

National Occupational Health and Safety Commission

CYANIDE POISONING

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Foreword

The National Occupational Health and Safety Commission, Worksafe Australia, is a tripartite body established by the Commonwealth Government to develop, facilitate and implement a national approach to occupational health and safety.

The National Commission comprises representatives of the peak employee and employer bodies - the Australian Council of Trade Unions (ACTU) and Australian Chamber of Commerce and Industry (ACCI) - as well as the Commonwealth, State and Territory governments.

Since its establishment, the National Commission has produced occupational health guides. Before the National Commission was established, a series of similar guides was published by the National Health and Medical Research Council.

This Guide has been reviewed and endorsed by a working group of the National Commission as part of the co-ordinated effort by the Commonwealth, State and Territory governments and employee and employer organisations to make Australian workplaces safe and healthy.

Although this Guide has been endorsed by the National Commission, it is an advisory document only. It is produced and distributed in the interests of providing useful information on occupational health and safety for employers, employees and others. This document does not replace statutory requirements under relevant State and Territory legislation.

This Guide is aimed primarily at workers and managers but should also be useful to occupational health and safety personnel and others. It may be used in conjunction with appropriate training and consultation, in line with good management practice.

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Introduction

This Guide outlines some of the potential health hazards associated with the use of cyanide.

This Guide should be read in conjunction with the following Worksafe Australia Guides:

- *Electroplating*; and
- *Atmospheric Contaminants*.

The National Commission publication, *Exposure Standards for Atmospheric Contaminants in the Occupational Environment* (latest edition), should also be consulted.

Reference should be made to the manufacturer's specific product information in the form of a material safety data sheet (MSDS). The MSDS should be updated regularly. MSDS should conform to the National Commission's recommended format and should be freely accessible to all employees.

Identification

Cyanide compounds include cyanide salts, such as sodium cyanide (NaCN), potassium cyanide (KCN) and calcium cyanide (CaCN) and the gas hydrogen cyanide (HCN) also known as hydrocyanic gas or prussic acid.

Cyanide salts are used in the extraction of gold and silver from ores, electroplating and metal cleaning. Hydrogen cyanide is a highly toxic and flammable gas and is mainly used in the manufacture of other chemicals, such as methyl methacrylate, cyanide salts and chelating agents. It has a minor use as a fumigant and rodenticide and is also a by-product of blast furnaces, gas works, coke ovens and processes such as electroplating, petroleum refining, metallurgy and photography. Hydrogen cyanide may be given off when nitrogen-containing plastics burn, and will also be produced when cyanide solids or liquids are mixed with moisture or carbon dioxide in air, steam, acids, acid salts or acid fumes.

Hydrogen cyanide gas and cyanide salts are among the most rapidly acting of all known poisons. Even small concentrations are extremely hazardous. Cyanide salts are odourless when dry, however, when damp they may have a slight odour of hydrogen cyanide. Hydrogen cyanide has a bitter almond smell. However, a person's sense of smell cannot be relied on as a warning signal to detect its presence since not everyone can smell it. This is further complicated because the sense of smell easily fatigues.

Cyanide gas is highly flammable and in liquid* form is both very volatile and flammable. Exposure of cyanides to strong oxidisers such as nitrates and chlorates may cause fires and explosions.

* **Note:** HCN is a liquid at below 2°C

Health Hazards

When considering the hazards associated with any workplace, it is essential to understand the relationship between 'hazard', 'exposure' and 'risk'.

'Hazard' is the potential for an agent or process to do harm. 'Risk' is the likelihood that an agent will produce injury or disease under specified conditions.

Health effects can occur only if an employee is actually exposed to the hazard. The risk of injury or disease usually increases with the duration and frequency of exposure to the agent, and the intensity/concentration and toxicity of the agent.

Toxicity refers to the capacity of an agent to produce disease or injury. The evaluation of toxicity takes into account the route of exposure and the actual concentration of an agent in the body.

Although cyanide poisoning is uncommon, all employees where cyanide or cyanide compounds are used should be well-versed in first aid treatment and have emergency kits for treatment of cyanide poisoning on hand.

The signs and symptoms of fear of over-exposure to cyanide are similar to those for mild poisoning. These include nausea, headache, sense of suffocation and agitation. As already mentioned, cyanide poisoning is uncommon and, unless there is firm evidence to show that cyanide contamination has occurred, a patient is most likely to be suffering from something else. Kelocyanor, dicobalt edetate, which is used to treat cyanide poisoning, may make the situation worse if it is given to someone who is not suffering from cyanide poisoning.

Acute cyanide poisoning

Mild cyanide poisoning

Onset of symptoms after exposure is very rapid. Symptoms and signs of mild cyanide poisoning include headaches, giddiness, nausea and vomiting (if the cyanide has been ingested). The person has difficulty breathing, a sense of suffocation and a feeling of general weakness with heaviness of arms and legs. Cyanide causes irritation of the nose, mouth and throat.

Severe cyanide poisoning

Severe cyanide poisoning may be characterised by gasping for breath and loss of consciousness. After loss of consciousness, breathing may be weak or absent. Cardiac arrest and death may result.

Chronic cyanide poisoning

Chronic cyanide poisoning symptoms are similar to those of mild cyanide poisoning. These symptoms include headaches, dizziness, nausea or vomiting, and visual and peripheral nervous system effects. Repeated or prolonged skin contact to low concentrations of potassium cyanide dust may lead to dermatitic effects ('cyanide rash') characterised by itching and skin eruptions.

Mechanisms of cyanide poisoning

Cyanide compounds are highly toxic, causing harm by interfering with the body's use of oxygen. Cyanide poisoning essentially causes suffocation in the patient. This is because cyanide stops the use of oxygen in metabolic pathways. Some doses of cyanide may affect the central nervous system, slow the heart or stop electrical activity of the brain.

Cyanide compounds act very rapidly and may enter the body by inhalation of gas, skin absorption or by ingestion.

Prevention and Control Measures

Following the identification of a hazard, evaluation of work practices and conditions must be undertaken so that effective prevention and control measures can be implemented. This should be considered an integral part of management's responsibilities.

When storing, using or disposing of cyanide, State and Territory requirements must be followed. The following practices should be adopted to assist in evaluating and minimising the risk to occupational health and safety. Education to promote knowledge about relevant hazards is essential if appropriate working procedures are to be followed. MSDS should be made available to all employees.

Evaluation

Environmental sampling and analysis should be undertaken at regular intervals by qualified occupational health and safety professionals in accordance with the methods recommended by the appropriate occupational health authority.

Monitoring

Monitoring may be used for the evaluation of a hazard and for assessing the effectiveness of control measures. The design and implementation of a monitoring program should be carried out by, or in consultation with, a properly qualified person.

Monitoring of the work environment involves the measurement of atmospheric contaminants at selected locations in the workplace (static, positional monitoring). Personal monitoring involves the measurement of atmospheric contaminants in the breathing zone of the individual worker. Biological monitoring involves measurement of the concentration of a contaminant, its metabolites or other indicators in the tissues or body fluids of the worker. In some cases, biological monitoring may be required to supplement static or personal monitoring.

Where it has been demonstrated that the exposure of the employee to a specific contaminant is approaching the relevant exposure standard, or where biological monitoring indicates that an unacceptable exposure is occurring, *immediate action must be taken to reduce the health hazard* and intensive monitoring should continue.

Records of the results of any monitoring should be maintained and employees should be informed of these results.

Exposure standards

The National Commission's publication on exposure standards recommends the following time-weighted average levels, which apply to an eight-hour working day for a five-day working week, and levels which should not be exceeded at any time (peak). The 1991 edition of the National Commission publication, *Exposure Standards for Atmospheric Contaminants in the Occupational Environment*, recommends the following exposure standards:

hydrogen cyanide - 10 ppm, peak, skin, 10 mg/m³, peak, skin; and

cyanide salts (as CN) - 5 mg/m³, skin.

The most recent edition of *Exposure Standards for Atmospheric Contaminants in the Occupational Environment* must always be consulted for current values.

The 'skin' notation means that absorption can occur through the skin, mucous membranes or eyes. Both the cyanide solutions and the gas can be absorbed through the skin. If actual skin contact with cyanide solutions occurs, then the exposure limits as weighted averages no longer apply.

The exposure standards do not represent 'no-effect' levels which guarantee protection to every employee.

Control measures

Where there is a likelihood of employee exposure to cyanide compounds, steps should be taken to minimise that exposure as far as practicable. A thorough examination of work practices is essential. Procedures should be adopted to ensure that employees are not unnecessarily exposed to the hazard. Control measures include, but are not limited to, the following, which are ranked in priority of their effectiveness:

- elimination/substitution and process modification;
- engineering controls;
- administrative controls; and
- use of personal protective equipment.

Engineering controls

Engineering controls should be such that the concentrations of atmospheric contaminants given off by the operations do not exceed the recommended exposure standards.

Care in selection, design, installation, operation and regular maintenance is essential to ensure that the system adequately controls contamination at all times.

The design of an effective ventilation system is a highly skilled area of expertise and therefore should be performed only by those competent to do so. Special care in design is important where combustible, inflammable or potentially explosive materials are involved. Inlets and outlets must not be blocked and must be kept clear at all times.

Air from a local exhaust ventilation system should not be recirculated into the workroom. It should be discharged to the outside air, distant from other work areas, air-conditioning inlets or compressors supplying breathing air.

General ventilation systems are not usually as satisfactory in the control of health hazards as is the use of ventilated process enclosures or local exhaust ventilation, but they may be useful to control minor emissions of contaminants of low toxicity. In designing a mechanical ventilation system where such contamination occurs, particular attention should again be given to fan selection and to the placement of air extractors and fresh air supply openings. In particular, movement of air should be arranged so that clean air streams are drawn past employees and contaminated ones lead away from them. Such systems require rigorous control over all sources of natural ventilation and air movement which may disturb planned air movement, for example, the operation of air-conditioning systems or the opening and closing of doors and windows. Changes or additions to a balanced ventilation system must be implemented in such a way that they will not result in reduced efficiency of the entire ventilation system.

Particular attention should be given to the following precautions:

- Keep workplaces and stores well ventilated. Toxic concentrations of hydrogen cyanide gas can be reached when cyanide is in prolonged contact with air in a closed area.
- When opening a container storing cyanide, remove the lid, and move away to let the accumulated gas out of the container before returning to obtain the quantity required.

Personal protective equipment

In certain circumstances, personal protection of the individual may be required as a supplement to other preventive action. It should not be regarded as a substitute for other control measures and must only be used in conjunction with substitution and elimination measures.

Personal protective equipment must be appropriately selected, individually fitted and employees trained in its correct use and maintenance. Personal protective equipment must be regularly checked and maintained to ensure that the employee is being protected.

The following practices should be observed:

- Wear impervious gloves, for example, PVC, at all times when handling cyanide.
- Wear a protective apron, rubber boots and face shield or goggles whenever there is the possibility of being splashed with cyanide.
- Handle gloves and other protective equipment carefully and safely. Wash equipment immediately after use and store clean items well away from cyanide.
- Use the appropriate respiratory equipment for the concentration of cyanide dust or gas that may be in the air. This should comply with Australian Standard AS 1716. If there is any possibility of high concentrations of hydrogen cyanide gas, use self-contained or air-supplied breathing apparatus.
- Respiratory equipment should be kept in order and ready for use at all times. Do not store the equipment where cyanide is used or stored.

Environmental and personal hygiene

Cleaning of walls, floors, ceilings, overhead structures, windows, tables, ledges, machinery and other equipment should be effected either by vacuum cleaning using cleaners fitted with high efficiency particulate air (HEPA) filters for removing hazardous particles or by wet methods. HEPA filters must comply with the 99.97 per cent minimum efficiency requirement of Australian Standard AS 1324, section 4.3.1. Dry sweeping or blowing is not acceptable. Whenever the nature of the work requires it, floors, benches or tables should be covered with an impervious material which can be hosed or wetted easily.

The following practices should be observed:

- Do not mop up perspiration with either the sleeves of overalls or with fabric which is kept in the areas where cyanide is used or stored.
- Remove pervious clothing immediately if wet or contaminated. This clothing should be stored safely in closed containers until laundered or disposed of. Under no circumstances should this clothing be taken home.

- Do not touch the nose, eyes or mouth when handling cyanide.
- Do not eat, drink or smoke or keep food, drinks, utensils or cigarettes in areas where cyanide is in use.
- Hands and face must be washed before eating, drinking or smoking and before using toilet facilities.
- Emergency showers and eye-wash facilities should be provided within the immediate work area where cyanide compounds are regularly handled.

Employees should have ready access to clean work clothes, protective clothing, adequate washing and laundry facilities and, in some of the more hazardous situations, showers and changing rooms. Splashes by irritant or sensitising substances must be washed off immediately with soap and water. Contaminated clothing must be removed.

Education and training

All employees working with cyanide must be informed of the hazards from exposure to the contaminant and the precautions necessary to prevent damage to their health. Employees should be trained in appropriate procedures to ensure that they carry out their work so that as little contamination as possible is produced, and in the importance of the proper use of all safeguards against exposure to themselves and their fellow workers. Adequate training, both in the proper execution of the task and in the use of all associated engineering controls, as well as of any personal protective equipment, is essential.

Employees exposed to contamination hazards should be educated in the need for, and proper use of, facilities, clothing and equipment and thereby maintain a high standard of personal cleanliness. Special attention should be given to ensuring that all personnel understand instructions, especially newly recruited employees and those with English-language difficulties, where they are known.

Before handling any materials, MSDS should be obtained from the suppliers.

A management representative should be nominated as responsible for the supply and maintenance of, and training in, personal protective equipment.

Ensure that all employees understand the safety procedures associated with the storage and handling of cyanide. This should include a program on the use and maintenance of respiratory protective equipment.

Particular attention should be given to the following precautions:

- a notice of action to be taken in case of suspected poisoning should be displayed in a prominent place in all areas where cyanide is handled and stored and in the first aid station; and
- ensure that all employees have a knowledge of the procedures (outlined below) to be followed in case of fire or a spill or leak.

Health assessment

In some occupations, health assessment may form part of a comprehensive occupational health and safety strategy. Where employees are to undergo health assessment, there should be adequate consultation prior to the introduction of any such program. It is particularly valuable to be able to relate employee health and illness data to exposure levels in the workplace. Medical records must be confidential.

Fire

The majority of cyanides are not combustible. For example, the solid cyanides such as sodium cyanide and potassium cyanide will not burn and offer no direct hazard when stored in sealed metal containers. However, the gas hydrogen cyanide is flammable and may be produced, for example, on contact of solid cyanides with heat or water. When a significant amount of this gas is present, there is a risk of explosion. There is also a risk of explosion when water comes into contact with molten cyanide.

Instructions regarding action to be taken during a fire should be prefaced with a statement referring to appropriate training of personnel prior to attempting fire fighting.

If there is a fire where cyanide is used or stored:

- evacuate the area and call the fire brigade and keep upwind to avoid inhalation of smoke/fumes;
- anyone entering the area must wear self-contained breathing apparatus and full protective clothing, including boots; and
- use dry chemical fire extinguishers or sand to put the fire out - do not use water.

Storage

Particular attention should be given to the following storage precautions:

- Small quantities of cyanide must be stored separately in a locked poisons cupboard.
- For large quantities of cyanide, either:
 - the store should be of fire-resistant material with a concrete floor or a shipping container raised off the ground. The store should be well-ventilated. The cyanide should be placed in the store so that moisture cannot reach the base of the container if the floor were to become damp. The store should be securely locked, or
 - any other well-ventilated lockable enclosure approved by the relevant State or Territory government authority should be used.
- The store should have no sharp edges or protrusions which might damage the cyanide containers or labels. Strict procedures should be in place to check the condition of the containers and to ensure that damaged and deteriorated containers are disposed of properly.
- Keep cyanide in securely closed, original containers and arrange so that the oldest stock is used first.
- Cyanide stores must not contain acids or other incompatible substances in accordance with the section below.
- Do not eat, drink or smoke in a cyanide store and ensure that food, drinks, utensils or cigarettes are not kept in any of the areas where cyanide is stored.
- Do not store respiratory equipment, clothing or protective equipment where cyanide is stored.

Incompatibilities

To reduce the likelihood of accidental reactions:

- keep workplaces dry (reaction of cyanide with water can produce the highly toxic and flammable gas hydrogen cyanide);
- prevent contact with acids or acid fumes because hydrogen cyanide may be produced; and
- prevent contact with strong oxidising agents (for example, nitrates, nitrites, peroxides and chlorates).

Spills or leaks

In the event of spills or leaks:

- do not enter the area unless wearing self-contained breathing apparatus and full protective clothing, including boots;
- personnel protective equipment must be worn should any attempt be made to close off the source of the spill or leak;
- evacuate the area and move upwind to avoid inhalation of vapour and contact with skin and eyes;
- depending on the size and location of the spill, notify the fire brigade, police and/or emergency contact;
- no smoking, naked lights or ignition sources should be permitted;
- if safe to do so, stop the leak and pick up the spillage, placing it in a clean, dry sealable container labelled for disposal, treatment in a cyanide disposal system or reclamation;
- do not attempt to wash away the spilled material with water;
- treat the spillage area with sodium hypochlorite solution to deactivate any uncollected traces of cyanide; and
- prevent the spillage from spreading or entering drains, waterways or water storage by banking with sand or earth.

For spills or leaks of small quantities of cyanide:

- do not enter the area unless wearing self-contained breathing apparatus and full protective clothing, including boots;
- ventilate the area of the spill;
- evacuate the area and move upwind to avoid inhalation of vapour and contact with skin and eyes;
- depending on the size and location of the spill, notify the fire brigade, police and/or emergency contact;
- collect the spilled material in the most convenient and safe manner for reclamation or for treatment in a cyanide disposal system; and
- treat the spillage area with sodium hypochlorite solution to deactivate any uncollected traces of cyanide.

Disposal

Cyanide is an environmental hazard and requires treatment in a cyanide disposal system.

Empty containers which are not for re-use should be thoroughly rinsed with large amounts of water and this rinse used in the usual cyanide process. The containers, once thoroughly clean, should then be punctured or crushed and disposed of at approved municipal disposal sites.

First Aid

Rescue

It is essential that rescuers have been trained in the procedures to be followed and in the use of protective equipment.

Before entering an area contaminated by cyanide gas, rescuers must wear breathing apparatus complying with Australian Standard AS 1716.

Care should also be taken in handling a patient whose clothing is contaminated with cyanide as cyanide can be absorbed through the skin or the vapour breathed in. The clothing should be carefully removed and placed in a receptacle for decontamination.

The signs and symptoms of fear of over-exposure to cyanide are similar to those for mild poisoning. These include nausea, headache, sense of suffocation and agitation. As already mentioned, cyanide poisoning is uncommon and, unless there is firm evidence to show that cyanide contamination has occurred, a patient is most likely to be suffering from something else. Kelocyanor, dicobalt edetate, which is used to treat cyanide poisoning, may make the situation worse if it is given to someone who is not suffering from cyanide poisoning.

First aid

To be effective, first aid must be prompt. Immediately:

- remove the patient from the source of contamination - to fresh air if hydrogen cyanide gas (HCN) is present;
- if the patient is not breathing, *do not* use mouth to mouth or mouth to nose ventilation because of the danger to the rescuer, use a resuscitation bag and mask instead;
- if pulse is absent, start external cardiac massage;
- give 100 per cent oxygen by mask if available;
- remove all contaminated clothing, wash the affected areas with soap and copious amounts of water; and
- arrange for the urgent transfer of the patient, accompanied by an attendant with the cyanide emergency kit, to medical professionals.

For further information contact the Poisons Information Centre in your State or Territory or the National Poisons Information Centre on 008 251 525.

Emergency kit for cyanide poisoning

At all places where there is a risk of cyanide poisoning, the following items should be kept in an accessible and convenient position:

- an oxygen resuscitator and a source of oxygen;
- a clearly marked cyanide antidote box containing:
 - an approved airway,
 - elasticised tourniquet,
 - disposable indwelling intravenous cannulae,
 - 20 mL sterile disposable syringes and needles,
 - fluoride heparinised blood sample tubes,
 - skin prep swabs, dressings and adhesive tape, and
 - ampoules of Kelocyanor (dicobalt edetate), including the prescribing information outlining side effects and precautions*;
- a copy of the appropriate MSDS; and
- a copy of the Worksafe Australia Guide, Cyanide Poisoning.

*** Note: An adverse reaction can result from the cyanide antidote being given in the absence of cyanide poisoning. Reported adverse reactions include oedema of the face and neck, urticaria, palpitations, hypotension, collapse, convulsions, vomiting, chest pains and difficulty in breathing. The cyanide antidote should be administered only when cyanide poisoning is beyond doubt and only by a professional health attendant. NOTE EXPIRY DATE. Procedures should be in place to ensure that Kelocyanor supplies are replaced before the expiry date.**

See the appendix for details on professional medical care.

Appendix

Professional medical care

Treatment

Treatment should include the following measures:

- immediate attention should be directed toward assisted ventilation, administration of 100 per cent oxygen, insertion of intravenous lines and institution of cardiac monitoring, if available;
- attention should be given to monitoring the level of consciousness;
- administer antidote if signs of serious cyanide poisoning are present:
 - insert indwelling cannula into vein,
 - take blood in a fluoride heparinised tube for confirmation of diagnosis,
 - slowly inject one 20mL ampoule of Kelocyanor (300mg dicobalt edetate)*, immediately followed by 50 per cent dextrose 50mL, and
 - if there is no response, repeat to a maximum of 900mg, taking care to avoid adverse drug reactions;
- if cyanide has been swallowed, gastric lavage, charcoal and cathartics may be used after antidote therapy if less than two hours have passed since ingestion; and
- obtain an arterial blood gas measurement immediately, and correct any severe metabolic acidosis (pH below 7.20) with bicarbonate.

Supportive care

Supportive care should include the following measures:

- follow the patient's progress for at least 24-48 hours;
- watch for the development of pulmonary oedema and aspiration pneumonia in comatose patients;

- correct metabolic acidosis with bicarbonate when blood pH falls below 7.20 and be sure to correct electrolyte imbalance (for example, hyperkalemia, hypercalcemia); and
- discontinue 100 per cent oxygen after antidote is started.

*** Note:** An adverse reaction can result from the cyanide antidote being given in the absence of cyanide poisoning. Reported adverse reactions include oedema of the face and neck, urticaria, palpitations, hypotension, collapse, convulsions, vomiting, chest pains and difficulty in breathing. The cyanide antidote should be administered only when cyanide poisoning is beyond doubt and only by a professional health attendant. **NOTE EXPIRY DATE.** Procedures should be in place to ensure that Kelocyanor supplies are replaced before the expiry date.

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