Chemical Safety Guidance Series

February 2020

Cyanides: User Guidance

Occupational Health and Safety Service

HSD179C (rev 2)

UNIVERSITY OF CAMBRIDGE

Cyanides (CN): User Guidance

"Cyanides are powerful rapid-acting poisons by Inhalation, Ingestion or Skin Absorption"

1. Introduction:

Cyanides are a family of compounds containing the cyanide group (-CN), which is formed by combination of elemental carbon and nitrogen. Their toxicity is related to the ease of release of the cyanide group by acids, water or heat (including fire).

Inorganic cyanides are listed as *'poisons'* in Schedule 1 of The Poisons Rules, 1982, requiring them to be kept locked in a cupboard. These cyanides contain easily liberated cyanide ions. i.e. the common alkali metal cyanides (sodium, potassium and calcium cyanide), which are **very toxic**.

Common Alkali Metal Cyanides

Potassium Cyanide	KCN
Sodium Cyanide	NaCN
Calcium Cyanide	$Ca(CN)_2$

VERY TOXIC **CORROSIVE**

Metal Cyanides release very toxic and extremely flammable Hydrogen Cyanide gas when mixed with acids.

Calcium cyanide will also release hydrogen cyanide gradually when exposed to water or air. Simple metallic cyanides are very toxic, white, deliquescent (absorb moisture from the air), non-combustible solids that may have a faint odour of bitter almonds.

Heavy metal cyanide salts usually act less rapidly, releasing hydrogen cyanide more slowly.

Uses of man-made cyanides include, research, electroplating, metallurgy, organic chemicals production, photographic development, salt anti-caking agents, precious metal extraction, the production of plastics, insecticides, rodenticides, chelating agents and dye manufacture. Certain bacteria, fungi, insects, algae and plants naturally produce cyanides.

Exceptions from this guidance, under normal conditions and after risk assessment are:

Ferro-cyanides, ferri-cyanides and thiocyanates which are not in themselves regarded as very toxic because the potentially very toxic cyanide group is not readily released from these compounds and they are therefore exempt from The Poisons Rules, 1982.

Similarly organic cyanides which are usually called 'nitriles' have a CN group covalently bound to a carbon containing group and are not usually regarded as cyanides in the classic sense, since the potentially very toxic cyanide group is not easily liberated.

Note however, that these excepted compounds may release hydrogen cyanide when they decompose, under extreme conditions (such as in fires or in strong/hot acids) and they may also have other hazardous properties, see Appendix 1.

2. The Effects of Exposure to Cyanide:

The first symptoms of cyanide poisoning are rapid, deep breathing and shortness of breath, followed by convulsions and loss of consciousness. In cases of acute cyanide poisoning, death is extremely rapid.

The health effects of all forms of cyanide poisoning are similar when 'large' amounts are inhaled, ingested or absorbed, however, the severity and rapidity of onset is dependent on the route, the dose, the duration of exposure and the compound in question.

An acute exposure to high levels of cyanide (as little as 50mg of alkali metal cyanide in a single instantaneous dose) can cause cessation of breathing, coma and death.

Short term acute exposures to lower levels result in rapid, deep breathing, shortness of breath, convulsions and loss of consciousness. At even lower doses the first symptoms may be weakness, headaches, confusion and occasionally nausea and vomiting.

Long term chronic low levels of exposure may result in effects on the nervous system, brain, lungs, heart and the thyroid gland with loss of appetite, headache, weakness, nausea, dizziness, and symptoms of irritation of the upper respiratory tract and eyes.

ACUTE CONCENTRATION-RELATED AFFECTS OF HYDROGEN CYANIDE GAS

Conc. (ppm)	Effect
270	Immediately fatal
181	Fatal after 10 minutes
135	Fatal after 30 minutes
110	Fatal after 60 minutes
45-54	Tolerated 30 – 60 minutes without acute effect
18-36	Some symptoms possible after several hours

Note: Hydrogen Cyanide Gas is often referred to simply as 'Cyanide Gas'

Hydrogen cyanide gas may be detected by its almond-like odour; unfortunately up to 40% of people are unable to smell it and the ability to do so can depend upon factors such as olfactory fatigue and viral infections. For those who can, it is detectable at concentrations above 1 ppm. Whilst the Workplace Exposure Limits (WEL) for hydrogen cyanide are 4.5 ppm over 15 min and 0.9 ppm over 8hrs. (EH40 2005 as amended 2020). The WELs must not be exceeded, however the All work with cyanides should aim for zero exposure in compliance with best practice through the use of appropriate control measures.

Biological effects of exposure:

Cyanide binds irreversibly with the iron atom of haemoglobin, preventing it from transporting oxygen around the body. It also interferes with the function of ATP (adenosine triphosphate, the body's energy storage molecule) and this dual action halts the body's metabolism.

The effects of the 'loss' of functional haemoglobin can be partially mitigated by the prompt administration of oxygen by a trained first aider and/or the ambulance service.

3. RESPONSIBILITIES AND CONTROL MEASURES FOR CYANIDES*

1. **People must never work alone with cyanides**

2. It is the responsibility of the **user and their PI / supervisor** to ensure that a suitable and sufficient **risk assessment** has been carried out for their work with cyanide, remembering that users have a duty of care to first aiders and others who might be affected.

3. It is the responsibility of the user and their PI / supervisor to ensure that written safe working procedures are in place, including ensuring that work with cyanides are only carried out when an appropriately trained first aider and their equipment, oxygen etc, is available.

4. Only those people competent in handling cyanide and familiar with the written local rules pertaining to its use should be allowed to work with cyanide, unless undergoing training under strict and close supervision. It is the responsibility of the PI / supervisor to assess the user's competence.

5. Access to the cyanide work area should be restricted to those who know the dangers of cyanide, the symptoms and the emergency procedures.

6. Rigorous safe containment, segregation, decontamination and disposal procedures must be used.

7. Wherever reasonably practicable spill trays should be used.

8. Emergency procedures should include the cleaning-up of spills (having spillage kits if appropriate).

9. All those who are either working with, or could be exposed to, cyanides should wear appropriate Personal Protective Equipment (PPE), see section 4. below.

10. If it is possible / foreseeable that hydrogen cyanide gas could be generated, suitable precautions, such as working in a fume cupboard, should be used to prevent exposure to it and other workers in the area and the First Aider MUST be made aware of this possibility before the work commences.

11. It is the responsibility of the user to ensure that at **least one appropriately trained First Aider (in addition to any users at the time) is aware of the work and be available to respond quickly** if called, for the duration of the work.

12. It is the responsibility of the user to ensure that the first aider is familiar with the Cyanide work area, any potential hazards therein and the location of a safe place for the administration of first aid.

13. Only first aiders appropriately trained, competent and suitably equipped for treating Cyanide poisoning should attempt to administer first aid treatment.

14. The risk assessment should be made available to First Aiders (however, it is **not** the responsibility of the first aider to 'approve' risk assessments - this responsibility remains with the PI / supervisor).

15. While First Aiders have no safety management role, they can and may ask reasonable questions aimed at discovering the extent of the dangers they might face.

16. It is the **responsibility of the users** / user's co-workers to ensure that if first aid is summoned the **casualty is in a safe place**, **where it is safe to carry out first aid** and therefore the written safe system of work must include procedures to achieve this. Procedures for rescue in the event that it is unsafe to administer first aid in-situ should not make assumptions about the ability of the emergency services to carry out a rescue without consulting them.

* *In the past there have been several antidotes available, but most of these are associated with a significant risk of mortality if accidentally administered to someone who has not, in fact, been exposed to cyanide. Therefore, on consideration of all the evidence, both of the effectiveness and the circumstances where they have been used, the HSE have concluded that no antidote should be endorsed for first aid usage. Departments should dispose of any stocks of 'cyanide antidotes' that remain (e.g. Kelocyanor). Should an antidote be considered appropriate by the clinical staff at the Hospital (Addenbrookes) it would be for them to make this decision and to administer it.*

4. PERSONAL PROTECTIVE EQUIPMENT

All persons working with cyanides should wear sensible closed shoes covering the whole of the feet and suitable clothing covering the arms and the legs down to the shoes.

They must also wear dedicated Personal Protective Equipment (PPE), which should **put it on in the order listed below:**

1. Laboratory coat.
2. Disposable plastic full-body apron.
3. Safety glasses, goggles (preferred) and/or face shield as appropriate.
4. Inner disposable gloves ie: nitrile
5. Outer robust gloves ie: 'Marigold' or thick re-usable nitrile.

The PPE should be removed in the order below as follows;

1. Remove disposable plastic apron, folding it in on itself to contain contamination and dispose of as hazardous waste in a labelled sealable plastic bag.
2. Thoroughly wash and dry outer robust gloves before removing them.
3. Remove laboratory coat and if contamination is suspected place in a separate labelled sealable plastic bag for decontamination.
4. If inner disposable gloves could be contaminated then replace with fresh ones, placing the old pair in a labelled sealable plastic bag for disposal.
5. Remove safety glasses, goggles or face shield and if contamination is suspected place in a separate sealable plastic bag for decontamination.
6. Remove inner disposable gloves and if contamination is suspected place in a separate labelled sealable plastic bag for disposal.

A supply of suitable sealable plastic bags for containment / disposal of contaminated items should be kept with the PPE. Laboratory coats must not be sent for laundering before they have been decontaminated if there is any risk of cyanide contamination (if heavily contaminated then disposal may be the safest option).

All items for disposal should be treated as hazardous waste, and be labelled as such, before disposal via the University's hazardous waste procedure.

5. RESPONSE FOLLOWING A DEFINITE ABSORPTION OF CYANIDE.

Speed is essential – "Shout for help" –

Get immediate medical attention; dial 1-999 (9-99)

Summon First Aider

NOTE:

If there is any suspicion of gaseous hydrogen cyanide (cyanide gas)**, do **NOT** enter the area at risk.

If you are assisting in any way then appropriate PPE must be worn.

If anyone is referred to Addenbrookes Hospital the appropriate Safety Data Sheet (SDS) should accompany them together with information as to the nature of the incident.

See Appendix 2 for an outline of appropriate actions.

** The odour of hydrogen cyanide (similar to bitter almonds) is a warning that it is present at a level requiring action, **however**, the absence of an odour does not mean that it is not present, because there are considerable variations in the day to day ability of individuals to detect it.

Appendix 1.

Chemical properties of some common cyanides:

Calcium Cyanide is a white / colourless powder or crystals. It has a faint bitter almond odour. It is soluble in water with gradual liberation of hydrogen cyanide. It is a deadly poison when inhaled or digested. When heated to decomposition, it emits toxic fumes. Synonyms include: alcyanide, cyanogas, calcid, calcyan, and cyanide of calcium.

Copper Cyanide is a white solid that is insoluble in water. It is a poison and reacts violently with magnesium. When heated to decomposition, it emits very toxic fumes. Synonyms, include cupricin and cuprous cyanide.

Cyanogen is a colourless gas NC-CN with an almond-like odour. It is soluble in water, ethanol, and ethyl ether. It is a poison and is very toxic to the eye and is a very dangerous fire hazard via heat, flames, and oxidizers. When heated to decomposition or on contact with acid, acid fumes, water, or steam, it will react to produce highly toxic fumes. Synonyms include: carbon nitride, dicyanogen, ethanedinitrile, and oxalonitrile.

Cyanogen Chloride is a colourless gas CN_Cl with a highly irritating odour. It is soluble in water, ethanol, and ethyl ether. It is a poison and is very toxic to the eye. When heated to decomposition or on contact with water or steam, it will react to produce highly toxic and corrosive fumes. Synonyms include: chlorcyan, chlorine cyanide, and chlorocyanogen.

Potassium Cyanide is a white solid or colourless solution in water, with a faint bitter almond odour. It is very poisonous and reacts with acid or acid fumes to emit toxic and flammable hydrogen cyanide. When heated to decomposition, it emits very toxic fumes. Strong solutions are corrosive to skin, eyes, and mucous membranes. Synonyms include: potassium salt of hydrocyanic acid and cyanide of potassium.

Potassium Silver Cyanide is a poisonous, light-sensitive white crystalline solid. It is soluble in water and acids, and slightly soluble in ethanol. It emits very toxic fumes when heated to decomposition. Synonyms include: potassium argentocyanide and potassium dicyanoargentate.

Sodium Cyanide is a white crystalline solid that is odourless when dry, but emits a slight odour of hydrogen cyanide in damp air. It is very poisonous and reacts with acid, acid fumes, water, or steam to produce toxic and flammable hydrogen cyanide. Strong solutions are corrosive to skin, eyes, and mucous membranes. Synonyms for sodium cyanide are hydrocyanic acid, sodium salt, and cyanide of sodium.

Exceptions from this guidance, under normal conditions and after risk assessment:

Potassium Ferrocyanide is a pale yellow irritant solid which can release highly toxic hydrogen cyanide gas by the action of strong acids. Synonyms include, potassium hexacyanoferrate (II).

Potassium Ferricyanide consists of orange to red crystals, harmful by inhalation, ingestion and skin contact. Reaction with acid can yield very toxic hydrogen cyanide gas. Synonyms include, potassium cyanoferrate, red prussiate and potassium ferricyanate.

Potassium Thiocyanate is a white crystalline powder, harmful by inhalation, ingestion and skin contact (ulceration). Reaction with acid can yield very toxic hydrogen cyanide gas. Synonyms include, thiocyanic acid potassium salt, potassium isothiocyanate.

Acetonitrile is a colourless, **highly flammable**, volatile toxic solvent and possible teratogen that smells like ether. Synonyms include, methyl cyanide, cyanomethane, ethanenitrile, ethyl nitrile, methyl carbonitrile

Acrylonitrile is a colourless pungent volatile liquid, which is **very toxic, highly flammable**, **carcinogenic** and **mutagenic**. Synonyms include, propenenitrile, vinyl cyanide.

Appendix 2. Action Following an Incident with Cyanide

SPEED IS ESSENTIAL

Obtain immediate medical attention by dialling 1- 999 or 9-999

Summon an appropriately trained First Aider

THERE IS NO APPROVED FIRST AID ANTIDOTE

Follow the HSE Guidance on First Aid Action for Suspected Cyanide Poisoning:

Protect yourself and the casualty from further exposure during decontamination and treatment.	
Inhalation:	**Remove patient from exposure. Keep warm and at rest. Oxygen should be administered by a first aider. If breathing has ceased the first aider will apply artificial respiration using oxygen and a suitable mechanical device such as a bag and mask. Do not use mouth to mouth resuscitation as this could risk you coming into contact with cyanide.**
Skin Contact:	**Whilst wearing PPE, remove all contaminated clothing immediately. Wash the skin with plenty of water. Treat patient as for inhalation.**
Eye Contact:	**Immediately irrigate with water for at least ten minutes. Treat patient as for inhalation.**
Ingestion:	**Do not give anything by mouth. Treat patient as for inhalation.**

Symptoms: irritation of the throat, breath may smell of bitter almonds, dizziness, nausea, headache, weakness, drowsiness, rapid heart-beat, tight chest, deep breathing followed by loss of consciousness, cessation of breathing, heart failure and death.

The victim's face may appear 'healthy' or even be bright red, due to the action of cyanide on haemoglobin, however, the time between exposure and death may be only minutes, and therefore immediate treatment is essential.

OXYGEN AND ARTIFICIAL RESPIRATION SHOULD BE ADMINISTERED

The majority of victims of mild to moderate cyanide poisoning improve rapidly when treated with oxygen alone. The HSE advises that administration of oxygen is the most useful initial treatment for cyanide poisoning.

IF BREATHING HAS STOPPED: OXYGEN BY ARTIFICIAL RESPIRATION IS ESSENTIAL

Mouth-to-mouth resuscitation should **not** be used, because of the possible risk of secondary poisoning to the 'First Aider'. A suitable mechanical resuscitation device, through which oxygen can be given, should be used. The simplest solution is a bag and mask device (Ambu-Bag) connected to an oxygen supply.

THE VICTIM SHOULD BE REFERRED TO HOSPITAL AS SOON AS POSSIBLE.

ALERT DEPARTMENTAL SAFETY OFFICER AS SOON AS PRACTICABLE.

Review History: Reviewed with minor changes 2016 and 2020, including new WELs.

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HSD179C (rev 2)