IV. ENVIRONMENTAL DATA AND ENGINEERING CONTROLS

Environmental Concentrations

Little information has been found on concentrations of airborne ethylene dibromide in industrial or ambient air. In 1975, the Environmental Protection Agency (EPA) [19] reported measurements of atmospheric ethylene dibromide concentrations at selected sites near sources which were generally related to gasoline production, distribution, use, and manufacture of ethylene dibromide. Urban locations near major streets were selected in three Western cities to represent worst-case ambient concentrations of ethylene dibromide. Each site was within 200-300 feet of 2 or more gasoline service stations and was located near roadways carrying traffic loads of 25,000-50,000 vehicles/day. At each site, tandem TENAX-GC adsorption tubes with the necessary collection assembly were directed into the wind and positioned 5-6 feet above the ground. The collection assembly consisted of a prefilter of 8 μm mean pore size, a drying tube packed with silica gel, a tandem adsorption train packed with TENAX-GC support material housed in a dry-ice chest, and a vacuum pump controlled by a critical orifice needle to maintain a constant flowrate of 1 liter/minute. Adsorbed ethylene dibromide was extracted from the adsorbent with hexane and the hexane-ethylene dibromide mixture was stored in a freezer until analyzed. The analyses were performed by a gas-liquid chromatograph equipped with an electron capture detector capable of detecting as small a quantity of ethylene dibromide as 1-2 picograms/injection. All samples were initially identified on a Carbowax 20M column and further identified by analysis on a QF-1, DEGS, or OV-101 column, although unequivocal characterization by an independent method of analysis was not done. The results of the urban study, presented below in Table IV-1, suggest that urban workers may be continually exposed to miniscule quantities of ethylene dibromide. The significance of such an exposure is not known at present.

TABLE IV-1

AMBIENT AIR CONCENTRATIONS OF ETHYLENE DIBROMIDE AT URBAN ROADWAY SITES

City	Concentration	
	μg/cu m	ppb
Phoenix, Arizona	0.069	0.008
Los Angeles, California	0.11	0.013
Seattle, Washington	0.083	0.010

Adapted from reference 19

The concentration of airborne ethylene dibromide on the premises of an oil refinery ranged from 0.23 to 1.65 μg/cu m (0.00023 to 0.00165 mg/cu m) at two locations 50-400 feet downwind of a bulk transfer and a tank truckloading operation [19]. Sampling and analytical methods were those described for the urban air study above. Atmospheric concentrations of ethylene dibromide measured at the production facilities of two major manufacturers were reported to be between maximum values of 90 and 115 μg/cu m (0.090 and 0.115 mg/cu m) at downwind locations near the perimeters of the plant boundaries.

In 1975, the EPA [70] estimated the potential emission concentrations of ethylene dibromide from refueling losses and automotive evaporative or exhaust emission. In this report, both the most likely and worst-case emission concentrations were calculated, using the average value of 0.9-1.3 g of ethylene dibromide/gal of automotive fuel (one equivalent of organic bromine is added to gasoline for each two equivalents of lead added). The estimated emission rate for ethylene dibromide by measurement was reported to be 0.000063 g/g lead/gal. The reported losses for entrainment and spillage each were 0.000047 g/g lead/gal. Thus, the total loss because of refueling was reported to be 0.000157 g/g lead/gal. Evaporative losses were calculated to be 0.00014 g/g lead/gal from the automobile fuel tanks. The most likely estimate of loss from the carburetor was 0.0016 g/g lead/gal, whereas the worst case was 0.0043 g/g lead/gal. Exhaust emissions were also calculated, the most likely being 0.0065 g/g lead/gal and the worst case being 0.3 g/g lead/gal. Summarizing the three types of emissions, the total emissions calculated for refueling, evaporation, and exhaust was most likely 0.008397 g/g lead/gal and the worst case, 0.304597 g/g lead/gal. The total emissions can also be estimated directly in terms of ethylene dibromide by expressing the relative percentages of ethylene dibromide/lead in a gallon of gasoline. Usually, a gallon of leaded gasoline contains between 1.9 and 3.0 g of lead/gal [70]. Therefore, the total ethylene dibromide emissions would calculate to 0.02099 g/gal for the most likely situation and to 0.76149 g/gal for the worst-case situation, assuming an average lead content of 2.5 g/gal [70]. Therefore, NIOSH estimates that between 21 and 761 mg of ethylene dibromide may be released to the environment for every gallon of gasoline sold.

The Dow Chemical Company [71] submitted information from limited studies on the exposure of gas station operators to ethylene dibromide during their work that indicated that these workers were exposed to about 7 ppb (0.054 mg/cu m) while near the gas pump and had an 8-hour time-weighted average (TWA) exposure of about 5 ppb (0.038 mg/cu m). The 8-hour TWA concentration for garage mechanics was 3 ppb (0.023 mg/cu m). No further information or data were given in the submission.

Ethyl Corporation submitted data from personal and area monitoring by job classification for its ethylene dibromide-manufacturing plant at Magnolia, Arkansas, and provided a description of the sampling and analytical methods used [15]. Personal monitoring was conducted with a calibrated, battery-operated pump and charcoal collection tubes. The method for area monitoring was not specified. Carbon disulfide was used to desorb the ethylene dibromide, and the subsequent analyses were conducted in a gas-liquid chromatograph equipped with a flame ionization detector. Sampling times varied from 147 to 397 minutes and actual exposure concentrations ranged from 0.02 to 3.47 ppm (0.154 to 26.72 mg/cu m) of ethylene dibromide. The results of this monitoring are summarized in Table IV-2.

Ethyl Corporation also submitted environmental monitoring results for various worksites within its Magnolia manufacturing plant and within its blending plant at Baton Rouge, Louisiana [15]. Sampling times ranged from 129 to 309 minutes and ethylene dibromide concentrations varied from nondetectable to 18.25 ppm (140.525 mg/cu m). The results of this survey are presented in Table IV-3. For the most part, the environmental concentrations were lower in the blending plant than in the manufacturing plant, and within each plant, specific worksites had consistently lower concentrations than others. Samples taken at worksites where ethylene dibromide was unloaded, transferred, or stored, or where maintenance of process vessels was being done, were consistently higher than samples taken around the manufacturing or blending equipment itself.

E. I. du Pont de Nemours and Company submitted similar data from its blending facility in Deepwater, New Jersey [15]. The results of this survey are summarized in Tables IV-4 and IV-5.

These environmental and personal monitoring data suggest that current industrial operating procedures may maintain workplace air concentrations of ethylene dibromide substantially below the current federal standard 8-hour TWA concentration of 20 ppm.

TABLE IV-2

ETHYLENE DIBROMIDE CONCENTRATIONS BY
PERSONAL MONITORING AT ETHYL CORPORATION

Job Function	Date	Sample Time	Reported Concentration	
		(min)	ppm	mg/cu m
EDB control room operator	01/19/76	319	0.16	1.23
	01/20/76	397	0.69	5.31
	01/21/76	332	0.23	1.77
	01/21/76*	234	0.44	3.39
	01/22/76	313	0.225	1.73
	01/23/76	201	0.42	3.23
Vinyl bromide control room operator	01/19/76	314	0.10	0.77
	01/20/76	270	0.02	0.15
	01/21/76	319	0.14	1.08
	01/21/76*	217	<0.04	<0.31
	01/22/76	352	0.06	0.46
Loaders of EDB or VBr**	01/19/76	250	1.31	10.09
	01/19/76	241	1.64	12.63
	01/20/76	365	0.22	1.69
	01/20/76	204	1.67	12.86
	01/21/76	386	0.39	3.00
	01/21/76	208	0.06	0.46
	01/22/76	293	0.045	0.35
	01/22/76	221	0.04	0.31
	01/23/76	191	1.85	14.24
	01/23/76	180	1.57	12.09
Laboratory technician (Plant chemist)	01/19/76	121	3.47	26.72
	01/20/76	212	0.45	3.46
	01/21/76	147	0.09	0.69
	01/22/76	209	0.13	1.00
Production supervisor	01/22/76	250	0.04	0.31

*Denotes evening shift workers
**Load ethylene dibromide (EDB) or vinyl bromide (VBr), but at different times

Adapted from reference 15

TABLE IV-3

ETHYLENE DIBROMIDE CONCENTRATIONS IN AIR BY ENVIRONMENTAL MONITORING AT ETHYL CORPORATION

Location	Date	Sample Time	Reported Concentration	
		(min)	ppm	mg/cu m
Manufacturing plant				
Reaction building	07/14/75	234	0.59	4.54
Bulk storage	07/15/75	257	3.90	30.03
EDB* load rack	07/16/75	180	0.41	3.16
EDB surge tank	07/16/75	129	0.47	3.62
Top EDB-Br2 building	07/17/75	265	0.05	0.38
West of VBr** reactor	01/19/76	257	0.23	1.77
Alumina scrubber area by EDB building	01/20/76	248	18.25	140.52
East of VBr reactor	01/21/76	262	1.64	12.63
EDB storage area	01/21/76	265	1.40	10.78
East of VBr reflux pump (by stairs)	01/22/76	299	0.08	0.62
Portapak purge area	01/22/76	309	-	-
EDB surge (make) tank	01/23/76	208	4.81	37.04
Blending plant				
Load rack	04/01/75	240	0.56	4.31
"	04/18/75	274	0.21	1.62
"	07/23/75	275	0.10	0.77
Pump house	04/18/75	268	0.30	2.31
"	07/23/75	270	0.03	0.23
1st floor - blender tank	07/23/75	255	0.02	0.15
1st floor - blenders	07/09/75	247	<0.02	<0.15
2nd floor - blenders	07/09/75	249	0.04	0.31
3rd floor - EDB weigh tank	07/09/75	254	<0.03	<0.23
3rd floor - EDB weigh tank	07/23/75	253	0.04	0.31

*Ethylene dibromide
**Vinyl bromide

Adapted from reference 15

TABLE IV-4

ETHYLENE DIBROMIDE CONCENTRATIONS
BY PERSONAL MONITORING AT
E. I. DU PONT DE NEMOURS AND COMPANY

Job Description	Date	8-hr TWA Concentration	
		ppm	mg/cu m
Shipping and receiving	07/10/75	<0.065	<0.50
	07/11/75	0.130	1.00
	07/14/75	<0.065	<0.50
	07/17/75	0.256	1.97
	01/27/76	<0.004	<0.03
	01/28/76	0.033	0.25
	01/29/76	<0.004	<0.03
	01/30/76	0.579	4.45
	01/31/76	<0.004	<0.03
Laboratory technician	02/24/75	<0.007	<0.05
Blender operator	11/05/75	<0.114	<0.88

Adapted from reference 15

TABLE IV-5

ETHYLENE DIBROMIDE CONCENTRATIONS IN AIR BY
ENVIRONMENTAL MONITORING AT E. I. DU PONT DE NEMOURS AND COMPANY

Site	Date	Sample Time	Reported Concentration	
		(min)	ppm	mg/cu m
Top of tank car	11/21/74	2.7	3.068	23.60(A)
Unloading tank car	11/05/74	5.0	0.061	0.47(B)
	11/05/74	247.0	0.075	0.58(B)
	11/05/74	2.0	<0.001	<0.01(B)
Between blenders 3 & 4	08/12/74	-	<0.001	<0.01(C)
EDB* pumphouse	11/05/75	330.0	<0.046	<0.35
Chainer transfer	11/05/75	180.0	<0.118	<0.91
Top EDB tank	11/06/75	290.0	1.109	8.53(D)
Top of TS-8**	11/10/75	485.0	<0.034	<0.26
Compound bulk 5 feet above ground	11/10/75	490.0	<0.048	<0.37

*Ethylene dibromide
**Tank storage unit 8
(A) Breathing zone of workers
(B) 18 inches above ground during hookup, emptying, and disconnecting, respectively
(C) Spot sample
(D) 2 cars unloaded into tank during sampling period

Adapted from reference 15

Sampling and Analytical Methods

(a) Sampling

Most analytical methods are dependent on the reproducibility and effectiveness of the adsorption of ethylene dibromide by the different collection media and the subsequent desorption, chemical treatment, or extraction efficiencies. Air samples are normally collected and transported to a laboratory where chemical treatment or desorption and analysis occur at a later time.

Liquid absorption media, such as a 1:1 mixture of monoethanolamine and dioxane, have been used as trapping solutions for ethylene dibromide [72,73]. This medium decomposes ethylene dibromide and many other brominated organic contaminants to inorganic bromide and, as such, is not specific for ethylene dibromide.

Porous polymer beads have been used as a collection medium for chlorinated and brominated hydrocarbons [74]. This procedure has not been tested specifically for ethylene dibromide but has been used successfully for closely related halogenated hydrocarbons; thus, it seems feasible that ethylene dibromide could also be collected by this method. The same column is used for sample collection and gas-liquid chromatographic analysis, but only one analysis can be made on each sample.

Silica gel has been used as a collection medium for ethylene dibromide [75]. One advantage of using a solid adsorbent is that sample loss cannot occur from spillage during sampling or in transit for analysis. However, silica gel is a polar adsorbent and shows pronounced selectivity in adsorbing polar molecules, particularly water [76]. Studies with silica gel tubes indicated that water vapor could displace organic molecules during a normal sampling operation [77]. Although similar studies have not been conducted for ethylene dibromide, it is reasonable to assume that similar displacement of significant quantities of ethylene dibromide by water vapor could occur.

Activated charcoal has been used as an adsorbent in conjunction with gas-liquid chromatography [78,79]. Charcoal is an excellent collecting medium because of its nonpolarity and its affinity for organic vapors and gases. As such, water vapor does not readily displace organic molecules as is the case with silica gel. However, adsorption and desorption efficiencies may vary with different batches of charcoal; therefore, it is necessary to determine the desorption efficiency for each new batch of charcoal. Charcoal tubes containing as much as 600 mg of activated charcoal are commercially available [1].

In the past several years, direct-reading instruments and devices have been developed which make continuous or "on-the-spot" monitoring of halogenated hydrocarbons, including ethylene dibromide, feasible. These devices, when properly calibrated and used within their performance characteristics and limitations, can be helpful in monitoring airborne halogenated hydrocarbons [80]. Colorimetric indicator tubes are available from at least three sources [81-83] which provide semiquantitative measurement in the range of 1-200 ppm, although no detector tubes have been certified as yet by NIOSH for response to ethylene dibromide. The use of infrared light absorption at a wavelength of 8.4 μm [84] is claimed to detect airborne ethylene dibromide at a concentration of 0.1 ppm. These direct-reading instruments are portable and also may be used as part of a multipoint sampling system for continuous, unattended monitors.

Other sampling devices used for the collection of organic solvents and halogenated hydrocarbons may be adaptable to ethylene dibromide collection. These include sampling bottles [85], bubblers [86], and plastic bags [87,88]. No specific tests have been reported on the use of plastic bags for sampling ethylene dibromide. However, studies by Stewart et al [89], Smith and Pierce [90], and Calibrated Instruments, Inc, [91] indicate that halogenated hydrocarbons, such as vinyl chloride, dichloromethane, perchloroethylene, and trichloroethylene, may be successfully collected in plastic bags made of Saran, aluminimzed Scotch Pak, and Mylar. Sampling bags are commercially available with capacities ranging from approximately 0.5-96 liters. Although plastic bags have the disadvantage of being bulky when handled or transported to the analytical laboratory, they have the advantage of enabling samples of the collected air to be injected directly into the gas-liquid chromatograph, thus eliminating the need for sorbant materials, such as activated charcoal, alumina, and silica gel. Before actual field use can be evaluated, controlled laboratory experiments must be conducted to determine the effectiveness and practicality of these procedures.

(b) Analysis

Chemical analysis has been used to estimate ethylene dibromide concentrations in the collection media. Aeration has been used by Peterson et al [75] to desorb ethylene dibromide from the silica gel; pyrolysis of the free ethylene dibromide produced bromine and hydrobromic acid. These products were collected in a second absorption solution of 1% sodium carbonate and 1% sodium formate in deionized water and quantitated by titrimetric analysis of the inorganic bromide present. Aman et al [32] estimated the airborne ethylene dibromide concentration by absorbing the free ethylene dibromide with 1% sodium hydroxide and by quantitating the hypobromite formed iodometrically. Dumas [92] determined airborne ethylene dibromide concentrations by coulometric titration of sodium bromide after absorption of ethylene dibromide in methanolic sodium hydroxide and digestion by boiling under reflux for 15 minutes on a steam bath. These methods, like most chemical methods, require somewhat bulky apparatus and are not specific for ethylene dibromide since any aliphatic brominated compound will interfere and be included in the quantitative estimate.

Physicochemical methods have been developed or adapted to identify and quantitate concentrations of airborne ethylene dibromide. Christie et al [93] modified a refrigerant leak-detector lamp to detect organic halogen compounds, including ethylene dibromide, in the atmosphere at a minimum concentration of 5 ppm. The procedure is dependent on visual estimation of the intensity of a flame color in response to the vapor concentration and is not specific for ethylene dibromide.

Flame chemiluminescence has been reported by Crider [94] to detect ethylene dibromide concentrations in air of 0.03 ppm. This method has not been tested on mixtures of halogenated hydrocarbons, and it is too early in its development to enable prediction of the practicality of the method for area or personal monitoring in an occupational environment.

Other physicochemical methods have been developed for halogen compounds, but they have not been tested for identification and quantitation of ethylene dibromide. One of these methods, based on nitrogen enhancement of an AC spark, has been used for continuous measurement of halogenated compounds in field situations [95]. The instrument is lightweight, portable, fast-responding, and reportedly capable of detecting halogenated hydrocarbons in the ppm range. However, until testing with ethylene dibromide has been conducted, the feasibility and reliability of this instrument is not known.

In recent years, gas-liquid chromatography has become the most prevalent method for the detection and analysis of organic materials [1,96-101]. Direct analysis of airborne ethylene dibromide has been reported to result in measurement of amounts as small as 0.002 μg/cu m (0.000002 mg/cu m) [96]. Gas samples were drawn into a gas flask and subsequently injected directly into a gas-liquid chromatograph equipped with a hydrogen flame ionization detector system. This method has not been tested for ethylene dibromide personal monitoring in an occupational environment. However, it should be easily adaptable to surveying the workplace environment on a periodic basis should the need arise.

The combination of charcoal tube sampling followed by desorption and gas-liquid chromatographic analysis [78] has been developed and used in the occupational environment [15]. These procedures involve the use of charcoal tubes for sampling of the breathing zone, with subsequent benzene-methanol (99:1) desorption and analysis by a gas-liquid chromatograph equipped with an electron capture detector (S Tucker, written communication, March 1977). The quantitation range of the detector (40-800 monograms/sample solution) allows this method to be used to measure air concentrations of ethylene dibromide ranging from 1.6 μg/cu m (0.0002 ppm) to concentrations above 16 mg/cu m (2 ppm). The relative standard deviation for this analytical method in the range of 203-2,370 nanograms/charcoal tube sample is 0.070. The advantages of this combined method are that the sampling device is small, portable, and involves no liquids, and the analytical method is sensitive, rapid, and subject to minimal interference. These NIOSH recommended sampling and analytical methods are described in detail in Appendices I and II.

Engineering Controls

Engineering design and work practices for operations with ethylene dibromide should be oriented toward minimizing the vapor concentrations and toward preventing skin and eye contact with liquid ethylene dibromide. The achievement of these goals can be accomplished by the use of a properly constructed and maintained closed-system operation with appropriate safety precautions. Closed-system operations are effective only when the integrity of the system is maintained by frequent inspection for, and prompt repair of, any leaks. Where closed systems cannot be adequately designed and effectively used, local exhaust ventilation systems must be provided to direct vapor away from employees and to prevent the recirculation of exhaust air. Guidance for designing a local exhaust ventilation system can be found in _Industrial Ventilation--A Manual of Recommended Practice_ [102], or more recent revisions, and in _Fundamentals Governing the Design and Operation of Local Exhaust Systems, ANSI Z9.2-1971_ [103]. Ventilation systems of this type will require regular inspection and maintenance to ensure effective operation. These regularly scheduled inspections should include face velocity measurements of the collecting hood, inspection of the air mover and collector, and measurements of workroom air concentrations.

V. WORK PRACTICES

Strict adherence to stringent and detailed work practices is required to prevent hazardous occupational exposure to ethylene dibromide. The potential hazards from exposure to ethylene dibromide which determine to a large extent the nature of necessary work practices are: (1) the delayed and insidious onset of symptoms, (2) an odor threshold which is not adequate to provide warning of dangerous concentrations, (3) its irritating and penetrating effects on the skin, and (4) its potential for causing cancer, mutations, sterility, and fetal anomalies.

The principal method for manufacturing ethylene dibromide is the bromination of ethylene [1]. Small quantities of vinyl bromide, ethyl bromide, and ethyl chlorobromide may be formed as impurities in the production of ethylene dibromide [15], and caution must be taken to avoid exposure to these substances as well.

Ethylene dibromide is nonflammable and nonexplosive at ordinary temperatures, but since it can be decomposed to toxic and corrosive compounds, such as hydrobromic acid, by contact with open flames or red-hot surfaces [1], it should be appropriately stored and handled to prevent such contacts. Special precautions are necessary for maintenance and emergency repair work, such as welding, cutting, or any spark- and flame-generating operations. Furthermore, it is recommended that smoking be prohibited in workplace areas where ethylene dibromide is manufactured, handled, blended, or stored. Since decomposition may occur [16] and highly toxic aldehyde vapors and acid gases may be emitted [104], ethylene dibromide must be protected from direct light and excessive temperature. Ethylene dibromide reacts rapidly with certain metals, such as aluminum and magnesium, to form combustible and explosive organometallic compounds [104] and with liquid ammonia [16]. Therefore, it is recommended that reasonable precautions be taken to keep ethylene dibromide separated from these materials.

Engineering controls should be used to keep the concentration of airborne ethylene dibromide below the recommended occupational exposure limit. Ethylene dibromide should be used only in a closed system. Proper ventilation, consisting of forced-draft exhaust systems and tempered makeup air systems, should be used to minimize employee exposure to ethylene dibromide in the workplace, and to aid in reducing the extent of exposure in such routine operations as systems maintenance, routine cleanup, and daily sanitation practices. Design principles for all exhaust and ventilation systems should be in accordance with common engineering practices [102,103]. Portable exhaust systems should be used to reduce the concentrations of airborne ethylene dibromide in such situations as cleanup of small leaks and spills, line and vessel entry, and emergency decontamination. Periodic inspections by trained personnel should be made to determine the proper functioning of exhaust and ventilation systems by measuring airflow, static pressure, and leakage.

Untrained or nonessential personnel should be restricted from entering areas where ethylene dibromide is manufactured, handled, blended, or stored. Storage areas where ethylene dibromide is kept in large quantities, such as tanks and tank cars, should be diked with a system of sufficient volume to prevent contamination of surrounding areas in the event of a leak. Drainage within the diverting dikes should be channeled to a collection area for reclamation or disposal. Floors in the ethylene dibromide work areas should be constructed of ethylene dibromide-resistant materials and sealed or made impervious to ethylene dibromide to prevent adsorption, in the event of a spill or leak, and subsequent delayed release to the atmosphere. Periodic scheduled inspections should be made to ensure the proper functioning of dikes, collection systems, and floors. Any malfunctions should be immediately corrected.

All containers used to transport, hold, or process ethylene dibromide should be made of ethylene dibromide-resistant materials, such as lined steel or stainless steel, and should be periodically inspected for signs of wear, corrosion, or leaks by manual and instrumental means. All valves, pipes, and seals used in pumping ethylene dibromide from processing areas to storage areas or transportation loading sites should be made of ethylene dibromide-resistant materials and should be periodically inspected for possible leaks, weak points, or signs of wear.

Ethylene dibromide is a severe eye and skin irritant in humans (G Ter Haar, written communication, January 1977) and can be absorbed through the intact skin of animals in quantities sufficient to present an imminent hazard [33]. In view of this, the use of personal protective equipment, including nylon-impregnated neoprene gloves [105], ethylene dibromide-resistant and fire-retardant clothing, rubber boots or overshoes, bib-type aprons, and chemical safety goggles is recommended when contact by liquid ethylene dibromide with the skin and eyes is possible. In addition, it is recommended that proper respiratory protection be worn when entering an area where the concentration of the vapor of ethylene dibromide may be greater than the recommended occupational exposure limit. Clothing should be immediately removed if it becomes contaminated, and the skin of the exposed area should be thoroughly washed with water.

Personnel working with ethylene dibromide must be instructed in emergency procedures and participate in periodic, simulated emergency drills. All personnel not involved in the specified emergency operations must be immediately evacuated from the area. Special training sessions must be held and written emergency procedures must be updated periodically. These should include the location, use, and maintenance of first-aid, firefighting, and decontamination equipment.

To prevent the adverse effects caused by ethylene dibromide, it is recommended that exposure to ethylene dibromide vapor or liquid be kept at a minimum. Routine visual and functional inspections must be made by trained personnel to ensure that processes in which ethylene dibromide is used are completely closed. If leaks or spills occur in the processing, handling, or storage of ethylene dibromide, these must be promptly corrected, regardless of the ethylene dibromide concentration in the environment. It is recommended that nonessential personnel be evacuated from the immediate area where a leak or spill has occurred until decontamination of the area is complete. If employees must withdraw samples from a process involving the use of ethylene dibromide, an impervious suit, including gloves, boots, and air-supplied hood, should be worn. An effective exhaust system for trapping any ethylene dibromide vapor may be used in place of the air-supplied hood. Any waste or residues containing ethylene dibromide should be incinerated, buried, or otherwise disposed of so that no ethylene dibromide is released into the environment. Applicable local, state, and federal regulations should be followed. Air exhausted from ethylene dibromide workplace areas must be decontaminated by incineration, chemical treatment, or other effective means so that the release of ethylene dibromide into the environment will be minimized.

Safety showers and eyewash fountains should be located in or near areas where ethylene dibromide exposures are likely to occur and should be properly maintained. It is recommended that employees immediately remove contaminated clothing, flush all affected skin surfaces with water for at least 15 minutes, and then obtain medical attention.

Since ethylene dibromide is toxic when ingested and has caused death in a woman after ingestion [25], it is recommended that handwashing facilities, soap, and water be made available to the employees. As a good hygiene practice, it is recommended that employees wash their hands before consuming beverages or food, using tobacco, or using toilet facilities. The employer should provide lunchroom facilities physically separated from the ethylene dibromide work areas.

It is recommended that any contaminated article of personal protective equipment be discarded or, if feasible, decontaminated with soap and water. It is also recommended that employer-supplied clothing be worn while working with ethylene dibromide and that the employer arrange to have this clothing laundered daily and properly maintained. The employer should inform the launderers of the possible hazard of coming into contact with contaminated clothing and advise him on safe methods of handling such material. The employer should provide separate locker and change facilities for work and street clothes. As a good hygiene practice, it is recommended that shower facilities be provided for the employees and that they be required to shower before leaving the workplace at the end of the work shift.

Since ethylene dibromide is a component of some insecticidal fumigants and conventional work practice guidelines are inappropriate to protect agricultural workers from the hazards of exposure, it is recommended that the label precautions on such pesticides be followed and stringently adhered to. These label requirements usually specify allowable time limits before a fumigated space or area may be reentered and safe practices for the application of the particular fumigant mixture. Specific requirements of worker protection standards for agricultural pesticides can be found in 40 CFR 170.

In summary, precautions should be exercised with ethylene dibromide to prevent serious consequences which may result from ingestion, inhalation, and skin or eye contact. Processes in which ethylene dibromide is used in large quantities should be carried out in closed systems. Well-designed hoods, ventilation systems, and exhaust systems should be used to maintain concentrations below those specified by this standard. Personal protective equipment and clothing should be worn by employees engaged in the manufacture, handling, or blending of ethylene dibromide. It is important that employees be informed of the hazards associated with ethylene dibromide before job placement and whenever changes are made in any process that may alter their exposure. Appropriate posters and labels should be displayed. The US Department of Labor form OSHA-20, "Material Safety Data Sheet," or a similar OSHA-approved form, should be filled out and posted. All employees in the ethylene dibromide exposure area should know where the safety sheet is posted. Safety showers, eyewash fountains, and fire extinguishers should be located in areas where ethylene dibromide exposures are likely to occur, and employees should be instructed in their proper use and maintenance.

Records of maintenance schedules, written work practices, emergency procedures, storage locations and quantities of ethylene dibromide present in each location, employee accidents, and employee exposures should be kept and readily accessible to employees and management.

The safe handling of ethylene dibromide depends to a great extent on the effectiveness of employee education, proper safety instructions, intelligent supervision, and the use of proper and safe equipment. The education and training of employees to work safely and to use the personal protective equipment are the responsibility of management. Training classes for both new and current employees should be conducted frequently to maintain a high degree of safety in working with ethylene dibromide.