become more severe and widespread, developing into epileptiform type convul-

sions followed by coma and death due to pulmonary or circulatory failure or both. A period of delirium and mania may precede convulsions, but convulsions have been reported without any other warning symptoms. Kidney damage may occur; permanent brain damage may result.

In chronic poisoning, the effects of methyl bromide are usually limited to the central nervous system: Lethargy; muscular pains; visual, speech, and sensory disturbances; and mental confusion being the most prominent complaints. Ethyl bromide exposure has not been associated with chronic effects other than skin irritation.

MEDICAL SURVEILLANCE

Methyl bromide: Evaluate the central nervous system, respiratory tract, and skin in preplacement and periodic examinations.

Ethyl bromide: No specific considerations needed.

SPECIAL TESTS

None in common use. Blood bromide levels have been measured in cases of methyl bromide intoxication, but their value in routine monitoring of exposure has not been established.

PERSONAL PROTECTIVE METHODS

Rubber, not leather, protective clothing should be utilized. When masks are worn, they should provide full face protection.

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METHYL CHLORIDE

DESCRIPTION

CH_3Cl, methyl chloride, is a colorless gas possessing a faint, sweet odor.

SYNONYMS

Monochloromethane, chloromethane.

POTENTIAL OCCUPATIONAL EXPOSURES

Methyl chloride is used as a methylating and chlorinating agent in organic chemistry. In petroleum refineries it is used as an extractant for greases, oils, and resins. Methyl chloride is also used as a solvent in the synthetic rubber industry, as a refrigerant, and as a propellant in polystyrene foam production. In the past it has been used as a local anesthetic (freezing).

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

Aerosol packagers	Methyl cellulose makers
Drug makers	Polystyrene foam makers
Flavor extractors	Refrigeration workers
Low temperature solvent workers	Rubber makers
Methylation workers	Vapor pressure thermometer makers

PERMISSIBLE EXPOSURE LIMITS

The Federal standard is 100 ppm (210 mg/m^3) as an 8-hour TWA, with an acceptable ceiling concentration of 200 ppm; acceptable maximum peaks above the ceiling of 300 ppm are allowed for 5 minutes duration in a 3-hour period.

ROUTE OF ENTRY

Percutaneous absorption.

HARMFUL EFFECTS

Local—

Skin contact with the discharge from the pressurized gas may cause frostbite. The liquid may damage eyes.

Systemic—

Signs and symptoms of chronic exposure include staggering gait, difficulty in speech, nausea, headache, dizziness, and blurred vision. Vomiting has also occurred in some cases. These effects may be observed following a latency period of several hours.

Acute exposure is much like chronic except that the latency period is shorter and the effects more severe. Coma or convulsive seizures may occur. Acute poisoning predominantly depresses the central nervous system, but renal and hepatic damage may also occur. Recently noted in these cases is the depression of bone marrow activity. Recovery from severe exposure may take as long as 2 weeks.

MEDICAL SURVEILLANCE

Preplacement and periodic examinations should give careful consideration to a previous history of the central nervous system, and to renal or hepatic disorders.

SPECIAL TESTS

None in common use.

PERSONAL PROTECTIVE METHODS

Masks should be used in areas of high vapor concentrations.

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Scharnweber, H. C., G. N. Spears, and S. R. Cowles. 1974. Chronic methyl chloride intoxication in six industrial workers. J. Occup. Med. 16:112.

METHYLENE CHLORIDE

DESCRIPTION

$CHCl_2$, methylene chloride, is a nonflammable, colorless liquid with a pleasant aromatic odor noticeable at 300 ppm (this, however, should not be relied upon as an adequate warning of unsafe concentrations).

SYNONYMS

Dichloromethane, methylene dichloride, methylene bichloride.

POTENTIAL OCCUPATIONAL EXPOSURES

Methylene chloride is used mainly as a low temperature extractant of substances which are adversely affected by high temperature. It can be used as a solvent for oil, fats, waxes, bitumen, cellulose acetate, and esters. It is also used as a paint remover and as a degreaser.

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

Aerosol packagers	Leather finish workers
Anesthetic makers	Oil processors
Bitumen makers	Paint remover makers
Degreasers	Resin makers
Fat extractors	Solvent workers
Flavoring makers	Stain removers

PERMISSIBLE EXPOSURE LIMITS

The Federal standard is 500 ppm (1,740 mg/m^3) as an 8-hour TWA with an acceptable ceiling concentration of 1,000 ppm; acceptable maximum peaks above the ceiling of 2,000 ppm are allowed for 5 minutes duration in a 2-hour period.

Note: The 1976 ACGIH TLV is 200 ppm (720 mg/m^3.)

NIOSH has recommended a time-weighted average limit of 75 ppm in the absence of occupational exposure to carbon monoxide greater than 9 ppm (TWA). For carbon monoxide exposures greater than 9 ppm, a formula is recommended. NIOSH also recommended a ceiling limit of 500 ppm as determined by a 15-minute sampling period.

ROUTES OF ENTRY

Inhalation of vapors and percutaneous absorption of liqiud.

HARMFUL EFFECTS

Local—

Repeated contact with methylene chloride may cause a dry, scaly, and fissured dermatitis. The liquid and vapor are irritating to the eyes and upper respiratory tract at higher concentrations. If the liquid is held in contact with the skin, it may cause skin burns.

Systemic—

Methylene chloride is a mild narcotic. Effects from intoxication include headache, giddiness, stupor, irritability, numbness, and tingling

in the limbs. Irritation to the eyes and upper respiratory passages occurs at higher dosages. In severe cases, observers have noted toxic encephalopathy with hallucinations, pulmonary edema, coma, and death. Cardiac arrythmias have been produced in animals but have not been common in human experiences. Exposure to this agent may cause elevated carboxyhemoglobin levels which may be significant in smokers, or workers with anemia or heart disease, and those exposed to CO.

MEDICAL SURVEILLANCE

Changes in liver, respiratory tract, and central nervous system should be considered during preplacement or periodic medical examinations. Smoking history should be known; anemias or cardiovascular disease may increase the hazard.

SPECIAL TESTS

The metabolism and excretion of methylene chloride has been thoroughly studied. Blood and expired air analyses are useful indicators of exposure. Carboxyhemoglobin levels may be useful indicators of excessive exposure, especially in nonsmokers.

PERSONAL PROTECTIVE METHODS

Protective clothing, gloves to prevent skin contact, and, in areas of high concentration, fullface masks.

BIBLIOGRAPHY

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Weiss, G. 1967. Toxische enzephalose beim beruflichen umgang mit methylenchlorid. Zentralbl. Arbeitsmed. 17:282.

PROPYLENE DICHLORIDE

DESCRIPTION

$CH_3CHClCH_2Cl$, propylene dichloride, is a colorless liquid with a characteristic unpleasant odor.

SYNONYMS

1,2-Dichloropropane, propylene chloride.

POTENTIAL OCCUPATIONAL EXPOSURES

Propylene dichloride is widely used for degreasing and drycleaning; it is also used as a soil fumigant and in the manufacture of cellulose

plastics, rubber, waxes, scouring compounds and other manufacture of organic synthetics.

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

Cellulose plastic makers	Organic chemical synthesizers
Drycleaners	Rubber makers
Fat processors	Scouring compound makers
Fumigant workers	Solvent workers
Gum processors	Stain removers
Metal degreasers	Wax makers
Oil processors	

PERMISSIBLE EXPOSURE LIMITS

The Federal standard is 75 ppm (350 mg/m^3).

ROUTE OF ENTRY

Inhalation of vapor.

HARMFUL EFFECTS

Local—

Propylene dichloride may cause dermatitis by defatting the skin. More severe irritation may occur if it is confined against the skin by clothing. Undiluted, it is moderately irritating to the eyes, but does not cause permanent injury.

Systemic—

In animal experiments, acute exposure to propylene dichloride produced central nervous system narcosis, fatty degeneration of the liver and kidneys.

MEDICAL SURVEILLANCE

Evaluate the skin and liver and renal function on a periodic basis, as well as cardiac and respiratory status and general health.

SPECIAL TESTS

None in common use. Propylene dichloride can be determined in expired air.

PERSONAL PROTECTIVE METHODS

Barrier creams or gloves and protective clothing. Masks in areas of vapor concentration.

BIBLIOGRAPHY

Heppel, L. A., P. A. Neal, B. Highman, and V. T. Porterfield. 1946. Toxicology of 1,2-dichloropropane (propylene dichloride). 1. Studies on effects of daily inhalation. J. Ind. Hyg. Toxicol. 28:1.

TETRACHLOROETHANE

DESCRIPTION

$CHCl_2CHCl_2$, tetrachloroethane, is a heavy, volatile liquid which is nonflammable and has a sweetish, chloroform-like odor. Oxidative

decomposition of tetrachloroethane by ultraviolet radiation or by contact with hot metal results in the formation of small quantities of phosgene, hydrochloric acid, carbon monoxide, carbon dioxide, or dichloroacetyl chloride.

SYNONYMS

1,1,2,2-Tetrachloroethane, sym-tetrachloroethane, acetylene tetrachloride, ethanetetrachloride.

POTENTIAL OCCUPATIONAL EXPOSURES

Tetrachloroethane is used as a drycleaning agent, as a fumigant, in cement, and in lacquers. It is used in the manufacture of tetrachloroethylene, artificial silk, artificial leather, and artificial pearls. Recently, its use as a solvent has declined due to replacement by less toxic compounds. It is also used in the estimation of water content in tobacco and many drugs, and as a solvent for chromium chloride impregnation of furs.

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

Biologists	Mineralogists
Drycleaners	Oil processors
Fat processors	Paint makers
Fumigators	Phosphorus processors
Gasket makers	Resin makers
Herbicide workers	Soil treaters
Insecticide workers	Solvent workers
Lacquer workers	Varnish workers
Metal cleaners	Waxers

PERMISSIBLE EXPOSURE LIMITS

The Federal standard is 5 ppm (35 mg/m^3). NIOSH has recommended a time-weighted average limit of 1 ppm.

ROUTES OF ENTRY

Inhalation of vapor and absorption of liquid through the skin. There is some evidence that tetrachloroethane absorbed through the skin affects the central nervous system only.

HARMFUL EFFECTS

Local—

Repeated or prolonged contact with this chemical can produce a scaly and fissured dermatitis.

Systemic—

Early effects brought on by tetrachloroethane narcotic action include tremors, headache, a prickling sensation and numbness of limbs, loss of kneejerk, and excessive sweating. Paralysis of the interossei muscles of the hands and feet and disappearance of ocular and pharyngeal reflexes have also occurred due to peripheral neuritis which may de-

velop later. Blood changes include increases in mononuclear leukocytes, progressive anemia, and a slight thrombocytosis.

Clinical symptoms following these changes are fatigue, headache, constipation, insomnia, irritability, anorexia, and nausea. Later on, liver dysfunction may result in complaints of general malaise, drowsiness, loss of appetite, nausea, an unpleasant taste in the mouth, and abdominal discomfort. This may be followed by jaundice, mental confusion, stupor or delirium, hematemesis, convulsions, and purpuric rashes.

Pulmonary edema ascribed to capillary injury has been noted in severe cases, along with renal damage, though it is not known to what extent this contributes to the total toxic picture. Nephritis may develop, and the urine may contain albumin and casts. Fatty degeneration of the myocardium has been reported only in animal experiments.

MEDICAL SURVEILLANCE

Preplacement and periodic examination should be comprehensive because of the possible involvement of many systems. Special attention should be given to liver, kidney, and bone marrow function, as well as to the central and peripheral nervous systems. Alcoholism may be a predisposing factor.

SPECIAL TESTS

None commonly used. Blood or breath analyses may be useful.

PERSONAL PROTECTIVE METHODS

Gloves and protective clothing should be worn, and appropriate respirators or masks should be used in areas of elevated vapor concentration.

BIBLIOGRAPHY

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Rowe, V. K., T. Wukjkowski, M. A. Wolf, S. E. Sadek, and R. E. Steward. 1963. Toxicity of a solvent of 1,1,1-trichloroethane and tetrachloroethylene as determined by experiments on laboratory animals and human subjects. Am. Ind. Hyg. Assoc. J. 24:541.

TETRACHLOROETHYLENE

DESCRIPTION

$Cl_2C{=}CCl_2$, tetrachloroethylene, is a clear, colorless, nonflammable liquid with a characteristic odor. The odor is noticeable at 50 ppm, though after a short period it may become inconspicuous, thereby becoming an unreliable warning signal.

SYNONYMS

Perchloroethylene, carbon dichloride, ethylene tetrachloride.

POTENTIAL OCCUPATIONAL EXPOSURES

Tetrachloroethylene is a widely used solvent with particular use as a drycleaning agent, a degreaser, a chemical intermediate, a fumigant, and medically as an anthelmintic.

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

Cellulose ester processors	Metal degreasers
Degreasers	Printers
Dope processors	Rubber workers
Drug makers (anthelmintics)	Soap workers
Drycleaners	Solvent workers
Electroplaters	Tar processors
Ether processors	Vacuum tube makers
Fumigant workers	Wax makers
Gum processors	Wool scourers

PERMISSIBLE EXPOSURE LIMITS

The Federal standard is 100 ppm (670 mg/m^3), as an 8-hour TWA with an acceptable ceiling concentration of 200 ppm; acceptable maximum peaks above the ceiling of 300 ppm are allowed for 5 minutes duration in a 3-hour period. NIOSH has recommended a time-weighted average limit of 50 ppm and a ceiling limit of 100 ppm determined by 15-minute samples, twice daily.

ROUTES OF ENTRY

Inhalation of vapor and percutaneous absorption of liquid.

HARMFUL EFFECTS

Local—

Repeated contact may cause a dry, scaly, and fissured dermatitis. High concentrations may produce eye and nose irritation.

Systemic—

Acute exposure to tetrachloroethylene may cause central nervous system depression, hepatic injury, and anesthetic death. Cardiac arrhythmias and renal injury have been produced in animal experiments. Signs and symptoms of overexposure include malaise, dizziness, headache, increased perspiration, fatigue, staggering gait, and slowing of mental ability. These usually subside quickly upon removal into the open air.

MEDICAL SURVEILLANCE

Evaluate skin, and liver and kidney function, as well as central nervous system. Alcoholism may be a predisposing factor.

SPECIAL TESTS

Breath analyses may be helpful in evaluating exposures.

Workers with preemployment histories of liver, kidney, or nervous disorders should be advised as to possible increased risk.

PERSONAL PROTECTIVE METHODS

Skin protection in the form of barrier creams, gloves, and protective clothing should be used. In areas of vapor concentration, full face masks should be worn.

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1,1,1-TRICHLOROETHANE

DESCRIPTION

CH_3CCl_3, 1,1,1-trichloroethane, is a colorless, nonflammable liquid with an odor similar to chloroform. Upon contact with hot metal or exposure to ultraviolet radiation, it will decompose to form the irritant gases hydrochloric acid, phosgene, and dichloroacetylene.

SYNONYMS

Methyl chloroform.

POTENTIAL OCCUPATIONAL EXPOSURES

In recent years, 1,1,1-trichloroethane has found wide use as a substitute for carbon tetrachloride. In liquid form it is used as a degreaser and for cold cleaning, dip-cleaning, and bucket cleaning of metals. Other industrial applications of 1,1,1-trichloroethane's solvent properties include its use as a drycleaning agent, a vapor degreasing agent, and a propellant.

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

Degreasers	Metal degreasers
Drycleaners	Propellant makers
Machinery cleaners	Stain removers

PERMISSIBLE EXPOSURE LIMITS

The Federal standard is 350 ppm (1,900 mg/m^3). NIOSH has recommended a 350 ppm ceiling as determined by a 15-minute sampling period.

ROUTES OF ENTRY

Inhalation of vapor and moderate skin absorption.

HARMFUL EFFECTS

Local—

Liquid and vapor are irritating to eyes on contact. This effect is usually noted first in acute exposure cases. Mild conjunctivitis may develop but recovery is usually rapid. Repeated skin contact may produce a dry, scaly, and fissured dermatitis, due to the solvent's defatting properties.

Systemic—

1,1,1-trichloroethane acts as a narcotic and depresses the central nervous system. Acute exposure symptoms include dizziness, incoordination, drowsiness, increased reaction time, unconsciousness, and death.

MEDICAL SURVEILLANCE

Consider the skin, liver function, cardiac status, especially arrythmias, in preplacement or periodic examinations.

SPECIAL TESTS

Expired air analyses may be useful in monitoring exposure.

PERSONAL PROTECTIVE METHODS

1,1,1-Trichloroethane attacks natural rubber; therefore, protective clothing of leather, polyvinyl alcohol, or neoprene is recommended. In areas of high concentrations, fullface masks should be worn.

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1,1,2-TRICHLOROETHANE

DESCRIPTION

$CH_2ClCHCl_2$, 1,1,2-trichloroethane, is a colorless, nonflammable liquid. It is an isomer of 1,1,1-trichloroethane but should not be confused with it toxicologically. 1,1,2-Trichloroethane is comparable to carbon tetrachloride and tetrachloroethane in toxicity.

SYNONYMS

Vinyl trichloride.

POTENTIAL OCCUPATIONAL EXPOSURES

1,1,2-Trichloroethane is used as a chemical intermediate and as a solvent, but is not as widely used as its isomer 1,1,1-trichloroethane.

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

Organic chemical synthesizers
Solvent makers

PERMISSIBLE EXPOSURE LIMITS

The Federal standard is 10 ppm (45 mg/m^3) as a TWA.

ROUTES OF ENTRY

Inhalation of vapor and absorption through the skin.

HARMFUL EFFECTS

Local—

Irritation to eyes and nose, and infection of the conjunctiva have been shown in animals.

Systemic—

Little is known of the toxicity of 1,1,2-trichloroethane since no human toxic effects have been reported. Animal experiments show 1,1,2-trichloroethane to be a potent central nervous system depressant. The injection of anesthetic doses in animals was associated with both liver and renal neurosis.

MEDICAL SURVEILLANCE

Consider the skin, central nervous system, and liver and kidney function. Alcoholism may be a synergistic factor.

SPECIAL TESTS

None commonly used, but expired air analyses may be useful in monitoring exposure.

PERSONAL PROTECTIVE METHODS

Protective clothing and gloves should be worn. Respirators should be used in areas of high vapor concentration.

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TRICHLOROETHYLENE

DESCRIPTION

$ClCH=CCl_2$, trichloroethylene, a colorless, nonflammable, noncorrosive liquid has the "sweet" odor characteristic of some chlorinated hydrocarbons. Decomposition of trichloroethylene, due to contact with hot metal or ultraviolet radiation, forms products including chlorine gas, hydrogen chloride, and phosgene. Dichloroacetylene may be formed from the reaction of alkali with trichloroethylene.

SYNONYMS

Ethylene trichloride, ethinyl trichloride, trichloroethene.

POTENTIAL OCCUPATIONAL EXPOSURES

Trichloroethylene is primarily used as a solvent in vapor degreasing. It is also used for extracting caffeine from coffee, as a drycleaning agent,

and as a chemical intermediate in the production of pesticides, waxes, gums, resins, tars, paints, varnishes, and specific chemicals such as chloroacetic acid.

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

Anesthetic makers	Metal cleaners
Caffeine processors	Oil processors
Cleaners	Perfume makers
Disinfectant makers	Printers
Degreasers	Resin workers
Drug makers	Rubber cementers
Drycleaners	Shoe makers
Dye makers	Soap makers
Electronic equipment cleaners	Solvent workers
Fat processors	Textile cleaners
Glass cleaners	Tobacco denicotinizers
Mechanics	Varnish workers

PERMISSIBLE EXPOSURE LIMITS

The Federal standard is 100 ppm (535 mg/m^3) as an 8-hour TWA with an acceptable ceiling concentration of 200 ppm; acceptable maximum peaks above the ceiling of 300 ppm are allowed for 5 minutes duration in a 2-hour period. The NIOSH Criteria for a Recommended Standard recommends limits of 100 ppm as a TWA and a peak of 150 ppm determined by a sampling time of 10 minutes.

ROUTES OF ENTRY

Inhalation and percutaneous absorption.

HARMFUL EFFECTS

Local—

Exposure to trichloroethylene vapor may cause irritation of the eyes, nose, and throat. The liquid, if splashed in the eyes, may cause burning irritation and damage. Repeated or prolonged skin contact with the liquid may cause dermatitis.

Systemic—

Acute exposure to trichloroethylene depresses the central nervous system exhibiting such symptoms as headache, dizziness, vertigo, tremors, nausea and vomiting, irregular heart beat, sleepiness, fatigue, blurred vision, and intoxication similar to that of alcohol. Unconsciousness and death have been reported. Alcohol may make the symptoms of trichloroethylene overexposure worse. If alcohol has been consumed, the overexposed worker may become flushed. Trichloroethylene addiction and peripheral neuropathy have been reported. Recent reports indicate that exposure to trichloroethylene may induce liver tumors in mice.

MEDICAL SURVEILLANCE

Preplacement and periodic examinations should include the skin,

respiratory, cardiac, central, and peripheral nervous systems, as well as liver and kidney function. Alcohol intake should be evaluated.

SPECIAL TESTS

Expired air analysis and urinary metabolites have been used to monitor exposure.

PERSONAL PROTECTIVE METHODS

Gloves and protective clothing should be worn, and fullface mask should be used in areas of excessive vapor concentrations.

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VINYL CHLORIDE

DESCRIPTION

$CH_2=CHCl$, vinyl chloride, is a flammable gas at room temperature and is usually encountered as a cooled liquid. The colorless liquid forms a vapor which has a pleasant ethereal odor.

SYNONYMS

Chloroethylene, chloroethene, monochloroethylene.

POTENTIAL OCCUPATIONAL EXPOSURES

Vinyl chloride is used as a vinyl monomer in the manufacture of polyvinyl chloride and other resins. It is also used as a chemical intermediate and as a solvent.

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

Polyvinyl resin makers
Organic chemical synthesizers
Rubber makers

PERMISSIBLE EXPOSURE LIMITS

The Federal standard for exposure to vinyl chloride sets a limit of 1 ppm over an 8-hour period, and a ceiling of 5 ppm averaged over any period not exceeding 15 minutes.

ROUTES OF ENTRY

Vinyl chloride gas is absorbed by inhalation. Skin absorption has been suggested but experimental evidence is presently lacking.

HARMFUL EFFECTS

Local—

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

Systemic—

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

Chronic exposure of workers involved in reactor vessel entry and hand cleaning may result in the triad of acro-osteolysis, Raynaud's phenomenon, and sclerodermatus skin changes. Chronic exposure may also cause hepatic damage.

Vinyl chloride is regarded as a human carcinogen, and a causal agent of angiosarcoma of the liver. Excess cancer of the lung and the lymphatic and nervous systems has also been reported. Experimental evidence of tumor induction in a variety of organs, including liver, lung, brain, and kidney, as well as nonmalignant alterations, such as fibrosis and connective tissue deterioration, indicate the multisystem oncogenic and toxicologic effects of vinyl chloride.

MEDICAL SURVEILLANCE

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

SPECIAL TESTS

None in common use. Metabolism is being studied.

PERSONAL PROTECTIVE METHODS

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

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ALIPHATIC AMINES

The aliphatic amines are derivatives of ammonia (NH_3) in which one or more hydrogen atoms are replaced by alkyl or alkanol radicals. They tend to have a characteristic fishlike ammonia odor in the free base form.

These compounds are generally prepared by alkylation of ammonia or hydrogenation of the appropriate nitrite. They are widely used in industry, particularly as chemical intermediates.

The amines are basic compounds and may form strongly alkaline solutions which can be highly irritating and cause damage on contact with eyes and skin. Skin absorption may be significant as many are capable of cutaneous sensitization. Some members of this series may have physiologic or pharmacologic effects—e.g., histamine liberation and vasodilation, but, in general, local effects predominate in industrial exposures.

Because of the strong irritant properties of aliphatic amines, eyes, skin, and respiratory tract should be protected from exposure to them.

N-BUTYLAMINE

DESCRIPTION

CH_3-CH_2-CH_2-CH_2-NH_2, n-butylamine, is a flammable colorless liquid with an ammoniacal odor.

SYNONYMS

1-aminobutane.

POTENTIAL OCCUPATIONAL EXPOSURES

n-Butylamine is used in pharmaceuticals, dyestuffs, rubber, chemicals, emulsifying agents, photography, desizing agents for textiles, pesticides, and synthetic agents.

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

- Butylaminophenol makers
- Chemists
- Drug makers
- Dye makers
- Emulsifier makers
- Insecticide makers
- Petroleum dewaxers
- Rubber makers
- Tanning chemical makers

PERMISSIBLE EXPOSURE LIMITS

The Federal standard is 5 ppm (15 mg/m^3) as a ceiling value.

ROUTES OF ENTRY

Inhalation and percutaneous absorption.

HARMFUL EFFECTS

Local—

Butylamine vapor is irritating to the nose, throat, and eyes. Contact with the liquid may produce severe eye damage and skin burns.

Systemic—

Inhalation of concentrations at or above the threshold limit may produce mild headaches and flushing of the skin and face.

Butylamine vapor has produced pulmonary edema in animal experiments.

MEDICAL SURVEILLANCE

Evaluate risks of eye or skin injury and respiratory irritation in periodic or placement examinations.

SPECIAL TESTS

None have been developed.

PERSONAL PROTECTIVE METHODS

Protective clothing and goggles should be worn where possibility of skin or eye contact with the liquid exists. In areas of elevated vapor concentration, fullface masks with organic vapor canister or supplied air respirators and protective clothing should be worn. The odor and irritation of the mucous membranes cannot be relied upon for exposure control.

ETHANOLAMINES

DESCRIPTION

Monoethanolamine: $H_2NCH_2CH_2OH$, Diethanolamine: $HN(CH_2CH_2OH)$, Triethanolamine: $N(CH_2CH_2,(OH)_3$. All three compounds are water soluble liquids. Monoethanolamine has a low vapor pressure while the vapor pressure of the other ethanolamines is very low. Monoethanolamine and diethanolamine have ammonia odors while triethanolamine has only a faint non-ammonia odor. The acid salts have less odor and are of low volatility. Ethanolamines can be detected by odor as low as 2-3 ppm.

SYNONYMS

Monoethanolamine: Ethanolamine, 2-aminoethanol, colamine
Diethanolamine: 2,2'-Iminodiethanol
Triethanolamine: 2,2',2"-Nitrilotriethanol

POTENTIAL OCCUPATIONAL EXPOSURES

Monoethanolamine is widely used in industry to remove carbon dioxide and hydrogen from natural gas, to remove hydrogen sulfide and carbonyl sulfide, as an alkaline conditioning agent, and as an intermediate for soaps, detergents, dyes, and textile agents.

Diethanolamine is an absorbent for gases, a solubilizer for 2,4-dichlorophenoxyacetic acid (2,4-D), and a softener and emulsifier intermediate for detergents. It also finds use in the dye and textile industry.

Triethanolamine is used as a plasticizer, neutralizer for alkaline dispersions, lubricant additive, corrosion inhibitor, and in the manufacture of soaps, detergents, shampoos, shaving preparations, face and hand creams, cements, cutting oils, insecticides, surface active agents, waxes, polishes, and herbicides.

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

Cement makers	Plastic workers
Detergent makers	Polish makers
Dye makers	Soap makers
Emulsifier makers	Surfactant makers
Herbicide makers	Textile workers
Insecticide makers	2,4-D makers
Natural gas workers	

PERMISSIBLE EXPOSURE LIMITS

The Federal standard for monoethanolamine is 3 ppm (6 mg/m^3). There are no standards for the other compounds.

ROUTES OF ENTRY

Inhalation of vapor and percutaneous absorption.

HARMFUL EFFECTS

Local—

Ethanolamine has had wide use in industry, yet reports of injury

in man are lacking. Ethanolamine in animal experiments was highly irritating to the skin, eyes, and respiratory tract. Diethanolamine and triethanolamine produced much less irritation. In human experiments, ethanolamine produced only redness of the skin.

Systemic—

No specific published data on human exposure are available. Animal experiments indicate that it is a central nervous system depressant. Acute high level exposures produced pulmonary damage and non-specific hepatic and renal lesions in animals.

MEDICAL SURVEILLANCE

Evaluate possible irritant effects on skin and eyes.

SPECIAL TESTS

None in common use.

PERSONAL PROTECTIVE METHODS

Protective clothing should be worn, and in areas of elevated vapor concentrations, fullface masks should be supplied.

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ETHYLENEDIAMINE

DESCRIPTION

$H_2N\text{-}CH_2\text{-}CH_2\text{-}NH_2$, ethylenediamine, is a strongly alkaline, colorless, clear, thick, liquid with an ammonia odor.

SYNONYMS

Ethanediamine, 1,2-diaminoethane.

POTENTIAL OCCUPATIONAL EXPOSURES

Ethylenediamine is used as a solvent, an emulsifier for casein and shellac solutions, a stabilizer in rubber latex, a chemical intermediate in the manufacture of dyes, corrosion inhibitors, synthetic waxes, fungicides, resins, insecticides, asphalt wetting agents, and pharmaceuticals, and also in controlling acidity or alkalinity.

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

- Albumin processors
- Casein processors
- Drug makers
- Dye makers
- Emulsion workers
- Ethylenediamine tetraacetic acid (EDTA) makers
- Fungicide makers
- Insecticide makers
- Oil neutralizers
- Resin makers
- Rubber makers
- Shellac processors
- Surfactant makers

PERMISSIBLE EXPOSURE LIMITS

The Federal standard is 10 ppm (25 mg/m^3).

ROUTES OF ENTRY

Inhalation of vapor and percutaneous absorption.

HARMFUL EFFECTS

Local—

Ethylenediamine vapor may cause irritation of the nose and tingling of the face. Cutaneous sensitivity has been reported.

In animal experiments, the liquid has produced severe irritation of the eyes and corneal damage. It has also produced severe irritation and necrosis.

Systemic—

In animal experiments, high concentrations of ethylenediamine vapor have produced damage to liver, lungs, and kidneys.

MEDICAL SURVEILLANCE

Consider possible irritant effects on skin, eyes and respiratory system. History of allergic redness of skin or asthmatic symptoms may be important in placement and periodic examinations.

SPECIAL TESTS

None have been developed.

PERSONAL PROTECTIVE METHODS

Protective clothing, gloves, and goggles should be worn to protect the skin and eyes. Fullface masks with organic vapor canisters must be used in areas of high vapor concentrations. Recent reports indicate that a non-occupational allergic contact dermatitis may develop after use of pharmaceuticals containing ethylenediamine.

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CYANIDES AND NITRILES

This class of compounds contains the $-CN$ group and includes, in addition to cyanides and nitriles, related chemicals such as cyanogens, isocyanates, and cyanamides.

Hydrogen cyanide and its soluble salts are rapidly acting poisons. The cyanide ion when released in the body is capable of inhibiting many enzymes, the most sensitive being cytochrome oxidase. Deaths from acute exposure are due to chemical asphyxia at the cellular level.

In high concentrations, nitriles (R-CN) can cause similar symptoms, but the onset is slower. It is believed that the CN ion is released from

the nitriles, the rate of release determining the toxicity. In addition, nitriles may be primary irritants.

Other $-CN$ derivatives differ in their toxic properties and may not have the same mechanism of action.

There seems to be a detoxification mechanism for cyanide ion; the enzyme rhodanese (transulfurase) is the catalyst for the reaction

$$S_2O_3^{=} + CN^- \rightarrow SO_3^{=} + SCN^-$$

in which cyanide ion is converted to thiocyanate ion. Theoretically, this endogenously produced thiocyanate may have lesser toxic effects, similar to those seen in thiocyanate therapy, at high doses. It is unlikely that this is of practical significance, however, because of the minute quantities of CN^- and SCN^- ions involved in poisoning cases.

There are several tests of biological tissues available which are suitable for diagnostic purposes of acute intoxication but not for routine medical surveillance. Thiocyanate is excreted in the urine and may be present in the serum; smokers have a higher thiocyanate level than nonsmokers. Cyanide ion may also be found in blood and tissues.

ACETONITRILE

DESCRIPTION

CH_3-CN, acetonitrile, is a colorless liquid with an ether-like odor.

SYNONYMS

Methyl cyanide, ethanenitrile, cyanomethane.

POTENTIAL OCCUPATIONAL EXPOSURES

Acetonitrile is used as an extractant for animal and vegetable oils, as a solvent, particularly in the pharmaceutical industry, and as a chemical intermediate.

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

Animal oil processors
Organic chemical synthesizers
Vegetable oil processors

PERMISSIBLE EXPOSURE LIMITS

The Federal standard is 40 ppm (70 mg/m^3).

ROUTES OF ENTRY

Inhalation and percutaneous absorption.

HARMFUL EFFECTS

Local—

At high concentrations, nose and throat irritation have been reported. Splashes of the liquid in the eyes may cause irritation. Acetonitrile may cause slight flushing of the face and a feeling of chest tightness.

Systemic—

Acetonitrile has a relatively low acute toxicity, but there have been reports of severe and fatal poisonings in man after inhalation of high concentrations. Signs and symptoms may include nausea, vomiting, respiratory depression, weakness, chest or abdominal pain, hematemesis, convulsions, shock, unconsciousness, and death. In most cases there is a latent period of several hours between exposure and onset of symptoms. It has been thought that acetonitrile itself has relatively little toxic effect and that the delayed response is due to the slow release of cyanide. No chronic disease has been reported.

MEDICAL SURVEILLANCE

Consider the skin, respiratory tract, heart, central nervous system, renal and liver function in placement and periodic examinations. A history of fainting spells or convulsive disorders might present an added risk to persons working with toxic nitriles.

SPECIAL TESTS

None commonly used. Blood CN can be determined but may be of little help in evaluating low level exposures.

PERSONAL PROTECTIVE METHODS

Protective clothing should be worn, and in areas of high concentration, air supplied respirators and complete skin protection are necessary. Workers in these areas must be educated to the nature of acetonitrile hazard. They should also be trained in artificial respiration and in the use of amyl nitrite antidote in emergency situations.

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ACRYLONITRILE

DESCRIPTION

$CH_2=CH-CN$, acrylonitrile, is a colorless liquid with a faint acrid odor. It is both flammable and explosive.

SYNONYMS

Vinyl cyanide, cyanoethylene, propene nitrile.

POTENTIAL OCCUPATIONAL EXPOSURES

Acrylonitrile is used in the manufacture of synthetic fibers, acrylostyrene plastics, acrylonitrile-butadiene styrene plastics, nitrile rubbers, chemicals, and adhesives. It is also used as a pesticide.

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

Acrylic resin makers	Rubber makers
Organic chemical synthesizers	Synthetic fiber makers
Pesticide workers	Textile finish makers

PERMISSIBLE EXPOSURE LIMITS

The Federal standard is 20 ppm (45 mg/m^3).

ROUTES OF ENTRY

Inhalation and percutaneous absorption. It may be absorbed from contaminated rubber or leather.

HARMFUL EFFECTS

Local—

Acrylonitrile may cause irritation of the eyes. Repeated and prolonged exposure may produce skin irritation. When acrylonitrile is held in contact with the skin (e.g., after being absorbed into shoe leather or clothing), it may produce blistering after several hours of no apparent effect. Unless the contaminated clothing is removed promptly and the area washed off, blistering will occur.

Systemic—

Acrylonitrile exposure may produce nausea, vomiting, headache, sneezing, weakness, and light-headedness. Exposure to high concentrations may produce profound weakness, asphyxia, and death.

MEDICAL SURVEILLANCE

Consider the skin, respiratory tract, heart, central nervous system, renal and liver function in placement and periodic examinations. A history of fainting spells or convulsive disorders might present an added risk to persons working with toxic nitriles.

SPECIAL TESTS

None commonly used.

PERSONAL PROTECTIVE METHODS

Leather should not be used in protective clothing since it is readily penetrated by acrylonitrile. Rubber clothing should be frequently washed and inspected because it will soften and swell. Acrylonitrile should be handled with all of the same precautions as taken for hydrogen cyanide, and workers' education should be identical. Liquid splashed on skin should be immediately washed off. Eyes should be protected from splash (goggles), and, in areas of vapor concentration, special cyanide masks or air supplied masks should be provided. Workers should be trained in artificial respiration and in the use of amyl nitrite antidote in emergency situations.

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CALCIUM CYANAMIDE

DESCRIPTION

NCN=Ca, calcium cyanamide, is a blackish-grey, shiny powder.

SYNONYMS

Nitrolim, calcium carbimide, cyanamide.

POTENTIAL OCCUPATIONAL EXPOSURES

Calcium cyanamide is used in agriculture as a fertilizer, herbicide, defoliant for cotton plants, and pesticide. It is also used in the manufacture of dicyanidamide and calcium cyanide, as a desulfurizer in the iron and steel industry, and in steel hardening.

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

Ammonia makers	Herbicide workers
Cotton defoliant workers	Nitrogen compound makers
Cyanamide makers	Organic chemical synthesizers
Fertilizer workers	Steel workers

PERMISSIBLE EXPOSURE LIMITS

There is no Federal standard for calcium cyanamide. (Note: The 1976 ACGIH TLV was 0.5 mg/m^3.)

ROUTE OF ENTRY

Inhalation of dust.

HARMFUL EFFECTS

Local—

Calcium cyanamide is a primary irritant of the mucous membranes of the respiratory tract, eyes, and skin. Inhalation may result in rhinitis, pharyngitis, laryngitis, and bronchitis. Conjunctivitis, keratitis, and corneal ulceration may occur. An itchy erythematous dermatitis has been reported and continued skin contact leads to the formation of slowly healing ulcerations on the palms and between the fingers. Sensitization occasionally develops. Chronic rhinitis and perforation of the nasal septum have been reported after long exposures. All local effects appear to be due to the caustic nature of cyanamide.

Systemic—

Calcium cyanamide causes a characteristic vasomotor reaction. There is erythema of the upper portions of the body, face, and arms,

accompanied by nausea, fatigue, headache, dyspnea, vomiting, oppression in the chest, and shivering. Circulatory collapse may follow in the more serious cases. The vasomotor response may be triggered or intensified by alcohol ingestion. Pneumonia or lung edema may develop. Cyanide ion is not released in the body, and the mechanism of toxic action is unknown.

MEDICAL SURVEILLANCE

Evaluate skin, respiratory tract, and history of alcohol intake in placement or periodic examinations.

SPECIAL TESTS

None commonly used.

PERSONAL PROTECTIVE METHODS

In addition to personal protective equipment, waterproof barrier creams may be used to provide additional face and skin protection. Personal hygiene measures are to be encouraged, such as showering after work and a complete change of clothing. In areas of heavy dust concentrations, fullface dust masks are recommended.

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o-CHLOROBENZYLIDENE MALONITRILE

DESCRIPTION

$ClC_6H_4CH=C(CN)_2$ o-chlorobenzylidene malonitrile (OCBM), is a white crystalline solid.

SYNONYMS

OCBM, CS.

POTENTIAL OCCUPATIONAL EXPOSURES

OCBM is used as a riot control agent.

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

Riot controllers

PERMISSIBLE EXPOSURE LIMITS

The Federal standard is 0.05 ppm (0.4 mg/m^3).

ROUTE OF ENTRY

Inhalation.

HARMFUL EFFECTS

Local—

OCBM is extremely irritating and acts on exposed sensory nerve endings (primarily in the eyes and upper respiratory tract). The signs

and symptoms from exposure to the vapor are conjunctivitis and pain in the eyes, lacrimation, erythema of the eyelids, blepharospasms, irritation and running of the nose, burning in the throat, coughing and constricted feeling in the chest, and excessive salivation. Vomiting may occur if saliva is swallowed. Most of the symptoms subside after exposure ceases. Burning on the exposed skin is increased by moisture. With heavy exposure, vesiculation and erythema occur. Photophobia has been reported.

Systemic—

Animal experiments indicate that OCBM has a relatively low toxicity. The systemic changes observed in human experiments are nonspecific reactions to stress. OCBM is capable of sensitizing guinea pigs; there also appears to be a cross-reaction in guinea pigs previously sensitized to 1-chloroacetophenone (CN)

MEDICAL SURVEILLANCE

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

SPECIAL TESTS

None have been proposed.

PERSONAL PROTECTIVE METHODS

Because of its extremely irritant properties, those using OCBM in high concentrations should wear respirators and eye protection.

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HYDROGEN CYANIDE

DESCRIPTION

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

SYNONYMS

Hydrocyanic acid, prussic acid.

POTENTIAL OCCUPATIONAL EXPOSURES

Hydrogen cyanide is used as a fumigant, in electroplating, and in chemical synthesis of acrylates and nitriles, particularly acrylonitrile. It may be generated in blast furnaces, gas works, and coke ovens. Cyanide salts have a wide variety of uses, including electroplating, steel hardening, fumigating, gold and silver extraction from ores, and chemical synthesis.

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

- Acid dippers
- Acrylate makers
- Ammonium salt makers
- Blast furnace workers
- Cellulose product treaters
- Coke oven workers
- Cyanogen makers
- Electroplaters
- Fumigant workers
- Gas workers
- Gold extractors
- Jewelers
- Organic chemical synthesizers
- Polish makers
- Silver extractors
- Steel workers

PERMISSIBLE EXPOSURE LIMITS

The Federal standard for hydrogen cyanide is 10 ppm (11 mg/m^3). NIOSH has recommended 5 mg/m^3 expressed as cyanide and determined as a ceiling concentration based on a 10-minute sampling period.

ROUTES OF ENTRY

Inhalation of vapor and percutaneous absorption of liquid and concentrated vapor.

HARMFUL EFFECTS

Local—

Hydrogen cyanide is a mild upper respiratory irritant and may cause slight irritation of the nose and throat. There may also be irritation from skin and eye contact with the liquid. Hydrogen cyanide liquid may cause eye irritation.

Systemic—

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

MEDICAL SURVEILLANCE

Preplacement and periodic examinations should include the cardiovascular and central nervous systems, liver and kidney function, blood, history of fainting or dizzy spells.

SPECIAL TESTS

Blood CN levels may be useful during acute intoxication. Urinary thiocyanate levels have been used but are nonspecific and are elevated in smokers.

PERSONAL PROTECTIVE METHODS

If personal protective equipment is necessary, air supplied or self-contained gas masks specific for hydrogen cyanide, and clothing impervious to HCN vapor should be worn. Eye protection can be provided by fullface respirators or goggles. All personnel working with processes involving cyanides should be specially trained so that they fully understand the hazard, and so they will faithfully follow all rules laid down for safe handling.

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ISOCYANATES

DESCRIPTION

Both toluene diisocyanate (TDI) and methylene bisphenyl isocyanate (MDI) are liquids and may exist in different isomers: 2,4-toluene diisocyanate and methylene bisphenyl 4,4'-diisocyanate. Other less commonly used isocyanates are hexamethylene diisocyanate (HDI) and 1,5-naphthalene diisocyanate (NDI).

SYNONYMS

Toluene diisocyanate: TDI, tolylene diisocyanate, diisocyanatotoluene. Methylene bisphenyl isocyanate: MDI, diphenylmethane diisocyanate, methane diisocyanate.

POTENTIAL OCCUPATIONAL EXPOSURES

TDI is more widely used than MDI. Polyurethanes are formed by the reaction of isocyanates with polyhydroxy compounds. Since the reaction proceeds rapidly at room temperature, the reactants must be mixed in pots or spray guns just before use. These resins can be produced with various physical properties, e.g., hard, flexible, semirigid foams, and have found many uses, e.g., upholstery padding, thermal insulation, molds, surface coatings, shoe innersoles, and in rubbers, adhesives, paints, and textile finishes. Because of TDI's high volatility, exposure can occur in all phases of its manufacture and use. MDI has a much lower volatility, and problems generally arise only in spray applications.

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

Adhesive workers	Polyurethane makers
Insulation workers	Rubber workers
Isocyanate resin workers	Ship burners
Lacquer workers	Textile processors
Organic chemical synthesizers	Wire coating workers
Paint sprayers	

PERMISSIBLE EXPOSURE LIMITS

The Federal standard for MDI is 0.02 ppm (0.2 mg/m^3) as a ceiling value. The Federal standard for the 2,4 isomer of TDI is also 0.02 ppm (0.14 mg/mg^3) as a ceiling value. However, the standard recommended in the NIOSH Criteria Document for TDI is 0.005 ppm (0.036 mg/m^3) as a TWA and 0.02 for any 20-minute period.

ROUTE OF ENTRY

Inhalation of vapor.

HARMFUL EFFECTS

Local—

TDI and MDI may cause irritation of the eyes, respiratory tract, and skin. The irritation may be severe enough to produce bronchitis and pulmonary edema. Nausea, vomiting, and abdominal pain may occur. If liquid TDI is allowed to remain in contact with the skin, it may produce redness, swelling, and blistering. Contact of liquid TDI with the eyes may cause severe irritation, which may result in permanent damage if untreated. Swallowing TDI may cause burns of the mouth and stomach.

Systemic—

Sensitization to TDI and MDI may occur, which may cause an asthmatic reaction with wheezing, dyspnea, and cough. These symptoms may first occur during the night following exposure to these chemicals. Some decrease in lung function in the absence of symptoms has been observed in some workers exposed to TDI for long periods of time.

MEDICAL SURVEILLANCE

Preplacement and periodic medical examinations should include chest roentgenograph, pulmonary function tests, and an evaluation of any respiratory disease or history of allergy. Periodic pulmonary function tests may be useful in detecting the onset of pulmonary sensitization.

SPECIAL TESTS

None in common use.

PERSONAL PROTECTIVE METHODS

Protective clothing and goggles should be worn if there is a possibility of contact with the liquids. In areas of vapor concentration, full-

face masks with organic vapor canisters or respirators with supplied air and fullface pieces should be worn.

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AROMATIC HYDROCARBONS

Aromatic hydrocarbons are characterized by the presence of the aromatic nucleus. The basic aromatic nucleus is benzene, C_6H_6. In benzene, the carbon atoms are arranged as a regular hexagon, with a hydrogen atom attached to each of the carbon atoms. The bond between each of the carbon atoms is neither a single bond nor a double bond, but an intermediate form of higher stability. (The electronic character of the benzene nucleus is usually referred to as "resonance.") The fact that the bonds are intermediate between single and double results in all of the carbon atoms being equivalent. The hydrogen atoms on the aromatic nucleus may be replaced by other univalent elements or groups. Aromatic hydrocarbons encompass compounds that include only carbon and hydrogen.

Aromatic hydrocarbons have enjoyed wide usage as solvents and as chemical intermediates. Benzene, the typical aromatic hydrocarbon, has been replaced as a commercial solvent by toluene and other less toxic compounds. These chemicals are also used as feedstock for many organic compounds and are used in the manufacture of fuels, dyes, pharmaceuticals, plastics, resins, and polyesters.

Typically, the vapor of aromatic hydrocarbons causes central nervous system depression or other effects, and, depending on the compound, hepatic, renal, or bone marrow disorders. Vapor is absorped through the lungs, and the liquid may be absorbed through the skin. Repeated and prolonged skin contact may cause defatting of the skin, which leads to dermatitis.

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BENZENE

DESCRIPTION

C_6H_6, benzene, is a clear, volatile, colorless, highly flammable liquid with a charactersitic odor. The most common commercial grade