

Occupational Health Guideline for Paraquat

INTRODUCTION

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienists, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent information and data in summary form.

SUBSTANCE IDENTIFICATION

- Formula: (a) $C_{12}H_{14}N_2Cl_2$; (b) $C_{12}H_{14}N_2(CH_3SO_4)_2$
- Synonyms: (a) 1,1'-dimethyl-4,4'-bipyridinium dichloride; (b) 1,1'-dimethyl-4,4'-bipyridinium bis (methosulfate)
- Appearance and odor: Odorless, colorless solid

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for paraquat is 0.5 milligram of paraquat per cubic meter of air (mg/m^3) averaged over an eight-hour work shift. The American Conference of Governmental Industrial Hygienists has recommended for paraquat a Threshold Limit Value of $0.1 mg/m^3$.

HEALTH HAZARD INFORMATION

• Routes of exposure

Paraquat can affect the body if it is inhaled, comes in contact with the eyes or skin, or is swallowed. It may enter the body through the skin.

• Effects of overexposure

Exposure to paraquat may cause irritation of the eyes, nose, throat, and skin. It may also cause nose bleeding and abnormalities or loss of fingernails. Exposure to mixtures of paraquat and a related compound, diquat, may cause serious and permanent injury to the eyes. Swallowing paraquat may cause burning in the mouth

and throat, nausea, vomiting, abdominal pain, diarrhea, heart, kidney, and lung damage, and liver damage with yellow jaundice.

• Reporting signs and symptoms

A physician should be contacted if anyone develops any signs or symptoms and suspects that they are caused by exposure to paraquat.

• Recommended medical surveillance

The following medical procedures should be made available to each employee who is exposed to paraquat at potentially hazardous levels:

1. Initial Medical Examination:

—A complete history and physical examination: The purpose is to detect pre-existing conditions that might place the exposed employee at increased risk, and to establish a baseline for future health monitoring. Examination of the eyes, respiratory system, heart, liver, and kidneys should be stressed. The skin should be examined for evidence of chronic disorders.

—14" x 17" chest roentgenogram: Paraquat causes human lung damage. Surveillance of the lungs is indicated.

—FVC and FEV (1 sec): Paraquat is a respiratory irritant. Persons with impaired pulmonary function may be at increased risk from exposure. Periodic surveillance is indicated.

—Urinalysis: Since kidney damage has been observed in humans exposed to paraquat, a urinalysis should be performed, including at a minimum specific gravity, albumin, glucose, and a microscopic on centrifuged sediment.

—Liver function tests: Since liver damage has been observed in humans exposed to paraquat, a profile of liver function should be obtained by using a medically acceptable array of biochemical tests.

2. Periodic Medical Examination: The aforementioned medical examinations should be repeated on an annual basis.

• Summary of toxicology

Paraquat as a mist or aerosol is an irritant of the eyes, mucous membranes, and skin. In rats exposed to aero-

These recommendations reflect good industrial hygiene and medical surveillance practices and their implementation will assist in achieving an effective occupational health program. However, they may not be sufficient to achieve compliance with all requirements of OSHA regulations.

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service Centers for Disease Control
National Institute for Occupational Safety and Health

U.S. DEPARTMENT OF LABOR
Occupational Safety and Health Administration

sols of paraquat, the LC50 for 6 hours was 1 mg/m³; death was delayed and resulted from pulmonary hemorrhage and edema. In a study of 30 workers spraying paraquat over a 12 week period, approximately 50% of them had minor irritation of the eyes or nose; 1 worker had an episode of epistaxis. Of 296 spray operators with skin exposure described as gross and prolonged, 55 had damaged fingernails; the most common lesion was transverse white bands of discoloration, but loss of nail surface, transverse ridging, gross deformity of the nail plate, and loss of nails also occurred. Paraquat is commonly combined in commercial herbicides with diquat, a related compound; in several instances the commercial preparations splashed in the eyes have caused serious injury. There have been loss of corneal and conjunctival epithelium, mild iritis, and residual corneal scarring. In contrast, in the eye of a rabbit, one drop of a 50% aqueous solution of pure paraquat caused slow development of mild conjunctival inflammation, and pure diquat proved even less irritating. Presumably the surfactants present in the commercial preparations are responsible for the severe eye injuries in humans. The results from injection or ingestion of paraquat are in marked contrast to the irritant effects usually encountered from occupational exposure. Intraperitoneal injection or oral administration to rats at doses which caused delayed death resulted in a peculiar proliferative lesion in the lung; there was alveolar, perivascular, and peribronchial edema, with cellular proliferation into the alveolar walls resulting in large solid areas of the lung with no air-containing cavities. There are several reports of fatal accidental ingestion by humans; in 2 cases, one person ingested about 114 ml of a 20% solution, while the other was believed to have taken only a mouthful of the liquid, most of which was rejected immediately; the former died after 7 days and the latter after 15 days. Initial symptoms included burning in the mouth and throat, nausea, vomiting, and abdominal pain with diarrhea. After 2 to 3 days, signs of liver and kidney toxicity developed including jaundice, oliguria, and albuminuria; there were E.C.G. changes suggesting toxic myocarditis with conduction defects. Shortly before death there was respiratory distress; at autopsy, findings in the lung included hemorrhage, edema, and massive solid areas which were airless owing to fibroblastic proliferation in the alveolar walls and elsewhere. There is no evidence that inhalation or skin absorption causes the rapid progressive pulmonary fibrosis and injury to the heart, liver, and kidneys occurring from ingestion.

CHEMICAL AND PHYSICAL PROPERTIES

• Physical data

1. Molecular weight: (a) 257.2; (b) 408
2. Boiling point (760 mm Hg): Decomposes at 175–180 C (347–356 F)
3. Specific gravity (water = 1): Data not available
4. Vapor density (air = 1 at boiling point of para-

quat): Not applicable

5. Melting point: Data not available

6. Vapor pressure at 20 C (68 F): Essentially zero

7. Solubility in water, g/100 g water at 20 C (68 F):

Very soluble

8. Evaporation rate (butyl acetate = 1): Not applicable

• Reactivity

1. Conditions contributing to instability: None

2. Incompatibilities: Contact with strong oxidizers may cause fires and explosions.

3. Hazardous decomposition products: Toxic gases and vapors (such as hydrogen chloride, oxides of nitrogen and sulfur, and carbon monoxide) may be released when paraquat decomposes.

4. Special precautions: None

• Flammability

1. Not combustible

• Warning properties

Grant states that "in tests on rabbit eyes pure paraquat at 50% concentration caused only mild superficial inflammation, developing in twelve hours and clearing in two to four days with no damage to the cornea."

MONITORING AND MEASUREMENT PROCEDURES

• General

Measurements to determine employee exposure are best taken so that the average eight-hour exposure is based on a single eight-hour sample or on two four-hour samples. Several short-time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee).

• Method

An analytical method for paraquat is in the *NIOSH Manual of Analytical Methods*, 2nd Ed., Vol. 3, 1977, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00261-4).

RESPIRATORS

• Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforce-

ment and Safety Administration) or by the National Institute for Occupational Safety and Health.

- In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.

PERSONAL PROTECTIVE EQUIPMENT

- Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent skin contact with paraquat or solutions containing paraquat, where skin contact may occur.

- Clothing contaminated with paraquat should be placed in closed containers for storage until it can be discarded or until provision is made for the removal of paraquat from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the paraquat, the person performing the operation should be informed of paraquat's hazardous properties.

- Where exposure of an employee's body to paraquat or solutions containing paraquat may occur, facilities for quick drenching of the body should be provided within the immediate work area for emergency use.

- Non-impervious clothing which becomes contaminated with paraquat should be removed immediately and not reworn until the paraquat is removed from the clothing.

- Employees should be provided with and required to use dust- and splash-proof safety goggles where paraquat or solutions containing paraquat may contact the eyes.

SANITATION

- Skin that becomes contaminated with paraquat should be immediately washed or showered to remove any paraquat.

- Eating and smoking should not be permitted in areas where paraquat or solutions containing paraquat are handled, processed, or stored.

- Employees who handle paraquat or solutions containing paraquat should wash their hands thoroughly before eating, smoking, or using toilet facilities.

COMMON OPERATIONS AND CONTROLS

The following list includes some common operations in which exposure to paraquat may occur and control methods which may be effective in each case:

Operation

Use as an agricultural herbicide, desiccant, defoliation agent during pre-harvest; use as an herbicide for non-agricultural purposes on highway margins, around commercial buildings; use to control aquatic weeds

Manufacture, formulation, and processing of paraquat and aqueous solutions of the salts

Controls

Personal protective equipment

Personal protective equipment

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

• Eye Exposure

If paraquat or solutions containing paraquat get into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.

• Skin Exposure

If paraquat or solutions containing paraquat get on the skin, immediately flush the contaminated skin with water. If paraquat or solutions containing paraquat soak through the clothing, remove the clothing immediately and flush the skin with water. If irritation persists after washing, get medical attention.

• Breathing

If a person breathes in large amounts of paraquat, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

• Swallowing

When paraquat or solutions containing paraquat have been swallowed and the person is conscious, give the person large quantities of water immediately. After the water has been swallowed, try to get the person to vomit by having him touch the back of his throat with his finger. Do not make an unconscious person vomit. Get medical attention immediately.

• Rescue

Move the affected person from the hazardous exposure. If the exposed person has been overcome, notify someone else and put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILL AND DISPOSAL PROCEDURES

- Persons not wearing protective equipment and clothing should be restricted from areas of spills until cleanup has been completed.

- If paraquat is spilled, the following steps should be taken:

1. Ventilate area of spill.

2. Collect spilled material in the most convenient and safe manner and deposit in sealed containers for reclamation or for disposal in a secured sanitary landfill. Liquid containing paraquat should be absorbed in vermiculite, dry sand, earth, or a similar material.

- Waste disposal method:

Paraquat may be disposed of in sealed containers in a secured sanitary landfill.

REFERENCES

- American Conference of Governmental Industrial Hygienists: "Paraquat," *Documentation of the Threshold Limit Values for Substances in Workroom Air* (3rd ed., 2nd printing), Cincinnati, 1974.
- Bullivant, C. M.: "Accidental Poisoning by Paraquat: Report of Two Cases in Man," *British Medical Journal*, 1:1272-1273, 1966.
- Cant, J. S. and Lewis, D. R. H.: "Ocular Damage Due to Paraquat and Diquat," *British Medical Journal*, 2:224, 1968.
- Christensen, H. E., and Luginbyhl, T. L. (eds.): *NIOSH Toxic Substances List*, 1974 Edition, HEW Publication No. 74-134, 1974.
- Clark, D. G., et al.: "The Toxicity of Paraquat," *British Journal of Industrial Medicine*, 23:126-132, 1966.
- Gage, J. C.: "Toxicity of Paraquat and Diquat Aerosols Generated by a Size-selective Cyclone: Effect of Particle Size Distribution," *British Journal of Industrial Medicine*, 25:304-314, 1968.
- Gleason, M. N., Gosselin, R. E., Hodge, H. C., and Smith, R. P.: *Clinical Toxicology of Commercial Products* (3rd ed.), Williams and Wilkins, Baltimore, 1969.
- Grant, W. M.: *Toxicology of the Eye* (2nd ed.), C. C. Thomas, Springfield, Illinois, 1974.
- Hearn, C. E. D., and Keir, W.: "Nail Damage in Spray Operators Exposed to Paraquat," *British Journal of Industrial Medicine*, 28:399-403, 1971.
- Spencer, E. Y.: *Guide to the Chemicals Used in Crop Protection* (6th ed.), Publication 1093, Research Branch Agriculture, Canada, 1973.
- Stolman, A. (ed.): *Progress in Chemical Toxicology*, Academic Press, New York, 1965-1969.
- Swan, A. A. B.: "Exposure of Spray Operators to Paraquat," *British Journal of Industrial Medicine*, 26:322-329, 1969.
- Thienes, C. H., and Haley, T. J.: *Clinical Toxicology* (5th ed.), Lea and Febiger, Philadelphia, 1972.
- Toner, P. G., et al.: "Fine Structure of the Lung Lesion in a Case of Paraquat Poisoning," *Journal of Pathology*, 102:182-185, 1970.

RESPIRATORY PROTECTION FOR PARAQUAT

Condition	Minimum Respiratory Protection* Required Above 0.5 mg/m ³
Particulate Concentration	
1.5 mg/m ³ or less	Any chemical cartridge respirator with an organic vapor cartridge(s) and dust and mist filter(s), including pesticide respirators which meet the requirements of this class. Any supplied-air respirator. Any self-contained breathing apparatus.
Greater than 1.5 mg/m ³ ** or entry and escape from unknown concentrations	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode. A combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.
Fire Fighting	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.
Escape	Any gas mask providing protection against organic vapors and particulates, including pesticide respirators which meet the requirements of this class. Any escape self-contained breathing apparatus.

*Only NIOSH-approved or MSHA-approved equipment should be used.

**Use of supplied-air suits may be necessary to prevent skin contact while providing respiratory protection from airborne concentrations of paraquat; however, this equipment should be selected, used, and maintained under the immediate supervision of trained personnel. Where supplied-air suits are used above a concentration of 1.5 mg/m³, an auxiliary self-contained breathing apparatus operated in positive pressure mode should also be worn.