

IV. ENVIRONMENTAL DATA, SAMPLING, AND ANALYTICAL METHODS

Environmental Data

Data on workplace air concentrations for the various nitriles are limited. Air monitoring data for adiponitrile and acetonitrile were obtained during plant visits [4]. For adiponitrile monitoring, 43 samples (8-hour TWA's) for two field operators showed no detectable exposure (lower detection limit of 0.02 ppm). Of 12 stationary samples, 10 showed no detectable adiponitrile, whereas 1 sample indicated 0.25 ppm and another near a temporary high exposure source indicated 7.5 ppm. In a second plant, all samples for adiponitrile indicated TWA concentrations below 1 ppm. In a third plant using acetonitrile in a closed system, a single full-shift TWA concentration of 9.46 ppm was obtained. Several plants also monitor for the presence of hydrogen cyanide or total cyanide [4].

Sampling

Few papers discuss methods of collecting samples of nitriles in workplace air. Marich and Borskii [90] discussed a method of collecting succinonitrile by drawing 2 liters of air, during 10-15 minutes, through a porous plate absorber containing 2 ml of a nitrating mixture. Colorimetric determination of succinonitrile in the resulting solution was then performed. A syringe-type air sampler has been used to collect acetonitrile at a flowrate of 300 cc/minute [91]. This sampling procedure was used in conjunction with the potassium permanganate method of analysis.

Kondo et al [92] experimentally sampled for acetone cyanohydrin and acetonitrile and other organic cyanides in air using a glass and Teflon apparatus consisting of: (1) a charcoal Celite column for cleaning the air sample, (2) absorbent cotton soaked with a known quantity of an organic cyano compound, (3) a drying tube, (4) collecting tubes with an absorbing solution of deionized water, and (5) a pump. A flowrate of 500 ml/minute was used, and 100% recovery was found for acetone cyanohydrin and acetonitrile when up to 20 liters of air were drawn. Recovery sharply declined with air samples of over 20 liters. Experimentation with flowrates of from 345 ml/minute to 10 liters/minute, with a fixed sample volume of 10 liters, yielded total recovery of nearly 100% in all cases.

Charcoal tube sampling was found to be in use at various plants in the United States [4] for collection of acetonitrile, adiponitrile, and propionitrile. Methylene chloride or chloroform was used as a desorption solution for adiponitrile, and carbon disulfide plus 2% acetone was used for desorbing propionitrile. In a NIOSH health hazard evaluation and technical assistance report [93], acetonitrile was sampled with charcoal

tubes and desorbed with toluene. The NIOSH Manual of Analytical Methods [94] recommends sampling with charcoal tubes for acetonitrile and for tetramethylsuccinonitrile; acetonitrile is desorbed with benzene, and tetramethylsuccinonitrile is desorbed with carbon disulfide. A 10-liter air sample is obtained at a rate of 0.2 liter/minute or less. For sampling, the tubes are placed in a vertical position, and after sampling, the tubes are sealed at each end and submitted to a laboratory for analysis. This charcoal tube method has undergone a thorough laboratory evaluation by NIOSH, and the sampling method has been rated as "B," or "acceptable." A similar charcoal tube sampling method has been recommended for tetramethylsuccinonitrile [94]. A calibrated personal sampling pump with a flowrate that can be accurately determined at $\pm 5\%$ for 1.0 liter/minute is required, and a sample of 50 liters is recommended. A larger air sample than that required for estimation of acetonitrile is necessary to detect tetramethylsuccinonitrile in the range 1.80-8.20 mg/cu m (0.3-1.5 ppm).

A solid sorption tube containing sodium hydroxide flakes, developed for collection of concentrations of airborne hydrogen cyanide [95], is being considered by industry for collection of total cyanide in atmospheres where both hydrogen cyanide and a cyanohydrin are present (J Mair, personal communication, July 1978). Collection of acetone cyanohydrin in dilute sodium hydroxide has been attempted experimentally [96]. Complete dissociation of acetone cyanohydrin occurred during collection of air containing this compound at 0.8 liter/minute in absorption vessels containing 5 ml of 0.05 normal sodium hydroxide. Hydrogen cyanide was analyzed by colorimetric determination. Since acetone cyanohydrin is more stable in some acidic media [4], collection in an impinger containing an acid-absorbing solution may be necessary if the cyanohydrin is to be analyzed separately from hydrogen cyanide.

Because succinonitrile, malononitrile, and tetramethylsuccinonitrile exist as solids at room temperature (Table XII-2), sampling for particulates would be an appropriate additional method of nitrile collection. However, no such sampling data have been identified.

NIOSH recommends that tetramethylsuccinonitrile be sampled with charcoal tubes and desorbed with carbon disulfide. Because benzene has been shown to be quite toxic [97], it is recommended that toluene be substituted for it as a desorbing solution for acetonitrile following collection by charcoal tube. The use of charcoal tubes is preferable to alternate methods because the tubes are relatively simple to prepare, ship, and store; personal sampling is easily achieved; and sampling tubes and pumps are commercially available. Sampling with charcoal tubes may suffice for the collection of other mononitriles and dinitriles, but sorbent capacity for these compounds and effectiveness of desorbing solvents need to be determined. The recommended methods of sampling for acetonitrile and tetramethylsuccinonitrile are described in Appendix I. There are, at the

present time, no recommended sampling methods for n-butyronitrile, isobutyronitrile, propionitrile, adiponitrile, malononitrile, succinonitrile, acetone cyanohydrin, and glycolonitrile.

Analytical Methods

Several methods have been used to measure the selected nitriles in air samples. The two major analytical methods are based on colorimetry and gas chromatography.

A general colorimetric method for determination is based on the decomposition of nitriles in alkaline solution with liberation of free ammonia [98]. The free ammonia is determined colorimetrically using Nessler's reagent. However, this method is nonspecific for nitriles, and ammonia, formaldehyde, and hydrogen sulfide interfere. Marich and Borskii [90] developed a colorimetric method for analyzing samples of succinonitrile, utilizing the pink-violet reaction products of succinonitrile nitro derivatives with alkali in a toluene-acetone medium followed by acidification of the solution. The method is sensitive to less than a microgram of succinonitrile in the final solution and provides a stable color for up to 30 minutes; however, nitro and halogenated aromatic hydrocarbons interfere with the determination.

Collection and determination of acetonitrile by the permanganate oxidation method has been used [91]. This method was developed for acrylonitrile and was adapted for acetonitrile analysis. A sample of approximately 800 cc of air is required, and reduction of permanganate ions by the nitrile yields quadrivalent manganese ions, indicated by a change in the color of the solution from pink to blue green. The color change is rapid for acetonitrile concentrations in excess of 25 ppm (42 mg/cu m). It is possible to estimate concentrations down to 25 ppm, and the reduction of permanganate by acetonitrile may be useful in obtaining on-the-spot estimates for the concentration of acetonitrile [91]. However, acrylonitrile, ethyl acrylate, methyl methacrylate, methyl vinylpyridine, and similar compounds interfere in the analysis.

Acetonitrile has been detected alone at 125 ppm with 20% error using laser absorption spectroscopy [99]. In a prepared gas mixture, the minimum detectable concentration was 400 ppm.

A spot test for malononitrile [100], using benzofurazan oxide in an alkaline medium, yields an intense violet color. The color develops to a maximum in 20-30 minutes and then slowly fades to red. The reagent is also useful for detecting malononitrile on thin-layer chromatography plates or determining it colorimetrically in solutions.

Another spot test for malononitrile involves the reaction of nitroprusside with the nitrile in alkali hydroxide solution to yield a

blood-red color [101]. Use of such a reaction may allow a determination of malononitrile in submicrogram quantities in solution.

Several gas chromatographic techniques [98,102-106] have been described for analysis of nitriles. These techniques allow for the separation and identification of nitriles from other nitriles and related substances. Adiponitrile has been collected and determined in the presence of impurities associated with its production from adipic acid [102] or acrylonitrile [105]. Traces of acetonitrile and other impurities have been determined in acrylonitrile by gas chromatography using a flame-ionization detector [106]. A similar procedure allowed separation and determination of acetonitrile and propionitrile in the presence of unsaturated nitriles [103].

The solutions obtained by Kondo et al [92] in experimental air sampling were injected directly into a gas chromatographic column. Using 10-liter air samples collected at 760 mmHg and 25 C, the authors found that the minimum detectable concentrations of acetone cyanohydrin and acetonitrile were 2.15 and 4.46 ppm, respectively. It was determined that several organic solvents with boiling points above 100 C and deionized water gave excellent separation of the organic cyanides from the solvent peaks. The packing agent PEG 6000 proved best for stability and sharpness of peaks. A mixture of acrylonitrile, propionitrile, butyronitrile, succinonitrile, and adiponitrile in an aqueous solution containing hydrochloric acid and potassium chloride was successfully analyzed by gas chromatography using a hot wire detector [104]. However, gas chromatographic methods do not provide for specific determination of nitriles, and substances with similar retention times may interfere. In the absence of interfering substances, nitriles may be separated and determined by comparison with appropriate standards.

The use of a gas chromatograph equipped with a flame-ionization detector is recommended for analysis of acetonitrile and tetramethylsuccinonitrile in the NIOSH Manual of Analytical Methods [94]. Method S165 for acetonitrile was validated over the range 31.4-140.2 mg/cu m with a coefficient of variation of 0.072. Method S155 for tetramethylsuccinonitrile was found to have a coefficient of variation of 0.075 when validated over the range 1.80-8.20 mg/cu m. The same method, with appropriate modifications, may be applied to the determination of concentrations of other airborne mononitriles and dinitriles because of the similar physical and chemical properties of compounds in each category (Table XII-2). The plants visited in preparation of this document used gas chromatography with a flame-ionization detector for analysis of samples of propionitrile and adiponitrile [4]. However, the application of this method to n-butyronitrile, isobutyronitrile, propionitrile, adiponitrile, malononitrile, and succinonitrile has not as yet been tested or validated by NIOSH. There are, at the present time, no recommended methods for analyzing acetone cyanohydrin and glycolonitrile.

V. CONTROL OF EXPOSURES

Engineering Controls

In processes for the production, packaging, storage, and use of nitriles, the application of good chemical engineering principles and care in the selection of process equipment, particularly pumps and valves, are necessary to ensure that nitriles and cyanide-containing wastes are not released to the occupational or community environments [4]. The use of instrumentation and remote controls are recommended for monitoring processes and for allowing rapid and safe intervention for routine operations, as well as for emergencies that might develop from failures of the process or equipment. In general, use of a closed system to prevent the release of materials from a process is recommended. To maintain the integrity of a closed system, an engineering control program, including frequent inspections, preventive maintenance, and prompt repair of leaks, is essential.

When closed systems are not practical or leaks develop, exposure to nitriles in the occupational environment is possible. The likelihood of exposure increases during operations that require handling, transferring, or sampling of raw materials, nitrile products, or wastes. Exposure is also possible during required maintenance or repair of equipment, by entry into tanks, vessels, or other confined spaces, or when an emergency or a nonroutine situation develops. Therefore, a ventilation system such as a hood, glove box, or local exhaust system is necessary when nitriles are handled in an open system. In addition, a ventilation system is desirable as a standby, should a closed system fail. The principles set forth in Industrial Ventilation--A Manual of Recommended Practice [107] and in Fundamentals Governing the Design and Operation of Local Exhaust Systems [108] should be applied to control atmospheric concentrations and to prevent the release of raw materials, nitrile products, or wastes during those operations when exposure is possible. Fire hazard and explosion potential should be considered in designing ventilation systems as well as other equipment. See Table V-1 for fire hazard properties of the selected nitriles.

To ensure effective operation of ventilation systems, routine inspection should include face velocity measurements of the collecting hood, examination of the air mover and collection or dispersion system, and measurements of atmospheric concentrations of nitriles in the work environment. Any changes in the work operation, process, or equipment that may affect the ventilation system should be promptly evaluated to ensure that control measures provide adequate protection for employees. Because hydrogen cyanide may be present, all facilities require frequent inspection and preventive maintenance to ensure that leaks are readily detected and

TABLE V-1
FIRE HAZARD PROPERTIES OF SELECTED NITRILES*

Nitrile	Flashpoint (Closed Cup)		Ignition Temperature F (C)	Flammable Limits		Flammability Class
	F	(C)		Lower (Percent by Volume)	Upper	
Acetonitrile	42	(6)	975 (524)	3.0	16.0	I B
Propionitrile	36	(2)	-	3.1	-	I B
n-Butyronitrile	76	(24)	935 (501)	1.65	-	I C
Acetone cyanohydrin	165	(74)	1270 (688)	2.2	12.0	III B
Succinonitrile	270	(132)	-	-	-	III B
Adiponitrile	200	(93)	-	-	-	III B
Malononitrile	234	(112)	-	-	-	III B

*Similar data for isobutyronitrile, glycolonitrile, and tetramethylsuccinonitrile were unobtainable.

Adapted from references 4,109, and from 29 CFR 1910.106

repaired to avoid exposure of employees. Nitriles and materials used in manufacturing processes may be corrosive, and systems for such manufacturing should be constructed of corrosion-resistant materials such as stainless steel or other passivated metal. All exhaust gases from ventilation systems should be passed through a system operated to prevent release of raw materials, nitriles, and wastes at unacceptable concentrations into the occupational and community environments.

Contingency planning for emergencies, inadvertent release of materials, and breakdown of facilities is vital, and the planned procedures should be facilitated by the availability of appropriate equipment at proper locations and by trained personnel. In addition to overall contingency planning for the total plant site, contingency planning on a department or process basis within the plant is necessary. Such plans should be written out, well understood by the department's personnel, and updated as required. They should include provisions for satisfying the following requirements:

- (a) Reporting requirements: how and whom to notify to obtain prompt and proper help, and how to document the incident later.
- (b) Medical care: arrangements to secure prompt removal of injured personnel to local medical centers and to ensure professional triage and care in medical emergencies related to the workplace. First aid at the plant site should be integrated into the total program. There should be coordination among the medical, safety, fire, and guard departments of the industrial establishment; the local county and state police; and the participating administrative, medical, and surgical staff of external medical facilities.
- (c) Steps to take to keep any spilled chemical from reaching a waterway, overloading a process waste water sewer, or creating an airborne cloud.
- (d) Data on the toxicity, solubility, explosibility, flammability, and reactivity of materials being handled.
- (e) Inventory of spill contingency equipment and where it is located.
- (f) Procedures for handling water-soluble and insoluble chemicals, and other chemicals that require special consideration.
- (g) Adequate containment structures (such as a dike) or devices around storage facilities for liquid nitriles.
- (h) Tank-car and tank-truck loading and unloading facilities having a potential for serious spills require consideration of vehicle

positioning and inspections, procedures to keep equipment from being moved during loading or unloading, equipment design features, instrumentation, and employee monitoring of operations.

In addition to internal reporting procedures, plant management personnel should clearly understand the need for external reporting procedures, both those required by regulatory agencies and those to be followed in good community relations. Information on these requirements should be readily accessible to supervisors along with lists of appropriate names and telephone numbers. Each plant should also be prepared to assess the impact or hazards of a specific spill or release of material should it reach a waterway or create an airborne cloud. New facilities should be reviewed in the design phase and during construction to build in effective means of minimizing spills.

As a general approach, the employer should take necessary steps to review material-handling operations, maintenance and repair procedures, and process operations to identify areas and job locations where employees may come in contact with nitriles, hydrogen cyanide, other raw materials, and cyanide containing waste products. Factors to be considered include at least the following:

- (a) Transfer, loading and unloading facilities, and related procedures for moving chemicals to and from storage tanks, trucks, railcars, and marine equipment.
- (b) Sources of process upsets, and process startup, shutdown, and cleanup procedures.
- (c) Equipment and storage tank diking, surface drainage routing, and sewer system layout.
- (d) History of individual department spillages, clarity of operating procedures, availability of information regarding the characteristics of the chemicals handled, and their contingency planning.
- (e) Mooring practices, booming, dock design, hose systems, catch or drip pans, collection systems, curbing, spill contingency equipment, preferred valve types, equipment blanking practices, lighting, barge design, loading logs, and communications systems for marine facilities.
- (f) Operating procedure recommendations, piping and valve identification, capping or plugging of drain and vent valves, hose connection design, lighting, and winterizing practices for in-plant process and transfer equipment.

- (g) Recommended practices for diking to contain the contents of the largest tank within the diked area, with dike valves maintained normally closed for storage tank areas.

Work Practices

Work practices appropriate to the manufacture, handling, storage, and use of nitriles are primarily concerned with preventing skin and eye contact with liquids, aerosols, and vapor of nitriles and preventing inhalation of nitriles, raw materials, and decomposition products. Acute exposure to nitriles produces signs and symptoms similar to those for exposure to cyanide [10,31,32,35].

There is evidence from case reports of industrial exposure that nitriles may be absorbed through the intact skin [2,10,16,40,42]. Systemic toxicity produced by skin absorption appears to be delayed, probably due to the low rate of metabolic release of cyanide. Prevention of exposure to nitriles in the occupational environment is also a primary goal of a work-practices program. Once exposure has occurred, prevention of adverse effects depends on early recognition of signs and symptoms and the taking of immediate countermeasures.

Areas of potential exposure by inhalation or skin contact should be posted, and the present practice is to restrict access to such areas to designated employees [4]. When skin contact with a nitrile occurs or is suspected, any contaminated clothing or personal protective equipment should be promptly removed and the affected area washed immediately with soap and water. Organic solvents should not be applied to the affected area because possible defatting of the skin or absorption of the solvent may result. Organic solvents may also enhance absorption of the nitrile. Mixtures that have more than additive toxic action, such as nitriles and acetone [46,47], may pose an additional risk to workers. Emergency showers should be available where exposures may occur. Where contact with the eyes is possible, emergency eyewash stations should be provided. Both emergency showers and eyewash facilities should be checked periodically to ensure that they are in good operating condition.

Washrooms and showers should be provided in convenient locations, and employees should be urged to wash or shower after each workshift. To minimize exposure time, whenever employees are exposed through skin contact they should be required to clean up immediately and change contaminated work clothes.

Work practices, handling procedures, and the use of protective devices should be developed to minimize contact with nitriles. The wearing of personal protective garments and equipment is necessary for additional positive protection during those activities and situations where exposures are likely.

Training

In all areas where nitriles are handled, written instructions informing employees of the particular hazards of the compounds, methods of handling the materials, procedures for cleaning up spills, personal protective equipment requirements, and procedures for emergencies should be on file and readily available to employees. The employer should establish a program of instruction to familiarize all potentially exposed employees with these procedures. A Material Safety Data Sheet (illustrated in Appendix II) should be used as a guide by employers in providing the necessary information, but this should be supplemented with specific instruction and training in work operations involving potential contact with or inhalation exposure to a nitrile.

Only properly trained individuals should be permitted access to areas in which exposures to nitriles are likely. This is particularly important in areas or during operations where cyanide may be released. All such areas and operations should be clearly identified by appropriate posted warnings (Chapter I, Section 3). In addition, an effective continuing education and training program should be organized and conducted [4]. Such a program should include at least the following:

- (a) Standardized written procedures, with appropriate personnel training and periodic review, for all routine phases of plant operation.
- (b) Identification of leak and spill potential through job procedure analysis.
- (c) Unsafe condition reports by employees as a mechanism for pointing out spill potentials.
- (d) Reporting forms for all leaks and spills of any materials, indicating whether or not they reach a waterway; investigation and review of all significant leaks and spills, with the objective of preventing recurrence.
- (e) Periodic inspection procedures for dike valve conditions, transfer station valves, and material-handling procedures.
- (f) Spill containment drills.
- (g) Flyers or bulletins to publicize incidents, "near misses," or typical unsafe conditions.
- (h) New ideas on health and safety aspects of the job.
- (i) Slogans, posters, and other types of exhibits to maintain employee interest.

- (j) Publicizing plant and department health and safety performance.
- (k) Editorials by plant manager in plant newspaper or bulletins, and emphasis on their importance at employees' and supervisors' meetings.

For the prevention of injuries resulting from contact of nitriles with the eyes, skin, or other sensitive tissues, employees should wear and be trained in the use of personal protective garments and equipment as recommended in Chapter I, Section 4, in areas where exposure to nitriles is possible.

Good work practices, personal hygiene, and proper training of employees are necessary to control the hazards associated with workplace exposure to nitriles. Employees should be thoroughly trained in all work operations and emergency procedures and in how to use required equipment and protective devices. The effective use of good work practices to prevent exposures depends on the knowledge and cooperation of employers and employees. The employer should take all necessary steps to ensure that each employee:

- (a) Receives adequate instruction and training in safe work procedures, the proper use of all operational equipment, the correct use of protective devices and practices, and all emergency procedures.
- (b) Periodically attends refresher sessions and drills to maintain a high level of competence in safe work practices and emergency procedures.
- (c) Is provided with proper tools, equipment, and personal protective clothing or devices.
- (d) Is given adequate, responsible supervision to ensure that all safety requirements and practices are followed.

Protective Clothing, Devices, and Equipment

Gloves, boots, aprons, goggles, face shields, and other personal protective equipment should be made available for employee use. This equipment should be kept clean and in good condition. All personal protective equipment should be cleaned frequently, inspected regularly, and repaired or replaced as necessary. This equipment should be stored in appropriately designated containers or locations when not in use. Protective clothing (resistant to penetration by nitriles, raw materials, and wastes) should have all openings closed and fit snugly about the neck, wrists, and ankles whenever the wearer is in an exposure area. Clean work clothing should be put on before each workshift. At the end of the

workshift, the employee should remove soiled clothing and shower before putting on street clothing. Street and work clothing should be separated within the change area. Clothing or other material should not be blown with air under pressure because of the potential generation of airborne dust. Soiled clothing should be deposited in a designated, labeled container and appropriately laundered before reuse.

Each employee potentially exposed to nitrile vapor, or likely to come in contact with a nitrile in a solution or as a solid, should be provided with, and required to wear, adequate protective clothing and other equipment for the tasks and area of work. Adequate supervision should be exercised to ensure that the protective clothing and equipment are regularly and properly worn. The garments and equipment should be inspected and maintained on a regular basis. Items damaged by wear or abuse to the extent that the effectiveness of protection is impaired or doubtful should be repaired or replaced. All personal protective devices should be washed thoroughly after each wearing and before being reused. If any such item becomes contaminated with a nitrile during the workshift, it should be immediately flushed with a large amount of water; when such flushing makes the item unsuitable for continued wear, it should be removed and replaced by a clean one.

Respirators are not recommended as an alternative to engineering controls for routine use, but they may be needed during maintenance and repair operations that require opening of systems, during process sampling, and during emergencies or other nonroutine situations. A device-fitting program, including initial quantitative fit tests, is necessary to ensure that the respirator chosen provides sufficient protection to the wearer under conditions that may be expected during actual use. Procedures for quantitative faceseal testing and some types of systems available are described in A Guide to Industrial Respiratory Protection [110].

Eye protection is of particular importance because of the irritant effects of nitriles. Well-fitted chemical safety goggles should be worn as protection from irritating concentrations of nitrile vapor or aerosols, and as protection from mists, splashes, and spills of nitriles or other solutions. Full-length, plastic face shields may also be worn to protect the face from splashes and spills, but chemical safety goggles are still necessary to protect the eyes from vapor, mists, and splashes that may enter behind the edge of the shield [4]. A full-facepiece respirator will also provide the necessary eye protection.

Emergency and First-Aid Practices

Each plant should establish a program to meet any emergency that can reasonably be anticipated. The employees and emergency teams should be

thoroughly informed and trained in their responsibilities and actions in dealing with emergencies. Stations equipped with first-aid supplies and equipment, approved respiratory protective devices, protective garments, and other special equipment as needed should be established and maintained in readiness at easily accessible locations adjacent to areas of likely emergencies.

In emergency operations or other operations where airborne concentrations are unknown, respiratory protection should be provided to employees. Employees assigned to an operation requiring the use of respiratory protective devices should be examined to determine whether they are capable of performing the task while using the device. It is the employer's responsibility to inform employees of the necessity of using a respiratory protective device when the air concentration of a nitrile cannot be maintained at or below the limit. Respiratory protective devices should be kept clean and in good working order (29 CFR 1910.134), and should be cleaned and inspected after each use. Cleanliness of respirators is particularly important because of the hazard associated with skin exposure to nitriles. Respirators will often restrict the wearer's field of vision and perhaps mobility. This may pose additional safety hazards, so safety procedures appropriate to the job should be developed.

In areas where a high concentration of hydrogen cyanide is accidentally produced by decomposition of a nitrile, a self-contained breathing apparatus or a full-facepiece, air-supplied respirator of the pressure-demand type with auxiliary self-contained air supply should be available for employees engaged in emergency operations.

When employees are required to enter any room, equipment, or other confined space suspected of, or possibly subject to, contamination by a nitrile, tests should be made to determine the safety of the atmosphere before employees enter. The odor of certain nitriles may provide warning of high concentrations but does not necessarily indicate the extent of respiratory protection required (Chapter I, Section 4). Recommended procedures are as follows:

- (a) No individual may enter any tank or equipment until it has been flushed free of nitriles, the atmosphere therein has been determined to contain the normal concentration of oxygen and not to contain dangerous concentrations of nitriles and other possible contaminants, and a permit has been issued by the responsible supervisor.
- (b) No individual may enter any tank or confined space wherein the entrance is not large enough to admit an individual fitted with safety harness, lifeline, and an emergency respiratory protective device.

- (c) An individual may work in a tank or confined space only with another person outside in constant contact and having rescue equipment and assistance available.
- (d) Pipelines and hoses, if any, should be blanked off or disconnected to prevent inadvertent entry of a nitrile into a confined space wherein an individual is working [4].

Respiratory protective devices approved for escape or evacuation should be readily available at prominently and clearly identified locations throughout areas where excessive exposure to a nitrile is possible. The equipment is required in numbers sufficient for use by all operating and maintenance personnel likely to be present in an area.

Eye-flushing stations and safety showers are necessary in plant areas where splashes or spills of nitriles are possible. On any contact with a nitrile, flushing of the eyes or skin with water is necessary to prevent or to reduce local irritation and systemic poisoning [2,4,40,42.] Showers and eye flushing facilities should be clearly marked as to location and should have emergency and first-aid instructions posted nearby.

Employees should exercise care not to transfer nitriles from contaminated hands, gloves, or other protective garments or equipment to unprotected eye or skin surfaces.

Material Handling

The following practices and procedures are recommended whenever nitriles are handled:

- (a) Enclosed process machinery and containers of nitriles or solutions containing nitriles should be kept closed or covered, except when operations require otherwise.
- (b) Protective clothing and equipment should be supplied and worn when needed to prevent exposure to liquid or vapor containing a nitrile.
- (c) Containers of nitriles should be securely closed during transport.
- (d) Large containers (portable tanks, drums, etc) should be moved and handled by appropriate mechanical equipment.
- (e) Transfer of a nitrile or solutions containing a nitrile to or from a container should be done with care to minimize any splashing and to prevent spills. Transfer by pumping through hermetically sealed lines is preferred. Lines should be flushed free of nitriles before breaking connections.

- (f) Transfer of nitriles or solutions containing nitriles from tank cars or tank trucks should be done only by adequately trained employees following safe procedures.
- (g) Tanks, machines, pumps, valves, and lines should be drained and flushed thoroughly with water and/or steam before maintenance or repair work is performed on them. Care should be exercised to avoid contact with the drained or flushed fluids.
- (h) Containers and lines should be purged of nitriles before doing any external welding, grinding, or other operation that might provide a source of ignition for flammable vapors.
- (i) Spills and leaks of nitriles or solutions should be immediately diluted with water and treated with an alkali. A decontamination procedure outlined for acetone cyanohydrin uses calcium hypochlorite and cautions to maintain a pH of 9.5 or more [4]. Employees can flush the neutralized spill to a chemical sewer system using an abundant flow of water. Employees should wear respiratory protective devices and protective garments during the cleanup of spills.
- (j) Eyes and skin surfaces coming into contact with a nitrile should be immediately flushed with large amounts of water. In the case of contact with the eyes, a physician should be consulted as soon as possible.
- (k) Ventilation, enclosures, remote controls, and other engineering controls or administrative procedures should be properly used or followed [4].

Sanitation

Food should not be stored, prepared, dispensed (including vending machines), or eaten in work areas where nitriles are manufactured, stored, or used. Employees should exercise great care not to transfer material from contaminated gloves, garments, or respirators to the eyes, mouth, or skin. Lunchroom or lounge areas, if provided, should be separate from work areas and protected from contamination by nitriles.

Spills and leaks of any nitrile should be cleaned up immediately, and employees engaged in cleanup should wear adequate personal protective garments and approved respiratory protective devices. Any employee whose skin or clothing becomes wetted with a nitrile should take a shower as soon as possible and change the contaminated clothing (including contaminated footwear).

Spills may be covered with sand or other suitable mineral aggregate. When the absorbed material can be handled safely, it should be removed from

the work area and disposed of in a suitable sanitary landfill. Storage facilities containing liquid nitriles should be appropriately diked to contain emergency spills.

Liquid wastes containing nitriles should not be flushed into a community sewer system unless such action neither interferes with sewage treatment nor violates applicable Federal, state, or local regulations and ordinances regarding water contamination. Disposal or treatment of solid or liquid wastes should not result in prohibited or undesirable contamination of water, air, or land. Organic components of waste water may be treated by either chemical or biologic oxidation processes. The latter processes usually involve impounding the waste liquor, in which case precautions must be taken to ensure that seepage or effluent from the impoundment does not contaminate ground water or adjacent watercourses. Recycling spilled material back into the process should be considered.