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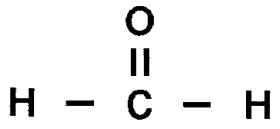
FORMALDEHYDE:

EVIDENCE OF CARCINOGENICITY



U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Centers for Disease Control
National Institute for Occupational Safety and Health

The National Institute for Occupational Safety and Health (NIOSH) Current Intelligence Bulletin is the primary product of the Current Intelligence System. The purpose of the Current Intelligence System is to promptly review, evaluate, and disseminate new information received by NIOSH that may indicate either the existence of an occupational hazard not previously recognized or a greater hazard than generally known. The Current Intelligence System staff within the Division of Criteria Documentation and Standards Development was responsible for the preparation of this Bulletin.

Current Intelligence Bulletins are disseminated to NIOSH staff, other government agencies, and the occupational health community, including labor, industry, academia, and public interest groups. The Bulletins are intended to disseminate new data that may affect prevailing perceptions of occupational hazards. They convey important public health information and recommend voluntary protective measures. Current Intelligence Bulletins do not recommend occupational standards, nor are they intended to have any regulatory significance.

IDENTIFIERS AND SYNONYMS FOR FORMALDEHYDE

Chemical Abstracts Service Registry Number: 50-00-0
NIOSH RTECS Number: LP8925000
Chemical Formula: CH_2O

BFV
Fannoform
Formaldehyde, gas
Formaldehyde, solution
Formalin
Formalith
Formic aldehyde
Formol
Fyde
HCHO
Ivalon
Karsan
Lysoform
Methanal
Methyl aldehyde
Methylene oxide
Morbicid
Oxomethane
Oxymethylene
Paraform
Superlysoform

Mention of company name or product does not constitute endorsement by the National Institute for Occupational Safety and Health.

FORMALDEHYDE: *Evidence of Carcinogenicity*

April 15, 1981

The National Institute for Occupational Safety and Health (NIOSH) recommends that formaldehyde be handled as a potential occupational carcinogen and that appropriate controls be used to reduce worker exposure. These recommendations are based primarily on a Chemical Industry Institute of Toxicology (C I I T) study in which laboratory rats and mice exposed to formaldehyde vapor developed nasal cancer, and are supported by a New York University study where rats exposed to a mixture of formaldehyde and hydrochloric acid vapors developed nasal cancer. Formaldehyde has also been shown to be a mutagen in several short-term laboratory studies. In addition to the carcinogenic potential, other adverse health effects caused by formaldehyde are described. NIOSH requests that producers and distributors of formaldehyde, and of substances and materials containing formaldehyde, give this information to their employees and customers, and that professional and trade associations and unions inform their members.

BACKGROUND

Formaldehyde is a colorless, flammable gas with a strong, pungent odor. It can form explosive mixtures with air and oxygen. As an important industrial chemical of major commercial use, formaldehyde is found throughout the environment. In outdoor air it can originate from many sources such as incinerators, photochemical smog, and engine exhaust. Atmospheric levels of formaldehyde have been reported to range from less than 0.005 ppm to 0.06 ppm near industrial outlets or in areas of heavy smog. Workers who smoke are exposed to additional levels of formaldehyde, since cigarette smoke contains as much as 40 ppm of formaldehyde by volume. Thus, an individual who smokes a pack of cigarettes a day would inhale 0.38 mg,[1,2] whereas occupational exposure to formaldehyde at 3 ppm could result in a daily intake of 29.0 mg.

Production and Uses - Formaldehyde is usually manufactured by reacting methanol vapor and air over a catalyst (chemical initiator). This results in formaldehyde containing trace amounts of methanol and formic acid. Formaldehyde is sold mainly as an aqueous (water-based) solution called formalin, which is 37% to 50% formaldehyde by weight. It is also used in its solid form as paraformaldehyde and s-trioxane.[1] The U.S. produced about 6.4 billion pounds of aqueous formaldehyde

in 1978.[3] Most of this quantity was used domestically. The U.S. consumption of formaldehyde by the year 1983 will likely exceed 7.5 billion pounds. (See appendix for list of major producers of formaldehyde.)

Half of the formaldehyde produced is used to produce synthetic resins such as urea- and phenol-formaldehyde resins. These resins are used primarily as adhesives when making particleboard, fiberboard, and plywood. Urea-formaldehyde concentrates are used in various coating processes, in paper products, and in making foams for thermal insulation. The textile industry uses formaldehyde for producing creaseproof, crushproof, flame resistant, and shrinkproof fabrics. Acetal resins, made from formaldehyde, are used to mold plastic parts for automobiles, home appliances, hardware, and garden and sporting equipment.[4] Formaldehyde is used in some medicines because it modifies and reduces the toxicity of viruses, venoms, and irritating pollens.[5] The use of formaldehyde in embalming fluids is now required by all state laws.[6]

The widespread use of formaldehyde is due to its high reactivity, colorless nature, purity in commercial form, and low cost. In making other chemicals, it can link similar and dissimilar molecules together. In the paper industry, formaldehyde and its derivatives impart wet strength, as well as shrink and grease resistance. Leather and fur can be tanned by formaldehyde. Formaldehyde is used in the photographic industry because it hardens and insolubilizes the gelatin surfaces of film and papers.[5] The table below lists, in alphabetical order, various products made with or containing formaldehyde.[4]

TABLE - Product Uses of Formaldehyde

Adhesives	Insulation, Foam & Some Others
Cosmetics	Intermediate Chemicals
Deodorants	Laminates
Detergents	Leathers, Fur & Hair
Dyes	Lubricants, Synthetic
Embalming Fluids	Paints
Explosives	Paper
Fertilizers	Pharmaceuticals
Fiberboard, Plywood (indoor-outdoor), Particle board	Plastics/moldings (Automobile Appliances, and Sporting Equipment)
Hardware, Garden	Rubber
Filters	Surface Coatings
Food	Textiles
Friction Materials	Urethane Resins
Fuels	Watersoftening Chemicals
Fungicides	

Occupational Exposures - During a 1972-74 survey, NIOSH estimated that 1.6 million workers were exposed to formaldehyde in more than 60 industrial categories. Of these workers, about 57,000 were exposed to formaldehyde 4 hours or more per day. Nearly one-third of the 1.6 million workers (507,200) were engaged in medical and other health services. Another one-third of them (457,200) were in the following industrial categories: chemicals and allied products, printing and publishing, paper and allied products, machinery (except electrical), retail general merchandise, automotive dealers and service stations, eating and drinking places (i.e., busboys, cooks, dishwashers, etc.), and personal services (such as funeral services and crematories, photographic studios, and dry-cleaning plants). Appendix I lists many of the occupational groups exposed to formaldehyde. However, not all workers in each occupational group are exposed to formaldehyde. Therefore it would be prudent for workers in these groups to check their work environment for formaldehyde or products which contain formaldehyde.[7] Appendix II gives ranges of formaldehyde concentrations, by industry, that were found by NIOSH investigators during the past 10 years.

Exposure Standards - The U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) standard for formaldehyde requires an 8-hour time-weighted average (TWA) concentration limit of 3 ppm, a ceiling concentration of 5 ppm, and an acceptable maximum peak above the ceiling concentration of 10 ppm for no more than a total of 30 minutes during an 8-hour shift.[8]

In 1976, NIOSH recommended, based upon the irritant effects of formaldehyde, that employee exposure to formaldehyde in the occupational environment be controlled to a concentration no greater than 1.2 milligrams per cubic meter of air (1 ppm) for any 30-minute sampling period.[9] The carcinogenic potential of formaldehyde was not known at that time, and therefore was not considered in developing the recommendations.

TOXICITY

Carcinogenicity/Mutagenicity - Evidence for the carcinogenicity of formaldehyde was first reported in October 8, 1979. Preliminary data from an ongoing inhalation study of rats and mice, sponsored by the Chemical Industry Institute of Toxicology (C I I T), indicated that for exposures of 15 ppm for 6 hours/day, 5 days/week for 16 months formaldehyde is carcinogenic in rats. Some rats had developed cancer by the 12th month. The study, conducted by Battelle Columbus Laboratories, follows a C I I T protocol using Fischer 344 rats and B6C3F1 mice, exposed in groups of 120 animals of each sex, at each of three exposure levels, plus controls, for 6 hours per day, 5 days per week. The study design calls for groups of animals of both species to be exposed concurrently to either 15, 6, or 2 ppm of formaldehyde vapor.[10]

After 16 months of exposure at 15 ppm, three rats developed squamous cell carcinomas originating in the epithelium of the nasal turbinates. A fourth case of nasal squamous cell carcinoma developed in the group exposed to 6 ppm; however, this cancer appeared to have originated from a different site (i.e., from a layer of

the skin on the nose rather than the nasal turbinates). In a second progress report (January 16, 1980), the C I I T stated that between the 16th and the 18th month of exposure, a sharp increase in the number of cases of nasal cancer had been observed in rats exposed to 15 ppm formaldehyde. A total of 36 rats developed squamous cell carcinomas of the nasal turbinates after 18 months of exposure. Up to the 18th month sacrifice, no similar tumor had been observed in rats exposed to 2 or 6 ppm or in mice exposed to 2, 6 or 15 ppm formaldehyde.[11,12]

The C I I T presented its latest interim report at the Third C I I T Conference on Toxicology (November 20 and 21, 1980).[13] It has shown that after 24 months of exposure to 15 ppm formaldehyde, a total of 93 rats have developed squamous cell carcinomas of the nasal turbinates. Two rats have developed respiratory epithelial carcinomas. Furthermore, two rats exposed to 6 ppm and two mice exposed to 15 ppm formaldehyde have also developed squamous cell carcinomas of the nasal turbinates.

Lesions typical of an enzootic viral infection of the salivary gland, sialodacryoadenitis, were found in rats of all exposure groups at the 12th month necropsy. However, mice did not contract the disease. The possibility that the viral infection contributed to the carcinoma response in the C I I T study cannot be discounted, but it is considered unlikely for the following reasons: 1) mice which were not affected by the viral infection developed the nasal cancer; 2) the signs of infection occurred only for a short period of time during the 11th and 12th month of exposure and the first nasal cancers were detected at the 12th month. Therefore, the nasal cancer had probably already formed by the time of the infection.

Squamous cell carcinoma of the nasal turbinates rarely occurs spontaneously. In two recently completed inhalation studies sponsored by C I I T, involving a total of 1,920 Fischer 344 rats, and in two feeding studies involving 1,680 rats, no similar cancer was observed.[10] At the National Cancer Institute, only two cases of nasal squamous cell carcinoma have been observed in 5,884 unexposed Fischer 344 rats.[14]

The interim data from the C I I T in this study indicate that formaldehyde causes nasal cancer in rats. No factors now apparent would significantly alter the interpretation of the existing results.

Epidemiologic studies conducted to date do not permit a definitive evaluation of the carcinogenic risk of formaldehyde to humans.

Because of the concern of the federal regulatory and research agencies about the exposure of humans to formaldehyde, in January 1980, the Interagency Regulatory Liaison Group (IRLG) reviewed the formaldehyde carcinogenicity data in detail. As a result, the Consumer Product Safety Commission (CPSC) in cooperation with the IRLG agencies, convened a panel of scientists from eight federal agencies under the auspices of the National Toxicology Program to review health data related to formaldehyde. This panel has stated, "It is the conclusion of the Panel that it is prudent to regard formaldehyde as posing a carcinogenic risk to humans."[15]

Most chemicals known to cause cancer are also capable of causing a change in the genetic material within a cell (mutation).[16] Therefore, mutagenicity tests support the results of animal tests to determine carcinogenic potential. Formaldehyde has long been known to be mutagenic. Positive findings of the mutagenicity of formaldehyde have been reported in the following laboratory experimental systems: fruit flies (drosophila), grasshoppers, flowering plants, fungi, and bacteria.[17]

A recent report (October 19, 1979) of the New York University (NYU), Institute of Environmental Medicine supports the C I I T evidence of formaldehyde being a carcinogen in experimental animals.[18] One hundred male Sprague-Dawley rats were exposed to a mixture of formaldehyde and hydrogen chloride (HCl) at concentrations of 14.6 ppm and 10.6 ppm, respectively, for a total of 544 days, 6 hours/day over a period of 814 days. The most important finding was that 25 rats developed squamous cell carcinomas of the nasal cavity, and 2 developed benign papillomas (nonmalignant circumscribed tumor of skin cells) of the nasal cavity. The time from first exposure to death from these cancers ranged from 305 to 705 days (mean: 549 days).

Formaldehyde and HCl can combine in the environment to form the chemical bis (chloromethyl) ether (BCME).[19,20] BCME was first reported to cause cancer in rats by subcutaneous administration in 1969.[21] Since then, inhalation studies have shown that BCME causes lung and nasal cancer in rats.[22,23] The most common type of nasal cancer was esthesioneuroepithelioma (tumor of the nerve tissue) and not squamous cell carcinoma.[22,23]

It is not known if the nasal cancer observed in the NYU mixed exposure study was caused by formaldehyde, HCl, BCME, or a combination of these substances. However, formaldehyde seems the most probable etiologic agent for the following reasons. In the NYU study 27 rats developed nasal tumors, 25 of which were squamous cell carcinomas of the nasal cavity. This type of nasal cancer has been seen infrequently in the BCME inhalation studies and has never been observed to occur spontaneously in the more than 2,000 control animals at NYU over a period of many years.[18] This is the same type of tumor as that produced by formaldehyde in the C I I T study at similar levels of exposure. Second, in the NYU study no rat developed lung cancer as was observed in the BCME inhalation studies. For example, of 40 cancers of the respiratory tract reported in one BCME inhalation study,[23] 14 cancers (13 squamous cell, 1 adenocarcinoma) were from the lung and 26 cancers (17 esthesioneuroepithelioma, 1 squamous cell, and 8 others) were from the nasal cavity.

Other Health Effects - The first signs or symptoms noticed on exposure to formaldehyde at concentrations ranging from 0.1 to 5 ppm are burning of the eyes, tearing (lacrimation), and general irritation to the upper respiratory passages. Higher exposures (10 to 20 ppm) may produce coughing, tightening in the chest, a sense of pressure in the head, and palpitation of the heart.[2,24,25] Exposures at 50 - 100 ppm and above can cause serious injury such as collection of fluid in the lungs (pulmonary edema), inflammation of the lungs (pneumonitis), or death.[9]

In one report, five nurses working near an artificial kidney (hemodialysis) machine developed wheezing and recurrent episodes of productive cough.[26] The

attacks generally occurred in winter and often followed colds. The formaldehyde used to sterilize the machine was found to have caused this respiratory distress.

Dermatitis due to formaldehyde solutions or formaldehyde-containing resins is a well-recognized problem.[27] After a few days of exposure, a worker may develop a sudden inflammatory (eczematous) reaction of the skin of the eyelids, face, neck, scrotum, and flexor surfaces of the arms. An eczematous reaction may also appear on the fingers, back of the hands, wrists, forearms, and parts of the body that are exposed to the rubbing of clothing. This sometimes occurs after years of repeated exposure.

RECOMMENDATION

Formaldehyde has induced a rare form of nasal cancer in both Fischer 344 rats and in B6C3F1 mice as reported in an ongoing study by the C I I T. In a second study by NYU, formaldehyde appears to have induced the same type of cancer in Sprague-Dawley rats. Although humans and animals may differ in their susceptibility to specific chemical compounds, any substance that produces cancer in experimental animals should be considered a cancer risk to humans. Formaldehyde has also demonstrated mutagenic activity in several test systems. Although a substance cannot as yet be designated a potential occupational carcinogen based solely on results of mutagenicity tests, positive results in mutagenicity tests should be used as supporting evidence for identifying a potential occupational carcinogen.

Based on these results, NIOSH recommends that formaldehyde be handled in the workplace as a potential occupational carcinogen. Safe levels of exposure to carcinogens have not been demonstrated, but the probability of developing cancer should be reduced by decreasing exposure. An estimate of the extent of the cancer risk to workers exposed to various levels of formaldehyde at or below the current 3 ppm standard has not yet been determined. In the interim NIOSH recommends that, as a prudent public health measure, engineering controls and stringent work practices be employed to reduce occupational exposure to the lowest feasible limit. The "Guidelines for Minimizing Employee Exposure to Formaldehyde", Appendix IV, should be adapted to specific work situations.

Ronald F. Coene, P.E.
Acting Director

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APPENDIX I

cupations Involving Exposure to Formaldehyde

Accountants
Adult Education Teachers
Advertising Agents and Salesmen
Aeronautical and Astronautical Engineers
Agriculture and Biological Technicans
Air Conditioning, Heating, and Refrigeration
Aircraft
Animal Caretakers, Except Farm
Archivists and Curators
Asbestos and Insulation Workers
Assemblers
Automobile Body Repairmen
Automobile Mechanics
Bakers
Bank Tellers
Barbers
Bartenders
Billing Clerk
Biological Scientists
Bookbinders
Bookkeepers
Bookkeeping and Billing Machine Operators
Bootblacks
Bottling and Canning Operatives
Brickmasons and Stonemasons
Bus Drivers
Busboys
Cabinetmakers
Carpenter Apprentices
Carpenters
Carpenters' Helpers
Carpet Installers
Cashiers
Cement and Concrete Finishers
Chambermaids and Maids, Except Private Household
Checkers, Examiners, and Inspectors; Manufacturers
Chemical Technicians
Chemists
Child Care Workers, Except Private Household
Cleaners and Charwomen
Clerical Supervisions, N.E.C.
Clerical Workers - Miscellaneous
Clerical Workers - Not Specified
Clinical Laboratory Technologists and Technicians
Clothing Ironers and Pressers
Compositors and Typesetters
Computer and Peripheral Equipment Operators
Computer Programmers
Computer Specialists, N.E.C.
Construction Laborers, Except Carpenters' Helper
Cooks, Except Private Household
Counter Clerks, Except food
Craftsmen and Kindred Workers, N.E.C.
Cranemen, Derrickmen, and Hoistmen
Credit men
Cutting Operatives, N.E.C.
Decorators and Window Dressers
Dental Assistants
Dental Hygienists
Dental Laboratory Technicians
Dentists
Designers
Dishwashers
Draftsmen
Dressmakers and Seamstresses, Except Factory
Drill Press Operatives
Dry Wall Installers and Lathers
Duplicating Machine Operators
Dyers
Editors and Reporters
Electric Power Linemen and Cablemen
Electrical and Electronic Engineering Technicians
Electrical and Electronic Engineers
Electrician Apprentices
Electricians
Elevator Operators
Embalmers
Engineering and Science Technicians, N.E.C.
Engineers, N.E.C.
Engravers, Exc. Photoengravers
Estimators and Investigators, N.E.C.
Expediters and Production Controllers
File Clerk
Filers, Polishers, Sanders, and Buffers
Food Counter and Fountain Workers
Food Service Workers, N.E.C., Except Private
Foremen, N.E.C.
Fork Lift and Tow Motor Operatives
Freight and Material Handlers
Funeral Directors
Furnacemen, Smeltermen, and Pourers
Furniture and Wood Finishers
Garage Workers and Gas Station Attendants
Gardeners and Groundskeepers, Exc. Farm
Geologists
Glaziers
Graders and Sorters, Manufacturing
Grinding Machine Operatives
Guards and Watchmen
Hairdressers and Cosmetologists
Health Administrators
Health Aides, Except Nursing
Health Record Technologists and Technicians
Health Technologists and Technicians, N.E.C.
Heat Treaters, Annealers, and Temperers
Heavy Equipment Mechanics, Including Diesel
Household Appliance and Accessory Installers
Housekeepers, Except Private Household
Industrial Engineering Technicians
Industrial Engineers
Inspectors, N.E.C.
Insurance Adjusters, Examiners, and Investigators
Insurance Agents, Brokers, and Underwriters
Janitors and Sextons
Jewelers and Watchmakers
Job and Die Setters, Metal
Key Punch Operators
Laborers - Miscellaneous
Laborers - Not Specified
Lathe and Milling Machine Operatives
Laundry and Dry Cleaning Operatives, N.E.C.
Librarians
Loom Fixers
Machine Operatives - Miscellaneous Specified
Machine Operatives - Not Specified
Machinists
Mail Handlers, Except Post Office
Managers and Administrators, N.E.C.
Meat Cutters and Butchers, Except Manufacturing
Meat Cutters and Butchers, Manufacturing
Mechanic, Exc. Auto, Apprentices
Mechanical Engineers
Mechanics and Repairmen - Miscellaneous
Mechanics and Repairmen - Not Specified
Metal Platers
Millwrights
Mine Operatives, N.E.C.
Mixing Operatives
Molders, Metal
Motion Picture Projectionists
Nursing Aides, Orderlies, and Attendants
Office Machine Operators, N.E.C.
Office Managers, N.E.C.
Officers, Pilots, and Pursers; Ship
Oilers and Greasers, Exc. Auto
Operations and Systems Researchers and Analysers
Operatives - Miscellaneous
Operatives - Not Specified
Opticians, and Lens Grinders and Polishers
Packers and Wrappers, Except Meat and Produce
Painters and Sculptors
Painters, Construction and Maintenance
Painters, Manufactured Articles
Pattern and Model Makers, Except Paper
Payroll and Timekeeping Clerks
Personal Service, N.E.C. - Attendants
Personnel and Labor Relations Workers
Pharmacists
Photoengravers and Lithographers
Photographers
Photographic Process Workers
Physicians, Medical and Osteopathic
Plumbers and Pipe Fitters
Podiatrists
Practical Nurses
Precision Machine Operatives, N.E.C.
Pressmen and Plate Printers, Printing
Pressman Apprentices
Punch and Stamping Press Operatives
Purchasing Agents and Buyers, N.E.C.
Radio and Television
Radiologic Technologists and Technicians
Receptionists
Recreation and Amusement - Attendants
Recreation Workers
Registered Nurses
Research Workers, not specified
Restaurant, Cafeteria, and Bar Managers
Riveters and Fasteners
Sailors and Deckhands
Sales Managers and Department Heads, Retail Trade
Sales Managers, Except Retail Trade
Salesmen and Sales Clerks, N.E.C.
Sawyers
Secretaries, N.E.C.
Sheetmetal Workers and Tinsmiths
Shipping and Receiving Clerks
Shoe Repairmen
Shoemaking Machine Operatives
Sign Painters and Letterers
Social Workers
Solders
Specified Craft Apprentices, N.E.C.
Spinners, Twisters, and Winders
Stationary Engineers
Stationary Firemen
Statistical Clerks
Statisticians
Stenographers
Stock Clerks and Storekeepers
Stock Handlers
Tailors
Teachers, Except College and University, N.E.C.
Technicians, N.E.C.
Telephone Installers and Repairmen
Telephone Linemen and Splicers
Telephone Operators
Textile Operatives, N.E.C.
Therapists
Therapy Assistants
Ticket, Station, and Express Agents
Tile Setters
Tool and Die Maker Apprentices
Tool and Die Makers
Truck Drivers
Typists
Upholsterers
Vehicle Washers and Equipment Cleaners
Veterinarians
Waiters
Warehousemen, N.E.C.
Weighers
Welders and Flame-cutters
Winding Operatives, N.E.C.
Writers, Artists, and Entertainers, N.E.C.

is list of occupational groups is primarily a list of specific job titles and therefore a neric classification such as textile workers will be made up of several groups (e.g., emen, machine operative, clothing ironer, etc.).

E.C. - Not elsewhere classified

APPENDIX II

Some Formaldehyde Concentrations, by Industry, from NIOSH Industrial Hygiene Surveys.

Industry	Formaldehyde Level
Fertilizer Production	0.2 - 1.9 ppm
Dyestuffs	<0.1 - 5.9 ppm
Textile Manufacture	<0.1 - 1.4 ppm
Resins (Non-foundry)	<0.1 - 5.5 ppm
Bronze Foundry	0.12 - 8.0 ppm
Iron Foundry	<0.02 - 18.3 ppm
Treated Paper	0.14 - 0.99 ppm
Hospital Autopsy Room	2.2 - 7.9 ppm
Plywood Industry	1.0 - 2.5 ppm

This information was adapted from a written communication from Richard A. Keenlyside, M.D., Medical Officer, NIOSH to the Deputy Director, NIOSH, November 7, 1980.

APPENDIX III

List of Major Manufacturers of Formaldehyde

Allied Chemical Corporation
Borden, Inc.
Celanese Corporation
E. I. du Pont de Nemours and Co., Inc.
GAF Corporation
Georgia-Pacific Corporation
Getty Oil, Inc.
Gulf Oil Corporation
Hercules, Inc.
International Minerals and Chemical Corporation
Monsanto Company
Occidental Petroleum Corporation
Reichold Chemicals, Inc.
Tenneco, Inc.
Univar Corporation
Wright Chemical Corporation

APPENDIX IV

GUIDELINES FOR MINIMIZING EMPLOYEE EXPOSURE TO FORMALDEHYDE

NIOSH recommends that formaldehyde be handled in the workplace as a potential occupational carcinogen. Exposure should be limited to as few employees as possible, while minimizing workplace exposure levels. The area in which formaldehyde is used should be restricted to only those employees essential to the process or operation. The guidelines listed below are general in nature and should be adapted to specific work situations as required.

EXPOSURE MONITORING

Initial and routine employee exposure surveys should be made by competent industrial hygiene and engineering personnel. These surveys are necessary to determine the extent of employee exposure and to ensure that controls are effective.

The NIOSH Occupational Exposure Sampling Strategy Manual,[1] may be helpful in developing efficient programs to monitor employee exposure to formaldehyde. The manual discusses determination of the need for exposure measurements and selection of sampling times.

Employee exposure measurements should primarily consist of 8-hour TWA (time-weighted average) exposure estimates calculated from personal or breathing zone samples (air that would most nearly represent that inhaled by the employees). In addition, short term samples should be taken during periods of maximum expected exposure by using all available knowledge of the area, employee work procedures, and processes. Area and source measurements may be useful to identify problem areas, processes, and operations.

CONTROLLING EMPLOYEE EXPOSURE

There are four basic methods of limiting employee exposure to formaldehyde. None of these is a simple industrial hygiene or management decision and careful planning and thought should be used prior to implementation.

o Product Substitution

The substitution of an alternative material with a lower potential health risk is an important method for reducing exposure. However, extreme care must be used when selecting possible substitutes. Alternatives to formaldehyde should be fully evaluated with regard to possible health effects prior to selection.

o Contaminant Controls

The most effective control of airborne concentrations of formaldehyde is at the source of contamination by enclosure of the operation and/or use of local exhaust ventilation. Guidelines for selected processes and operations can be found in the NIOSH Recommended Industrial Ventilation Guidelines:[2]

When enclosing a process or operation, a slight vacuum should be used to create negative pressure so that leakage will result in the flow of external air into the enclosure and minimize contamination of the workplace. This can be accomplished with a well-designed local exhaust ventilation system that physically encloses the process as much as possible, with sufficient capture velocity to keep the contaminant from entering the work atmosphere.

Ventilation equipment should be checked at least every three months to ensure adequate performance. System effectiveness should be checked soon after any change in production, process, or control which might result in significant increases in airborne exposure to formaldehyde.

o Employee Isolation

If feasible, employees may be isolated from direct contact with the work environment by the use of automated equipment operated by personnel observing from a closed control booth or room. The control room is maintained at a greater air pressure than that surrounding the process equipment so that air flow is out of, rather than into, the room. This type of control will not protect those employees that must do process checks, adjustments, maintenance, and related operations. These employees will need to use personal protective equipment.

o Personal Protective Equipment

The use of personal protective equipment, which may include respirators, goggles, gloves, etc., should not be used as the only means to prevent or minimize exposure during routine operations.

However, exposure to formaldehyde can be controlled with the use of this equipment:

- During the time period necessary to install or implement engineering or work practice controls; or

- In work situations in which engineering and work practice controls have proven ineffective; or,

— For maintenance; or

— For operations which require entry into tanks or closed vessels; or

— In emergencies.

Proper maintenance procedures, good housekeeping in the work area, and employee education are all vital aspects of a good control program. Employees should be informed as to the nature of the hazard, its control, and appropriate personal hygiene procedures.

MEDICAL SURVEILLANCE

Effects such as upper respiratory irritation or dermatitis should alert management that unacceptable exposure to formaldehyde is occurring. A medical surveillance program should be made available that can evaluate these effects. In addition, skin protection should be stressed in the workplace to keep the number of new cases of dermatitis to a minimum.

AVAILABILITY OF REFERENCES

(1) From GPO as #017-033-00247-9 for $2.75.
(2) From GPO as #017-033-00136-7 for $3.90.

GPO publications can be ordered from:

Superintendent of Documents
U.S. Government Printing Office
Washington, D.C. 20402

CUMULATIVE LIST OF NIOSH CURRENT INTELLIGENCE BULLETINS

1.	Chloroprene	- January 20, 1975
2.	Trichloroethylene (TCE)	- June 6, 1975
3.	Ethylene Dibromide (EDB)	- July 7, 1975
4.	Chrome Pigment	- June 24, 1975 - October 7, 1975 - October 8, 1976
5.	Asbestos - Asbestos Exposure during Servicing of Motor Vehicle Brake and Clutch Assemblies	- August 8, 1975
6.	Hexamethylphosphoric Triamide (HMPA)	- October 24, 1975
7.	Polychlorinated Biphenyls (PCBs)	- November 3, 1975 - August 20, 1976
8.	4,4'-Diaminodiphenylmethane (DDM)	- January 30, 1976
9.	Chloroform	- March 15, 1976
10.	Radon Daughters	- May 11, 1976
11.	Dimethylcarbamoyl Chloride (DMCC) Revised	- July 7, 1976
12.	Diethylcarbamoyl Chloride (DECC)	- July 7, 1976
13.	Explosive Azide Hazard	- August 16, 1976
14.	Inorganic Arsenic - Respiratory Protection	- September 27,1976
15.	Nitrosamines in Cutting Fluids	- October 6, 1976
16.	Metabolic Precursors of a Known Human Carcinogen, Beta-Naphthylamine	- December 17,1976
17.	2-Nitropropane	- April 25, 1977
18.	Acrylonitrile	- July 1, 1977
19.	2,4-Diaminoanisole in Hair and Fur Dyes	- January 13, 1978
20.	Tetrachloroethylene (Perchloroethylene)	- January 20, 1978
21.	Trimellitic Anhydride (TMA)	- February 3, 1978
22.	Ethylene Thiourea (ETU)	- April 11, 1978
23.	Ethylene Dibromide and Disulfiram Toxic Interaction	- April 11, 1978
24.	Direct Black 38, Direct Blue 6, and Direct Brown 95 Benzidine Derived Dyes	- April 17, 1978
25.	Ethylene Dichloride (1,2-Dichloroethane)	- April 19, 1978
26.	NIAX® Catalyst ESN	- May 22, 1978
27.	Chloroethanes - Review of Toxicity	- August 21, 1978
28.	Vinyl Halides - Carcinogenicity	- September 21,1978
29.	Glycidyl Ethers	- October 12, 1978
30.	Epichlorohydrin	- October 12, 1978
31.	Adverse Health Effects of Smoking and the Occupational Environment	- February 5, 1979
32.	Arsine (Arsenic Hydride) Poisoning in the Workplace	- August 3, 1979
33.	Radiofrequency (RF) Sealers and Heaters: Potential Health Hazards and Their Prevention	- December 4, 1979
34.	Formaldehyde: Evidence of Carcinogenicity	- April 15, 1981

NOTE: Bulletins #1 through #18 and #19 through #30 have been reprinted as NIOSH publications, #78-127 and #79-146 respectively, for the convenience of those that desire a complete series of Current Intelligence Bulletins. Distribution of these publications and single copies of Bulletins #31 and later are available from NIOSH Publications Dissemination, Division of Technical Services, 4676 Columbia Parkway, Cincinnati, Ohio 45226.

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