保護工人健康叢書

工業中的氰化物危害-預防中毒及醫治

香港勞工處

緒言

這本小冊子是「保護工人健康」叢書之一，目的是使僱主和工人知道在工業製造過程中所使用之有害物質的潛在危險，並就減少這些危險的可行措施，提供建議。

工業經營的僱主有責任去確保工作環境不致危害其僱員的健康。要做到這一點，僱主不但須應用所有防護身體的設備及措施，而且更須向其僱員灌輸這方面的知識，提高其警覺，務使他們無論何時都堅守安全的原則。

這本小冊子和叢書中其他小冊子是免費的，可向勞工處職業健康科索取。

職業健康科隨時提供有關工業健康事宜和減少工業健康危險的指導。

香港勞工處

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工業中的氰化物危害——預防中毒及醫治

引言

一、 氰化物中毒是由於身體細胞受到化學性抑制不能吸取氧氣而產生，因而導致嚴重窒息及迅速死亡。從毒理學觀點來看，工業中所採用的物質主要可分爲下列三類：

（一） 氰化氫、氰及平常的氰化氫鹽如氰化鈉、氰化鉀及氰化銅；

（二） 氰的鹵化化合物（氯化物或溴化物）；

（三） 腈，例如丙烯腈及乙腈。

氰化氫：HCN

特性

二、 氰化氫是一種沒有顏色及容易揮發的液體，特性是氣味如苦杏仁。（某些植物，例如杏仁，可自然製造出葡糖或扁桃甙，當其進行水解作用時，很容易產生氰化氫。）氰化氫的沸點爲攝氏二十五·七度，可溶解於酒精及含水醚酸。氰化氫氣經常存在工業中。界限值（TLV），亦即最高值爲每百萬份空氣中有十份或每立方米空氣有十毫克的含量。

氰化氫的來源

三、 工業中的氰化氫可能在下列情況下產生：

（一） 開採黃金及其他金屬時；

（二） 製造顏料時；

（三） 製造丙烯腈及一甲基丙烯酸鹽樹脂時；

(四) 用作化學工業的中間化合物；

(五) 船隻及倉庫使用烟薰法時；

(六) 鼓風爐、煤氣廠及煉焦爐亦可能產生氰化氫。

四、 電鍍廠內的一種特別危險事物爲氰化物溶液與酸接觸，產生氰化氫氣體。因此若不適當控制鍍浴流出的物體，便很可能產生這項危險。

侵入體內

五、 氰化氫烟霧可經由呼吸道迅速侵入人體。液狀或濃烟狀的氰化氫則可能透過皮層，直接吸入體內。雖然很少人會咽下這種液體，但假如咽下者亦會導致中毒。

臨床效驗

六、 氰化氫及平常的氰化氫鹽是所有已知的毒物中最快產生作用的。氰化物的主要作用是抑制細胞(呼吸)色素氧化酶，因而停止細胞吸取氧氣。由於這種酶實際上存在於所有細胞內及由於氰化氫很快擴散到身體各部份，故能立即停止體內所有細胞的呼吸作用。

七、 高濃度的氰化氫經吸入幾次後，便會使人立即昏厥及停止呼吸。若吸入的份量不多，最初的症狀是頭痛、虛弱、頭腦混亂及偶然感到噁心及嘔吐。同時眼部及喉部會感覺受刺激及胸肺有壓抑感。初時，通常呼吸加速及加深，但稍後即會減慢及氣喘。

氰化鈉及氰化鉀

特性

八、 這兩種氰化鹽是白色結晶體，很易溶於水中。氰塵的界限值是每立方米五毫克。

氰化鈉及氰化鉀的來源

九、 氰化鈉及氰化鉀廣泛使用於下列工業：

(一) 金屬加熱處理；

(二) 電鍍；

(三) 提煉金、銀鑛。

十、 上述有毒物質如滿溢流出，例如電鍍廠有此事發生時，則含鹽的溶液，一旦與酸接觸便會產生氰化氫氣體。

侵入體內

十一、 加熱處理氰化物浴時，氰化鈉及氰化鉀鹽會氣化，因此會透過皮層、呼吸或咽食侵入體內。

臨床效驗

十二、 正如吸入氰化氫時一樣，體內的細胞（呼吸）色素氧化酶會大受抑制，因而使細胞幾乎完全中斷呼吸。

氯化氰及溴化氰

特性

十三、 氯化氰及溴化氰均爲帶有刺鼻氣味的無色氣體。氯化氰的界限值是百萬份之〇·三或每立方米〇·六毫克。

氯化氰及溴化氰的來源

十四、 兩種氣體都是應用於有機合成中。

侵入體內

十五、 此等氣體均於呼吸時侵入體內。

臨床效驗

十六、 這兩種氰的毒性，與氰化氫的毒性大致相同，但即使在低濃度時也會對呼吸道造成極大刺激，引起強烈的呼吸反應，導致氣管與支氣管出血及肺水腫等現象。由於產生刺激作用，很少會有人自願在高濃度氰化氣體的環境中逗留。因此感染氰化物毒性的機會不多。

丙烯腈

特性

十七、 丙烯腈（$CH_2=CN$）是一種明淨無色揮發性液體，其沸點是攝氏七十七度，界限值則爲百萬份之二或每立方米四．五毫克。

丙烯腈的來源

十八、 由於丙烯腈分子的不飽和特性，最適宜用作聚合反應，所以在塑膠、合成橡膠及其他有機合成的製造中，均普遍使用丙烯腈。

侵入體內

十九、 丙烯腈氣可經由呼吸侵入人體。同時亦可經由口部或透過皮層侵入體內。

臨床效驗

二十、 吸入丙烯腈氣的影響，一如吸入氰化氫，不過反應較緩。吸入低濃度丙烯腈後，會有頭痛、虛弱、噁心及嘔吐等迹象。但吸入濃度較高的丙烯腈則會發生昏迷，甚卡死亡。丙烯腈濺液也能嚴重刺激眼睛及皮膚。

氰化物對健康的危害

急性中毒

二十一、 氰化物極之危害健康，如氰化物經由呼吸（最常發生）、咽食或透過皮層侵入體內，則會發生急性中毒，導致迅速死亡。中毒的迹象及症狀如下：

(一) 頭痛及虛弱；
(二) 眼部及喉部受到刺繳；
(三) 胸腔緊縮的感覺；
(四) 臉色蒼白及呼吸用力；
(五) 迅速喪失知覺；
(六) 癱瘓及死亡。

二十二、 嚴重的急性中毒雖然可以復原，但由於後遺症的影響，部份中樞神經系統可能受到永久性的損害。

慢性中毒

二十三、 長期接觸濃度較低的氰化物，雖然不致發生嚴重中毒，但亦會感染慢性中毒，而慢性中毒的症狀並不明確。染此症者會手脚肌肉無力、頭痛、及患甲狀腺疾病等。

刺繳效應

二十四、 氰化物會刺激或灼傷皮膚及粘膜。

使用氰化物的預防措施

防止工人接觸的一般原則

二十五、 處理氰化氫液體及氣體時，應盡可能使用密封系統或容器。有關的設備、容器及工序須經特別設計，以免氰化氫洩入周圍地方。

二十六、　應採取所有必須的預防措施，防止氰化物鹽與酸液或空氣中含酸微粒接觸，包括高濃度的二氧化碳、硝酸鹽——亞硝酸鹽混合物或過氧化物。氰化物溶劑或溶液應存放在密封或緊閉的容器內。

二十七、　使用氰化物時，應特別注意工場的通風設備，確保工人不致處身於有毒環境中。

二十八、　處理氰化物的人士應熟知其危險性和使用時所需的預防措施，並須配備測驗毒性的儀器及適當的急救措施包括人工呼吸。

二十九、　提供及使用個人防護設備及衣物，以防止吸入、咽下或皮膚接觸氰化物。此外，更須配置設備以應付意外及緊急情況。

三十、　氰化物工人的個人衞生包括注意手部清潔、不在存有氰化物地方飲食及避免接觸染有氰化物的衣物。

三十一、　應備有緊急淋浴及洗滌眼部設備。

三十二、　應備有氰化物中毒救護包。

氰化物中毒救護包

急救包

三十三、　遇有吸入亞硝酸戊酯必須採用指定的急救措施。急救包應包括二十四安瓿，每安瓿含零點二毫升亞硝酸戊酯。亞硝酸戊酯可能變質，安瓿內的壓力亦會增高。爲防有此發生，應將安瓿存放在攝氏十五度以下，存放期不得超過製造商建議的有效日期或一年以上。

醫生使用的救護包

三十四、　醫生使用的救護包應包括下列各項：——

一、　亞硝酸戊酯安瓿（零點三毫升）；

二、　消毒的硝酸鈉溶液安瓿（每安瓿含有十毫升百分之三的溶液）；

三、消毒的硫化硫酸鈉溶液安瓿（每安瓿含有五十毫升百分之二十五的溶液）；

四、含三百毫克二鈷依地酸溶於二十毫升葡萄糖水的安瓿；

五、消毒的注射管（十毫升和二十毫升）及靜脈注射針；

六、壓脈器；

七、胃液抽驗管（橡膠）；

八、洗胃用的大注射管。

急救措施

三十五、氰化物中毒很快便會引致死亡，所以必須盡快採取下列急救措施：

（一）將病人移離氰化物污染地方；

（二）立即傳召醫生；

（三）將所有污染衣物除去，及以大量清水沖洗皮膚上的氰化物；

（四）協助傷者躺下，如天氣寒冷，則蓋上毛氈或其他保暖被舖；

（五）神智清醒的病人可不需接受進一步治療，惟仍須繼續休息，直至完全康復爲止；

（六）倘情況繼續轉壞或病人陷入半昏迷或昏迷狀態，則應將一安瓿亞硝酸打破，並將之倒於布塊中，然後將布塊緊置病人鼻下；這樣可每三分鐘重覆一次，直至用完六安瓿；

（七）如有氧氣，施用氧氣；

（八）如病人停止呼吸，則應開始進行壓胸法人工呼吸（注意：不可採用口對口方法）；

（九）如病人曾吞下氰化物，但神智清醒，則應使彼飲下一杯微暖鹽水或肥皂水，使彼嘔吐。倘病人經已昏迷，則不可將任何東西放入其口中。在此種情況下，如急救員懂得洗胃技巧，可進行洗胃。

由醫生進行的治療方法

二鈷乙二胺—（一，二）四乙醋（Dicobalt edetate）

二十六、 二鈷乙二胺——（一，二）四乙醋爲氰化物中毒的認可解毒劑，惟此種藥物本身有害健康。二鈷乙二胺——（一，二）四乙醋的毒性會爲氰化物中和。除非有足夠證據顯示病人體內曾吸入氰化物，例如，病人曾接觸氰化物並陷入昏迷，否則不可給予解毒劑。

二十七、 倘醫生已考慮所有情況，並且肯定爲一宗氰化物中毒事件，而病人對急救措施失去反應，則可爲其在靜脈緩慢（超過二至四分鐘）注射一安瓿溶於二十毫升葡萄糖水的三百毫克二鈷乙二胺——（一，二）四乙醋。

二十八、 倘有需要，可重覆使用藥劑，惟最多不可超過三安瓿。二鈷乙二胺——（一，二）四乙醋能夠將氰化物離子沖淡，使其變爲無毒。

亞硝酸鹽／硫代硫酸鹽治療法

二十九、 未有發明二鈷乙二胺——（一，二）四乙醋治療法前，對昏迷病人所採用的傳統治療法乃在其靜脈依次注射下述藥物：

（一） ○·三克亞硝酸鈉溶於十至十五立方厘米無菌水中。注射速度不可超過每分鐘二·五至五立方厘米及隨即用同一針注射下述藥物；

（二） 二十五克硫代硫酸鈉，溶於五十立方厘米無菌水中，注射時用同一緩慢速度。

四十、 在靜脈注射亞硝酸鹽並非沒有危險，此外，此種解毒作用是將體內循環的氰化物離子固定，惟此種作用對消除固定在細胞組織上的氰化物並無多大效用。如病人可能因腦溢血而失去知覺，則不可使用此種治療法。但是假如病人對二鈷乙二胺——（一，二）四乙醋失去反應，則可試用亞硝酸鹽／硫代硫酸鹽治療法。

倘有任何疑問，請向中環統一碼頭道二十八號海港政府大樓十六樓勞工處職業健康科查詢。（電話：五—八五二四〇四一）

INTRODUCTION

This booklet forms part of a series on the protection of workers' health. The aim of these booklets is to highlight to employers and workers the potential dangers of harmful substances used in industrial processes and to offer advice on measures which can be adopted to minimize such dangers.

It is the responsibility of the manager of an industrial undertaking to ensure that the working environment does not constitute a danger to the health of his employees. To achieve this, he must not only apply all recognized physical safeguards but must be satisfied that his employees are aware of the danger of adverse environmental conditions and that they strictly adhere to the safety principles at all times.

This booklet and others in the series are available free of charge on application to the Occupational Health Division of the Labour Department.

Advice on matters of industrial health and ways and means of reducing industrial health hazards is available from the Occupational Health Division at all times.

Labour Department
Hong Kong
December 1986

CYANIDE HAZARDS IN INDUSTRY— POISONING PREVENTION AND TREATMENT

Introduction

1. Cyanide poisoning arises from a chemical inhibition of the body cells to utilize oxygen which may result in severe asphyxia and rapid death. From the toxicological point of view the substances involved in industry may be divided into three main categories:—

(1) Hydrogen cyanide, cyanogen and simple salts of hydrogen cyanide such as sodium, potassium and copper cyanide;

(2) Halogenated compounds of cyanogen (chloride or bromide);

(3) Nitriles e.g. acrylonitrile and acetonitrile.

HYDROGEN CYANIDE: HCN

Properties

2. Hydrogen Cyanide is a colourless, volatile liquid with a characteristic odour of bitter almonds. (The glucoside amygdalin which occur in nature in some plants notably almonds readily yields HCN upon hydrolysis.) It has a boiling point of 25.7°C, is soluble in alcohol and ether acid miscible with water. The gas form is often encountered in industry. The threshold limit value (TLV) which is also the ceiling value is 10 p.p.m. or 10 mg/m^3 in air.

Source of exposure

3. In industry hydrogen cyanide may be encountered as follows:—

(1) In the extraction of gold and other metals;

(2) In the preparation of pigments;

(3) In the manufacture of acrylo nitrile and methacrylate resins;

(4) In the chemical industry as an intermediate compound;

(5) In the fumigation of ships and warehouses;

(6) Hydrogen cyanide may be generated in blast furnaces, gas works and coke ovens.

4. A particular hazard in plating shops may result if cyanide solutions are allowed to come into contact with acid since this causes the evolution of HCN gas. This is most likely to occur when effluent from plating baths is not properly controlled.

Entry to body

5. HCN vapour is absorbed rapidly through the respiratory tract. The liquid and possibly concentrated vapour may also be absorbed directly through skin. Ingestion of liquid although unlikely could also cause poisoning.

Clinical effects

6. HCN and its simple salts are among the most rapidly acting of all known poisons. The main action of cyanide is inhibition of cytochrom oxidase, thus stopping the utilisation of oxygen by cells. Since this enzyme is present

in practicably all cells and since cyanide is very rapidly diffusible to all parts of the body, it is capable of bringing to a halt practicably all cellular respiration.

7. A few inhalation of high concentration of hydrogen cyanide may be followed by almost immediate collapse and cessation of respiration. At much lower doses the earliest symptons may be headaches, weakness, confusion, and occasionally nausea and vomiting. Irritation of the eyes and throat and a sensation of chest constriction may be noticed. The respiratory rate and depth will usually be increased at the beginning and later become slow and gasping.

SODIUM AND POTASSIUM CYANIDE

Properties

8. These two salts of hydrogen cyanide are white crystalline solids readily soluble in water. The TLV of cyanide dust is 5 mg/m^3.

Sources of exposure

9. Sodium and potassium cyanide are used extensively in industry as follows:—

(1) Heat treatment of metals;
(2) Electroplating;
(3) Extraction of gold and silver from their ores.

10. It should be noted that if effluent from any of these poisons, such as from a plating shop, containing these salts in solution come into contact with acid HCN gas will be generated.

Entry to body

11. Entry to body is by ingestion, through the skin and by inhalation when the salts are vaporised as in heat treatment in cyanide bath.

Clinical effects

12. As with hydrogen cyanide, cytochrome oxidase as inhibited widely throughout the body causing the interruption of almost all cellular respiration.

CYANOGEN CHLORIDE ANO CYANOGEN BROMIDE

Properties

13. Both cyanogen chloride and cyanogen bromide are colourless gases with pungent odours. The TLV of cyanogen chloride is 0.3 p.p.m. or 0.6 mg/m^3.

Source of exposure

14. Both gases are used in organic synthesis.

Entry to body
15. Entry to body is by inhalation.

Clinical effects
16. Both cyanogens have the same general toxicity as hydrogen cyanide, but they are also intensely irritating to the respiratory tract at low concentration. They cause a violent respiratory reaction with haemorrhagic exudation in the trachea and bronchi and pumonary oedema. Because of the irritant effect it is unlikely that anyone would remain voluntarily in a high enough concentration of either of these gases to cause the typical cyanide effect.

ACRYLONITRILE (VINYL CYANIDE)

Properties
17. Acrylonitrile (CH_2=CN) is a clear colourless volatile liquid with a boiling point of 77°C. The TLV is 2 p.p.m. or 4.5 mg/m^3.

Source of exposure
18. Because of the unsaturated character of the molecule it is well suited for polymerisation reactions and is used extensively in the manufacture of plastics and synthetic rubber and other organic synthesis.

Entry to body
19. By inhalation of the vapour. Absorption can also take place by mouth and through the skin.

Clinical effects
20. The inhalation of acrylonitrile vapour has the same effect as the inhalation of hydrogen cyanide but it acts more slowly. In low concentration the effects are headache, weakness, nausea and vomiting. Heavier concentration will result in unconsciousness and death. Splashes of the liquid may cause severe eye and skin irritation.

HEALTH HAZARD OF CYANIDE EXPOSURE

Acute poisoning
21. The great hazard of exposure to cyanide and body entry by inhalation (most common), ingestion or percutaneous routes is acute poisoning which can produce death very rapidly. Suggestive signs and symptoms are:—

(1) Headache and weakness;
(2) Irritation of eys and throat;
(3) Sensation of chest constriction;
(4) Pallor and deep breathing;
(5) Rapid loss of consciousness;
(6) Paralysis and death.

22. When recovery takes place after a severe episode of acute poisoning there may be permanent effects due to residual damage of parts of the central nervous system.

Chronic poisoning

23. The picture of chronic poisoning which might arise from continuous exposure to cyanides at levels below those which produce severe clinical effects is not clear-cut. Muscle weakness of the arms and legs, headaches and thyroid diseases have been suggested as associated ailments.

Irritant effects

24. Cyanides can cause an irritant and burn effect on skin and mucous membranes.

PRECAUTION IN USE OF CYANIDES

General principles in preventing worker exposure

25. HCN liquid and gas should be handled in closed systems or containers in so far as is practicable. The equipment, containers and work process should be designed to prevent the escape of HCN into the surroundings.

26. All necessary precautions should be taken to prevent cyanide salts from coming into contact with liquid or airborne acids, including large concentrations of carbon dioxide, nitrate-nitrite mixture or peroxides. The substances as solvents or solutions should be stored in sealed or tightly closed containers.

27. Special attention should be paid to the ventilation arrangements in workplace when cyanides are used to ensure that workers are not exposed to toxic levels.

28. Persons who handle cyanides should be fully informed of the hazards involved and necessary precaution in use and instrument on the recognition of poisoning and appropriate first aid measures including artificial respiration.

29. Personal protective equipment and clothing when necessary to prevent inhalation, or ingestion or skin contact with cyanides, should be available and used and should include provision for accident and emergency.

30. Personal hygiene for cyanide workers should include attention to hand cleanliness, no food or drink in cyanide area and avoidance of cyanide contaminated clothing.

31. Emergency shower and eye wash arrangements should be available.

32. Cyanide poisoning treatment kits should be available.

CYANIDE POISONING TREATMENT KITS

First aid kit

33. Inhalation of amyl nitrite is a prescribed first aid measure and the first aid kit should contain 24 ampules each containing 0.3 ml. of amyl nitrite. Deterioration of the amyl nitrite and development of high pressures within

the ampules is a possibility and to prevent the ampule should be stored at below 15°C and either the manufacturers recommended expiry date or a shelf life of one year should not be exceeded.

Treatment kit for use by doctors

34. A treatment kit for use by a medical practitioner should include the following:—

(1) Amyl nitrite ampules (0.3 ml.);
(2) Ampules of sterile sodium nitrite solution (10 ml. of a 3% solution in each);
(3) Ampules of sterile sodium thiosulphate solution (50 ml. of a 25% solution in each);
(4) Ampules containing 300 mgm dicobalt EDTA in 20 ml. glucose solution (Kelocyanor);
(5) Sterile syringes (10 and 20 ml) and intravenous needles;
(6) Tourniquet;
(7) Gastric tube (rubber);
(8) Large syrinage for gastric lavage.

FIRST AID MEASURES

35. Cyanide poisoning can cause death very rapidly and speed in the implementation of the following first aid measures is essential:—

(1) Remove the patient from cyanide contaminated area;
(2) Summon medical aid at once;
(3) Remove all contaminated clothing and wash cyanide off the skin with copious quantities of water;
(4) Put and keep the patient lying down with blanket or other covering if cold;
(5) A conscious patient is unlikely to require further treatment but should be kept at rest until full recovery;
(6) If condition is worsening or the patient is semi-conscious or unconscious break an ampule of amyl nitrite in cloth and hold under the patient's nose. This may be repeated every 3 minutes, using up to 6 ampules;
(7) Administer oxygen if available;
(8) If breathing stops start artificial respiration by the Holger-Nielson method (note that mouth-to-mouth method should not be used);
(9) If the patient has swallowed cyanide and is conscious induce vomiting by having him drink a cupful of lukewarm salt or soapy water. If the patient is unconscious do not give anything by mouth. In such case gastric lavage is indicated if the first aider has the necessary skill.

Treatment by medical practitioner

Dicobalt edetate

36. Dicobalt edetate (Kelocyanor) is the accepted antidote for cyanide poisoning, but itself can produce harmful effects. The toxicity of dicobalt

edetate is reciprocally neutralised by cyanide and the antidote should not be given unless there is reasonable evidence that cyanide has been absorbed e.g. a patient exposed to cyanide lapsing into unconsciousness.

37. If when all circumstances are considered the doctor accepts the case as one of cyanide poisoning, which has failed to respond to first aid measures the recommended treatment is to inject slowly (over 3–4 minutes) by the intravenous route one ampule containing 300 mgm dicobalt edetate in 20 ml. glucose solution (Kelocyanor).

38. If necessary the dose may be repeated to a maximum of 3 ampules. The edetate acts by diluting the cyanide ion and rendering it non-toxic.

Nitrite/thiosulphate treatment

39. Prior to the development of dicobalt edetate the classical therapy for the unconscious patient consisted of intravenous injections in succession of:—

(1) Sodium nitrite 0.3 gm dissolved in 10–15 c.c. sterile water and given at a rate not exceeding 2.5–5 c.c. per minute and followed immediately through the same needle by

(2) Sodium thiosulphate 25 gm in 50 c.c. sterile water injected at the same slow rate.

40. The intravenous injection of nitrite is not itself devoid of risk and moreover the antidotal action which depends on fixing circulating cyanide ion is largely ineffective for tissue fixed cyanide. This form of therapy is moreover contraindicated when a cerebral haemorrhage is a possible cause of the loss of consciousness. If however the patient fails to respond to the dicobalt edetate antidote, it may be desirable to try nitrite/thiosulphate treatment.

If you are in any doubt whatever, please contact the Occupational Health Division of the Labour Department at Harbour Building, 15th floor, 38 Pier Road, Central. (Tel. No.: 5-8524041)

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