HETA 96-0091-2597
Photoart (Stannard Associates, Inc.)
Fredricksburg, Virginia

Stan Salisbury, CIH

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, technical and consultative assistance to Federal, State, and local agencies; labor; industry; and other groups or individuals to control occupational health hazards and to prevent related trauma and disease. Mention of company names or products does not constitute endorsement by the National Institute for Occupational Safety and Health.

ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by the Atlanta Field Office, of the Hazard Evaluations and Technical Assistance Branch, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). Desktop publishing by Pat Lovell.

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

Health Hazard Evaluation Report 96-0091-2597
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September 1996

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SUMMARY

On May 17, 1996, the National Institute for Occupational Safety and Health (NIOSH) conducted a health hazard evaluation (HHE) at Photoart (Stannard Associates, Inc.), a retail photoprocessing and camera supply store, located in the Spotsylvania Mall shopping center in Fredericksburg, Virginia. This request was submitted confidentially by three employees who worked at the Photoart establishment. Employees expressed concerns about a lack of protective clothing and a need for better containment and handling of chemicals used by photoprocessing equipment operators.

The HHE consisted of a one-day site visit to: walk through the establishment to inspect photoprocessing equipment and observe workpractices; conduct air monitoring for total organic vapors, formaldehyde, sulfur dioxide (SO_2), acetic acid, and ammonia; perform a visual inspection of heating, ventilation, and air-conditioning systems; make air flow measurements; review existing health and safety programs; and conduct informal interviews with several employees.

Air monitoring did not detect excess inhalation exposures to photoprocessing chemical gasses or vapors. However, many of the chemicals used pose a risk of allergic skin reactions from direct skin contact. Protective goggles, gloves, and aprons are now required, but further training of employees in the safe use of photoprocessing chemicals should be undertaken through full implementation of an effective Hazard Communications Program. More comfortable environmental conditions could also be achieved by improving exhaust ventilation in the photoprocessing lab and installing an air economizer system on the rooftop heating, ventilating, and air conditioning system HVAC system.

Keywords: SIC 7384 (Photofinishing Laboratories), photoprocessing, ventilation, hazard communications, protective clothing, ammonia, acetic acid, formaldehyde, sulfur dioxide.

TABLE OF CONTENTS

INTRODUCTION

On May 17, 1996, a NIOSH Health Hazard Evaluation (HHE) was conducted at the Photoart store located in the main building of the Spotsylvania Mall in Fredericksburg, Virginia. The Photoart General Manager cooperated fully during the evaluation and explained how the equipment and chemicals were being used and handled. The site visit consisted of:

- a walk through survey to observe and document the photoprocessing equipment operated at the facility,
- observation of work practices for operating the equipment and for mixing and handling of photographic chemicals,
- air monitoring with direct reading detector tubes for formaldehyde, sulfur dioxide (SO_2), acetic acid, and ammonia,
- visual inspection of heating, ventilation, and air-conditioning systems,
- air flow measurements of exhaust systems and observation of air flow patterns,
- review of existing health and safety programs,
- inspection of the chemical storage area and types of protective clothing used,
- direct reading measurements for organic vapors using a photoionization detector, and
- informal interviews with several employees to discuss adverse health symptoms experienced at work.

BACKGROUND

Photoart is a photoprocessing establishment operated within a 2300 sq. ft. store space inside the Spotsylvania Mall. The store consists of a 24x54 ft. customer service area, a 30x10 ft. photoprocessing lab, a small (about 8x8 ft.) chemical mixing and storage room behind the photoprocessing lab, and a back storeroom, office, and bathroom. The entire store space is served by one heating, ventilation, and air-conditioning (HVAC) package unit mounted on the roof of the mall directly above the store. Each store in the Mall has its own system. Mechanical specifications on this unit were not available. Store hours are Monday through Saturday, from 10:00 a.m. to 9:00 p.m. The store has 12-13 employees with as many as 5-6 on duty during hours of peak workload. Some employees arrive as early as 8:30 a.m. to open the store. Services provided include color and black & white film developing, color and black & white photo printing, slide film processing, and photographic enlargements. Photo supplies, cameras, and picture frames are also sold.

ACTIONS TAKEN

Upon receipt of the HE request, and after consulting with the HE employee requesters, the Photoart General Manager was contacted by the NIOSH investigator to discuss the request and schedule a site visit. In response to this call, the NIOSH investigator received (organized by process) copies of all material safety data sheets for the photographic chemicals used. After reviewing the MSDSs, a site visit was scheduled for May 17, 1996.

On the morning of May 17, following an introductory meeting, the General Manager explained the operation of all photoprocessing equipment and described what chemicals were used in each processing machine. The operation of two small silver recovery units was also described. These units were used for collecting silver from developer chemicals used in the color and black & white printer/processor equipment. In addition to the photoprocessing lab, the chemical storage area was inspected and the procedures used for mixing chemicals were discussed. Protective clothing and tasks requiring its use were reviewed. Other locations evaluated included the back store room and office areas.

A rough drawing of the floor plan was made and locations of all supply, return, and exhaust vents were noted. The area above the suspended ceiling was checked to determine the layout and configuration of HVAC ductwork. The photoprocessing lab exhaust system, designed to exhaust air through two ceiling vents, was inspected to determine why it was not operating. After finding the fan control thermostat, the exhaust fans were turned on, and air flow was measured at the face of each of the two ceiling mounted exhaust vents. Air flow readings were obtained using a TSI, Inc. Model 8360 VelociCalc® meter with a digital readout. This instrument measures velocity by the cooling effect of air passing over a heated (hot-wire) sensor at the end of a probe. The accuracy of this instrument is ± 2.5% of the reading. A series of measurements taken across the face of the exhaust openings were averaged. This average air flow was multiplied by the area of the exhaust vent opening to determine exhaust air flow in cubic feet per minute (cfm). Air changes per hour for the photoprocessing lab were estimated by dividing photoprocessing room volume by the volume of air pulled through the exhaust fans.

Following the walk through, access was obtained from the Mall management office to inspect the HVAC package unit located on the roof of the Mall building. The panels were removed from the HVAC unit to inspect the coils, condensate pan, air filters, outside air vents and dampers. Some adjustments were made to the outside air damper minimum stop setting to move the outside air damper from its fully-closed position.

After returning from the roof, when the photoprocessing was moderately active, background air testing was done using direct reading air monitoring methods. Area sampling for ammonia, acetic acid, formaldehyde, and sulfur dioxide (SO_2) was accomplished using Dräger direct-reading colorimetric indicator tubes and a hand-operated bellows pump. These tubes contain a chemically impregnated media that changes color in proportion to the air concentration of the chemical substance being tested. The limit of detection of each type of detector tube used was: ammonia, 5 parts per million (ppm); acetic acid, 5 ppm; formaldehyde, 0.2 ppm; and SO_2, 0.5 ppm.

Instantaneous measurements to assess relative levels of volatile organic compounds (VOCs) were obtained in various locations throughout the Photoart facility. This monitoring was done with an HNU Systems Model DL 101 portable photoionization analyzer. This monitor detects a wide variety of ionizable gases including ammonia, acetic acid, and many other organic vapors. The sensor consists of a sealed ultraviolet light source that emits photons energetic enough to ionize many chemical compounds. These ions are driven to a collector electrode where an electric current (proportional to concentration) is measured. The probe was configured with a 10.2 electron volt lamp. This lamp will ionize a wide variety of organic compounds, including ammonia and acetic acid, but will exclude normal constituents of air such as nitrogen, oxygen, carbon dioxide, etc. Measurements were taken with the instrument set on maximum sensitivity.

A confidential interview was conducted with one of the Photoart employees. Topics discussed included work history, job responsibilities, adverse health complaints or symptoms experienced while at work, and efforts taken by Photoart management to implement health and safety programs. Following this interview, several other employees were informally questioned about their health status.

FINDINGS

1. Photoprocessing operations and chemistry used by Photoart include C41 Rapid Access color film processing, RA4 color paper processing, E6 slide processing, and black and white film and paper processing. The photoprocessing lab was cramped for space because of the many large processing machines located there. The following processing machines are used:

- Fugi Model FA720 enlarger and color paper processor (RA4)
- Noritsu Model QSF-BW47OLU black and white film processor
- Noritsu Model 1001 black and white paper processor
- Noritsu Model QSF-450L-3U color film processor (C41)
- Noritsu Model 1202 color paper processor (RA4)

- Noritsu Model R410L-3U slide processor (E6)
- Drew Omni 32 and IMC RU4 silver recovery units

Photoprocessing chemicals and their potential adverse health effects are summarized in Table 1.

Table 1

Process	Equipment	Processing Chemistry	Hazardous Ingredients	Adverse Health Effects (as pre-formulated concentrates)
RA4	Fugi FA720 enlarger Noritsu 1202 processor	Color Developer	- CD-3 developer - polyethylene glycol - diethylhydroxylamine - potassium hydroxide	allergic contact dermatitis, upper respiratory irritation skin and eye irritation
		Bleach Fix	- ammonium thiosulfate - ammonium ferric EDTA - acetic acid - sodium metabisulfite	respiratory and eye irritation (ammonium thiosulfate can decompose to form sulfur dioxide or can release ammonia if exposed to intense heat or hot acid)
		Kodak Stabilizer	- polyvinylpyrrolidone - organo silicone - dipropylene glycol - substituted thiazoline-3-one	skin and eye irritation allergic skin reaction
C41	Noritsu QSF-450L-3U	Color Developer	- CD-4 developer	allergic contact dermatitis other nonallergic skin conditions
		Bleach	- ammonium hydroxide - ammonium ferric EDTA - ammonium acetate - ammonium nitrate - ammonium bromide	skin and eye irritation respiratory irritation from inhalation of mist
C41	Noritsu QSF-450L-3U	Fixer	- ammonium thiocyanate - ammonium thiosulfate - sodium metabisulfite - nitrilotriacetic acid, trisodium salt	respiratory and eye irritation (heating ammonium thiocyanate or mixing it with acid can release hydrogen cyanide gas) (ammonium thiosulfate can decompose to form SO_2 or can release ammonia if exposed to intense heat or hot acid)
		Stabilizer	Kodak Flexicolor LF contains: hexamethylenetetramine (releases trace amounts of formaldehyde, or higher levels of formaldehyde and ammonia in an acid medium)	respiratory irritation (formaldehyde has been classified as a potential human carcinogen (nasal cancer), and is a strong respiratory and eye irritant)
E6	Noritsu R410L-3U slide processor	First Developer	- acetic acid - diethylene glycol - potassium bromide - potassium hydroquinone, monosulphonate	eye and upper respiratory irritation
		Reversal Bath	propionic acid	eye and skin irritant

Table 1 (Continued)				
Process	**Equipment**	**Processing Chemistry**	**Hazardous Ingredients**	**Adverse Health Effects** (as pre-formulated concentrates)
		Color Developer	- CD-3 developer - acetic acid - potassium phosphate - potassium hydroxide	allergic contact dermatitis, upper respiratory irritation skin and eye irritation
		Pre-bleach	Kodak proprietary stabilizing agent (contains 1-thioglycerol)	may cause allergic skin reaction may liberate formaldehyde and sulfur dioxide in contact with strong acids or formaldehyde in contact with strong bases
		Bleach	- ammonium ferric (EDTA) - ammonium bromide	skin and eye irritation respiratory irritation from inhalation of mist
		Fixer	- ammonium thiosulfate - ammonium hydroxide - sodium metabisulfite	skin and eye irritation respiratory irritation from inhalation of mist (ammonium thiosulfate can decompose to form SO_2 or can release ammonia if exposed to intense heat or hot acid)
		Final Rinse	- organo silicone - dipropylene glycol - substituted thiazoline-3-one	may cause allergic skin reaction
BW Film	Noritsu QSF-BW47OLU black and white film processor	Developer	- sodium bisulfite - potassium sulfite - sodium sulfite - potassium carbonate - glutaraldehyde bis(sodium bisulfite) - potassium hydroxide - hydroquinone	eye and skin burns may cause allergic skin reaction
		Fixer	- ammonium thiosulfate - sodium acetate - aluminum sulfate - sulfuric acid - acetic acid	possible skin or eye irritation from part B concentrate that is 10-15% sulfuric acid (ammonium thiosulfate can decompose to form SO_2 or can release ammonia if exposed to intense heat or hot acid)
		Photo-Flo	- propylene glycol - p-tert-octylphenoxy-polyethoxyethyl alcohol	eye irritation
BW Paper	Noritsu 1001 black and white paper processor	Kodak Polymax RT developer	- potassium sulfite - sodium sulfite - potassium carbonate - hydroquinone	skin and eye irritation may cause allergic skin reaction

2. The ceiling exhaust fans for the photoprocessing lab were not operating. A thermostat, designed to activate these fans when air temperature near the ceiling reached a certain level, could not monitor this temperature increase. During a store-front renovation, the thermostat control box had been moved up and out of the way to an area above the suspended ceiling where temperatures remained relatively cool. After renovation was completed ceiling tiles were reinstalled, but the thermostat was not returned to its original location. During the NIOSH survey, this thermostat was moved back

below the suspended ceiling and the control was set to keep the exhaust fans operating.

3. Air velocity measurements showed the two exhaust fans respectively pulled 40 and 43 cubic feet of air per minute (cfm) from the ceiling space above the photoprocessing lab. There was also a slight draft from air moving out of the lab doorway into surrounding areas, indicating the lab had a slight positive pressure relative to other parts of the store. All room areas in the store had separate supply and return vents.

4. Inspection of the rooftop HVAC unit found the outside air vent fully closed even though the minimum set point control was set at 20% open. To open the outside air vent slightly (visually estimated as 10% open), this control was set to 55%. Anything below 50% closed the outside air damper completely. The HVAC unit did not appear to have an economizer control that could automatically bring in greater outside air volumes when outside air temperature fell below 65° F. The only control appeared to be a freeze thermostat that would automatically close the outside air damper when outside air temperature dropped below 40° F. Except for the out-of-calibration minimum outside air control, the HVAC unit was in good condition. Cooling coils and condensate pan were clean and air filters had been recently replaced and were properly seated in the mounting racks.

5. The highest airborne concentration for any of the substances monitored was acetic acid, measured during the mixing of a 25-gallon batch of RA4 bleach-fix solution. Mixing was done by the Photoart General Manager in a small room located directly behind the processing lab. One batch was reported to last about one week. To mix a batch, 60 liters (L) of water was added to a portable (on casters) stainless steel tank equipped with a motorized impeller. Pre-mixed containers of replenisher solutions (parts A, B, and C) were sequentially poured into the open top tank. Protective clothing worn during mixing included goggles, nitrile rubber gloves, and an apron.

During pouring of each of these components, vapors emanating from the mixing tank were monitored with detector tubes. The results were as follows in Table 2.

Table 2

Solution	Components (by weight)	Test Results
AGFA 94BX-MR Bleach-Fix Replenisher Part A	Ammonium Thiosulfate 40-45% Sodium Metabisulfite 5-15% Water 45-50%	Ammonia - None Detected
Part B	Ammonium Ferric EDTA 40-45% Water 55-60%	Ammonia - less than 1 ppm
Part C	Acetic Acid 60-65% Water 35-40%	Acetic Acid - 5 ppm

After the three solutions and water were mixed, the contents of the mixing tank were pumped into a 30-gallon plastic holding tank. When bleach-fix solution is needed for the RA4 (color paper) processor machines, employees dispense the needed amount from the holding tank into a transfer container. The transfer container is then hand carried to one of the RA4 processor machines where it is poured into the machine's bleach-fix receiver tank. An identical procedure was used for mixing RA4 color developer solution. However, no monitoring was done because a sufficient amount of solution was on hand from a batch that was mixed prior to the NIOSH site visit. Information received from Photoart following the site visit indicated that this bulk mixing process is no longer performed, and only premixed solutions of RA4 bleach-fix and developer are now being used.

6. General area air tests with colormetric detector tubes during the afternoon in the center of the photoprocessing area (near the color film processor) did not detect measurable concentrations of acetic acid, formaldehyde, SO_2, or ammonia. Organic vapor monitoring with the HNU photoionizer showed normal background concentrations. Instrument readings from inside Photoart were about the same as outdoor air readings taken from the Spotsylvania Mall parking lot.

Positive HNU readings were noted when placing the instrument's probe directly above the fixer tank or the bleach tank in the 450 L-3U C41 processor, possibly caused by a build-up of ammonia vapors inside tanks containing ammonium compounds (see Table 1). A positive reading was also noted when the probe was placed above the fixer solution tank for the R410 L-3U E6 slide processor. This solution also contains ammonium compounds.

A formaldehyde detector tube was used to draw an air sample from the 450 L-3U C41 processor tank containing Kodak Flexicolor LF stabilizer. Although this stabilizer can release trace amounts of formaldehyde (as indicated by its MSDS), no formaldehyde was detectable with a direct-reading colormetric detector tube (limit of detection was 0.2 ppm).

7. Internal chemical storage tanks on many of the processing machines were not labeled to show chemical contents or specific hazard warnings, as required by OSHA's Hazard Communications Standard.[1] Generic tags such as "developer," "fixer," "bleach-fix," etc. were sometimes the only identification. Some labels identifying specific chemicals, obtained from chemical suppliers such as Kodak or AGFA, were being used for some of the tanks, but most were either missing, out of date, or had fallen off.

8. A three-ring binder containing MSDS information on photoprocessing chemicals was accessible to the employees, but Photoart has yet to prepare a written hazard communications plan, conduct employee training, or label all chemical containers with specific chemical identification and appropriate hazard warnings. The chemical storage shelf had recently been organized and chemicals grouped by process and chemical type (e.g., color developer, part A). Three by five cards were used to identify the groupings, but the cards were taped on, and many were loose or about to fall off the shelf.

9. Comments received from the Photoart employees indicate that the most common health complaint was headache. Several employees felt these could be stress related, and not the result of chemical exposures. There was one report that some employees had experienced lightheadedness and dizziness. There was also a report that some employees had experienced occasional nasal irritation when pouring chemicals into the processing machines. According to employees, Photoart's policy requiring the wearing of goggles, lab coats, and protective gloves when handling chemicals was implemented only a few days before the NIOSH site visit.

10. A Survivair® half-mask chemical cartridge respirator was hanging on a hook in the mixing area along with other protective clothing such as the apron and goggles. The cartridges were NIOSH approved (TC 23C-318) for protection against organic vapors and acid gasses. According to the Photoart General Manager, this respirator was purchased for one specific employee who complained about odors and breathing problems when mixing chemicals. This person was no longer working at Photoart. The respirator was not used by any other employees. Photoart was not aware of OSHA's respiratory protection program requirements.

RECOMMENDATIONS

1. Housekeeping could use improvement, especially in the chemical storage and mixing room. Acids, bases, and organics should be stored separately and the most hazardous materials should be stored on the lowest shelves. Chemicals should be stored in closed cabinets where there is less chance for containers to be accidentally pushed over the ends of the open shelves now being used. Corrosive chemicals should be stored in cabinets specifically designed for these types of materials.

2. To assist photoprocessing operators in selecting and mixing the appropriate photo-chemicals, it would help to store chemicals in clearly marked storage bins where each bin identifies the chemical's

intended use. This identification system could include items such as: process, machine, chemical type, and chemical item (e.g., C41, 450 L-3U, developer, starter solution). Clearly written and concise replenishment instruction sheets should be prepared for each photoprocess machine's chemical supply tanks. Employees responsible for replenishing chemicals should be able to easily follow these procedures to ensure the chemicals are mixed correctly with sufficient safeguards to prevent dispensing a chemical into the wrong machine or tank. The groupings shown in Table 1 can serve as a guide in accomplishing this task.

3. Photoart should fully implement an OSHA Hazard Communication Program. Specific guidance was provided during the NIOSH site visit including a copy of OSHA's Publication 3084, *Chemical Hazard Communications.* The OSHA consultation program for Virginia is also available to provide assistance in implementing this program. The name and phone number for this assistance was contained in the materials furnished by NIOSH during the site visit.

4. As required by the OSHA HazCom Program, photoprocessing machine chemical storage tanks must be labeled to identify the name of the chemical and the appropriate hazard warnings (e.g., may cause allergic skin reactions). These warnings and chemical names should be easily readable on all storage bottles and containers at all times. Labels should not be obscured by the position of the container on its storage shelf. Vendors should be able to furnish the appropriate labels.

5. Chemical contents of the silver recovery systems and tanks should also be labeled with identification of the chemical and appropriate hazard warnings. Although not required by OSHA HazCom, Photoart is encouraged to also label the hoses used with this system.

6. Exhaust fans should be replaced with fans capable of pulling up to 250 cfm (each fan). The existing fans are pulling less than 50 cfm each. Increasing fan capacity will place the processing lab under negative pressure relative to other rooms adjacent to the lab. Increasing exhaust volume will help control odors in the customer service area, provide more effective capture and exhaust of warm air near the ceiling above processing machines, and will increase general ventilation to achieve the recommend 10 air changes per hour.[2]

7. An air economizer system should be installed on the rooftop package unit. Elements of this system are already in place. Energy savings during the winter season could more than cover the cost of the system, and ventilation would be greatly improved when cool outdoor air could be used to cool the photoprocessing lab.

8. OSHA no longer requires a written respirator protection plan where voluntary respirator use is allowed, as long as no hazardous atmospheres are present.[3] However, respirators purchased for voluntary use should be inspected, cleaned, maintained and properly stored. The respiratory hanging in the chemical mixing room should not be left out and exposed in this manner. It should be cleaned, checked, and sealed in a plastic bag after each use. If anyone desires to use this respirator simply to avoid odors or to have an extra measure of protection in case of an accidental spill, this person should be trained and fit tested.

9. Based on workplace observations, the negative results from air monitoring tests, and the toxic properties of the photoprocessing chemicals used, the greatest potential exposure risk is from direct skin contact with developer solutions. Although many of the newer color developers have reduced toxicity, allergic skin reactions may still occur.[4] All Photoart employees should be warned about the potential for skin reactions to these chemicals and advised to seek medical attention quickly if any unusual conditions are noted. Protective clothing should always be used when handling chemicals. Employees should wash their hands immediately after mixing or dispensing chemicals, even if they believe no liquids contacted their skin. Additional recommendations for prevention of allergic contact dermatitis is contained in the Kodak publication, *Safe Handling of Photographic Chemicals*. Several copies of this publication were given to the Photoart General Manager at the time of the NIOSH site visit. This document has many photoprocessing work practice

recommendations that should be shared with all Photoart employees.

10. Use of nitrile rubber gloves may be appropriate for only certain photoprocessing chemicals. For example, continuous contact with acetic acid will break through nitrile rubber in less than one hour, yet butyl rubber is resistant to acetic acid break through for over eight hours. Nitrile rubber is also not recommended for protection from certain amines. Nitrile rubber offers excellent protection against formaldehyde and inorganic acids and bases such as sulfuric acid and potassium hydroxide.[5] Specific guidance for selection of appropriate protective clothing for use with photographic chemicals should be obtained from chemical suppliers or producers such as AGFA or Kodak.

11. Procedures for handling chemical spills should be developed. This includes appropriate supplies, written plans, and employee training. This could be added to or be part of a hazard communications program.

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APPENDIX

Health Hazard Evaluation Criteria

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for the assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects even though their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy). In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: (1) NIOSH Recommended Exposure Limits (RELs)[1], (2) American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs™)[2], and (3) the U.S. Department of Labor, OSHA Permissible Exposure Limits (PELs)[3]. In July 1992, the 11th Circuit Court of Appeals vacated the 1989 OSHA PEL Air Contaminants Standard. OSHA is currently enforcing the 1971 standards which are listed as transitional values in the current Code of Federal Regulations; however, some states operating their own OSHA approved job safety and health programs continue to enforce the 1989 limits. NIOSH encourages employers to follow the 1989 OSHA limits, the NIOSH RELs, the ACGIH TLVs, or whichever is the more protective criterion. The OSHA PELs reflect the feasibility of controlling exposures in various industries where the agents are used, whereas NIOSH RELs are based primarily on concerns relating to the prevention of occupational disease. It should be noted when reviewing this report that employers are legally required to meet those levels specified by an OSHA standard and that the OSHA PELs included in this report reflect the 1971 values.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8-to-10-hour workday. Some substances have recommended short-term exposure limits (STEL) or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from higher exposures over the short-term.

Health Hazard Information

Formaldehyde

The chemical "formaldehyde" is a colorless, pungent gas at room temperature with an approximate odor threshold of about 1 ppm. While the term "formaldehyde" is also used to describe various mixtures of formaldehyde, water, and alcohol, the term "formalin" more precisely describes aqueous solutions, particularly those containing 37 to 50 percent formaldehyde and 6 to 15 percent alcohol stabilizer. Most formaldehyde enters commerce as formalin.[4]

Exposure can occur through inhalation and skin absorption. The acute effects associated with formaldehyde are irritation of the eyes and respiratory tract and sensitization of the skin. The first symptoms associated with formaldehyde exposure, at concentrations ranging from 0.1 to 5 parts per million (ppm), are burning of the eyes, tearing, and general irritation of the upper respiratory tract. There is variation among individuals, in terms of their tolerance and susceptibility to acute exposures of the compound.[5]

In two separate studies, formaldehyde has induced a rare form of nasal cancer in rodents. Formaldehyde exposure has been identified as a possible causative factor in cancer of the upper respiratory tract in a proportionate mortality study of workers in the garment industry.[6] NIOSH identifies formaldehyde a suspected human carcinogen and recommends that exposures be reduced to the lowest feasible concentration. The OSHA PEL is 0.75 ppm as an 8-hour TWA and 2 ppm as a STEL.[7] The ACGIH has designated formaldehyde to be a suspected human carcinogen and therefore, recommends that worker exposure by all routes "should be carefully controlled to levels as low as possible" below the TLV. ACGIH has set a ceiling limit of 0.3 ppm.[2]

Sulfur Dioxide

Sulfur Dioxide is a colorless gas with a pungent, irritating odor similar to burning sulfur. Its odor threshold is reported to be between 3 to 5 ppm. Sulfur dioxide is an upper respiratory irritant. Irritant effects are caused by the rapid formation of sulfurous acid on contact with moist membranes of the nasal passages and throat. As a result, only minimal amounts of SO_2 reach the lungs unless the exposed person is breathing heavily. A 20-minute exposure to 8 ppm has produced reddening of the throat and mild nose and throat irritation. SO_2 is objectionably irritating at 20 ppm. At 500 ppm SO_2 is so objectionable that a person cannot inhale a single deep breath. In severe cases where very high concentrations of SO_2 have been produced in closed spaces, SO_2 has caused severe airways obstruction, hypoxemia (insufficient oxygenation of the blood), pulmonary edema (a life threatening accumulation of fluid in the lungs), and death in minutes.[8]

NIOSH, OSHA (in 1991), and ACGIH have set an 8-hour TWA exposure limit of 2 ppm for SO_2. This limit was established to reduce the effects of coughing, increase in sputum production, and bronchoconstriction, that have been demonstrated in exposed workers.[9] The STEL is 5 ppm. The currently enforceable OSHA PEL is 5 ppm.

Acetic Acid

Acetic acid has a strong vinegar-like odor detectable by smell at concentrations as low as 0.2 - 1 ppm. The odor is readily apparent at 10 ppm.[8] Acute exposure to acetic acid vapor can cause redness, inflammation, lacrimation, runny nose, sore throat, coughing, bronchitis, pulmonary edema, labored breathing, and shortness of breath. Skin contact with concentrated solutions produces redness, blistering and deep burns. These signs may be delayed for as long as four hours after contact.[10]

NIOSH, OSHA, and ACGIH have established an 8-hour TWA exposure limit of 10 ppm for acetic acid. NIOSH and ACGIH also recommend short-term exposures (15 minutes) be kept below 15 ppm.

Ammonia

Ammonia is a severe irritant of the eyes, respiratory tract, and skin. It has an irritating and pungent odor detectable for some people at concentrations just above 1 ppm. For others the odor threshold could be as high as 50 ppm. Complaints of irritation and discomfort begin at 20-25 ppm. Exposure for 5 minutes at 133 ppm causes nose and throat irritation, and at 400-700 ppm immediate severe irritation of eyes, nose, and throat. Direct eye contact with the liquid can cause severe irritation, hemorrhage, swollen eyelids, and partial or total blindness if not treated immediately.[8] Concentrated (28%) ammonia solutions (ammonium hydroxide) are moderately corrosive to the skin and highly corrosive to the eyes. Common household ammonia solutions containing about 5% ammonia are less hazardous to the skin. Ammonia is used as an oxidizing agent in many photographic processes.[11] NIOSH has established a REL for ammonia of 25 ppm as an 10-hr TWA and 35 ppm as a STEL. These limits are also endorsed by the ACGIH.[12] The current limit enforced by OSHA for ammonia is 50 ppm measured as a 15-minute STEL.[3]

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