

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

BIBLIOGRAPHY

- Konzen, R. B., B. F. Craft, L. D. Scheel, and C. H. Gorski. 1966. Human response to low concentrations of p,p-diphenylmethanediisocyanate (MDI). *Amer. Ind. Hyg. Assoc. J.* 27:121.
- Longley, E. O. 1964. Methane diisocyanate: A respiratory hazard? *Arch. Environ. Health* 8:898.
- U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health. 1973. *Criteria for a Recommended Standard . . . Occupational Exposure to Toluene Diisocyanate*. U.S. Government Printing Office, Washington, D.C. 20402.

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 absorbed 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.

BIBLIOGRAPHY

- Gerarde, H. W. 1960. *Toxicology and Biochemistry of Aromatic Hydrocarbons*. Elsevier Publishing Co., New York.

BENZENE

DESCRIPTION

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

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

SYNONYMS

Benzol, phenyl hydride, coal naphtha, phene, benxole, cyclohexatriene.

POTENTIAL OCCUPATIONAL EXPOSURES

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

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

Adhesive makers	Furniture finishers
Asbestos product impregnators	Glue makers
Dry-battery makers	Linoleum makers
Chemists	Maleic acid makers
Benzene hexachloride makers	Nitrobenzene makers
Burnishers	Petrochemical workers
Carbolic acid makers	Putty makers
Chlorinated benzene workers	Rubber makers
Detergent makers	Styrene makers
Dye makers	Welders

PERMISSIBLE EXPOSURE LIMITS

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

ROUTES OF ENTRY

Inhalation of vapor which may be supplemented by percutaneous absorption although benzene is poorly absorbed through intact skin.

HARMFUL EFFECTS

Local—

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

Systemic—

Acute exposure to benzene results in central nervous system depression. Headache, dizziness, nausea, convulsions, coma, and death

may result. Death has occurred from large acute exposure as a result of ventricular fibrillation, probably caused by myocardial sensitization to endogenous epinephrine. Early reported autopsies revealed hemorrhages (non-pathognomonic) in the brain, pericardium, urinary tract, mucous membranes, and skin.

Chronic exposure to benzene is well documented to cause blood changes. Benzene is basically a myelotoxic agent. Erythrocyte, leukocyte, and thrombocyte counts may first increase, and then aplastic anemia may develop with anemia, leukopenia, and thrombocytopenia. The bone marrow may become hypo- or hyper-active and may not always correlate with peripheral blood.

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

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

MEDICAL SURVEILLANCE

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

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

SPECIAL TESTS

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

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

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

PERSONAL PROTECTIVE METHODS

Protective clothing should be worn at all times; benzene-wetted clothing should be changed at once. Impervious clothing and gloves to cover exposed areas of body should be worn where exposure is continuous. In areas where there is likelihood of spill or splash, face shields or goggles should be provided. In areas of elevated vapor concentration, organic vapor cartridge masks or supplied air or self-contained breathing apparatus may be required.

BIBLIOGRAPHY

- Forni, A. M., A. Cappellini, E. Pacifico, and E. C. Vigliani. 1971. Chromosome changes and their evolution in subjects with past exposure to benzene. *Arch. Environ. Health* 23:385.
- Sherwood, R. J., and F. W. G. Carter. 1970. The measurement of occupational exposure to benzene vapor. *Ann. Occup. Hyg.* 13:125.
- Tauber, J. B. 1965. Instant benzol death. *J. Occup. Med.* 12:520.

DIPHENYL

DESCRIPTION

$C_{12}H_{10}$, diphenyl, is a colorless to light yellow, leaflet solid with a potent characteristic odor.

SYNONYMS

Biphenyl, phenylbenzene.

POTENTIAL OCCUPATIONAL EXPOSURES

Diphenyl is a fungistat for oranges which is applied to the inside of shipping containers and wrappers. It is also used as a heat transfer agent and as an intermediate in organic synthesis. Diphenyl is produced by thermal dehydration of benzene.

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

Orange packers

Fungicide workers

Organic chemical synthesizers

PERMISSIBLE EXPOSURE LIMITS

The Federal standard is 0.2 ppm (1 mg/m³).

ROUTES OF ENTRY

Inhalation of vapor or dust; percutaneous absorption.

HARMFUL EFFECTS*Local—*

Repeated exposure to dust may result in irritation of skin and respiratory tract. The vapor may cause moderate eye irritation. Repeated skin contact may produce a sensitization dermatitis.

Systemic—

In acute exposure, diphenyl exerts a toxic action on the central nervous system, on the peripheral nervous system, and on the liver. Symptoms of poisoning are headache, diffuse gastrointestinal pain, nausea, indigestion, numbness and aching of limbs, and general fatigue. Liver function tests may show abnormalities. Chronic exposure is characterized mostly by central nervous system symptoms, fatigue, headache, tremor, insomnia, sensory impairment, and mood changes. Such symptoms are rare, however.

MEDICAL SURVEILLANCE

Consider skin, eye, liver function and respiratory tract irritation in any preplacement or periodic examination.

SPECIAL TESTS

None in common use.

PERSONAL PROTECTIVE METHODS

Because of its low vapor pressure and low order of toxicity, it does not usually present a major problem in industry. Protective creams, gloves, and masks with organic vapor canisters for use in areas of elevated vapor concentrations should suffice. Elevated temperature may increase the requirement for protective methods or ventilation.

BIBLIOGRAPHY

Hakkinen, I., E. Siltanen, S. Herberg, A. M. Seppalainen, P. Karli, and E. Viskula. 1973. Diphenyl poisoning in fruit paper production. *Arch. Environ. Health* 26:70.

NAPHTHALENE**DESCRIPTION**

C₁₀H₈, naphthalene, is a white crystalline solid with a characteristic "moth ball" odor.

SYNONYMS

Naphthalin, moth flake, tar camphor, white tar.

POTENTIAL OCCUPATIONAL EXPOSURES

Naphthalene is used as a chemical intermediate or feedstock for synthesis of phthalic, anthranilic, hydroxyl (naphthols), amino (naphthylamines), and sulfonic compounds which are used in the manufacture of various dyes. Naphthalene is also used in the manufacture of hydro-naphthalenes, synthetic resins, lampblack, smokeless powder, and celluloid. Naphthalene has been used as a moth repellent.

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

Beta naphthol makers	Lampblack makers
Celluloid makers	Moth repellent workers
Coal tar workers	Phthalic anhydride makers
Dye chemical makers	Smokeless powder makers
Fungicide makers	Tannery workers
Hydronaphthalene makers	Textile chemical makers

PERMISSIBLE EXPOSURE LIMITS

The Federal standard is 10 ppm (50 mg/m³).

ROUTE OF ENTRY

Inhalation of vapor or dust.

HARMFUL EFFECTS

Local—

Naphthalene is a primary irritant and causes erythema and dermatitis upon repeated contact. It is also an allergen and may produce dermatitis in hypersensitive individuals. Direct eye contact with the dust has produced irritation and cataracts.

Systemic—

Inhaling high concentrations of naphthalene vapor or ingesting may cause intravascular hemolysis and its consequences. Initial symptoms include eye irritation, headache, confusion, excitement, malaise, profuse sweating, nausea, vomiting, abdominal pain, and irritation of the bladder. There may be progressive jaundice, hematuria, hemoglobinuria, renal tubular blockade, and acute renal shutdown. Hematologic features include red cell fragmentation, icterus, severe anemia with nucleated red cells, leukocytosis, and dramatic decreases in hemoglobin, hematocrit, and red cell count. Individuals with a deficiency of glucose-6-phosphate dehydrogenase in erythrocytes are more susceptible to hemolysis by naphthalene.

MEDICAL SURVEILLANCE

Consider eyes, skin, blood, liver, and renal function in placement and follow-up examinations. Low erythrocyte glucose 6-phosphate dehydrogenase increases risk.

SPECIAL TESTS

None in common use.

PERSONAL PROTECTIVE METHODS

As used in industry, they are rarely necessary. In dusty areas and areas of high vapor concentration, dust type or organic vapor canister masks should be supplied. Skin protection with gloves, barrier creams, or protective clothing may be useful.

STYRENE/ETHYL BENZENE

DESCRIPTION

$C_6H_5CH=CH_2$, styrene, is a colorless to yellowish, very refractive, oily liquid with a penetrating odor.

$C_6H_5C_2H_5$, ethyl benzene, is a colorless flammable liquid with a pungent odor.

SYNONYMS

Styrene: Cinnamene, cinnemenol, cinnamol, phenethylene, phenylethylene, styrene monomer, styrol, styrolene, vinyl benzene.

Ethyl benzene: Ethylbenzol, phenylethane, EB.

POTENTIAL OCCUPATIONAL EXPOSURES

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

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

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

Adhesive makers	Polyester resin laminators
Aviation fuel blenders	Polystyrene makers
Emulsifier agent makers	Potting compound workers
Fibrous glass moulders	Protective coating workers
Insulator makers	Resin makers
Lacquer workers	Rubber makers
Organic chemical synthesizers	Solvent workers
Petroleum refinery workers	Varnish makers.

PERMISSIBLE EXPOSURE LIMITS

The Federal standard for styrene for an 8-hour TWA is 100 ppm (420 mg/m³). The acceptable ceiling concentration is 200 ppm with an acceptable maximum peak of 600 ppm for a maximum duration of 5 minutes in any 3 hours. The Federal standard for ethyl benzene is 100 ppm (435 mg/m³).

ROUTES OF ENTRY

Inhalation of vapor; percutaneous absorption.

HARMFUL EFFECTS

Local—

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

Systemic—

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

MEDICAL SURVEILLANCE

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

SPECIAL TESTS

None in common use. Mandelic acid in urine has been used as a measure of the intensity of styrene exposure.

PERSONAL PROTECTIVE METHODS

Barrier creams or gloves and protective clothing may be all that are needed where the vapor concentrations do not exceed existing standards. Where vapor concentration exists above allowable standards, masks with organic vapor canisters and face plates or respirators with air supply are recommended. Clothing saturated with styrene or ethylbenzene should be changed at once. Personal hygiene is encouraged with frequent changes of work clothes.

BIBLIOGRAPHY

- Stewart, R. D., H. C. Dodd, E. D. Baretta, and A. W. Schaffer. 1968. Human exposure to styrene vapor. *Arch. Environ. Health* 16:656.
- Wilson, R. H. 1944. Health hazards encountered in the manufacture of synthetic rubber. *J. Am. Med. Assoc.* 124:701.

TOLUENE

DESCRIPTION

$C_6H_5CH_3$, toluene, is a clear, colorless, noncorrosive liquid with a sweet, pungent, benzene-like odor.

SYNONYMS

Toluol, methylbenzene, phenylmethane, methylbenzol.

POTENTIAL OCCUPATIONAL EXPOSURES

Toluene may be encountered in the manufacture of benzene. It is

also used as a chemical feed for toluene diisocyanate, phenol, benzyl and benzyl derivatives, benzoic acid, toluene sulfonates, nitrotoluenes, vinyl toluene, and saccharin; as a solvent for paints and coatings; or as a component of automobile and aviation fuels.

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

Aviation fuel blenders,	Perfume makers
Benzene makers	Petrochemical workers
Chemical laboratory workers	Rubber cement makers
Coke oven workers	Saccharin makers
Gasoline blenders	Solvent workers
Lacquer workers	Toluene diisocyanate makers
Paint thinner makers	Vinyl toluene makers

PERMISSIBLE EXPOSURE LIMITS

The Federal standard is 200 ppm as an 8-hour TWA with an acceptable ceiling concentration of 300 ppm; acceptable maximum peaks above the ceiling of 500 ppm are allowed for 10 minutes duration. NIOSH has recommended a limit of 100 ppm (TWA) with a ceiling of 200 ppm for a ten minute sampling period.

ROUTES OF ENTRY

Inhalation of vapor and percutaneous absorption of liquid.

HARMFUL EFFECTS

Local—

Toluene may cause irritation of the eyes, respiratory tract, and skin. Repeated or prolonged contact with liquid may cause removal of natural lipids from the skin, resulting in dry, fissured dermatitis. The liquid splashed in the eyes may cause irritation and reversible damage.

Systemic—

Acute exposure to toluene predominantly results in central nervous system depression. Symptoms and signs include headache, dizziness, fatigue, muscular weakness, drowsiness, incoordination with staggering gait, skin paresthesias, collapse, and coma.

MEDICAL SURVEILLANCE

Preplacement and periodic examinations should evaluate possible effect on skin, central nervous system, as well as liver and kidney function. Hematologic studies should also be done if there is significant contamination of the solvent with benzene.

SPECIAL TESTS

Hippuric acid levels above 5 g/liter of urine may result from exposure greater than 200 ppm determined as a TWA. Blood levels can also be determined for toluene.

PERSONAL PROTECTIVE METHODS

Where vapor concentration exists above allowable standards, em-

ployees should be provided with respirators (air supplied) or gas masks with organic vapor canister and fullface plate. Impervious clothing, gloves, or other coverings to protect potentially exposed areas of the body should be supplied to employees in operations requiring continued exposure to liquid toluene. Toluene-wet clothing should be immediately removed unless impervious, and work clothing changed at least twice a week. Safety glasses or goggles should be worn in areas where splash or spill is likely.

BIBLIOGRAPHY

- Jenkins, L. J., R. A. Jones, and J. Siegel. 1970. Long-term inhalation screening studies of benzene, toluene, o-xylene, and cumene on experimental animals. *Toxicol. Appl. Pharmacol.* 16:818.
- U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health. 1973. *Criteria for a Recommended Standard . . . Occupational Exposure to Toluene.* U.S. Government Printing Office, Washington, D.C.

XYLENE

DESCRIPTION

$C_6H_4(CH_3)_2$, xylene, exists in three isomeric forms, ortho-, meta- and para-xylene. Commercial xylene is a mixture of these three isomers and may also contain ethyl benzene as well as small amounts of toluene, trimethyl benzene, phenol, thiophene, pyridine, and other non-aromatic hydrocarbons. Metaxylene is predominant in commercial xylene and shares physical properties with ortho-xylene in that both are mobile, colorless, flammable liquids. Para-xylene, at low temperature (13-14 C), forms colorless plates or prisms.

SYNONYMS

Xylol, dimethylbenzene.

POTENTIAL OCCUPATIONAL EXPOSURES

Xylene is used as a solvent; as a constituent of paint, lacquers, varnishes, inks, dyes, adhesives, cements, cleaning fluids and aviation fuels; and as a chemical feedstock for xylidines, benzoic acid, phthalic anhydride, isophthalic, and terephthalic acids, as well as their esters (which are specifically used in the manufacture of plastic materials and synthetic textile fabrics). Xylene is also used in the manufacture of quartz crystal oscillators, hydrogen peroxide, perfumes, insect repellants, epoxy resins, pharmaceuticals, and in the leather industry.

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

Adhesive workers	Phthalic anhydride makers
Aviation gasoline workers	Polyethylene terephthalate film makers
Benzoic acid makers	Quartz crystal oscillator makers
Cleaning fluid makers	Solvent workers
Histology technicians	Synthetic textile makers
Lacquer workers	Terephthalic acid makers
Leather workers	Varnish makers
Paint workers	

PERMISSIBLE EXPOSURE LIMITS

The Federal standard is 100 ppm (435 mg/m³).

ROUTES OF ENTRY

Inhalation of vapor and, to a small extent, percutaneous absorption of liquid.

HARMFUL EFFECTS

Local—

Xylene vapor may cause irritation of the eyes, nose, and throat. Repeated or prolonged skin contact with xylene may cause drying and defatting of the skin which may lead to dermatitis. Liquid xylene is irritating to the eyes and mucous membranes, and aspiration of few milliliters may cause chemical pneumonitis, pulmonary edema, and hemorrhage. Repeated exposure of the eyes to high concentrations of xylene vapor may cause reversible eye damage.

Systemic—

Acute exposure to xylene vapor may cause central nervous system depression and minor reversible effects upon liver and kidneys. At high concentrations xylene vapor may cause dizziness, staggering, drowsiness, and unconsciousness. Also at very high concentrations, breathing xylene vapors may cause pulmonary edema, anorexia, nausea, vomiting, and abdominal pain.

MEDICAL SURVEILLANCE

Preplacement and periodic examinations should evaluate possible effects on the skin and central nervous system, as well as liver and kidney functions. Hematalogic studies should be done if there is any significant contamination of the solvent with benzene.

SPECIAL TESTS

Although metabolites are known, biologic monitoring has not been widely used. Hippuric acid or the ether glucuronide of ortho-toluic acid may be useful in diagnosis of meta-, para- and ortho-xylene exposure, respectively.

PERSONAL PROTECTIVE METHODS

When vapor concentrations exceed allowable standards, fullface masks with organic vapor canisters or air supplied respirators should be furnished. Impervious protective clothing and gloves should be worn to cover exposed portions of the body of employees exposed to liquid xylene. Xylene-wet clothing should be changed quickly. Personal hygiene, as well as appropriate changes of work clothes, is necessary. Goggles or safety glasses in areas of spill or splash, or in areas where vapors concentrate, are advised. Barrier creams may be useful.

BIBLIOGRAPHY

Matthaus, W. 1964. Beitrag zur hornhauterkrankung von oberflächenbearbeiten in der mobilindustrie. *Klin. Monatsbl. Augenheilkd.* 144:713.

Morley, R., D. W. Eccleston, C. P. Douglas, W. E. J. Greville, D. J. Scott, and J. Anderson. 1970. Xylene poisoning: a report of one fatal case and two cases of recovery after prolonged unconsciousness. *Br. Med. J.* 3:442.

PHENOLS AND PHENOLIC COMPOUNDS

This group of compounds is characterized by the substitution of one or more hydrogens in a benzene ring by hydroxyl ($-OH$) groups. Phenol (C_6H_5OH) is the simplest of the compounds. Additional substitutions are possible. Quinone ($C_6H_4O_2$) is included in this group because it is derived from hydroquinone although its physical, chemical, and toxic properties are quite different. These substances are widely distributed in industry and some (e.g., phenolcresol) find use in pharmaceuticals because of their disinfectant action.

These materials generally enter the body by inhalation and percutaneous absorption. Their toxicity varies, but some are highly irritating to the skin, mucous membranes of the upper respiratory tract, and eyes. Some are corrosive for all tissue; cresote, a complex mixture of phenolic and aromatic compounds, may cause skin cancer. Systemic effects usually involve the central nervous or cardio-vascular systems or both; this may be accompanied by renal and hepatic damage.

Appropriate engineering controls and personal protective devices should be used to prevent absorption by either the respiratory or percutaneous route, and eye protection should be utilized where necessary.

CRESOL

DESCRIPTION

$CH_3C_6H_4OH$, cresol, is a mixture of the three isomeric cresols, ortho-, meta-, and para-cresol, and is a colorless, yellowish, brownish-yellow, or pinkish liquid with a phenolic odor. Creosols are soluble in alcohol, glycol, and dilute alkalis. Also they may be combustible.

SYNONYMS

Cresylic acid, cresylol, hydroxytoluene, methyl phenol, oxytoluene, tricresol.

POTENTIAL OCCUPATIONAL EXPOSURES

Cresol is used as a disinfectant, as an ore flotation agent, and as an intermediate in the manufacture of chemicals, dyes, plastics, and antioxidants. A mixture of isomers is generally used; the concentrations of the components are determined by the source of the cresol.

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

Antioxidant makers	Paint remover workers
Chemical disinfectant workers	Pitch workers
Dye makers	Plastic makers
Flotation agent makers	Resin makers
Foundry workers	Stain workers
Insulation enamel workers	Wool scourers

PERMISSIBLE EXPOSURE LIMITS

The Federal standard is 5 ppm (22 mg/m³).

ROUTES OF ENTRY

Inhalation or percutaneous absorption of liquid or vapor.

HARMFUL EFFECTS

Local—

Cresol is very corrosive to all tissues. It may cause burns if it is not removed promptly and completely and in case of extensive exposure, if it is not removed completely from contaminated areas of the body very quickly, death may result. When it contacts the skin, it may not produce any sensation immediately. After a few moments, prickling and intense burning occur. This is followed by loss of feeling. The affected skin shows wrinkling, white discoloration, and softening. Later gangrene may occur. If the chemical contacts the eyes, it may cause extensive damage and blindness. A skin rash may result from repeated or prolonged exposure of the skin to low concentrations of cresol. Discoloration of the skin may also occur from this type of exposure.

Systemic—

When cresol is absorbed into the body either through the lungs, through the skin, or mucous membranes, or by swallowing, it may cause systemic poisoning. The signs and symptoms of systemic poisoning may develop in 20 or 30 minutes. These toxic effects include: weakness of the muscles, headache, dizziness, dimness of vision, ringing of the ears, rapid breathing, mental confusion, loss of consciousness, and sometimes death.

Prolonged or repeated absorption of low concentrations of cresol through the skin, mucous membranes, or respiratory tract may cause chronic systemic poisoning. Symptoms and signs of chronic poisoning include vomiting, difficulty in swallowing, salivation, diarrhea, loss of appetite, headache, fainting, dizziness, mental disturbances, and skin rash. Death may result if there has been severe damage to the liver and kidneys.

MEDICAL SURVEILLANCE

Consider the skin, eyes, respiratory system, and liver and kidney function in placement or periodic examinations.

SPECIAL TESTS

Can be determined in urine, but because large amounts are normally present, a urine test is of little value as a procedure for evaluating exposure.

PERSONAL PROTECTIVE METHODS

Protective goggles and clothing should be worn to prevent direct contact with cresol. Masks with organic vapor canisters are advisable in areas of vapor concentration.

BIBLIOGRAPHY

American Industrial Hygiene Association. 1969. Community air quality guides. Phenol and cresol. *Am. Ind. Hyg. Assoc. J.* 30:425.

CREOSOTE**DESCRIPTION**

Creosote is a flammable, heavy, oily liquid with a characteristic sharp, smoky smell, and caustic burning taste. In pure form it is colorless, but the industrial product is usually brownish. It is produced by the destructive distillation of wood or coal tar at temperatures above 200 C. The chemical composition is determined by the source and may contain guaiacol, creosols, phenol, cresols, pyridine, and numerous other aromatic compounds.

SYNONYMS

Creosotum, cresote oil, brick oil.

POTENTIAL OCCUPATIONAL EXPOSURES

Creosote is used primarily as a wood preservative, and those working with the treated wood may be exposed. It is also used as a waterproofing agent, an animal dip, a constituent in fuel oil, a lubricant for die molds, as pitch for roofing, and in the manufacture of chemicals and lampblack. In the pharmaceutical industry, it is used as an antiseptic, disinfectant, antipyretic, astringent, styptic, germicide, and expectorant.

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

Coal tar workers	Pitch workers
Fuel oil blenders	Water proofers
Lampblack makers	Wood preservers
Organic chemical synthesizers	

PERMISSIBLE EXPOSURE LIMITS

There is no Federal standard for creosote.

ROUTE OF ENTRY

Skin absorption.

HARMFUL EFFECTS*Local—*

The liquid and vapors are strong irritants producing local erythema,

burning, itching, pigmentation (grayish yellow to bronze), vesiculation, ulceration, and gangrene. Eye injuries include keratitis, conjunctivitis, and permanent corneal scars. Contact dermatitis is reported in industry. Photosensitization has been reported. Skin cancer may occur.

Systemic—

Symptoms of systemic illness include salivation, vomiting, vertigo, headache, loss of pupillary reflexes, hypothermia, cyanosis, convulsions, thready pulse, respiratory difficulties, and death.

MEDICAL SURVEILLANCE

Consider the skin, eyes, respiratory tract, and central nervous system in placement and periodic examination.

SPECIAL TESTS

None commonly used.

PERSONAL PROTECTIVE METHODS

Protective clothing should be worn where employees are exposed to the liquid or high vapor concentration. Masks with fullface protection and organic vapor canisters should be worn. Gloves and goggles are advisable in any area where spill or splash might occur.

BIBLIOGRAPHY

Arief, A. J. 1965. Acute, toxic, polioencephalitis (creosote). *J. Am. Med. Assoc.* 193:745.

HYDROQUINONE

DESCRIPTION

$C_6H_4(OH)_2$, hydroquinone, exists as colorless, hexagonal prisms.

SYNONYMS

Quinol, hydroquinol, p-diphenol, hydrochinone, dihydroxybenzene, p-dihydroxybenzene, p-hydroxyphenol, 1,4-benzenediol.

POTENTIAL OCCUPATIONAL EXPOSURES

Hydroquinone is a reducing agent and is used as a photographic developer and as an antioxidant or stabilizer for certain materials which polymerize in the presence of oxidizing agents. Many of its derivatives are used as bacteriostatic agents, and others, particularly 2,5-bis(ethyleneimino) hydroquinone, have been reported to be good antimitotic and tumor-inhibiting agents.

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

Antioxidant makers	Organic chemical synthesizers
Bacteriostatic agent makers	Photographic developer makers
Drug makers	Plastic stabilizer workers
Fur processors	Stone coating workers
Motor fuel blenders	Styrene monomer workers
Paint makers	

250 OCCUPATIONAL DISEASES

PERMISSIBLE EXPOSURE LIMITS

The Federal standard is 2 mg/m³.

ROUTE OF ENTRY

Inhalation of dust.

HARMFUL EFFECTS

Local—

The dust is a mild primary irritant. Skin sensitization to the dry solid is very rare but does occur on occasion from contact with its alkaline solutions. The skin may be depigmented by repeated applications of ointments of hydroquinone, but this virtually never occurs from contact with dust or dilute water solutions. Following prolonged exposure to elevated dust levels, brownish conjunctiva stains may appear. These may be followed by corneal opacities and structural changes in the cornea which may lead to loss of visual acuity. The early pigmentary stains are reversible, while the corneal changes tend to be progressive.

Systemic—

Oral ingestion of large quantities of hydroquinone may produce blurred speech, tinnitus, tremors, sense of suffocation, vomiting, muscular twitching, headache, convulsions, dyspnea and cyanosis from methemoglobinemia, and coma and collapse from respiratory failure. The urine is usually green or brownish green. No systemic symptoms have been found following inhalation of hydroquinone dust.

MEDICAL SURVEILLANCE

Careful examination of the eyes, including visual acuity and slit lamp examinations, should be carried out in preplacement and periodic examinations. Also examine skin.

SPECIAL TESTS

Hydroquinone is excreted in the urine as a sulfate ester. This has not been helpful in following worker exposure to dust.

PERSONAL PROTECTIVE METHODS

The eyes should be protected by goggles or dust masks with full-face shield. Protective clothing is recommended along with good hygiene practice, clothes changing after each shift, and showering prior to dressing in street clothes. Oxidation of hydroquinone may produce quinone vapor which is highly irritating.

BIBLIOGRAPHY

- Anderson, B., and F. Oglesby. 1958. Corneal changes from quinone-hydroquinone exposure. *Arch. Ophthalmol.* 59:495.
Seutter, E., and A.H.M. Sutorius. 1972. Quantitative analysis of hydroquinone in urine. *Clin. Chim. Acta.* 38:231.

PHENOL

DESCRIPTION

C_6H_5OH , phenol, is a white crystalline substance with a distinct aromatic, acrid odor.

SYNONYMS

Carbolic acid, phenic acid, phenylic acid, phenyl hydrate, hydroxybenzene, monohydroxybenzene.

POTENTIAL OCCUPATIONAL EXPOSURES

Phenol is used in the production or manufacture of explosives, fertilizer, coke, illuminating gas, lampblack, paints, paint removers, rubber, asbestos goods, wood preservatives, synthetic resins, textiles, drugs, pharmaceutical preparations, perfumes, bakelite, and other plastics (phenol-formaldehyde resins). Phenol also finds wide use as a disinfectant in the petroleum, leather, paper, soap, toy, tanning, dye, and agricultural industries.

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

Coal tar workers	Paint and paint remover workers
Disinfectant makers	Paper makers
Dye workers	Rubber reclaimers
Explosive workers	Soap workers
Fertilizer makers	Tannery workers
Illuminating gas workers	Weed killer users
Lampblack makers	Wood preservers
Organic chemical synthesizers	

PERMISSIBLE EXPOSURE LIMITS

The Federal standard is 5 ppm (19 mg/m³).

ROUTES OF ENTRY

Inhalation of mist or vapor; percutaneous absorption of mist, vapor, or liquid.

HARMFUL EFFECTS

Local—

Phenol has a marked corrosive effect on any tissue. When it comes in contact with the eyes it may cause severe damage and blindness. On contact with the skin, it does not cause pain but causes a whitening of the exposed area. If the chemical is not removed promptly, it may cause a severe burn or systemic poisoning.

Systemic—

Systemic effects may occur from any route of exposure. These include paleness, weakness, sweating, headache, ringing of the ears, shock, cyanosis, excitement, frothing of the nose and mouth, dark colored urine, and death. If death does not occur, kidney damage may appear.

Repeated or prolonged exposure to phenol may cause chronic phenol poisoning. This condition is very rarely reported. The symptoms of chronic poisoning include vomiting, difficulty in swallowing, diarrhea, lack of appetite, headache, fainting, dizziness, dark urine, mental disturbances, and possibly, skin rash. Liver and kidney damage and discoloration of the skin may occur.

MEDICAL SURVEILLANCE

Consider the skin, eye, liver, and renal function as part of any pre-placement or periodic examination.

SPECIAL TESTS

Phenol can be determined in blood or urine.

PERSONAL PROTECTIVE METHODS

In areas where there is likelihood of a liquid spill or splash, impervious protective clothing and goggles should be worn. In areas of heavy vapor concentrations, fullface mask with forced air supply should be used, as well as protective clothing, gloves, rubber boots, and apron.

BIBLIOGRAPHY

- American Industrial Hygiene Association. 1969. Community air quality guides. Phenol and cresol. *Am. Ind. Hyg. Assoc. J.* 30:425.
- Evans, S. J. 1952. Acute phenol poisoning. *Br. J. Ind. Med.* 9:227.
- Piotrowski, J. K. 1971. Evaluation of exposure to phenol: absorption of phenol vapor in the lungs and through the skin and excretion of phenol in urine. *Br. J. Ind. Med.* 28:172.

QUINONE

DESCRIPTION

$C_6H_4O_2$, quinone, exists as large yellow, monoclinic prisms; the vapors have a pungent, irritating odor.

SYNONYMS

Benzoquinone, chinone, p-benzoquinone, 1,4-benzoquinone

POTENTIAL OCCUPATIONAL EXPOSURES

Because of its ability to react with certain nitrogen compounds to form colored substances, quinone is widely used in the dye, textile, chemical, tanning, and cosmetic industries. It is used as an intermediate in chemical synthesis for hydroquinone and other chemicals.

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

Chemical laboratory workers	Organic chemical synthesizers
Cosmetic makers	Photographic film developers
Dye makers	Protein fiber makers
Gelatin makers	Tannery workers
Hydrogen peroxide makers	Textile workers

PERMISSIBLE EXPOSURE LIMITS

The Federal standard is 0.1 ppm (0.4 mg/m³).

ROUTE OF ENTRY

Inhalation of vapor.

HARMFUL EFFECTS*Local—*

Solid quinone in contact with skin or the lining of the nose and throat may produce discoloration, severe irritation, swelling, and the formation of papules and vesicles. Prolonged contact with the skin may cause ulceration. Quinone vapor is highly irritating to the eyes. Following prolonged exposure to vapor, brownish conjunctival stains may appear. These may be followed by corneal opacities and structural changes in the cornea and loss of visual acuity. The early pigmentary stains are reversible, while the corneal dystrophy tends to be progressive.

Systemic—

No systemic effects have been found in workers exposed to quinone vapor over many years.

MEDICAL SURVEILLANCE

Careful examination of the eyes, including visual acuity and slit lamp examinations, should be done during placement and periodic examinations. Also evaluate skin.

SPECIAL TESTS

No useful laboratory tests for monitoring exposure have been developed.

PERSONAL PROTECTIVE METHODS

In areas of high vapor concentrations, protection must be aimed at the eyes and respiratory tract. Fullface mask with organic vapor canisters or respirators with forced air afford protection. The skin can be damaged by contact with solid quinone, solutions, or vapor condensing on the skin, so protective clothing, gloves, and boots are indicated. Personal hygiene is encouraged, with clothes being changed after each shift or after becoming damp from contact with the liquid. Workers should shower before changing to street clothes.

BIBLIOGRAPHY

Anderson, B., and F. Oglesby. 1959. Corneal changes from quinone-hydroquinone exposure. *Arch. Ophthalmol.* 59:495.

AROMATIC HALOGENATED HYDROCARBONS

Aromatic compounds having a halogen bearing side chain are extensively used in the manufacture of basic and acid colors, pharmaceuticals, pesticides, resins, and as chemical intermediates. The vapor and

liquid of some of these compounds are highly irritating to all mucous membranes and skin, and some are powerful lacrimators.

The chlorinated naphthalenes and diphenyls produce a severe and disfiguring acne on skin contact. Percutaneous absorption and inhalation of vapor may lead to severe liver damage in certain instances.

With exception of the chlorinated benzenes, the more highly chlorinated the compound, the greater the toxicity.

BENZYL CHLORIDE

DESCRIPTION

$C_6H_5CH_2Cl$, benzyl chloride is a colorless liquid with an unpleasant, irritating odor.

SYNONYMS

Alpha-chlorotoluene.

POTENTIAL OCCUPATIONAL EXPOSURES

Benzyl chloride is used in production of benzal chloride, benzyl alcohol, and benzaldehyde. Industrial usage includes the manufacture of plastics, dyes, synthetic tannins, perfumes, resins, and pharmaceuticals.

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

Drug makers	Plastic makers
Dye makers	Resin makers
Gasoline additive makers	Rubber makers
Germicide makers	Tannin makers
Perfume makers	Wetting agent makers
Photographic developer makers	

PERMISSIBLE EXPOSURE LIMITS

The Federal standard is 1 ppm (5 mg/m³).

ROUTE OF ENTRY

Inhalation of vapor.

HARMFUL EFFECTS

Local—

Benzyl chloride is a severe irritant to the eyes and respiratory tract. At 160 mg/m² it is unbearably irritating to the eyes and nose. Liquid contact with the eyes produces severe irritation and may cause corneal injury. Skin contact may cause dermatitis.

Systemic—

Benzyl chloride is regarded as a potential cause of pulmonary edema. One author has reported disturbances of liver functions and mild leukopenia in some workers, but this has not been confirmed. Sarcomas have been produced in rats which were injected with benzyl chloride.

MEDICAL SURVEILLANCE

Replacement and periodic examinations should include the skin, eyes, and an evaluation of the liver, kidney, respiratory tract, and blood.

SPECIAL TESTS

None in common use.

PERSONAL PROTECTIVE METHODS

Personal protective equipment should include industrial filter respirators with goggles, and protective clothing for face, hands, and arms.

BIBLIOGRAPHY

Mikhailova, T. V. 1965. Comparative toxicity of chloride derivatives of toluene: benzyl chloride, benzal chloride, and benzotrchloride. *Gig. Tr. Prof. Zabol.* 8:14. (Translation published in 1965. *Fed. Proc. (Trans. Suppl.)* 24:877.)

CHLORODIPHENYLS AND DERIVATIVES**DESCRIPTION**

$C_{12}H_{10-x}Cl_x$, Chlorodiphenyls, are diphenyl rings in which one or more hydrogen atoms are replaced by a chlorine atom. Most widely used are chlorodiphenyl (42% chlorine), containing 3 chlorine atoms in unassigned positions, and chlorodiphenyl (54% chlorine) containing 5 chlorine atoms in unassigned positions. These compounds are light, straw-colored liquids with typical chlorinated aromatic odors; 42% chlorodiphenyl is a mobile liquid and 54% chlorodiphenyl is a viscous liquid.

Chlorinated diphenyl oxides are ethers of chlorodiphenyls and are included in this group. They range from clear, oily liquids to white to yellowish waxy solids, depending on the degree of chlorination.

SYNONYMS

Chlorobiphenyls, polychlorinated diphenyl, PCB.

POTENTIAL OCCUPATIONAL EXPOSURES

Chlorinated diphenyls are used alone and in combination with chlorinated naphthalenes. They are stable, thermoplastic, and non-flammable, and find chief use in insulation for electric cables and wires in the production of electric condensers, as additives for extreme pressure lubricants, and as a coating in foundry use.

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

Cable coaters	Plasticizer makers
Dye makers	Resin makers
Electric equipment makers	Rubber workers
Herbicide workers	Textile flameproofers
Lacquer makers	Transformer workers
Paper treaters	Wood preservers

PERMISSIBLE EXPOSURE LIMITS

The Federal standards for dichlorophenyl (42%) and dichloro-

diphenyl (54%) are 1 mg/m³ and 0.5 mg/m³ respectively.

ROUTES OF ENTRY

Inhalation of fume or vapor and percutaneous absorption of liquid.

HARMFUL EFFECTS

Local—

Prolonged skin contact with its fumes or cold wax may cause the formation of comedones, sebaceous cysts, and pustules, known as chloracne. Irritation to eyes, nose, and throat may also occur. The above standards are considered low enough to prevent systemic effects, but it is not known whether or not these levels will prevent local effects.

Systemic—

Generally, toxic effects are dependent upon the degree of chlorination; the higher the degree of substitution, the stronger the effects. Acute and chronic exposure can cause liver damage. Signs and symptoms include edema, jaundice, vomiting, anorexia, nausea, abdominal pains, and fatigue.

Studies of accidental oral intake indicate that chlorinated diphenyls are embryotoxic, causing stillbirth, a characteristic grey-brown skin, and increased eye discharge in infants born to women exposed during pregnancy.

MEDICAL SURVEILLANCE

Placement and periodic examinations should include an evaluation of the skin, lung, and liver function. Possible effects on the fetus should be considered.

SPECIAL TESTS

None in common use.

PERSONAL PROTECTIVE METHODS

Protection of exposed skin should be encouraged, since the above standards may not be low enough to prevent chloracne. Barrier creams, protective clothing, and good personal hygiene are good protective measures. Respirators should be used in areas of vapor concentration.

BIBLIOGRAPHY

- Meigs, J. W., J. J. Albom, and B. L. Kartin. 1954. Chloracne from an unusual exposure to arochlor. *J. Am. Med. Assoc.* 154:1417.
- Peakall, D. B. 1972. Polychlorinated diphenyls: occurrence and biological effects. *Residue Rev.* 44:1.

CHLORINATED BENZENES

DESCRIPTION

Chlorinated benzenes are aromatic rings with one or more chlorines

substituted for a hydrogen. Included in this group are:

Chlorobenzene: phenyl chloride, monochlorobenzene, chlorobenzol.

o-dichlorobenzene: 1,2-dichlorobenzene

m-dichlorobenzene: 1,3-dichlorobenzene.

p-dichlorobenzene: 1,4-dichlorobenzene.

1,2,3-trichlorobenzene: None.

1,2,4-trichlorobenzene: None.

1,3,5-trichlorobenzene: None.

1,2,4,5-tetrachlorobenzene: None.

Hexachlorobenzene: perchlorobenzene.

Compounds with only a few chlorines are usually colorless liquids at room temperature and have an aromatic odor. The more highly substituted compounds are crystals (typically monoclinic).

SYNONYMS

None.

POTENTIAL OCCUPATIONAL EXPOSURES

Chlorobenzene is used as a solvent and as an intermediate in dye-stuffs. o-Dichlorobenzene is used as a solvent, fumigant, insecticide, and chemical intermediate. p-Dichlorobenzene finds use as an insecticide, chemical intermediate, disinfectant and moth preventative. Other chlorinated benzenes are not as widely used in industry but find use as chemical intermediates, and to an even lesser extent, as insecticides and solvents.

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

Cellulose acetate workers	Insecticide makers and workers
Deodorant makers	Lacquer workers
Disinfectant workers	Organic chemical synthesizers
Dyers	Paint workers
Dye makers	Resin makers
Fumigant workers	Seed disinfectors

PERMISSIBLE EXPOSURE LIMITS

The Federal standards are:

chlorobenzene	75 ppm	350 mg/m ³
o-dichlorobenzene	50 ppm	300 mg/m ³
p-dichlorobenzene	75 ppm	450 mg/m ³

Threshold limit values for the other compounds have not as yet been established.

ROUTES OF ENTRY

Inhalation of vapor, percutaneous absorption of the liquid.

HARMFUL EFFECTS

Local—

Chlorinated benzenes are irritating to the skin, conjunctiva, and

mucous membranes of the upper respiratory tract. Prolonged or repeated contact with liquid chlorinated benzenes may cause skin burns.

Systemic—

In contrast to aliphatic halogenated hydrocarbons, the toxicity of chlorinated benzenes generally decreases as the number of substituted chlorine atoms increases. Basically, acute exposure to these compounds may cause drowsiness, incoordination, and unconsciousness. Animal exposures have produced liver damage.

Chronic exposure may result in liver, kidney, and lung damage as indicated by animal experiments.

MEDICAL SURVEILLANCE

Placement and periodic examinations should consider skin, liver, lung, and kidney.

SPECIAL TESTS

None commonly used. Urinary excretion of 2,5-dichlorophenol may be useful as an index of exposure.

PERSONAL PROTECTIVE METHODS

Barrier creams, protective clothing, and good personal hygiene are good preventive measures. Respirators in areas of vapor concentrations are advised.

BIBLIOGRAPHY

- Brown, V. K. H., C. Muir, and E. Thorpe. 1969. The acute toxicity and skin irritant properties of 1,2,4-trichlorobenzene. *Ann. Occup. Hyg.* 12:209.
- Girard, R., F. Tolot, P. Martin, and J. Bourret. 1969. Hemopathies graves et exposition a des derives chlores du benzene (a propos de 7 cas). *J. Med. Lyon* 50:771.
- Hollingsworth, R. L., V. K. Rowe, F. Oyen, T. R. Tokelson, and E. M. Adams. 1956. Toxicity of o-dichlorobenzene. Studies on animals and industrial experience. *AMA Arch. Ind. Health* 17:180.
- Pagnotto, L. D., and J. E. Walkley. 1965. Urinary dichlorophenol as an index of paradichlorobenzene exposure. *Am. Ind. Hyg. Assoc. J.* 26:137.
- Tolot, F., B. Soubrier, J. R. Bresson, and P. Martin. 1969. Myelose proliferative devoullence rapide. Role etiologique possible des derives chlores du benzene. *J. Med. Lyon* 50:761.
- Varshavskaya, S. P. 1968. Comparative toxicological characteristics of chlorobenzene and dichlorobenzene (ortho- and para-isomers) in relation to the sanitary protection of water bodies. *Hyg. Sanit.* 33:17.

CHLORINATED NAPHTHALENES

DESCRIPTION

$C_{10}H_{8-x}Cl_x$, the chlorinated naphthalenes, are naphthalenes in which one or more hydrogen atoms have been replaced by chlorine to form wax-like substances, beginning with monochloronaphthalene and going on to the octochlor derivatives. Their physical states vary from mobile liquids to waxy-solids depending on the degree of chlorination.

SYNONYMS

Chloronaphthalenes

POTENTIAL OCCUPATIONAL EXPOSURES

Industrial exposure from individual chlorinated naphthalenes is rarely encountered; rather it usually occurs from mixtures of two or more chlorinated naphthalenes. Due to their stability, thermoplasticity, and nonflammability, these compounds enjoy wide industrial application. These compounds are used in the production of electric condensers, in the insulation of electric cables and wires, as additives to extreme pressure lubricants, as supports for storage batteries, and as a coating in foundry use.

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

Cable coaters	Rubber workers
Condenser impregnators	Solvent workers
Electric equipment makers	Transformer workers
Insecticide workers	Wire coaters
Petroleum refinery workers	Wood preservers
Plasticizer makers	

PERMISSIBLE EXPOSURE LIMITS

The Federal standards are:

Trichloronaphthalene	5.0 mg/m ³	Set I
Tetrachloronaphthalene	2 mg/m ³	Set I
Pentachloronaphthalene	0.5 mg/m ³	Set G
Hexachloronaphthalene	0.2 mg/m ³	Set H

ROUTES OF ENTRY

Inhalation of fumes and percutaneous absorption of liquid.

HARMFUL EFFECTS

Local—

Chronic exposure to chlorinated naphthalenes can cause chloracne, which consists of simple erythematous eruptions with pustules, papules, and comedones. Cysts may develop due to plugging of the sebaceous gland orifices.

Systemic—

Cases of systemic poisoning are few in number and they may occur without the development of chloracne.

It is believed that chloracne develops from skin contact and inhalation of fumes, while systemic effects result primarily from inhalation of fumes. Symptoms of poisoning may include headaches, fatigue, vertigo, and anorexia. Jaundice may occur from liver damage. Highly chlorinated naphthalenes seem to be more toxic than those chlorinated naphthalenes with a lower degree of substitution.

MEDICAL SURVEILLANCE

Preplacement and periodic examinations should be concerned particularly with skin lesions such as chloracne and with liver function.

SPECIAL TESTS

None are in common use.

PERSONAL PROTECTIVE METHODS

Skin contact should be avoided whenever possible. Barrier creams, protective clothing, and good personal hygiene are all good preventive measures. Use of respirators in areas of vapor concentration is advised.

BIBLIOGRAPHY

- Kleinfeld, M., J. Messite, R. Swencicki. 1972. Clinical effects of chlorinated naphthalene exposure. *J. Occup. Med.* 14:377.
- Mayers, M. R., and M. G. Silverberg. 1938. Effects upon the skin due to exposure to some chlorinated hydrocarbons. *Ind. Bull. N.Y. State Dep. Labor.* 17:358 and 425.
- Mayers, M. R. and A. R. Smith. 1942. Systemic effects from exposure to certain chlorinated hydrocarbons. *Ind. Bull. N. Y. State Dep. Labor* 21:30.

AROMATIC AMINES

The aromatic amines are aromatic hydrocarbons in which at least one hydrogen atom has been replaced by an amino ($-NH_2$) group. The hydrogen atoms in the amino group may be replaced by aryl or alkyl groups, giving rise to secondary and tertiary amino compounds. The aromatic amines are infrequently formed in nature although they do occur, e.g., anthranilic acid esters in grapes. They are generally synthesized by nitration of the aromatic hydrocarbon with subsequent reduction to the amine; an alternate method is by reaction of ammonia and a chloro- or hydroxy-hydrocarbon. Their most important uses are as intermediates in the manufacture of dyestuffs and pigments; however, they are also used in the chemical, textile, rubber, dyeing, paper, and other industries.

Most of the aromatic amines in the free base form are readily absorbed through the skin in addition to the respiratory route. The amino salts have a lower lipid solubility and, therefore, a lower amount of skin absorption. The two major toxic effects of these compounds are methemoglobinemia and cancer of the urinary tract. Other effects may be hematuria, cystitis, anemia, and skin sensitization.

Several of the aromatic amines have been shown to be carcinogenic in humans or animals or both. Occupational tumors of the bladder were recognized in the dyestuff industry as early as 1895. The most common site of cancer is the bladder, but cancer of the pelvis, ureter, kidney, and urethra do occur. It is thought that bladder cancer results from the presence of an active metabolite(s) of the amino compound in the urine, which acts on the bladder epithelium. Several of these metabolites have been identified and have been shown to have carcinogenic properties by implantation in mouse bladders. Man and the dog seem to be more sus-

ceptible to bladder tumors, suggesting a similarity in metabolism of the aromatic amino compounds.

The minimum exposure which produces cancer is not known. There are documented cases of tumors with exposures of less than one year; however, the latent period from first exposure to the development of tumors is usually long and ranges from 4 to over 40 years, with a mean of about 20 years. Bladder tumors are also relatively common in unexposed populations, and the incidence is considerably increased in heavy smokers. They are more common in older age males. It is unknown whether smoking plus exposure to a bladder carcinogen would be synergistic, but this seems possible, e.g., asbestos and smoking.

Clinically, occupationally induced bladder tumors are indistinguishable from those found in the general population; however, they generally occur at an earlier age than usual. These tumors may range from the extremes of benign papillomas to infiltrating carcinomas. Severe or fatal complications which may arise from papillomas are local spreading tumors, severe hemorrhage, and infection of the bladder and kidney.

Hematuria often does not appear until the tumor(s) is inoperable. Micro-examination of the urine is not specific, but routine cystoscopy is a reliable indicator of tumors at an early stage. Exfoliative cytology of urinary sediment using the stained smear method of Papanicolaou permits early differentiation of malignant neoplasms and benign papillomas from normal tissue. Those individuals who give a positive test should be examined by cystoscopy and followed indefinitely. Renal pelvis, ureteric, and urethral tumors can also be detected by cytodiagnosis.

Because there may be significant skin absorption of the aromatic amines, protective clothing and polyvinyl chloride or rubber gloves should be worn, and there should be adequate wash and change facilities. Workers exposed to carcinogens should have a complete change of work clothes in addition to protective clothing. The recommended means of control of carcinogenic compounds is by engineering methods aimed at zero exposure levels and a program of periodic medical surveillance.

BIBLIOGRAPHY

- Case, R. A. M., M. E. Hosker, D. B. McDonald, and J. T. Pearson. 1954. Tumors of the urinary bladder in workmen engaged in the manufacture and use of certain dyestuff intermediates in the British chemical industry. Part I. The role of aniline, benzidine, alpha-naphthylamine, and beta-naphthylamine. *Brit. J. Ind. Med.* 11:75.
- Rye, W. A., P. F. Woolrich, and R. P. Zanes. 1970. Facts and myths concerning aromatic diamine curing agents. *J. Occup. Med.* 12:211.
- Scott, T. S. 1962. *Carcinogenic and Chronic Toxic Hazard of Aromatic Amines.* Elsevier Publishing Company, New York.
- Weisburger, J. H., P. H. Grantham, E. Vanhorn, N. H. Steigbigel, D. P. Rall, and E. K. Weisburger. 1964. Activation and detoxification of N-2-fluorenylacetamide in man. *Cancer Res.* 24:475.

2-ACETYLAMINOFLUORENE

DESCRIPTION

$C_{12}H_{11}NO$, 2-Acetylaminofluorene, is a tan crystalline solid.

SYNONYMS

2-acetaminofluorene, N-acetylaminophenathrene, N-2-fluorenylacetamide.

POTENTIAL OCCUPATIONAL EXPOSURES

Very little 2-acetylaminofluorene is produced. It is used primarily for cancer research purposes. It was patented as a pesticide, but was never used for this purpose. Thus, occupations in which exposure may occur are those in areas of research.

PERMISSIBLE EXPOSURE LIMITS

2-Acetylaminofluorene is included in the Federal standard for carcinogens; all contact with it should be avoided.

ROUTES OF ENTRY

Probably by inhalation and percutaneous absorption.

HARMFUL EFFECTS

Local—

Unknown.

Systemic—

2-Acetylaminofluorene's carcinogenic activity was first discovered in rats in which it produced nodular hyperplasia and cancer consistently in the bladder, kidney, pelvis, liver, and pancreas by ingestion. Later feeding experiments in dogs demonstrated bladder and liver tumors. Guinea pigs appear resistant to its carcinogenic effects. No human effects have been reported.

MEDICAL SURVEILLANCE

Preplacement and periodic examinations should include history of other exposure to carcinogens, smoking history, family history, alcohol, and medications. The skin, respiratory tract, kidney, bladder, and liver should be evaluated for possible effects. Sputum and bladder cytology should be performed. Fetal effects may occur.

The scope and frequency of medical surveillance examinations can be related to the hazard, which probably is greater among research chemists or those involved in animal inhalation studies.

SPECIAL TESTS

None in common use, although urinary metabolites are known.

PERSONAL PROTECTIVE METHODS

Personal protective methods are designed to supplement engineering controls and to prevent all skin or inhalation exposure.

Full body protective clothing and gloves may be required. Those employed in handling operations should be provided with fullface, supplied air respirators of continuous flow or pressure demand type. On exit from a regulated area, employees should shower and change into

street clothes; leaving their protective clothing and equipment at the point of exit to be placed in impervious containers at the end of the work shift for decontamination or disposal. Effective methods should be used for decontamination and changing of clothes and gloves.

BIBLIOGRAPHY

- Morris, H. P., and W. H. Eyestone. 1953. Tumors of the liver and urinary bladder of the dog after ingestion of 2-acetylaminofluorene. *J. Natl. Cancer Inst.* 13:1139.
- Wilson, R. H., F. DeEds, and A. J. Cox, Jr. 1941. The toxicity and carcinogenic activity of 2-acetylaminofluorene. *Cancer Res.* 1:595.

AMINODIPHENYL

DESCRIPTION

$C_6H_5H_6H_4NH_2NH_2$, 4-aminodiphenyl, is a yellowish brown crystal.

SYNONYMS

Biphenylene, p-phenylaniline, xenylamine, 4-aminobiphenyl, 4-biphenylamine, p-aminobiphenyl, p-aminodiphenyl, p-biphenylamine.

POTENTIAL OCCUPATIONAL EXPOSURES

It is no longer manufactured commercially and is only used for research purposes. 4-Aminodiphenyl was formerly used as a rubber antioxidant and as a dye intermediate.

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

- Diphenylamine workers
- Research workers

PERMISSIBLE EXPOSURE LIMITS

4-Aminodiphenyl is included in the Federal standards for carcinogens; all contact with it should be avoided.

ROUTES OF ENTRY

Inhalation and percutaneous absorption.

HARMFUL EFFECTS

Local—

None reported.

Systemic—

4-Aminodiphenyl is a known human bladder carcinogen. An exposure of only 133 days has been reported to have ultimately resulted in a bladder tumor. The latent period is generally from 15 to 35 years. Acute exposure produces headaches, lethargy, cyanosis, urinary burning, and hematuria. Cystoscopy reveals diffuse hyperemia, edema, and frank slough.

MEDICAL SURVEILLANCE

Placement and periodic examinations should include an evaluation of exposure to other carcinogens; use of alcohol, smoking, and medications; and family history. Special attention should be given on a regular basis to urine sediment and cytology. If red cells or positive smears are seen, cystoscopy should be done at once. The general health of exposed persons should also be evaluated in periodic examinations.

SPECIAL TESTS

None commonly used. One urinary metabolite is 3-amino-4-hydroxydiphenyl.

PERSONAL PROTECTIVE METHODS

These are designed to supplement engineering controls and to prevent all skin or respiratory contact. Full body protective clothing and gloves should be used by those employed in handling operations. Full-face, supplied air respirators of continuous flow or pressure demand type should also be used. On exit from a regulated area, employees should shower and change into street clothes, leaving their clothing and equipment at the point of exit to be placed in impervious containers at the end of the work shift for decontamination or disposal. Effective methods should be used to clean and decontaminate gloves and clothing.

BIBLIOGRAPHY

- Melick, W. F., H. M. Escue, J. J. Naryka, R. A. Mezera, and E. P. Wheeler. 1955. The first reported cases of human bladder tumors due to a new carcinogen — xenylamine. *J. Urol.* 74:760.
- Melick, W. F., and J. J. Naryka. 1968. Carcinoma in situ of the bladder in workers exposed to xenylamine: diagnosis by ultraviolet light cystoscopy. *J. Urol.* 99:178.
- Melick, W. F., J. J. Naryka, and E. R. Kelly. 1971. Bladder cancer due to exposure to para-aminobiphenyl: a 17-year follow-up. *J. Urol.* 106:220.

ANILINE

DESCRIPTION

$C_6H_5NH_2$, aniline, is a clear, colorless, oily liquid with a characteristic odor.

SYNONYMS

Aminobenzene, phenylamine, aniline oil, aminophen, arylamine.

POTENTIAL OCCUPATIONAL EXPOSURES

Aniline is widely used as an intermediate in the synthesis of dye-stuffs. It is also used in the manufacture of rubber accelerators and antioxidants, pharmaceuticals, marking inks, tetryl, optical whitening agents, photographic developers, resins, varnishes, perfumes, shoe polishes, and many organic chemicals.

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

Acetanilide workers	Perfume makers
Bromide makers	Photographic chemical makers
Coal tar workers	Plastic workers
Disinfectant makers	Printers
Dye workers	Rocket fuel makers
Ink makers	Rubber workers
Leather workers	Tetryl makers
Lithographers	Varnish workers
Nitraniline workers	

PERMISSIBLE EXPOSURE LIMITS

The Federal standard is 5 ppm (19 mg/m³).

ROUTES OF ENTRY

Inhalation of vapors; percutaneous absorption of liquid and vapor.

HARMFUL EFFECTS

Local—

Liquid aniline is mildly irritating to the eyes and may cause corneal damage.

Systemic—

Absorption of aniline, whether from inhalation of the vapor or from skin absorption of the liquid, causes anoxia due to the formation of methemoglobin. Moderate exposure may cause only cyanosis. As oxygen deficiency increases, the cyanosis may be associated with headache, weakness, irritability, drowsiness, dyspnea, and unconsciousness. If treatment is not given promptly, death can occur. The development of intravascular hemolysis and anemia due to aniline-induced methemoglobinemia has been postulated, but neither is observed often in industrial practice, despite careful study of numerous cases.

MEDICAL SURVEILLANCE

Preplacement and periodic physical examinations should be performed on all employees working in aniline exposure areas. These should include a work history to elicit information on all past exposures to aniline, other aromatic amines, and nitro compounds known to cause chemical cyanosis, and the clinical history of any occurrence of chemical cyanosis; a personal history to elicit alcohol drinking habits; and general physical examination with particular reference to the cardiovascular system. Persons with impaired cardiovascular status may be at greater risk from the consequences of chemical cyanosis. A preplacement complete blood count and methemoglobin estimation should be performed as baseline levels, also follow-up studies including periodic blood counts and hematocrits.

SPECIAL TESTS

Methemoglobin levels, and other abnormal hemoglobins, and/or

urine para-aminophenols, and other aniline metabolites, have been used for biologic monitoring for occupational aniline exposure.

PERSONAL PROTECTIVE METHODS

In areas of vapor concentration, the use of respirators alone is not sufficient; skin protection by protective clothing should be provided even though there is no skin contact with liquid aniline. Butyl rubber protective clothing is reportedly superior to other materials. In severe exposure situations, complete body protection has been employed, consisting of air-conditioned suit with air supplied helmet and cape. Personal hygiene practices including prompt removal of clothing which has absorbed aniline, thorough showering after work and before changing to street clothes, and clean working clothes daily are essential.

BIBLIOGRAPHY

- Dutkiewicz, T., and J. Piotrowski. 1961. Experimental investigations on the quantitative estimation of aniline absorption in man. *Pure Appl. Chem.* 3:319.
- Scarpa, C. 1955. The aniline test as detector of a sensitivity. *Acta. Allergol.* 9:203.
- Vasilenko, N.M., V. A. Volodchenko, L. N. Khizhnyakova, V. I. Avezday, V. V. Manfanovsky, V. S. Antonovskaya, E. V. Krylova, N. A. Voskobionikova, A. I. Gnezdilova, and I. S. Sonkin. 1972. Data to substantiate a decrease of the maximum permissible concentration of aniline in the air of working zones. *Gig. Sanit.* 37:31.
- Wetherhold, J. M., A. L. Linch, and R. C. Charsha. 1960. Chemical cyanosis—causes, effects, and prevention. *Arch. Environ. Health* 1:75.

BENZIDINE AND ITS SALTS

DESCRIPTION

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

SYNONYMS

4,4'-Biphenyldiamine, para-diaminodiphenyl, 4,4'-diaminobiphenyl, 4,4'-diphenylenediamine, benzidine base.

POTENTIAL OCCUPATIONAL EXPOSURES

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

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

Biochemists	Plastic workers
Dye workers	Rubber workers
Medical laboratory workers	Wood chemists
Organic chemical synthesizers	

PERMISSIBLE EXPOSURE LIMITS

Benzidine and its salts are included in a Federal standard for carcinogens; all contact with them should be avoided.

ROUTES OF ENTRY

Inhalation, percutaneous absorption, and ingestion of dust.

HARMFUL EFFECTS*Local—*

Contact dermatitis due to primary irritation or sensitization has been reported.

Systemic—

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

MEDICAL SURVEILLANCE

Placement and periodic examinations should include an evaluation of exposure to other carcinogens; use of alcohol, smoking, and medications; and family history. Special attention should be given on a regular basis to urine sediment and cytology. If red cells or positive smears are seen, cystoscopy should be done at once. The general health of exposed persons should also be evaluated in periodic examinations.

SPECIAL TESTS

None in common use although several metabolites are known.

PERSONAL PROTECTIVE METHODS

These are designed to supplement engineering controls and to prevent all skin or respiratory contact. Full body protective clothing and gloves should also be used. On exit from a regulated area employees should shower and change into street clothes, leaving their protective clothing and equipment at the point of exit to be placed in impervious containers at the end of the work shift for decontamination or disposal. Effective methods should be used to clean and decontaminate gloves and clothing.

BIBLIOGRAPHY

Laham, S., J. P. Farant, and M. Potvin. 1971. Biochemical determination of urinary bladder carcinogens in human urine. *Occup. Health Rev.* 21:14.

3,3'-DICHLOROBENZIDINE AND ITS SALTS**DESCRIPTION**

$C_6H_3Cl_2NH_2C_6H_3Cl_2NH_2$, 3,3'-dichlorobenzidine, is a gray or purple crystalline solid.

SYNONYMS

4,4'-Diamino-3,3'-dichlorobiphenyl, 3,3'-dichlorobiphenyl-4,4'-diamine, 3,3'-dichloro-4,4'-biphenyldiamine.

POTENTIAL OCCUPATIONAL EXPOSURES

The major uses of dichlorobenzidine are in the manufacture of pigments for printing ink, textiles, plastics, and crayons and as a curing agent for solid urethane plastics. There are no substitutes for many of its uses.

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

Pigment makers

Polyurethane workers

PERMISSIBLE EXPOSURE LIMITS

3,3'-Dichlorobenzidine and its salts are included in a Federal standard for carcinogens; all contact with it should be avoided.

ROUTES OF ENTRY

Inhalation and probably percutaneous absorption.

HARMFUL EFFECTS

Local—

May cause allergic skin reactions.

Systemic—

3,3'-Dichlorobenzidine was shown to be a potent carcinogen in rats and mice in feeding and injection experiments, but no bladder tumors were produced. However, no cases of human tumors have been observed in epidemiologic studies of exposure to the pure compound.

MEDICAL SURVEILLANCE

Preplacement and periodic examinations should include history of exposure to other carcinogens, smoking, alcohol, medication, and family history. The skin, lung, kidney, bladder, and liver should be evaluated; sputum or urinary cytology may be helpful.

SPECIAL TESTS

None in common use.

PERSONAL PROTECTIVE METHODS

These are designed to supplement engineering controls and to prevent all skin or respiratory contact. Full body protective clothing and gloves should be used by those employed in handling operations. Fullface supplied air respirators of continuous flow or pressure demand type should also be used. On exit from a regulated area, employees should shower and change into street clothes, leaving their protective clothing and equipment at the point of exit to be placed in impervious containers at the end of the work shift for decontamination or disposal. Effective methods should be used to clean and decontaminate gloves and clothing.

BIBLIOGRAPHY

- Glassman, J. M., and J. W. Meigs. 1951. Benzidine (4,4'-diaminobiphenyl) and substituted benzidines. A microchemical screening technique for estimating levels of industrial exposure from urine and air samples. *AMA Arch. Ind. Hyg. Occup. Med.* 4:519.
- Sciarini, L. J., and J. W. Meigs. 1961. Biotransformation of the benzidines—III. Studies on diorthotolidine, dianisidine, and dichlorobenzidine: 3,3' Disubstituted Congeners of Benzidine (4,4'-diaminophenyl). *Arch. Environ. Health* 2:584.

4-DIMETHYLAMINOAZOBENZENE

DESCRIPTION

$C_6H_5NNC_6H_4N(CH_3)_2$, 4-dimethylaminoazobenzene, is a flaky yellow crystal.

SYNONYMS

Aniline-N,N-dimethyl-p(phenylazo), benzeneazo dimethylaniline, fat yellow, oil yellow, butter yellow, methyl yellow.

POTENTIAL OCCUPATIONAL EXPOSURES

4-Dimethylaminoazobenzene is only used for research purposes. It was formerly used as a dye, but has been substituted by diethylaminoazobenzene. It was also formerly used for coloring margarine and butter.

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

Research workers

PERMISSIBLE EXPOSURE LIMITS

4-Dimethylaminoazobenzene is included in the Federal standard for carcinogens; all contact with it should be avoided.

ROUTES OF ENTRY

Probably inhalation and percutaneous absorption.

HARMFUL EFFECTS

Local—

Unknown.

Systemic—

Cancer of the liver has been produced in rats and mice in feeding experiments. No human effects have been reported.

MEDICAL SURVEILLANCE

Preplacement and periodic examinations should include a history of exposure to other carcinogens; use of alcohol, smoking, and medications; and family history. Special attention should be given to liver size and liver function tests.

SPECIAL TESTS

None commonly used.

PERSONAL PROTECTIVE METHODS

These are designed to supplement engineering controls and to prevent all contact with skin and the respiratory tract. Protective clothing and gloves should be provided, and also appropriate type dust or supplied air respirators. On exit from a regulated area, employees should shower and change into street clothes, leaving their clothes at the point of exit, to be placed in impervious containers at the end of the work shift for decontamination or disposal.

BIBLIOGRAPHY

Miller, J. A., and E. C. Miller. 1953. The carcinogenic aminoazo dyes. *Adv. Cancer Res.* 1:339.

4,4'-METHYLENEBIS(2-CHLOROANILINE)

DESCRIPTION

$\text{CH}_2(\text{C}_6\text{H}_4\text{ClNH}_2)_2$, 4,4'-methylenebis (2-chloroaniline) or moca, is a yellow to light gray-tan pellet and is also available in liquid form.

SYNONYMS

Moca, 4,4'-diamino-3,3'-dichlorodiphenylmethane, 4,4'-methylene-2,2-dichloroaniline.

POTENTIAL OCCUPATIONAL EXPOSURES

Moca is primarily used in the production of solid elastomeric parts. Other uses are as a curing agent for epoxy resins and in the manufacture of cross-linked urethane foams used in automobile seats and safety padded dashboards; it is also used in the manufacture of gun mounts, jet engine turbine blades, radar systems, and components in home appliances.

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

Elastomer makers

Polyurethane foam workers

Epoxy resin workers

PERMISSIBLE EXPOSURE LIMITS

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

ROUTES OF ENTRY

Inhalation; percutaneous absorption.

HARMFUL EFFECTS

Local—

None reported.

Systemic—

Feeding experiments with rats produced liver and lung cancer. No tumors were found in experiments with dogs. No tumors or other ill-

ness have been reported from chronic exposure in man except a mild cystitis which subsided within a week.

MEDICAL SURVEILLANCE

Preplacement and periodic examinations should include a history of exposure to other carcinogens, alcohol and smoking habits, use of medications, and family history. Special attention should be given to liver size and function and to any changes in lung symptoms or X-rays.

SPECIAL TESTS

None commonly used.

PERSONAL PROTECTIVE METHODS

These are designed to supplement engineering controls and to prevent all contact with skin and the respiratory tract. Protective clothing and gloves should be provided, and also appropriate type dust or supplied air respirators. On exit from a regulated area, employees should shower and change into street clothes, leaving the protective clothing and equipment at the point of exit, to be placed in impervious containers at the end of the work shift for decontamination or disposal.

BIBLIOGRAPHY

- Linch, A. L., G. B. O'Connor, J. R. Barnes, A. S. Killian, Jr., and W. E. Neeld, Jr. 1971. Methylene-bis-ortho-chloroaniline (MOCA): Evaluations of hazards and exposure control. *Am. Ind. Hyg. Assoc. J.* 32:802.
- Mastromatteo, E. 1965. Recent health experiences in Ontario. *J. Occup. Med.* 7:502.

alpha-NAPHTHYLAMINE

DESCRIPTION

$C_{10}H_7NH_2$, alpha-naphthylamine, exists as white needlelike crystals which turn red on exposure to air.

SYNONYMS

1-Aminonaphthalene, naphthalidam, naphthalidine.

POTENTIAL OCCUPATIONAL EXPOSURES

alpha-Naphthylamine is used in the manufacture of dyes, condensation colors, and rubber, and in the synthesis of many chemicals such as alpha-naphthol, sodium naphthionate o-naphthionic acid, Nevile's acid, Winther's acid, sulfonated naphthylamines, alpha-naphthylthiouria (a rodenticide), and N-phenyl-alpha-naphthylamine.

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

Dye makers	Rubber workers
Chemical synthesizers	

PERMISSIBLE EXPOSURE LIMITS

alpha-Naphthylamine is included in the Federal standard for carcinogens; all contact with it should be avoided.

ROUTES OF ENTRY

Inhalation and percutaneous absorption.

HARMFUL EFFECTS

Local—

None reported.

Systemic—

It has not been established whether alpha-naphthylamine is a human carcinogen per se or is associated with an excess of bladder cancer due to its beta-naphthylamine content. Workers exposed to alpha-naphthylamine developed bladder tumors. The mean latent period was 22 years compared to 16 years for beta-naphthylamine. One animal experiment demonstrated papillomata, but these results have never been confirmed.

MEDICAL SURVEILLANCE

Placement and periodic examinations should include an evaluation of exposure to other carcinogens; use of alcohol, smoking, and medications; and family history. Special attention should be given on a regular basis to urine sediment and cytology. If red cells or positive smears are seen, cystoscopy should be done at once. The general health of exposed persons should also be evaluated in periodic examinations.

SPECIAL TESTS

None commonly used. Some metabolites are known.

PERSONAL PROTECTIVE METHODS

These are designed to supplement engineering controls and to prevent all skin or respiratory contact. Full body protective clothing and gloves should be used by those employed in handling operations. Full-face, supplied air respirators of continuous flow or pressure demand type should also be used. On exit from a regulated area, employees should shower and change into street clothes, leaving their protective clothing and equipment at the point of exit to be placed in impervious containers at the end of the work shift for decontamination or disposal. Effective methods should be used to clean and decontaminate gloves and clothing. Showers should be taken prior to dressing in street clothes.

beta-NAPHTHYLAMINE

DESCRIPTION

$C_{10}H_7NH_2$, beta-Naphthylamine, is a white to reddish crystal.

SYNONYMS

2-Naphthylamine, 2-aminonaphthalene.

POTENTIAL OCCUPATIONAL EXPOSURES

beta-Naphthylamine is presently used only for research purposes. It is present as an impurity in alpha-naphthylamine. It was widely used in the manufacture of dyestuffs, as an antioxidant for rubber, and in rubber coated cables.

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

- beta-Naphthylamine workers
- Research workers

PERMISSIBLE EXPOSURE LIMITS

beta-Naphthylamine is included in the Federal standard for carcinogens; all contact with it should be avoided.

ROUTES OF ENTRY

Inhalation and percutaneous absorption.

HARMFUL EFFECTS*Local—*

beta-Naphthylamine is mildly irritating to the skin and has produced contact dermatitis.

Systemic—

beta-Naphthylamine is a known human bladder carcinogen with a latent period of about 16 years. The symptoms are frequent urination, dysuria, and hematuria. Acute poisoning leads to methemoglobinemia or acute hemorrhagic cystitis.

MEDICAL SURVEILLANCE

Preplacement and periodic examinations should include an evaluation of exposure to other carcinogens; use of alcohol, smoking, and medications; and family history. Special attention should be given on a regular basis to urine sediment and cytology. If red cells or positive smears are seen, cystoscopy should be done at once. The general health of exposed persons should also be evaluated in periodic examinations.

SPECIAL TESTS

None in common use; some metabolites are known.

PERSONAL PROTECTIVE METHODS

These are designed to supplement engineering controls and to prevent all skin or respiratory contact. Full body protective clothing and gloves should be used by those employed in handling operations. Full-face, supplied air respirators of continuous flow or pressure demand type should also be used. On exit from a regulated area, employees should shower and change into street clothes, leaving their clothing and equipment at the point of exit to be placed in impervious containers at the end of the work shift for decontamination or disposal. Effective methods should be used to clean and decontaminate gloves and clothing. Showers should be taken prior to dressing in street clothes.

NITRO COMPOUNDS

The aliphatic nitro compounds are characterized by the $-C-NO_2$ structure. Closely related chemicals are the alkyl nitrites ($-C-O-NO$), alkyl nitrates ($-C-O-NO_2$), and chloronitroparaffins (e.g., CCl_2NO_2). All differ significantly in their chemical and toxicological characteristics.

The aromatic nitro compounds, in which a nitro group is substituted directly on a benzene ring, are a more homogeneous group. Most of them can be produced by nitration of the aromatic. They are widely used, especially in explosive and dyestuff manufacture. Aromatic nitro compounds rapidly penetrate the skin, and this may be the major route of absorption. In acute exposures, they produce cyanosis and in chronic exposures, anemia. Local irritation and liver damage are also common. A portion of the absorbed dose is excreted in the urine unchanged; however the major portion is first metabolized to aminophenol derivatives before excretion. Many colorimetric tests are available for detecting the parent compounds or metabolites in the urine.

Other clinical tests which may be of value are urinalysis, blood chemistry, and blood analysis for anemia, methemoglobin, and Heinz bodies. Physical examinations are an important aspect of prevention. Individuals with cardiovascular, renal, hepatic, or respiratory diseases, blood dyscrasia, allergies, or chronic alcoholism may be at increased risk from exposure to aromatic nitro compounds.

Work practices should include protective clothing made of butyl rubber and emphasis on personal hygiene.

BIBLIOGRAPHY

Von Oettingen, W. F. 1941. The Aromatic Amino and Nitro Compounds: Their Toxicity and Potential Dangers. Public Health Bulletin No. 271. U.S. Public Health Service, Washington, D. C.

DINITROBENZENE

DESCRIPTION

$C_6H_4(NO_2)_2$, dinitrobenzene, may exist in three isomers; the meta-form is the most widely used.

SYNONYMS

Dinitrobenzol.

POTENTIAL OCCUPATIONAL EXPOSURES

Dinitrobenzene is used in the synthesis of dyestuffs, dyestuff intermediates, and explosives and in celluloid production.

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

Celluloid makers

Explosive workers

Dye makers

Organic chemical synthesizers

PERMISSIBLE EXPOSURE LIMITS

The Federal standard for all isomers of dinitrobenzene is 1 mg/m³.

ROUTES OF ENTRY

Inhalation and percutaneous absorption of liquid.

HARMFUL EFFECTS

Local—

Exposure to dinitrobenzene may produce yellowish coloration of the skin, eyes, and hair.

Systemic—

Exposure to any isomer of dinitrobenzene may produce methemoglobinemia, symptoms of which are headache, irritability, dizziness, weakness, nausea, vomiting, dyspnea, drowsiness, and unconsciousness. If treatment is not given promptly, death may occur. Consuming alcohol, exposure to sunlight, or hot baths may make symptoms worse. Dinitrobenzene may also cause a bitter almond taste or burning sensation in the mouth, dry throat, and thirst. Reduced vision may occur. In addition liver damage, hearing loss, and ringing of the ears may be produced. Repeated or prolonged exposure may cause anemia.

MEDICAL SURVEILLANCE

Preemployment and periodic examinations should be concerned particularly with a history of blood dyscrasias, reactions to medications, alcohol intake, eye disease, and skin and cardiovascular status. Liver and renal functions should be evaluated periodically as well as blood and general health.

SPECIAL TESTS

Methemoglobin levels should be followed until normal in all cases of suspected cyanosis. Dinitrobenzene can be determined in the urine; levels greater than 25 mg/liter may indicate significant absorption.

PERSONAL PROTECTIVE METHODS

Dinitrobenzene is readily absorbed through intact skin and its vapors are highly toxic. Protective clothing impervious to the liquid should be worn in areas where the likelihood of splash or spill exists. When splash or spill occurs on ordinary work clothes, they should be removed immediately and the area washed thoroughly. In areas of elevated vapor concentrations fullface masks with organic vapor canisters or air supplied respirators with fullface piece should be used. Daily changes of work clothing and mandatory showering at the end of each shift before changing to street clothes should be enforced.

BIBLIOGRAPHY

Beritic, T. 1956. Two cases of meta-dinitrobenzene poisoning with unequal response. *Brit. J. Ind. Med.* 13:114.

DINITRO-O-CRESOL

DESCRIPTION

$\text{CH}_3\text{C}_6\text{H}_2(\text{NO}_2)_2\text{OH}$, dinitro-o-cresol, exists in 9 isomeric forms of which 3,5-dinitro-o-cresol is the most important commercially. It is a yellow crystalline solid.

SYNONYMS

DNOC; 4,6-Dinitro-o-cresol is also known as 3,5-dinitro-o-cresol, 2-methyl-4,6-dinitrophenol, 3,5-dinitro-2-hydroxytoluene.

POTENTIAL OCCUPATIONAL EXPOSURES

DNOC is widely used in agriculture as a herbicide and pesticide; it is also used in the dyestuff industry.

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

Dye makers

Pesticide workers

Herbicide workers

PERMISSIBLE EXPOSURE LIMITS

The Federal standard for all isomers of DNOC is 0.2 mg/m³.

ROUTES OF ENTRY

Inhalation and percutaneous absorption.

HARMFUL EFFECTS

Local—

None reported except for staining of skin and hair.

Systemic—

DNOC blocks the formation of high energy phosphate compounds, and the energy from oxidative metabolism is liberated as heat. Early symptoms of intoxication by inhalation or skin absorption are elevation of the basal metabolic rate and rise in temperature accompanied by fatigue, excessive sweating, unusual thirst, and loss of weight. The clinical picture resembles in part a thyroid crisis. Weakness, fatigue, increased respiratory rate, tachycardia, and fever may lead to rapid deterioration and death. Bilateral cataracts have been seen following oral ingestion for therapeutic purposes.

These have not been seen during industrial or agricultural use.

MEDICAL SURVEILLANCE

Consider eyes, thyroid, and cardiovascular system, as well as general health.

SPECIAL TESTS

None commonly used.

PERSONAL PROTECTIVE METHODS

Since dinitro-o-cresol is used extensively in agriculture as well as

industry, worker education to the toxic properties of the chemical are necessary. Where there is a possibility of skin contamination or vapor inhalation, full protection should be provided. Impervious protective clothing and fullface masks with organic vapor canisters or air supplied respirators are advised. A clean set of work clothes daily, and showers following each shift before change to street clothes are essential.

BIBLIOGRAPHY

- Bistrup, P. L., and D. J. H. Payne. 1951. Poisoning by dinitro-ortho-cresol; report of eight fatal cases occurring in Great Britain. *Br. Med. J.* 2:16.
- Harvey, D. G., P. L. Bidstrup, and J. A. L. Bonnell. 1951. Poisoning by dinitro-ortho-cresol; some observations on the effects of dinitro-ortho-cresol administered by mouth to human volunteers. *Brit. Med. J.* 2:13.
- Hayes, W. J., Jr. *Clinical handbook on economic poisons*, Pub. 476, p. 109. U.S. Government Printing Office, Washington.
- Markicevic, A., D. Prpic-Majic, and N. Bosnar-Turk. 1972. Rezultati ciljanih pregleda radnika eksponiranih dinitroorth krezolu (DNOC). *Ark. Hig. Rad. Toksikol.* 23:1.

DINITROPHENOL

DESCRIPTION

There are six isomers of dinitrophenol of which 2,4-dinitrophenol is the most important industrially. It is an explosive, yellow crystalline solid.

SYNONYMS

DNP.

POTENTIAL OCCUPATIONAL EXPOSURES

2,4-DNP is used in the manufacturing of dyestuff intermediates, wood preservatives, pesticides, herbicides, explosives, chemical indicators, photograph developers, and also in chemical synthesis.

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

Chemical indicator makers	Organic chemical synthesizers
Dye makers	Photographic developer makers
Explosive workers	Wood preservative workers
Herbicide workers	

PERMISSIBLE EXPOSURE LIMITS

There is no Federal standard for DNP. A useful guideline of 0.2 mg/m³ is based on data for dinitro-o-cresol.

ROUTES OF ENTRY

Percutaneous absorption and inhalation of dust and vapors.

HARMFUL EFFECTS

Local—

DNP causes yellow staining of exposed skin. Dermatitis may be due to either primary irritation or allergic sensitivity.

Systemic—

The isomers differ in their toxic effects. In general, DNP disrupts oxidative phosphorylation (as in the case of DNOC) which results in increased metabolism, oxygen consumption, and heat production. Acute intoxication is characterized by sudden onset of fatigue, thirst, sweating, and oppression of the chest. There is rapid respiration, tachycardia, and a rise in body temperature. In less severe poisoning, the symptoms are nausea, vomiting, anorexia, weakness, dizziness, vertigo, headache, and sweating. The liver may be sensitive to pressure, and there may also be jaundice. DNP poisoning is more severe in warm environments. If not fatal, the effects are rapidly and completely reversible. Chronic exposure results in kidney and liver damage and cataract formation. Occasional hypersensitivity reactions, e.g., neutropenia, skin rashes, peripheral neuritis, have been seen after oral use.

MEDICAL SURVEILLANCE

Consider skin, eyes, thyroid, blood, central nervous system, liver and kidney function, as well as general health in preplacement and periodic examinations.

SPECIAL TESTS

Can be measured in urine as such or as an aminophenol derivative.

PERSONAL PROTECTIVE METHODS

Because of its wide use in agriculture, lumbering, photography, as well as in the petrochemical industry, worker education to the toxic properties of dinitrophenol are important. Impervious protective clothing, fullface masks with organic vapor canisters or air supplied respirators are necessary in areas of high concentration of dust or vapor. Spills and splashes that contaminate clothing require the worker to immediately change clothes and wash the area thoroughly. Workers should have clean work clothes on every shift and should be required to shower prior to changing to street clothing.

BIBLIOGRAPHY

- Gisclard, J. B., and M. M. Woodward. 1946. 2,4-Dinitrophenol poisoning: a case report. *J. Ind. Hyg. Toxicol.* 28:47.
- Gosselin, R. E., H. C. Hodge, R. P. Smith, and M. N. Gleason. 1976. *Clinical Toxicology of Commercial Products*, 4th ed. Williams and Wilkins Co. Baltimore.

DINITROTOLUENE**DESCRIPTION**

Six isomers of DNT exist, the most important being 2,4-dinitro-1-toluene.

SYNONYMS

Dinitrotoluol, DNT.

POTENTIAL OCCUPATIONAL EXPOSURES

DNT is used in the manufacture of explosives and dyes in organic synthesis, e.g., trinitrotoluene.

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

Dye makers	Organic chemical synthesizers
Explosive workers	

PERMISSIBLE EXPOSURE LIMITS

The Federal standard is 1.5 mg/m³.

ROUTES OF ENTRY

Inhalation of vapor and percutaneous absorption of liquid.

HARMFUL EFFECTS

Local—

None.

Systemic—

The effects from exposure to dinitrotoluene are caused by its capacity to produce anoxia due to the formation of methemoglobin. Cyanosis may occur with headache, irritability, dizziness, weakness, nausea, vomiting, dyspnea, drowsiness, and unconsciousness. If treatment is not given promptly, death may occur. The onset of symptoms may be delayed. The ingestion of alcohol may cause increased susceptibility. Repeated or prolonged exposure may cause anemia.

MEDICAL SURVEILLANCE

Preemployment and periodic examinations should be concerned particularly with a history of blood dyscrasias, reactions to medications, alcohol intake, eye disease, skin, and cardiovascular status. Liver and renal functions should be evaluated periodically as well as blood and general health.

SPECIAL TESTS

None commonly used. Forms a blue color with alcoholic NaOH.

PERSONAL PROTECTIVE METHODS

Liquid soaked clothing should be immediately removed and the skin area washed thoroughly. Impervious protective clothing should be provided if skin exposure to liquid is anticipated. In areas of elevated vapor concentration, fullface masks with organic vapor canisters or air-supplied respirators should be required.

BIBLIOGRAPHY

Norwood, W. D. 1943. Trinitrotoluene (TNT), its effective removal from the skin by a special liquid soap. *Ind. Med.* 12:206.

NITROBENZENE**DESCRIPTION**

$C_6H_5NO_2$, nitrobenzene, is a pale yellow liquid whose odor resembles bitter almonds.

SYNONYMS

Nitrobenzol, oil of mirbane, oil of bitter almonds.

POTENTIAL OCCUPATIONAL EXPOSURES

Nitrobenzene is used in the manufacture of explosives and aniline dyes and as a solvent and intermediate. It is also used in shoe and floor polishes, leather dressings, and paint solvents, and to mask other unpleasant odors. Substitution reactions with nitrobenzene are used to form meta-derivatives.

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

Aniline dye makers	Paint makers
Explosive makers	Polish makers
Organic chemical synthesizers	

PERMISSIBLE EXPOSURE LIMITS

The Federal standard is 1 ppm (5 mg/m³).

ROUTES OF ENTRY

Inhalation and percutaneous absorption of liquid.

HARMFUL EFFECTS**Local—**

Nitrobenzene may cause irritation of the eyes.

Systemic—

There is a latent period of 1-4 hours before signs and symptoms appear. Nitrobenzene affects the central nervous system producing fatigue, headache, vertigo, vomiting, general weakness, and in some cases severe depression, unconsciousness, and coma. Nitrobenzene is a powerful methemoglobin former; cyanosis appears when methemoglobin reaches 15%. Sulfhemoglobin formation may also contribute to nitrobenzene toxicity. Chronic exposure may lead to spleen and liver damage, jaundice, liver impairments, and hemolytic icterus. Anemia and Heinz bodies in the red blood cells have also been observed. Alcohol ingestion may increase the toxic effects.

MEDICAL SURVEILLANCE

Preemployment and periodic examinations should be concerned particularly with a history of dyscrasias, reactions to medications, alcohol intake, eye disease, skin, and cardiovascular status. Liver and renal functions should be evaluated periodically, as well as blood and general health.

SPECIAL TESTS

Follow methemoglobin levels until normal in all cases of suspected cyanosis. The metabolites in urine, p-nitro and p-amino phenol, can be used as an evidence of exposure.

PERSONAL PROTECTIVE METHODS

Impervious protective clothing should be worn in areas where risk of splash or spill exists. When splashed or spilled on ordinary work clothes, the clothes should be removed at once and the skin area washed thoroughly. In areas of vapor concentration fullface masks with organic vapor canisters or air supplied respirators should be used. Clean work clothing should be supplied daily, and showering made mandatory after each shift before workers change to street clothes.

BIBLIOGRAPHY

- Andreescheva, N. G. 1964. Substantiation of the maximum permissible concentration of nitrobenzene in atmospheric air. *Hyg. Sanit.* 29:4.
- Myslak, A., J. K. Piotrowski, and E. Musialowicz. Acute nitrobenzene poisoning. A case report with data on urinary excretion of p-nitro-phenol and p-amino-phenol. *Arch. Tokiol.* 28:208.
- Salmowa, J., J. Piotrowski, and U. Neuhorn. 1963. Evaluation of exposure to nitrobenzene. Absorption of nitrobenzene vapor through lungs and excretion of p-nitrophenol in urine. *Brit. J. Ind. Med.* 20:41.

4-NITROBIPHENYL**DESCRIPTION**

$C_6H_5C_6H_4NO_2$, 4-nitrobiphenyl, exists as yellow plates or needles.

SYNONYMS

4-Nitrodiphenyl, p-nitrobiphenyl, p-nitrodiphenyl, PNB.

POTENTIAL OCCUPATIONAL EXPOSURES

4-Nitrobiphenyl was formerly used in the synthesis of 4-aminodiphenyl. It is presently used only for research purposes; there are no commercial uses.

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

PERMISSIBLE EXPOSURE LIMITS

4-Nitrobiphenyl was included in the Federal standard for carcinogens; all contact with it should be avoided.

ROUTES OF ENTRY

Inhalation and percutaneous absorption.

HARMFUL EFFECTS

Local—

None reported.

Systemic—

4-Nitrobiphenyl is considered to be a human carcinogen. This is based on the evidence that it will induce bladder tumors in dogs and that human cases of bladder cancer were reported from a mixed exposure to 4-aminodiphenyl and 4-nitrobiphenyl. These human cases were attributed to 4-aminodiphenyl because the information available at the time showed that it produced bladder tumors in dogs. 4-Amino biphenyl may be a metabolite.

MEDICAL SURVEILLANCE

Placement and periodic examinations should include an evaluation of exposure to other carcinogens, as well as an evaluation of smoking, of use of alcohol and medications, and of family history. Special attention should be given on a regular basis to urine sediment and cytology. If red cells or positive smears are seen, cystoscopy should be done at once. The general health of exposed persons should also be evaluated in periodic examinations.

SPECIAL TESTS

None commonly used. Can probably be determined in the urine as a metabolite.

PERSONAL PROTECTIVE METHODS

These are designed to supplement engineering controls and to prevent all skin or respiratory contact. Full body protective clothing and gloves should be used by those employed in handling operations. Full-face, supplied air respirators of continuous flow or pressure demand type should also be used. On exit from a regulated area, employees should shower and change into street clothes, leaving their protective clothing and equipment at the point of exit to be placed in impervious containers at the end of the work-shift for decontamination or disposal. Effective methods should be used to clean and decontaminate gloves and clothing.

BIBLIOGRAPHY

- Deichmann, W. B. 1967. Introduction p. 3. In: K. F. Lampe, ed. *Bladder Cancer, A Symposium*. Aesculapius Publishing Co., Birmingham, Alabama.
- Melick, W. F., H. M. Escue, J. J. Naryka, R. A. Mezera, and E. P. Wheeler. 1955. The first reported cases of human bladder tumors due to a new carcinogen—xenylamine. *J. Urol.* 74:760.

NITROGLYCERIN and ETHYLENE GLYCOL DINITRATE

DESCRIPTION

$C_3H_5(ONO_2)_3$, nitroglycerin.

$O_2NOCH_2OCH_2ONO_2$, ethylene glycol dinitrate.

Both are oily, yellow liquids and are highly explosive. They may be detonated by mechanical shock, heat, or spontaneous chemical reaction.

SYNONYMS

Nitroglycerin: nitroglycerol, glyceryl trinitrate, trinitroglycerol, glonoin, trinitrin.

Ethylene glycol dinitrate: nitroglycol, glycol dinitrate, ethylene dinitrate, EGDN.

POTENTIAL OCCUPATIONAL EXPOSURES

Although ethylene glycol dinitrate is an explosive in itself, it is primarily used to lower the freezing point of nitroglycerin; together these compounds are the major constituents of commercial dynamite, cordite, and blasting gelatin. Occupational exposure generally involves a mixture of the two compounds. Ethylene glycol dinitrate is 160 times more volatile than nitroglycerin. Nitroglycerin is also used as a pharmaceutical.

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

Drug makers

Explosive makers

PERMISSIBLE EXPOSURE LIMITS

The Federal standard for nitroglycerin is 0.2 ppm (2 mg/m³). The standard for ethylene glycol dinitrate and/or nitroglycerin is 0.2 ppm (1 mg/m³) as a ceiling value, and, at concentrations greater than 0.02 ppm, personal protection may be necessary to avoid headache. These levels should be reduced when the substance is also absorbed percutaneously.

ROUTES OF ENTRY

Inhalation of dust or vapor; ingestion of dust; percutaneous absorption.

HARMFUL EFFECTS

Local—

None reported.

Systemic—

Exposure to small amounts of ethylene glycol dinitrate and/or nitroglycerin by skin exposure, inhalation, or swallowing may cause severe throbbing headaches. With larger exposure, nausea, vomiting, cyanosis, palpitations of the heart, coma, cessation of breathing, and death may occur. A temporary tolerance to the headache may develop, but this is lost after a few days without exposure. On some occasions a worker may have anginal pains a few days after discontinuing repeated daily exposure.

MEDICAL SURVEILLANCE

Placement and periodic examinations should be concerned with central nervous system, blood, glaucoma, and especially history of alcoholism.

SPECIAL TESTS

None commonly used, but urinary and blood ethylene glycol dinitrate may be determined by gas chromatography.

PERSONAL PROTECTIVE METHODS

Both compounds are readily absorbed through the skin, lungs, and mucous membranes. It is, therefore, essential that adequate skin protection be provided for each worker: impervious clothing where liquids are likely to contaminate and full body clothing where dust creates the problem. All clothing should be discarded at the end of the shift and clean work clothing provided each day. Showers should be taken at the end of each shift and prior to changing to street clothing. In case of spill or splash that contaminates work clothing, the clothes should be changed at once and the skin area washed thoroughly. Masks of the dust type or organic vapor canister type may be necessary in areas of concentration of dust or vapors.

BIBLIOGRAPHY

- Bartalini, E., G. Cavagna, and V. Foa. 1967. Epidemiological and clinical features of occupational nitroglycerol poisoning in Italy. *Med. Lavoro*. 58:618.
- Carmichael, P., and J. Lieben. 1963. Sudden death in explosive workers. *Arch. Environ. Health* 7:424.
- Lund, R. P., J. Haggendal, and G. Johnsson. 1968. Withdrawal symptoms in workers exposed to nitroglycerin. *Br. J. Ind. Med.* 25:136.
- Munch, J. C., B. Friedland, and M. Shepard. 1965. Glyceryl trinitrate. II. Chronic toxicity. *Ind. Med. Surg.* 34:940.

NITROPARAFFINS

DESCRIPTION

Nitroparaffins are characterized by a $-C-NO_2$ group and may be either mono- or poly-substituted. Only certain mononitroparaffins are included in this section: nitromethane (CH_3NO_2), nitroethane ($C_2H_5-NO_2$), 1-nitropropane ($C_3H_7-NO_2$), and 2-nitropropane ($CH_3-CH(NO_2)-CH_3$). All of these are colorless liquids. Other mononitroparaffins are not commonly used, and use of the polynitroparaffins is limited almost entirely to fuels and fuel additives.

SYNONYMS

None.

POTENTIAL OCCUPATIONAL EXPOSURES

Nitroparaffins are used as solvents for cellulose esters, vinyl copolymer, and other resins, oils, fats, waxes, and dyes. They are also used in various coating materials such as shellac, synthetic and processed rubber, paint and varnish removers, alkyl resins, and other high polymer coatings, and also in organic synthesis.

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

Cellulose workers	Resin makers
Dye makers	Rubber makers
Fat processors	Stainers
Organic chemical synthesizers	Wax makers
Plastic makers	

PERMISSIBLE EXPOSURE LIMITS

The Federal standards for these substances are: nitromethane 100 ppm (250 mg/m³), nitroethane 100 ppm (310 mg/m³), 1-nitropropane 25 ppm (90 mg/m³), and 2-nitropropane 25 ppm (90 mg/m³).

ROUTE OF ENTRY

Inhalation of vapor.

HARMFUL EFFECTS*Local—*

The nitroparaffins are irritants to the eyes and upper respiratory tract. There may be slight skin irritation due to solvent drying of skin.

Systemic—

Only one report of occupational illness from nitroparaffins has been reported. The workers were exposed to 20-45 ppm of 2-nitropropane and complained of anorexia, nausea, vomiting diarrhea, and occipital headache. Animal experiments indicate that high concentrations of nitroparaffins may produce light narcosis and central nervous system irritation. The lethal dose is generally lower than that producing significant narcosis. Liver and kidney damage have been observed in animals at lethal concentrations. Nitroparaffins release nitrate in vivo; however, methemoglobinemia and Heinz bodies have only been observed with 2-nitropropane. Experimental evidence also indicates that the toxicity of nitroparaffins increases with the size of the molecule.

MEDICAL SURVEILLANCE

Based on animal data, preplacement and periodic examination should consider respiratory and central nervous system effects as well as liver and kidney function.

SPECIAL TESTS

None commonly used. In the case of 2-nitropropane, Heinz bodies and methemoglobin levels would be of interest.

PERSONAL PROTECTIVE METHODS

Barrier creams or gloves to protect exposed skin and, where vapor concentrations are excessive, fullface mask with organic vapor canister or air supplied respirators are advised.

BIBLIOGRAPHY

Skinner, J. B. 1947. The toxicity of 2-nitropropane. *Ind. Med.* 16:441.

NITROPHENOL**DESCRIPTION**

There are three isomers of nitrophenol NO₂C₆H₄OH. The meta-

form is produced from m-nitroaniline, and the ortho- and para-isomers are produced by nitration of phenol. They are colorless to slightly yellowish crystals with an aromatic to sweetish odor.

SYNONYMS

None.

POTENTIAL OCCUPATIONAL EXPOSURES

Nitrophenols are used in the synthesis of dyestuffs and other intermediates and as a chemical indicator.

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

Chemical indicator makers	Organic chemical synthesizers
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PERMISSIBLE EXPOSURE LIMITS

There is no Federal standard for nitrophenol.

ROUTES OF ENTRY

Inhalation and percutaneous absorption of liquid.

HARMFUL EFFECTS

Local—

Unknown.

Systemic—

There is very little information available on the toxicity for humans of nitrophenols. Animal experiments have shown central and peripheral vagus stimulation, CNS depression, methemoglobinemia, and dyspnea. The p-isomer is the most toxic.

MEDICAL SURVEILLANCE

Based on animal studies, individuals with cardiovascular, renal, or pulmonary disease and those with anemia are probably more subject to poisoning by nitrophenol. Liver and renal function and blood should be evaluated in placement or periodic examinations.

SPECIAL TESTS

None commonly used. Nitrophenol is excreted rapidly in the urine as a conjugate. It may also be present as a metabolite of parathion.

PERSONAL PROTECTIVE METHODS

Nitrophenols are readily absorbed through intact skin and by inhalation; full body protective clothing and appropriate type organic vapor canisters in areas of concentrations of dust or vapors should be provided. Spills on work clothing necessitate immediate clothing change and thorough washing of the skin area. Clean work clothes should be supplied daily; showers should be taken at the end of each shift prior to changing to street clothes.

PICRIC ACID

DESCRIPTION

$C_6H_2(NO_2)_3OH$, picric acid, is a pale yellow, odorless, intensely bitter crystal which is explosive upon rapid heating or mechanical shock.

SYNONYMS

Picronitric acid, trinitrophenol, nitroxanthic acid, carbazotic acid, phenol trinitrate.

POTENTIAL OCCUPATIONAL EXPOSURES

Picric acid is used in the manufacture of explosives, rocket fuels, fireworks, colored glass, matches, electric batteries, and disinfectants. It is also used in the pharmaceutical and leather industries, and in dyes, copper and steel etching, forensic chemistry, histology, textile printing, and photographic emulsions.

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

Battery makers	Explosive makers
Colored glass makers	Forensic chemists
Copper etchers	Histology technicians
Disinfectant makers	Matchmakers
Drug makers	Photographic chemical workers
Dye makers	Tannery workers

PERMISSIBLE EXPOSURE LIMITS

The Federal standard for picric acid is 0.1 mg/m³.

ROUTES OF ENTRY

Inhalation and ingestion of dust; percutaneous absorption.

HARMFUL EFFECTS

Local—

Picric acid dust or solutions are potent skin sensitizers. In solid form, picric acid is a skin irritant, but in aqueous solution it irritates only hypersensitive skin. The cutaneous lesions which appear usually on exposed areas of the upper extremities consist of dermatitis with erythema, papular, and vesicular eruptions. Desquamation may occur following repeated or prolonged contact. Skin usually turns yellow upon contact, and areas around nose and mouth as well as the hair are most often affected. Dust or fume may cause eye irritation which may be aggravated by sensitization. Corneal injury may occur from exposure to picric acid dust and solutions.

Systemic—

Inhalation of high concentrations of dust by one worker caused temporary coma followed by weakness, myalgia, anuria, and later polyuria. Following ingestion of picric acid, there may be headache, vertigo, nausea, vomiting, diarrhea, yellow coloration of the skin, hema-

turia, and albuminuria. High doses may cause destruction of erythrocytes, hemorrhagic nephritis, and hepatitis. High doses which cause systemic intoxication will color all tissues yellow, including the conjunctiva and aqueous humor, and cause yellow vision.

MEDICAL SURVEILLANCE

Placement and periodic medical examinations should focus on skin disorders such as hypersensitivity atopic dermatitis, and liver and kidney function.

SPECIAL TESTS

None commonly used. It is probably excreted as picric and picramic acid in the urine.

PERSONAL PROTECTIVE METHODS

Skin protection by clothing and barrier creams can avoid the irritant and sensitizing action of picric acid. Masks of the dust type will prevent absorption by inhalation. Fullface masks are advisable or combination of chemical goggles with halfmask. Daily change of clean work clothes and showering after each shift before changing to street clothes are mandatory.

BIBLIOGRAPHY

- Chicago National Safety Council. 1969. Picric Acid. Data Sheet 351 (Revision A, Extensive). Chicago National Safety Council, Chicago, Illinois.
 Williams, R. T. 1959. Detoxication Mechanism, 2nd ed. J. Wiley and Sons, New York.

TETRYL

DESCRIPTION

Tetryl is a yellow solid.

SYNONYMS

Trinitrophenylmethylnitramine, nitramine, tetranitromethylaniline, pyrenite, picrylmethylnitramine, picrylnitromethylamine, N-methyl-N-2,4,6-tetranitroaniline, tetralite.

POTENTIAL OCCUPATIONAL EXPOSURES

Tetryl is used in explosives as an intermediary detonating agent and as a booster charge; it is also used as a chemical indicator.

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

Chemical indicator makers	Explosive makers
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PERMISSIBLE EXPOSURE LIMITS

The Federal standard is 1.5 mg/m³.

ROUTES OF ENTRY

Inhalation and skin absorption.

HARMFUL EFFECTS*Local—*

Tetryl is a potent sensitizer, and allergic dermatitis is common. Dermatitis first appears on exposed skin areas, but can spread to other parts of the body in fair skinned individuals or those with poor personal hygiene. The severest forms show massive generalized edema with partial obstruction of the trachea due to swelling of the tongue, and these cases require hospitalization. Contact may stain skin and hair yellow or orange. Tetryl is acutely irritating to the mucous membranes of the respiratory tract and the eyes, causing coughing, sneezing, epistaxis, conjunctivitis, and palpebral and periorbital edema.

Systemic—

Tetryl exposure may cause irritability, easy fatigability, malaise, headaches, lassitude, insomnia, nausea, and vomiting. Anemia either of the marrow depression or deficiency type has been observed among tetryl workers. Tetryl exposure has produced liver and kidney damage in animals.

MEDICAL SURVEILLANCE

Preplacement physical examination should give special attention to those individuals with a history of allergy, blood dyscrasias, or skin, liver, or kidney disease. Periodic examinations should be directed primarily to the control of dermatitis and allergic reactions, plus any effects on the respiratory tract, eyes, central nervous system, blood, liver, or kidneys.

SPECIAL TESTS

None in common use.

PERSONAL PROTECTIVE METHODS

Skin protection is necessary by means of protective clothing and gloves. Where significant air concentration of dusts or vapors exist, masks to prevent inhalation are necessary. Daily change to clean work clothes is strongly advised, with showers after each shift mandatory, before dressing in street clothes.

BIBLIOGRAPHY

- Bergman, B. B. 1952. Tetryl toxicity: a summary of ten years' experience. *AMA Arch. Ind. Hyg. Occup. Med.* 5:10.
 Hardy, H. L., and C. C. Maloof. 1950. Evidence of systemic effect of tetryl with summary of available literature. *AMA Arch. Ind. Med. Occup. Med.* 1:545.
 Norwood, W. D. 1943. Trinitrotoluene (TNT); its effective removal from the skin by a special liquid soap. *Ind. Med.* 12:206.

TRINITROTOLUENE**DESCRIPTION**

TNT exists in 5 isomers; 2,4,6-trinitrotoluene is the most commonly

used. All are crystalline solids in pure form. TNT is a relatively stable high explosive.

SYNONYMS

TNT, sym-trinitrotoluol, methyltrinitrobenzene.

POTENTIAL OCCUPATIONAL EXPOSURES

TNT is used as an explosive, i.e., as a bursting charge in shells, bombs, and mines.

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

PERMISSIBLE EXPOSURE LIMITS

The Federal standard is 1.5 mg/m³.

ROUTES OF ENTRY

Inhalation of dust, fume, or vapor; ingestion of dust; percutaneous absorption from dust.

HARMFUL EFFECTS

Local—

Exposure to trinitrotoluene may cause irritation of the eyes, nose, and throat with sneezing, cough, and sore throat. It may cause dermatitis and may stain the skin, hair, and nails a yellowish color.

Systemic—

Numerous fatalities have occurred in workers exposed to TNT from toxic hepatitis or aplastic anemia. TNT exposure may also cause methemoglobinemia with cyanosis, weakness, drowsiness, dyspnea, and unconsciousness. In addition it may cause muscular pains, heart irregularities, renal irritation, cataracts, menstrual irregularities, and peripheral neuritis.

MEDICAL SURVEILLANCE

Placement or periodic examinations should give special considerations to history of allergic reactions, blood dyscrasias, reactions to medications, and alcohol intake. The skin, eye, blood, and liver and kidney function should be followed.

SPECIAL TESTS

Urine may be examined for TNT by the Webster test or for the urinary metabolite 2,6-dinitro-4-aminotoluene; however, both may be negative if there is liver injury.

PERSONAL PROTECTIVE METHODS

Protective clothing should be worn. The Webster skin test (colorimetric test with alcoholic sodium hydroxide) or indicator soap should be used to make sure workers have washed all TNT off their skins. Daily change of clean work clothes should be provided, and showers

made compulsory at the end of each shift prior to changing to street clothes.

BIBLIOGRAPHY

- Goodwin, J. W. 1972. Twenty years of handling TNT in a shell loading plant. *Am. Ind. Hyg. Assoc. J.* 33:41.
- McConnell, W. J., and R. H. Flinn. 1946. Summary of twenty-two trinitrotoluene fatalities in World War II. *J. Ind. Hyg. and Toxicol.* 20:76.
- Morton, A. R., M. V. Ranadive, and J. A. Hathaway. 1976. Biological effects of trinitrotoluene from exposure below the threshold limit value. *Am. Ind. Hyg. Assoc. J.* 37:56.
- Norwood, W. D. 1943. Trinitrotoluene (TNT), its effective removal from the skin by a special liquid soap. *Ind. Med.* 12:206.

MISCELLANEOUS ORGANIC NITROGEN COMPOUNDS

This group of organic nitrogen compounds includes examples of heterocyclic compounds, hydrazines, substituted amides, an imine, and a nitrosoamine.

Heterocyclic nitrogen compounds contain one or more nitrogen atoms in the ring structure and are widely distributed in nature as well as in industrial use. The ring may be three, five, or six membered, and there may be other hetero atoms in addition to nitrogen.

The hydrazine compounds are characterized by their structure. Amides are derivatives of acids, and some have wide usage as solvents. Imines are highly reactive substances of the general structure, e.g., $R_2C=NH$. Many of them appear to be biological alkylating agents and to have radiomimetic properties. They are somewhat similar in these respects to epoxy compounds, with the nitrogen group in place of an oxygen in a ring structure.

The nitroso group, e.g., $-N=O$, forms another reactive class of nitrogen compounds widely used in synthetic chemical reactions. When combined with a carbon atom, e.g., $C-N=O$, they often show skin irritant or sensitizing properties, and some are methemoglobin formers. When attached to the nitrogen of certain aliphatic amines, however, e.g., $(CH_3)_2-N-N=O$ (N-nitroso dimethyl amine), they sometimes become potent experimental animal carcinogens.

ACRIDINE

DESCRIPTION

$C_{13}H_9N$, acridine, is a colorless or light yellow crystal, very soluble in boiling water.

SYNONYMS

Dibenzopyridine, 10-azaanthracene.