

I. RECOMMENDATIONS FOR CYANIDE STANDARDS

The National Institute for Occupational Safety and Health recommends that employee exposure to hydrogen cyanide (HCN) and the cyanide salts in the workplace be controlled by adherence to the following sections. The standards are designed to protect the health of workers for up to a 10-hour workday, and a 40-hour workweek over a working lifetime. Compliance with the standard should therefore prevent adverse effects of HCN and cyanide salts on the health of workers. The standards are measurable by techniques that are valid, reproducible, and available to industry and government agencies. Sufficient technology exists to permit compliance with the recommended standards. The standards will be subject to review and revision as necessary.

These criteria and recommended standards apply to occupational exposure of workers to HCN and cyanide salts. Synonyms for HCN are hydrocyanic acid, prussic acid, and formonitrile. For the purpose of this document, cyanide salts are defined as sodium cyanide (NaCN), potassium cyanide (KCN), or calcium cyanide (Ca(CN)₂). The word, cyanide, or the symbol, "CN", is used to designate salts as well as hydrogen cyanide.

The "action level" for hydrogen cyanide or a cyanide salt is defined as one-half the corresponding recommended ceiling environmental exposure limit. "Occupational exposure" to these compounds is defined as exposure to airborne concentrations greater than the corresponding action levels.

The criteria and recommended standards apply to any area in which HCN, any of the cyanide salts or materials containing any of them, alone or in combination with other substances, is used, produced, packaged,

processed, mixed, blended, handled, stored in large quantities, or applied. Exposure to cyanide at concentrations less than or equal to the respective action levels will not require adherence to the recommended standards except for sections 2-7, and 8(c). If "exposure" to other chemicals also occurs, for example to a combination of cyanide and methyl alcohol, provisions of any applicable standards for such other chemicals shall be followed also.

Section 1 - Environmental (Workplace Air)

(a) Concentration

Employee exposure to HCN shall be controlled so as not to exceed 5 milligrams per cubic meter of air expressed as CN (4.7 ppm), determined as a ceiling concentration based on a 10-minute sampling period.

Employee exposure to cyanide salts shall be controlled so as not to exceed 5 milligrams per cubic meter of air expressed as CN, determined as a ceiling value based upon a 10-minute sampling period.

Whenever the air is analyzed for cyanide salts, a concurrent analysis shall be made for HCN. Neither of the respective ceiling values may be exceeded nor may the combined values exceed 5 mg/cu m measured as CN during a 10-minute sampling period.

(b) Sampling and Analysis

Procedures for sampling, calibration of equipment, and analysis of air samples for HCN and cyanide salts shall be as provided in Appendices I and II, or by any method shown to be equivalent in precision, accuracy and sensitivity to those specified. A sampling period of about 10 minutes is

necessary to provide an amount of cyanide readily amenable to analysis by the cyanide selective electrode.

Section 2 - Medical

Medical surveillance shall be made available as specified below for all workers occupationally exposed to HCN or cyanide salts.

(a) Preplacement and annual medical examinations shall include:

(1) An initial or interim work and medical history with special attention to skin disorders and those non-specific symptoms, such as headache, nausea, vomiting, dizziness or weakness, that may be associated with chronic exposure.

(2) A physical examination giving particular attention to skin, thyroid, and the cardiovascular and upper respiratory systems.

(3) An evaluation of the advisability of the worker's use of negative- or positive-pressure respirators.

(b) Initial medical examinations shall be made available to presently employed workers within six months of the promulgation of a standard.

(c) The responsible physician and the employer shall be aware of the material contained in Appendix V and shall ensure that employees trained in these first-aid measures are on duty whenever there is occupational exposure to HCN or a cyanide salt.

(d) Two physician's treatment kits shall be immediately available to trained medical personnel at each plant where there is a potential for the release of, accidental or otherwise, or for contact with, hydrogen cyanide or cyanide salts. One kit should be portable in order that it may be carried by medical personnel while accompanying a patient to the

hospital. The other kit should be kept under lock and key to assure that it is intact and available when and if needed. The key should be readily available at all times to the work supervisor on duty and the storage place should be of such construction as to allow accessibility in the event of loss of the key.

(e) First-aid kits shall be immediately available at workplaces where there is a potential for the release, accidental or otherwise, of hydrogen cyanide or a potential for exposure to cyanide salts. This kit shall contain as a minimum two (2) boxes of ampules (2 dozen), each containing 0.3 ml of amyl nitrite. Ampules shall be replaced biannually or sooner if needed to ensure their potency. The amyl nitrite ampules should be protected from high temperatures. In all cases, the contents of the medical and first-aid kits shall be replaced before the manufacturer's assigned expiration dates. Suggested contents for these kits are listed in Appendix V.

(f) Medical records shall be maintained for all workers occupationally exposed to HCN or cyanide salts. Pertinent medical records shall be maintained for 5 years following the last exposure to HCN or cyanide salts. These medical records shall be made available to the designated medical representatives of the Secretary of Health, Education, and Welfare, of the Secretary of Labor, of the employer, and of the employee or former employee.

Section 3 - Labeling (Posting)

(a) All shipping and storage containers of HCN shall bear the following labeling in addition to, or in combination with, labels required by other statutes, regulations, and ordinances:

HYDROCYANIC ACID, LIQUID

DANGER: EXTREMELY HAZARDOUS LIQUID AND GAS

EXTREMELY FLAMMABLE

MAY BE FATAL IF SWALLOWED, INHALED,

OR ABSORBED THROUGH THE SKIN.

USE ONLY IN CLOSED SYSTEM.

In case of contact, immediately flush skin or eyes with plenty of water for at least 15 minutes; get medical attention. Remove contaminated clothing and wash before reuse.

POISON
First Aid

Carry patient to fresh air.
Have the patient lie down.
Remove contaminated clothing but keep patient warm.
Start artificial respiration if breathing stops.
Administer antidote (amyl nitrite ampule).
Call a physician.

Temporary Antidote

If cyanide gas is inhaled: Break an amyl nitrite ampule in a cloth and hold lightly under nose for 15 seconds. Repeat at about 15-second intervals.

If cyanide is swallowed: Break an amyl nitrite ampule in a cloth and hold lightly under nose for 15 seconds. Repeat inhalation of amyl nitrite 5 times at about 15 second intervals. If patient is conscious or when consciousness returns, give emetic (1 tablespoonful of salt to each glass of warm water) and repeat until vomit fluid is clear. Do not give an emetic to an unconscious or barely conscious person.

(b) The following warning sign shall be affixed in a readily visible location at or near entrances to areas containing HCN and where there is reasonable potential for emergencies:

DANGER!

CYANIDE HAZARD AREA

UNAUTHORIZED PERSONS KEEP OUT

DO NOT WORK ALONE IN THIS AREA

IN EMERGENCY: (Here include, as applicable,

- (1) location of gas masks and other emergency equipment,
- (2) instructions for sounding emergency alarm,
- (3) location of first-aid equipment and supplies, and
- (4) instructions for summoning medical aid.)

The sign shall be printed both in English and in the predominant language of non-English-reading workers. All workers shall receive training and information on the hazards and safe work practices in handling HCN and cyanide salts, and on first-aid procedures in poisoning by these compounds.

(c) When HCN gas is used as a fumigant, warning signs shall be prominently displayed about the area and at all entries to the area as follows:

DANGER!

HYDROGEN CYANIDE

EXTREMELY POISONOUS GAS

UNAUTHORIZED PERSONS

KEEP AWAY

Where state or local laws, ordinances, or regulations specify the wording and use of warning signs for use by fumigators, such required wording and posting may be used in conjunction with the wording given in this subsection.

(d) All containers of solid cyanide salts shall bear the following labeling in addition to or in combination with labels required by other statutes, regulations and ordinances. The proper chemical name for the specific cyanide compound being labeled shall appear in large, bold face type at the top of the label.

(Insert name of compound)
Inorganic Cyanide
DANGER! MAY BE FATAL IF SWALLOWED OR INHALED
CONTACT WITH ACID LIBERATES POISONOUS GAS
CAUSES EYE BURNS AND MAY IRRITATE SKIN.

Do not breathe gas or dust.
Do not get in eyes.
Avoid contact with skin.
Wash thoroughly after handling.
Keep container closed and away from acids. Store in a dry place.
In case of contact, immediately flush skin or eyes with plenty of water for at least 15 minutes; for eyes call a physician.
Sweep up spillage. Do not flush to sewer which may contain acid.

POISON
First Aid

Always have on hand a Cyanide First-Aid Kit.
Carry patient to fresh air, have him lie down.
Remove contaminated clothing but keep patient warm.
Start artificial respiration if breathing stops.
Administer antidote (amyl nitrite ampule).
Call a physician.

Temporary Antidote

If aerosolized salt has been inhaled or if solid or dissolved salt has caused poisoning after contact with the skin: Break an amyl nitrite ampule in a cloth and hold lightly under nose for 15 seconds. Repeat 5 times at about 15-second intervals. Repeat as necessary using a fresh amyl nitrite ampule every three minutes. Use artificial respiration if breathing stops.

If cyanide salt in any form is swallowed: proceed as above. If the victim is conscious and capable of some activity, give an emetic (1 tablespoonful of table salt in a glass of warm water) in repeated doses until the vomit fluid is clear. Never give anything by mouth to an unconscious person.

(e) Containers of $\text{Ca}(\text{CN})_2$ shall be labeled in the same manner as other solid cyanide salts, except that an additional warning is necessary because this material will react with water to release hydrogen cyanide. The statement of the hazard shall read as follows for $\text{Ca}(\text{CN})_2$:

DANGER! MAY BE FATAL IF SWALLOWED OR INHALED
CONTACT WITH WATER OR ACID LIBERATES POISONOUS GAS
CAUSES EYE BURNS AND MAY IRRITATE SKIN

(f) All containers of solutions of cyanide salts shall bear the following labeling in addition to, or in combination with, labels required by other statutes, regulations, or ordinances. The proper chemical name of the specific inorganic cyanide compound followed by the word "solution" shall appear in large, bold face type at the top of the label.

(insert name of compound) SOLUTION
(Inorganic Cyanide Solution)
DANGER! MAY BE FATAL IF SWALLOWED OR ABSORBED THROUGH SKIN
CAUSES BURNS
CONTACT WITH ACID LIBERATES POISONOUS GAS

Do not breathe gas.
Do not get in eyes, on skin, on clothing.
Wash thoroughly after handling.
Keep container closed and away from acids.
In case of contact, immediately flush skin or eyes with plenty of water for at least 15 minutes and call a physician.
Treat spillage with strong calcium hypochlorite solution and flush to sewer.

POISON
First Aid

Always have on hand a Cyanide First-Aid Kit.
Carry patient to fresh air, have him lie down.

Remove contaminated clothing but keep patient warm.
Start treatment immediately.
Call a physician.

Temporary Antidote

If gas is inhaled: Break an amyl nitrite ampule in a cloth and hold lightly under nose for 15 seconds. Repeat 5 times at about 15-second intervals. Repeat as necessary, using a fresh amyl nitrite ampule every three minutes. Use artificial respiration if breathing stops.

If swallowed: Break an amyl nitrite ampule in a cloth and hold lightly under nose for 15 seconds. If patient is conscious, or when consciousness returns, give emetic (1 tablespoonful of salt in a glass of warm water) and repeat until vomit fluid is clear. Repeat inhalation of amyl nitrite ampule every three minutes. Use artificial respiration if breathing stops.

Never give anything by mouth to an unconscious person.

(g) In areas where cyanide salts, as either solids or solutions, are stored, used or handled, the following sign shall be posted in readily visible locations, particularly at entrances to the area:

CAUTION
INORGANIC CYANIDE
Contact with Acid Will Release Poisonous Gas
ONLY AUTHORIZED PERSONS PERMITTED

IN EMERGENCY: (Here give the location of emergency equipment, instructions for sounding emergency alarm, and instructions for summoning medical aid.)

(h) During the loading or unloading of a cyanide salt solution into or from a tank car, tank truck, or other bulk transport container, the following warning signs shall be prominently displayed before and behind the transport vehicle or container and at other points of possible entry to the area:

WARNING
CYANIDE SOLUTION
Transfer of poisonous solutions in progress
UNAUTHORIZED PERSONS KEEP OUT

Section 4 - Personal Protective Equipment and Clothing

Engineering controls and safe work practices shall be used to maintain exposures to HCN and cyanide salts below the prescribed limits. Administrative controls may also be used to reduce exposure. However, because the inhalation of cyanides or their absorption through the skin may be immediately dangerous to life, the added protection of personal protective equipment and clothing must be provided for work procedures and for emergency situations as discussed below. Such equipment and clothing must be provided to the workers engaged in work with cyanide. Emergency equipment shall be located at well marked and identified stations within the cyanide work areas. This equipment must allow each and every worker to escape the area in case of a cyanide emergency.

(a) Respiratory Protection

Engineering controls shall be used whenever feasible to maintain airborne cyanide concentrations at or below the environmental limits recommended in Section 1 above. Compliance with the permissible exposure limits by the use of respirators is only allowed when airborne cyanide concentrations are in excess of the workplace environmental limits while required engineering controls are being installed or tested, when nonroutine maintenance or repair is being accomplished, or during emergencies. Appropriate respirators as described in Table I-1 for HCN and Table I-2 for cyanide salts shall be used only when permitted by the above restrictions. Respirators shall be selected and used in accordance with the following requirements:

(1) For the purpose of determining the type of respirator to be used, the employer shall measure, when possible, the airborne

concentration of HCN or cyanide salt in the workplace initially and thereafter whenever process, worksite, climate, or control changes occur which are likely to increase the airborne concentration of these cyanides. The employer shall ensure that no worker is being exposed to cyanide in excess of the standards either because of improper respirator selection, fit, use, or maintenance.

(2) A respiratory protective program meeting the requirements of 29 CFR 1910.134, which incorporates the American National Standard Institute's Practices for Respiratory Protection Z88.2-1969, shall be established and enforced by the employer.

(3) The employer shall provide respirators in accordance with Tables I-1 and I-2 and shall ensure that the employee uses the respirator provided.

(4) Respiratory protective devices shall be those approved under the provisions of 30 CFR 11, published in the Federal Register, March 25, 1972, as amended.

(5) Respirators specified for use in higher concentrations of HCN may be used in atmospheres of lower concentrations. Likewise, respirators specified for use in higher concentrations of cyanide salts are permitted in atmospheres of lower concentrations.

(6) The employer shall ensure that the respirators are adequately cleaned, maintained, and stored when not in use, and that employees are instructed in the use of respirators assigned to them and in testing for facepiece leakage before each use.

(7) Cartridges or canisters shall be discarded and replaced with fresh canisters after each use. Unused canisters shall be discarded and replaced when seals are broken, after three years if seals are unbroken, or on the manufacturer's recommendation, whichever is first. Cartridges and canisters shall not be used for periods of time in excess of those indicated in Tables I-1 and I-2.

(8) Emergency and escape-type respirators shall be made immediately available at the work stations for each worker when there is potential for exposure to concentrations of the various cyanides above the ceiling values. For purpose of selection of respiratory protective equipment, entry into areas containing unknown and/or suspected dangerous atmospheric concentrations of HCN or cyanide salts shall be treated as an emergency.

TABLE I-1

REQUIREMENTS FOR RESPIRATOR USAGE - HYDROGEN CYANIDE

Maximum Use Concentration (ppm of HCN)	Respirator Type for HCN Gas
Less than or equal to 90 ppm	<p>(1) Type C supplied-air respirator, demand or continuous-flow type (negative or positive pressure), with half or full facepiece.</p> <p>(2) Full facepiece gas mask, chin-style canister specific for HCN. The maximum service life of canisters is one hour.</p>
Less than or equal to 200 ppm	<p>Full facepiece gas mask, front- or back-mounted type canister specific for hydrogen cyanide. The maximum service life of canisters is one hour.</p>
Greater than 200 ppm	<p>(1) Self-contained breathing apparatus in pressure-demand mode (positive pressure) with full facepiece worn under gas-tight suit providing whole body protection.</p> <p>(2) Combination supplied-air respirator, pressure-demand type (positive pressure), with auxiliary self-contained air supply and full facepiece; all worn under gas tight suit providing whole body protection.</p>
Emergency (no concentration limit)	<p>(1) Positive pressure self-contained breathing apparatus worn under a gas-tight suit providing whole body protection.</p> <p>(2) Combination supplied-air respirator, pressure-demand type, with auxiliary self-contained air supply; all worn under gas-tight suit providing whole body protection.</p>
Evacuation or Escape (no concentration limit)	<p>(1) Self-contained breathing apparatus in demand or pressure-demand mode (negative or positive pressure).</p> <p>(2) Gas mask, full facepiece or mouthpiece type, with canister specific for HCN.</p>

NOTE:

During the use of any respirator with half mask, full facepiece or hood, protective clothing should be worn if there is a chance that liquid HCN may contact any part of the body.

TABLE I-2

REQUIREMENTS FOR RESPIRATOR USAGE - CYANIDE SALTS

Maximum Use Concentration (mg/cu m expressed as CN)	Respirator type for Cyanide Salts
Less than or equal to 25 mg/cu m	(1) Filter type respirators, approved for toxic dust, with half-mask (not applicable for $\text{Ca}(\text{CN})_2$). (2) Chemical cartridge respirators with replaceable cartridge for toxic dusts and acid gases; with half-mask. Maximum service life 4 hours.
Less than or equal to 50 mg/cu m	(1) Full-face gas mask, chest or back mounted type, with industrial size canister for toxic dust and hydrocyanic acid gas. Maximum service life 2 hours. (2) Type C supplied air-respirator, continuous-flow or pressure-demand type (positive pressure) with full facepiece. (3) Type A supplied-air respirator, (hose mask with blower) with full facepiece.
Greater than 50 mg/cu m	(1) Self-contained breathing apparatus with positive pressure in full facepiece. (2) Combination supplied-air respirator pressure-demand type with auxiliary self-contained air supply.
Emergency (no concentration limit)	(1) Self-contained breathing apparatus with positive pressure in facepiece. (2) Combination supplied-air respirator, pressure-demand type, with auxiliary self-contained air supply.
Evacuation or Escape (no concentration limit)	(1) Self-contained breathing apparatus in demand or pressure-demand mode (negative or positive pressure). (2) Full-face gas mask, front or back mount type with industrial size canister for toxic dust and hydrocyanic acid gas.

(b) Protective Clothing

Because HCN and cyanide salts, dry or in solution, may be absorbed readily through the skin or any break in the skin, the provision and use of protective clothing are necessary for the protection of workers in most operations where HCN and cyanide salts are used in pure or diluted condition.

(1) When entering a HCN gas-filled area in emergency situations, when the airborne concentration of HCN is unknown, or when the known airborne concentration is greater than 200 ppm, employees shall wear gas-tight suits in addition to the required respiratory protection. The gas-tight suits shall provide full body protection.

(2) Employees engaged in maintenance, repair, or other work on equipment, or in circumstances whereby they may be exposed to HCN liquid or gas, shall wear protective garments or suits made of material impervious to HCN and providing full body protection.

(3) Employees shall wear rubber gloves when engaged in any activity which may involve the handling of, or possible contact with, HCN.

(4) Employees shall wear footwear impervious to HCN when working in areas or engaged in activities where spillage of liquid cyanide is likely. Such footwear or overshoes should be worn by workers handling cylinders of HCN or cans of absorbed HCN.

(5) Eye protection shall be provided by the wearing of a full facepiece respiratory protective device whenever there exists a hazard of contact of the eyes or conjunctivae with HCN in liquid form. Any circumstances having the potential for injury of the eye by exposure to HCN

liquid or gas almost certainly will also present a potential for hazard by inhalation which requires the wearing of respiratory protection. In case of doubt, the respiratory protective device should be worn. Eye and face protective equipment and its use shall conform to 29 CFR 1910.133. Selection, use, and maintenance of eye protective equipment shall be in accordance with provisions of the American National Standard Institute's Practice for Occupational and Educational Eye and Face Protection, ANSI Z87.1-1968.

(6) Employees working in tanks or other confined spaces shall wear approved harness and lifelines. All standard safety precautions for work in such spaces shall be observed with special vigilance because of the great toxicity of HCN. In all such cases, at least one other employee shall be in attendance and in contact (preferably in sight contact) and in a safe area or at a distance where he will not be affected by emergencies involving the first employee. The second employee (buddy) should be alert and equipped to summon help and render aid if needed.

(7) Employees shall wear gloves when handling dry cyanide salts and when using or handling equipment whose surfaces may be contaminated with these salts in such manner that contact of the chemical with the employee's hands is possible or likely.

(8) Employees shall wear gloves made of rubber or other impervious material when engaged in any operation wherein contact of the hands with solutions of cyanide salts is possible or likely.

(9) Employees shall wear protective sleeves, aprons, and/or full body protective clothing as needed to protect their skin from contact with cyanide salts, dry or in solution. When handling solutions,

the outer garment shall be of rubber or other material impervious to the solutions involved in the exposures. The garments shall fit snugly about the wrist, arm, neck, waist, and/or ankle (as appropriate to the particular garment) and shall have closures which will exclude dust, powder, mist, and/or splashes of cyanide salts in either dry or liquid formulations.

(10) In areas where spills or splashes of solutions of cyanide salts are likely to occur, the employees shall wear shoes, boots, or overshoes made of rubber or other material impervious to these solutions.

(11) Chemical safety goggles shall be worn by employees engaged in any operation wherein there is danger or likelihood that dusts or solutions of cyanide salts will come into contact with the eye.

Full-length face shields with forehead protection shall be worn by employees engaged in any operation wherein there is danger or likelihood that dusts, molten salts, or solutions of cyanide salts may contact the face.

(12) The employer shall be responsible for maintaining all devices and clothing to be used for personal protection in a clean and effective condition.

Section 5 - Informing Employees of Hazards of HCN and Cyanide Salts

At the beginning of employment or assignment for work at operations or in areas which may involve potential exposure to HCN and/or to cyanide salts (dry solids, solutions, melts, aerosols), employees shall be informed of the hazards of such employment and the possible injuries. They shall be

instructed in the proper procedures for the safe handling and use of these compounds, in the operation and use of protective systems and devices, and in appropriate emergency and first-aid procedures.

Instructions shall include, as a minimum, all information in the pertinent Materials Safety Data Sheet(s) (Appendix IV). This information shall be posted in the work area and kept on file, readily accessible to the worker at all places of employment where exposure may occur. The worker shall be informed of the location and availability of this information.

Information as required shall be recorded on US Department of Labor Form OSHA-20 "Material Safety Data Sheet", or on a similar form approved by the Occupational Safety and Health Administration, US Department of Labor. In addition, workers shall be advised of the availability of pertinent sources of information on the toxicity and safe use of HCN and cyanide salts.

Section 6 - Work Practices and Control Procedures

(a) Hydrogen Cyanide

(1) HCN liquid and gas must be handled in closed systems or containers insofar as is practical. The equipment, containers, and work procedures shall be designed to prevent the escape of HCN into the surroundings and to prevent or minimize hazards of fire, explosion, and of worker exposure to HCN.

(2) Buildings in which HCN is to be stored, handled, or used must be designed to prevent fire and explosion hazards and to minimize the release of the highly toxic liquid or gas. Equipment and vessels

containing or using HCN should be isolated in rooms or buildings designed for, and devoted to, these purposes.

Building construction shall be fire- and explosion-resistant and shall meet the requirements of the National Fire Protection Association codes and of the local codes, regulations, and ordinances. Explosion vents and fire doors shall be provided in accordance with codes and good practice.

Each room or building shall have no less than two means of exit, with doors opening outward and provided with "panic bar" release latches. Exits shall be provided so that no location within the room or building is more than 75 feet from an exit and personnel can be evacuated in less than 1 minute.

(3) All regular work areas where HCN is handled or used must be adequately ventilated so that, under normal or reasonably anticipated operating conditions, the airborne concentrations of HCN will not exceed the standard recommended in Section 1. Local exhaust ventilation shall be used at points or areas of regular or anticipated release of HCN gas.

Equipment for very high rates of ventilation of an area may be provided for the rapid reduction of contamination of air by HCN when emergency situations arise.

The HCN-contaminated air from an exhaust ventilation system must either be passed through a suitable collector to remove the HCN or be discharged at a location or in a manner such that persons or animals will not be endangered by the toxic gas.

Ventilation equipment must meet the applicable codes for

explosionproof and fireproof installation of such equipment.

(4) Workers entering any space or area known to have, or suspected of having, a dangerous concentration of HCN in the air shall wear a self-contained breathing apparatus, pressure-demand type (positive pressure), with full facepiece and a gas-tight suit giving full body protection (see Section 4). Workers entering such areas must not remove the protective suits until they have showered because residual HCN may be on their surfaces. (Breathing apparatus using compressed oxygen shall not be used when entering tanks or similar confined spaces which may contain HCN.)

Any area or space in which HCN contamination is likely and the concentration of HCN in the air is unknown shall be considered dangerous until the concentration is determined and found to be safe (see Chapter IV.) Persons entering such an area or space to make tests or measurements of the concentrations shall use the buddy system and shall wear self-contained breathing apparatus and protective clothing.

(5) Workers engaged in operations, maintenance, or repair work wherein release of HCN liquid or gas and contact with the liquid or gas is possible or likely shall be provided with, be fully trained in the use of, and wear approved respiratory protective devices and gas-tight suits (see Section 4).

Rubber gloves must be worn while performing activities which may involve contact with HCN.

(6) No employee shall work alone in any area or space in which HCN exposure, contamination, or an emergency potentially dangerous to the employee's safety and health either exists or is likely to occur. A

second worker shall be in attendance and shall be equipped, as minimal protection, with impervious footwear and gloves, and an easily donned respirator. This second worker shall maintain contact with the first employee from a safe location and shall be ready to summon aid and to render assistance, if needed. In the event of leaks or spills of HCN liquid or gas, only authorized, trained personnel with proper protection may remain in the area. All other personnel shall leave or be removed from the area immediately and shall be observed for any signs or symptoms of cyanide poisoning and need for treatment. Leaks and spills should be made safely alkaline and/or cleaned up as quickly as possible.

(7) HCN shall be treated at all times as a flammable and explosive substance with the exercise of all usual precautions in handling such materials and in the elimination of ignition sources.

(8) All applicable laws, regulations, and ordinances, the supplier's recommendations, and the provisions of Chapter VI shall be observed in regards to the following:

(A) Unloading, emptying, returning, shipping, and/or disposing of cylinders of HCN.

(B) Handling, storing, opening, and using of absorbed liquid HCN.

(C) Loading and unloading tank cars and motor truck tanks for transport of HCN.

(D) Safeguarding of loading, unloading, and other transfers of HCN liquid.

(E) Inspecting and approving storage facilities.

(F) Preparing, cleaning, and maintaining tanks and vessels to contain HCN.

(G) Disposing of HCN waste.

(9) Each plant having HCN exposures shall develop emergency procedures for its specific circumstances and the emergencies which may arise therefrom. The employees shall be fully informed of the emergency procedures and of their responsibilities under the plan. Each employee shall receive careful instruction and detailed training in the actions and procedures required of him in an emergency, and necessary actions should be prominently posted in all potential hazard areas.

(10) In the event of excessive or continued airborne concentrations of HCN above the standard, immediate action must be taken to determine and to eliminate or to control the source or cause of the elevated HCN concentrations.

In work areas where the concentration of HCN exceeds 20 ppm or where there is a potential through leaks to produce HCN concentrations approximating the lethal concentration in a matter of minutes, an alarm shall be sounded and the following emergency procedures shall be instituted:

(A) All nonemergency personnel shall be evacuated from the area immediately.

(B) Only emergency personnel properly trained and equipped to deal with the emergency shall either remain or reenter the area.

(C) The area shall be roped off and warning signs posted to exclude all others from the area until tests show that the

atmospheric concentration of HCN is below the recommended standard.

Every plant to which the above may be applicable shall prepare workable HCN emergency procedures, augmenting overall plant emergency procedures. Each plant's HCN emergency procedures must be tailor-made for the requirements of that specific plant.

(11) In developing HCN emergency procedures, the following should be kept in mind:

(A) The plan must be concise. If it is complicated, it will not serve its purpose.

(B) Any plan adopted in any particular plant should be well known to all in that plant.

(C) Each individual in the plant should know what he personally must do immediately in the event of an HCN emergency.

(D) Any worker whose clothing has absorbed HCN liquid or gas should remove this clothing immediately. Workers wearing respiratory protective devices should not remove them until their clothing has been removed or thoroughly rinsed off.

(E) The buddy system should be used in all emergency work in an HCN-contaminated area.

(12) In using HCN for fumigation, the space shall be sealed by appropriate means to prevent gas leakage into surrounding spaces and areas. Warning signs shall be posted in accordance with Section 3, subsection (c) above. Alert guards shall be in attendance while fumigation is in progress and until the space being fumigated is opened up and thoroughly ventilated. Access routes shall be locked to prevent entry by unauthorized personnel. All laws, regulations, ordinances, and codes,

where applicable, shall be followed.

(b) Cyanide Salts

(1) All necessary precautions must be taken to prevent cyanide salts from coming into contact with liquid or airborne acids. In addition, precautions must be exercised to prevent $\text{Ca}(\text{CN})_2$ from coming into contact with water or humid atmospheres.

Cyanide salts must be protected also from contact with large concentrations of carbon dioxide. Carbon dioxide fire extinguishers must not be used where cyanide salts are present.

In any circumstance in which there is probable contact of cyanide salts with liquid or airborne acids such as CrO_3 , SO_2 , CO_2 , HCl etc, or of $\text{Ca}(\text{CN})_2$ with a high concentration of water vapor or with liquid water, the standards and requirements applicable to exposures to HCN shall also apply.

(2) Cyanide salts as solids or solutions must be stored in sealed or tightly closed containers. The containers must be protected from moisture or other sources of erosion or damage which destroy the integrity of the container or closure. No hooks should be used in handling cyanide containers.

Cyanides should be stored in an area where there is no likelihood of contact with acids, acid vapors, including large concentrations of carbon dioxide, nitrate-nitrite mixtures, or peroxides.

Storage areas must be adequately ventilated to ensure that cyanide concentrations do not exceed the recommended workplace environmental limits in Section 1.

All containers of cyanide salts must be labeled in accordance

with the recommendations in Section 3.

Areas in which cyanides are stored must be posted in accordance with the recommendations in Section 3.

(3) When containers of cyanide salts are removed or unloaded from trucks, boxcars, or poorly ventilated spaces, these should be thoroughly ventilated, purged, and tested before a worker enters.

When cyanide salts are placed in other containers for transport or temporary storage, such containers must be properly covered and labeled.

(4) Mechanical exhaust ventilation by local exhaust shall be provided for all operations producing, or likely to produce, dust or mists of cyanide salts in excess of the limit recommended in Section 1, or to vaporize HCN in excess of the recommended limit for that vapor.

Examples of such operations are:

(A) Transferring or moving powdered or granular forms of cyanide salts;

(B) Using solutions of cyanide salts in electroplating;

(C) Using baths of molten cyanide salts or mixtures of salts containing cyanides for case hardening.

(D) Crushing or abrading cast forms of cyanide salts.

(5) Employees engaged in the transfer or use of cyanide salts or solutions thereof shall wear gloves and other personal protective clothing or equipment as recommended in Section 4 to prevent contact of the

cyanide salt as either solids or solutions with the skin of the employees.

Clothing which has become wet with any solution containing compounds of cyanide should be removed at once. If the skin has been wet, the worker should wash the skin area with a copious flow of water, and he should be observed for any signs or symptoms of cyanide poisoning. First aid and/or medical treatment should be started immediately on appearance of any such signs or symptoms. (See for example Appendix V) Gloves and other protective clothing should be changed daily, more often if significant contamination occurs. Protective clothing and equipment which has been contaminated with inorganic cyanide solids or solutions should be placed in a closed container provided for this purpose and should be cleaned or laundered thoroughly before reuse.

(6) Employees should exercise caution to prevent or minimize splashes of cyanide containing solution or liquids. When engaged in operations likely to result in exposure to splashes of such fluids, employees must wear protective goggles and/or a full-length face shield. Cyanide salts or solutions thereof being added to open containers of fluid should be added slowly and carefully to minimize the chance of spillage or splashing. When powdered or granular cyanide salts are being added or when there is evolution of mist from the bath, the employees shall be encouraged to wear at least a filter type respiratory protective device as a measure of protection in addition to that provided by ventilation.

(7) Care must be exercised to avoid spills of cyanide salts or cyanide-containing solutions. Spills of cyanide salts should be immediately and carefully cleaned up by shoveling the material into a proper container. Care must be exercised to minimize any dispersal of

cyanide dust into the air. The worker should wear a filter-type respirator as added protection when engaged in such work. Any remaining residue of solid should be flushed away with water containing some alkaline material (Na_2CO_3 , NaOH , KOH , etc), or taken up by a wet cleaner after application of an alkaline fluid. Spills of cyanide solutions should be immediately flushed away with a copious flow of alkalinized water.

(8) Cyanide salts should not be flushed into any drain which may contain or subsequently receive acid waste. The cyanide spill should be flushed into a drain in a cyanide waste disposal system. Cyanide process waste solutions and flushings from spills should be passed through a cyanide waste disposal system. Such systems destroy the cyanide in alkaline solution by chlorination or treatment with other oxidizing agents.

(9) Nonreturnable containers and other containers or equipment contaminated with cyanides before being discarded should be washed thoroughly with alkalinized water to remove cyanide residues.

(10) When cyanide salts are used in fused salt baths, mechanical local exhaust ventilation should be provided to control any cyanide emissions.

Care in operation of the bath and in housekeeping must be exercised so that the area around the bath does not become covered with cyanide-containing powder or dust. Employees working at baths of fused cyanide salts should wear face shields and appropriate protective clothing to protect them from burns and skin contact with cyanides in the event of splashes. A shovel or similar tool should be used to add cyanide salts to a fused salt bath. The cyanide salt should not be added directly by hand.

(11) Inspection, cleaning, or repairing of tanks or other

equipment used with solutions of cyanide salts should be performed only by properly trained workmen under careful supervision.

(A) The tank should be drained of all cyanide solution as completely as possible, then filled with alkalized water and allowed to stand for 15 minutes, preferably with agitation. This procedure should be repeated; then a preliminary inspection may be made. Any encrustation should be removed by mechanical means and/or by means of a stream of water from a hose.

(B) If the tank is to be entered, the atmosphere in the tank should be tested for the presence of hydrogen cyanide and cyanide salts, to be certain it does not contain a dangerous airborne concentration of these or other materials.

(C) The tank should be purged with fresh air to ensure an adequate oxygen supply and air should be supplied to the tank while the worker is in the tank.

(D) Equipment other than tanks should be washed and vented similarly, as applicable.

(12) In the event of finding airborne concentrations of cyanide salts in excess of the limit, immediate action must be taken to eliminate the cause of the elevated airborne cyanide concentration. In case of any emergency situation (spills, leaks, or other unusual emissions of cyanide which result or potentially may result in dangerous airborne concentrations), all personnel shall be evacuated from the area. The personnel required to return to the area to institute corrective measures shall wear approved respiratory protective gear while entering and working

in the area until the situation is corrected.

(13) Any area in which there is the potential of an emergency involving HCN or a cyanide salt shall be posted in accordance with the provisions of Section 3, and emergency equipment stations shall be established. These stations shall be sufficient in number and so located as to be readily and immediately accessible to the workers in the area. The stations shall be provided with first-aid supplies and instructions for first-aid treatment of any persons suffering excessive exposure to cyanide. Approved type respiratory protective devices, as indicated in Section 4, shall be available at designated emergency stations. These devices shall be sufficient in number for the workers in the area and readily accessible.

(14) Workers entering any space or area known to have or suspected of having a dangerous concentration of HCN or a cyanide salt in the air shall wear a self-contained breathing apparatus (see Section 4) and full body protective clothing.

Any area or space in which cyanide contamination of the air is likely and the airborne cyanide concentration is unknown shall be considered dangerous until the concentration is determined and found to be safe (see Chapter IV). Persons entering such an area or space to make measurements of the concentrations, shall wear self-contained breathing apparatus and gas-tight suits.

(15) In the event of cyanide salts or solutions thereof coming into contact with the eyes, the eyes should be flushed for 15 minutes with a copious, gentle flow of water. Medical attention should be obtained immediately.

(16) No employee shall work alone in any area or space in

which exposure to cyanide salts or an emergency potentially dangerous to the employee's safety and life either exists or is likely to occur. A second worker shall be in attendance and in contact in a safe location and ready to summon aid and to render assistance, if needed.

(17) Eating, smoking, and the chewing of tobacco or gum shall be forbidden in areas where cyanide salts are handled. Carrying food, gum, and tobacco shall also be prohibited. Employees shall be required to wash carefully after working with cyanide salts and before eating, smoking or chewing.

(18) Each plant having potential exposure to cyanide salts shall develop emergency procedures for their specific circumstances and the emergencies which may arise therefrom. The employees shall be fully informed of the emergency procedures and of their responsibilities under the plan. Supervisors or other qualified persons shall give each employee careful instruction and detailed training in the actions and procedures required of the employee in an emergency. Instructions for sounding emergency alarms, reporting the emergency, and initiating the emergency procedures adopted by the plant shall be prominently posted in all potentially hazardous areas.

Designated employees shall be trained in the proper first aid and the use of the cyanide first-aid kits which shall be provided in nearby areas. A sufficient number of such employees shall be trained so that at least two employees at work in each shift are so trained. All workers shall be supplied with protective and safety equipment and fully trained in its use. Only specially trained employees shall be authorized to work in

areas in which a hazard of exposure to cyanide salts is present.

Section 7 - Sanitation Facilities

(a) Eyewash facilities and emergency showers shall be provided in areas where contact with HCN liquid or with cyanide salts as either solids or solutions is likely.

(b) Work clothing which has been contaminated by absorption of, or contact with, cyanide shall be thoroughly laundered before it is worn again.

(c) Clothing-change and locker-room facilities shall be provided in a nonexposure area. Workers should be encouraged to shower after work and to change work clothing frequently. Showers and basin washing facilities shall be located in the locker-room area.

(d) Food storage, preparation, and eating shall be prohibited in areas where HCN or cyanide salts are used. Smoking and the carrying of tobacco and other smoking materials shall also be prohibited in these areas. Clean and sanitary lunchroom facilities, if provided, must be in non-exposure areas.

(e) General plant housekeeping should be of a high order, assuring that escape routes and cyanide control equipment are kept clear. Plant sanitation shall meet the requirements of 29 CFR 1910.141.

Section 8 - Monitoring and Recordkeeping Requirements

Workers will not be considered to have occupational exposure to HCN or cyanide salts if environmental concentrations, as determined on the basis of an industrial hygiene survey conducted within 6 months of the

promulgation of standards, do not exceed half the recommended ceiling values. Surveys shall be repeated at least once every 3 years and within 30 days after any process change likely to result in increases of airborne concentrations of HCN or cyanide salts. Records of these surveys, including the basis for concluding that airborne concentrations of HCN and cyanide salts are at or below the occupational exposure levels, shall be maintained until a new survey is conducted. If the survey indicates that airborne concentrations of HCN or cyanide salts may exceed the respective occupational exposure levels, then the following requirements apply:

(a) Personal Monitoring

(1) A program of personal monitoring shall be instituted to identify and measure, or permit calculation of, the exposure of all employees who are occupationally exposed to HCN and/or cyanide salts. Interim monitoring of employee exposure to airborne concentrations of cyanide compounds shall be conducted at least every 6 months. If monitoring of an employee's breathing zone reveals that this employee is exposed to concentrations of cyanide in excess of the recommended ceiling value, the exposure of that employee shall be measured at least once every 30 days, control measures shall be initiated, and the employee shall be notified of his or her exposure and of the control measures being implemented to correct the situation. Such monitoring shall continue until two consecutive samplings, at least a week apart, indicate that employee exposure no longer exceeds the ceiling values in Section 1(a). Semiannual monitoring may then be resumed.

(2) In all personal monitoring, samples of airborne HCN and cyanide salts that, when analyzed, will provide an accurate

representation of the concentration of HCN and/or cyanide salts in the air which the worker breathes shall be collected. Procedures for sampling, calibration of equipment, and analysis of HCN and/or cyanide salts in samples shall be as provided in Section 1(b).

(3) For each determination, a sufficiently large number of samples shall be taken to characterize each employee's exposure during each workshift. Variations in work and production schedules shall be considered in deciding when samples are to be collected. The number of representative determinations for an operation or process shall be based on the variations in location and job functions of employees in relation to that operation or process.

(b) Area Monitoring

In workplaces where there is the potential for release of HCN in sufficient quantities to be lethal in a short time, airborne HCN concentrations shall be monitored continuously. Monitoring procedures to be followed should be in keeping with the guidelines in Appendix III.

(c) Recordkeeping Procedures

Records shall be maintained and shall include sampling and analytical methods, types of respiratory protective devices used, and ceiling concentrations found. Each employee shall have access to data on his or her own environmental exposures and records of such data shall be included in his or her medical records. Pertinent records of required medical examinations, including records of occupational accidents and environmental exposures within the workplace, shall be maintained for 5 years after the worker's last occupational exposure to cyanide and shall be

available to the designated medical representatives of the Secretary of Labor, of the Secretary of Health, Education, and Welfare, of the employer, and of the employee or former employee.

II. INTRODUCTION

This report presents the criteria and the recommended standards based thereon which were prepared to meet the need for preventing occupational diseases arising from exposure to hydrogen cyanide (HCN) and to cyanide salts. The criteria document fulfills the responsibility of the Secretary of Health, Education, and Welfare, under Section 20(a)(3) of the Occupational Safety and Health Act of 1970 to "...develop criteria dealing with toxic materials and harmful physical agents and substances which will describe...exposure levels at which no employee will suffer impaired health or functional capacities or diminished life expectancy as a result of his work experience."

The National Institute for Occupational Safety and Health (NIOSH), after a review of data and consultation with others, formalized a system for the development of criteria upon which standards can be established to protect the health of workers from exposure to hazardous chemical and physical agents. It should be pointed out that any recommended criteria for a standard should enable management and labor to develop better engineering controls resulting in more healthful work practices and should not be used as a final goal.

These criteria for a standard for HCN are part of a continuing series of criteria developed by NIOSH. The proposed standards apply to the processing, manufacture, and use of HCN and cyanide salts or their release as intermediates, byproducts, or impurities as applicable under the Occupational Safety and Health Act of 1970.

The standards were not designed for the population-at-large, and any

extrapolation beyond general occupational exposure is not warranted. They are intended to (1) protect against injury from HCN, and cyanide salts , (2) be measured by techniques that are valid, reproducible, and available to industry and official agencies, and (3) be attainable with existing technology.

For the purpose of this document, cyanide salts are defined as sodium cyanide, potassium cyanide, or calcium cyanide. Other cyanide salts are not included in this standard. The word cyanide is used to designate all the above mentioned salts and hydrogen cyanide as well. Lithium cyanide, gold cyanide, and silver cyanide, as well as all compounds which can hydrolyze or decompose to release the cyanide ion (CN), should be considered as potential contributors of CN ions to the atmosphere of the workplace although they are not specifically covered in this document.

There exists a paucity of information on the chronic toxicity of the cyanides in concentrations of up to 20 ppm. Further epidemiological research on populations likely to be occupationally exposed to HCN and cyanide salts is necessary. Animal toxicity experiments are needed to elucidate the relation and severity of vascular and neural lesions associated with chronic exposure at these levels, as well as to evaluate any possibility of carcinogenicity, mutagenicity, or teratogenicity.