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Florida Department of Agriculture and Consumer Services
Division of Plant Industry
Gainesville, Florida

Max Kiefer, 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.

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ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

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

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Health Hazard Evaluation Report 96–0164–2614

Florida Department of Agriculture and Consumer Services
Division of Plant Industry
Gainesville, Florida
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SUMMARY

On May 10, 1996, the National Institute for Occupational Safety and Health (NIOSH) received a management request for a health hazard evaluation (HHE) at the Florida Department of Agriculture and Consumer Services (FDACS), Division of Plant Industry (DPI) complex in Gainesville, Florida. The request asked NIOSH to evaluate potential health risks to workers in the Entomology, Nematology, and Plant Pathology laboratories, and to evaluate certain activities in the Sterile Fly Production facility. Additionally, NIOSH was asked to review general laboratory operations from a safety standpoint, and address a number of worker concerns associated with chemical handling, laboratory ventilation, and indoor air quality. No specific employee health problems were noted on this request.

On September 17–19, 1996, the NIOSH investigator conducted a site visit at the DPI complex in Gainesville, Florida. On September 17–18, the DPI laboratories (Plant Pathology, Nematology, Entomology), chemical storage areas, and the Sterile Fly facility were inspected. Personal breathing zone (PBZ) air sampling to assess employee exposure to isopropyl alcohol, ethyl alcohol, and xylene in the Entomology Slide Lab (E–124) and isopropyl alcohol and vermiculite in the Sterile Fly facility was conducted. Various laboratory procedures were reviewed, and chemical use and storage practices were assessed. Standard indoor environmental quality (IEQ) parameters (temperature, relative humidity [RH], and carbon dioxide [CO_2]) were monitored in Plant Pathology and Entomology. Sound levels in the Personnel office and the Herbarium (N–116) were measured in response to concerns about excess noise from nearby air–handling units (AHUs).

All monitoring results in the Entomology Slide Lab were well below the NIOSH Recommended Exposure Limit (REL) for the compounds monitored. An 11–minute sample from the worker disinfecting the Diet Preparation room in the Sterile Fly facility showed an isopropyl alcohol concentration of 258 parts per million (ppm); the NIOSH short–term exposure limit for isopropyl alcohol is 500 ppm. An activity–specific sample collected during the pupae sieving operation showed a respirable dust concentration of 5.9 milligrams per cubic meter (mg/m^3) for the 86–minute monitoring period; the full–shift time–weighted average (TWA) respirable dust exposure was 1.1 mg/m^3. Exposure criteria specific to vermiculite has not been established. The American Conference of Governmental Industrial Hygienists (ACGIH®) Threshold Limit Value (TLV®) –TWA for respirable particulate not otherwise classified (PNOC) is 3 mg/m^3. NIOSH has not established an REL for PNOC.

Although a written respiratory protection program has been established, use of disposable "dust" masks are not included in this program and one employee with facial hair was observed wearing a respirator. This may interfere with the face to facepiece seal. A possible fire risk was identified in the Entomology Slide Lab from flammable liquids stored adjacent to electrical outlets. The laboratory hoods in this room were not constructed of non–combustible material, and ventilation measurements showed the hood flow rates to be below the minimum acceptable range. Some chemical containers were not labeled or stored properly. Measurements of standard IEQ parameters indicated sufficient conditioned outside air was being provided to occupied areas. Sound level monitoring in the Herbarium and Personnel offices identified a low–frequency noise source originating from adjacent mechanical rooms, but the levels measured were well below occupational standards and recommended levels. A comprehensive safety program has been established and a high level of attention to safety and health by management and employees was evident at the FDACS DPI facility.

Recommendations for respirator program improvements, ventilation upgrades, and various specific items noted in the HHE request are provided in the Recommendations Section of this report.

A review of general safety and health programs and procedures at the FDACS DPI complex did not identify any immediate hazards. A good safety and health program has been established that involves both employees and management. Monitoring in the Entomology Slide Lab did not identify any overexposure to the compounds assessed. One 86–minute personal sample for vermiculite, obtained during the pupae sieving operation in the Sterile Fly facility, suggested that if this activity were conducted for a full work–shift, the respirable dust concentration could exceed the ACGIH TLV for respirable particulates. The Recommendations section of this report includes suggestions for improving: the respiratory protection program; ventilation enhancements; and chemical storage, handling, and labeling.

Keywords: SIC 9641 (Regulation of Agricultural Marketing and Commodities). Entomology, Plant Pathology, Nematology Laboratories, Sterile Fly Production, Vermiculite, Particulate Not Otherwise Classified, Xylene, Isopropyl Alcohol, Ethyl Alcohol.

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INTRODUCTION

On September 17–19, 1996, a representative from the National Institute for Occupational Safety and Health (NIOSH) conducted a site visit at the Florida Department of Agriculture and Consumer Services, Division of Plant Industry (FDACS DPI) in Gainesville, Florida. This visit was in response to a management request for a health hazard evaluation (HHE) to assess exposures during various laboratory activities, review specific laboratory procedures, and evaluate major safety and health programs.

Prior to the site visit, several of the facility's written safety and health programs and policies were reviewed, along with a list of employee health and safety concerns. During the site visit, the Entomology, Plant Pathology, and Nematology laboratories, and the Sterile Fly facility were inspected. Various work practices were also evaluated and environmental monitoring for solvents and vermiculite was conducted.

An initial response letter describing the actions taken by NIOSH, that included preliminary findings and recommendations, was issued to FDACS DPI management on October 7, 1996.

BACKGROUND

The FDACS DPI complex in Gainesville, Florida, houses the Entomology, Nematology, and Plant Pathology Laboratories in a contiguous single–story facility that also includes administrative support groups and clerical personnel. In addition to various laboratory functions, there is an extensive entomology museum and several research greenhouses. Scientists in all three laboratories provide direct support to DPI plant inspectors and assist citizens who have questions regarding plant problems. Activities conducted at the DPI laboratory complex include pest and plant disease identification, soil inspection, electrophoresis, insect preservation, and research. A wide variety of laboratory chemicals are used for these procedures. Although each functional department (Entomology, Nematology, Plant Pathology) has a main laboratory work area, many of the individual scientists have workstations in their offices equipped with small amounts of chemicals, slide preparation materials, and microscopes. Each laboratory has a dedicated chemical storage area with both shelf storage and a flammable storage cabinet for laboratory chemicals.

The Caribbean Fruit Fly Mass Rearing, or Sterile Fly, facility is located in a separate building constructed in 1987 on the DPI complex. Fourteen employees work at the Sterile Fly facility. The building encompasses approximately 15,000 ft^2 with the main portion of the facility accessible only through an air–lock system that routes employees through a locker room prior to entering the rearing area. This is intended to prevent unwanted pests from entering the facility, as well as preventing fertile Caribbean fruit flies (Caribflies) from escaping. There are positive and negative pressure controls within the facility to help prevent contamination problems, as well as temperature and humidity controls. The rearing area is divided into nine main areas, including rooms identified as: Adult Caribfly, Larvae, Pupae, Diet Preparation, Microbiology, Egg Preparation, and Quality Control. The Adult Caribfly room is maintained at a temperature range of 78°–80° F and 60%–70% relative humidity (RH). Some of the rooms (Larvae I and II) require higher temperatures (up to 82° F) and RH (85%–95%). Wall mounted PVC piping with mist generators are used for RH control.

DPI has an established safety program that includes a management and employee safety committee. Written procedures have been developed for many specific laboratory procedures, as well as for a number of safety and health programs, including: Respiratory Protection, Chemical Hygiene, and Bloodborne Pathogens. Many of the departments have also developed a specific safety manual. The Tallahassee office has provided Industrial hygiene support in the past.

METHODS

Ventilation Monitoring

The exhaust ventilation in the Entomology Slide Lab was assessed by measuring air velocity at the exhaust hood opening (face velocity). Fan operation was set on maximum during the measurements. Hood size was measured, and work practices of employees using these systems were observed.

Air velocity measurements were obtained with a TSI Velocicalc® model 8600 anemometer. This instrument measures air velocity in feet–per–minute (fpm). For each system evaluated, multiple measurements were obtained and the results averaged to obtain the mean velocity.

Air Sampling

Charcoal Tube Samples

Integrated personal and area air samples for xylene, isopropyl alcohol, and ethanol were obtained using standard charcoal tubes (100 milligrams front section/50 milligrams backup) as the collection medium. The samples were collected using constant–volume SKC model 223 low–flow sampling pumps. Flow rates of 25–100 cubic centimeters per minute (cc/min) were used to collect the samples. Both full–shift and activity–specific sampling was conducted. Pump calibration was checked prior to sampling using the soap bubble/buret technique. The pumps are equipped with a pump stroke counter and the number of strokes necessary to pull a known volume of air was determined. This information was used to calculate a cc's air per pump stroke "K" factor. The pump stroke count was recorded before and after sampling and the difference used to calculate the total volume of air sampled. Blanks were submitted with the samples. All samples were analyzed by NIOSH's Analytical Laboratory using NIOSH standard methods.[1]

Vermiculite Sampling

Personal and area air sampling for total and respirable vermiculite was conducted using calibrated Gillian HFS 513 air sampling pumps. For the respirable dust sampling, a flow rate of 1.7 liters per minute (LPM) was used to draw sample air through an MSA cyclone and a tared, 37 millimeter, 5 micron pore size, polyvinyl chloride filter. The cyclone removes the non–respirable fraction of particulate so the filter will collect only that portion of the dust (<10 micrometers) that penetrates to the deeper areas of the lung. All personal samples were collected using the respirable dust monitoring method. The total dust samples were also collected with a tared, 37 millimeter filter; however, no cyclone was used and the flow rate was adjusted to 2.0 LPM. Sampling time was for the duration of the specific vermiculite–handling tasks. A bulk sample of vermiculite was submitted to the analytical laboratory to determine if crystalline silica was present. Analysis was conducted according to NIOSH methods (4th. ed.) 7500, 0500, and 0600.

EVALUATION CRITERIA

General

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 becomes available.

The primary sources of environmental evaluation criteria for the workplace are: (1) NIOSH Recommended Exposure Limits (RELs)[1], (2) the 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 are 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.

Xylene

Xylene is a colorless, flammable organic liquid with a molecular structure consisting of a benzene ring with two methyl group (CH_3) substitutions. Xylene is used in paints and other coatings, and as a raw material in the synthesis of organic chemicals, dyes, and pharmaceuticals. It is also an ingredient of gasoline (ranging from 1% to 10%) and many other petroleum solvents.[4] A NIOSH investigation of service station attendants found xylene content in gasoline ranging from 3.3% to 22%.[5]

The vapor of xylene has irritant effects on the skin and mucous membranes, including the eyes and respiratory tract. This irritation may cause itching, redness, inflammation, and discomfort. Repeated or prolonged skin contact may cause erythema, drying, and defatting which may lead to the formation of vesicles. At high concentrations, repeated exposure to xylene may cause reversible damage to the eyes.[6]

Acute xylene inhalation exposure may cause headache, dizziness, incoordination, drowsiness, and unconsciousness.[7] Previous studies have shown that concentrations from 60 to 350 ppm may cause giddiness, anorexia, and vomiting.[6] At high concentrations, exposure to xylene has a narcotic effect on the CNS, and minor reversible effects on the liver and kidneys.[6,7,8]

Historical accounts of hematopoietic toxicity as a result of xylene exposure are likely due to the high concentration of benzene contamination in xylene prior to 1940. These effects previously reported are no longer associated with contemporary xylene exposure.[7,9,10]

The current OSHA PEL, NIOSH REL, and ACGIH TLV for xylene are 100 ppm over an 8-hour TWA. In addition, OSHA and NIOSH have published STELs for xylene of 150 ppm averaged over 15 minutes.

Isopropyl Alcohol/Ethyl Alcohol

Isopropyl alcohol, or isopropanol, is a colorless, volatile, flammable liquid of low toxicity that is used as a chemical intermediate, as a general purpose solvent, and is present in skin lotions, cosmetics, and pharmaceuticals.[4,6]

The vapor of isopropanol is irritating to the eyes and mucous membranes; inhalation of high concentrations can cause depression of the central nervous system.[6,11] The potential effects from dermal contact with the liquid are insignificant; cutaneous absorption should not contribute to systemic toxicity, and generally does not produce skin irritation, except with hypersensitive individuals.[4,6,11]

The inhalation exposure criteria established for isopropanol by NIOSH, OSHA, and ACGIH are equivalent to a full–shift TWA of 400 ppm, and a 15- minute STEL of 500 ppm.

Ethyl alcohol, or ethanol, is also a colorless, flammable, volatile solvent with a reported odor threshold of 84 ppm.[4] Ethanol is considered a dangerous fire risk, and in addition to it's use in alcoholic beverages, it is used as a solvent in a variety of industries. Ethanol vapor is an eye and mucous membrane irritant, and inhalation of high concentrations can cause central nervous system depression.[4,6] NIOSH, OSHA, and ACGIH have all established inhalation exposure criteria for ethanol that is equivalent to a full–shift TWA of 1000 ppm.

Phenol

Phenol is an irritant of the eyes, mucous membranes, and skin. Systemic absorption can cause convulsions as well as liver and kidney disease. The skin is a route of entry for the vapor and liquid phases. Phenol has a marked corrosive effect on any tissue. Symptoms of chronic phenol poisoning may include difficulty in swallowing, diarrhea, vomiting, lack of appetite, headache, fainting, dizziness, dark urine, mental disturbances, and possibly a skin rash.[6] The NIOSH REL, ACGIH TLV, and OSHA PEL for phenol are 5 ppm as a TWA. All criteria include a skin notation, which indicates that skin absorption may be a significant route of exposure.

Vermiculite/Particulates Not Otherwise Classified

Vermiculite is a ferromagnesium aluminum silicate that in its natural state resembles mica. When heated rapidly, vermiculite expands to a low density material with an increase in bulk volume of 8–12 times.[15] Most uses are for the expanded form of vermiculite, and these include loose–fill insulation, lightweight aggregate, carriers for fertilizers and pesticides, packing material, waste cleanup, and animal litter. Although there is no exact formula or composition, vermiculite contains approximately 23% silicate (mica), 15% magnesium oxide, and 6% iron oxide.[12] Exposure to vermiculite dusts may cause symptoms such as coughing, sneezing, and upper respiratory irritation. There is no described disease entity associated with inhalation exposure to vermiculite dust and epidemiological studies of exposed workers indicate that observed health effects are due to concomitant exposure to asbestos or crystalline silica.[13,15] No specific NIOSH REL, OSHA PEL, or ACGIH TLV has been established for vermiculite. The NIOSH REL for respirable mica containing less than 1% crystalline silica is 3 mg/m^3.

Regulatory standards exist for respirable particulates for many specific dusts (e.g., silica) and for a more general category termed "particulates not otherwise classified" (PNOC). Dusts, or mixtures of dusts, considered to be physical irritants for which no substance–specific toxicological data are available are generally placed in this category by OSHA for enforcement purposes.[14] Vermiculite is typically classified as PNOC.

The OSHA limit for respirable particulates nototherwise regulated (PNOR), sometimes referred to as "inert" or "nuisance" dust, is 5 milligrams per cubic meter (mg/m^3). Note that the term inert is not appropriate as all dusts will elicit some cellular response in the lung if inhaled in sufficient amounts.[4] The respirable fraction is considered to be that

portion of inhaled dust which penetrates to the non–ciliated portions of the lung.[15] In general, particles greater than 7–10 micrometers in diameter (μmd) are all removed in the nasal passages and have little probability of penetrating to the lung. Particles smaller than this can reach the air–exchange regions (alveoli, respiratory bronchioles) of the lung, and are considered more hazardous. The American Conference of Governmental Industrial Hygienists (ACGIH) has established a threshold limit value (TLV) of 10 mg/m^3 (total dust) for PNOC (containing no asbestos and < 1% crystalline silica) as a full–shift time weighted average (TWA) and 3 mg/m^3 for the respirable fraction.[?] NIOSH has not established a recommended exposure limit (REL) for PNOC.

Ventilation

Local exhaust ventilation (LEV) is commonly used to control contaminants at the point of generation to reduce the potential for employee exposure. Ventilation assessments, in conjunction with exposure monitoring results, help determine the adequacy of controls at a workstation. This information also assists with deciding if additional controls, or modification of existing controls, is warranted. The principle design parameter for LEV systems is capture velocity. Capture velocity is the velocity necessary to overcome opposing air currents and capture contaminated air by causing it to flow into the exhaust hood. Recommended capture velocities will vary depending on the contaminants' toxicity and volatility, the manner in which the material is used (e.g., heated, agitated), and room conditions (e.g., air currents). Criteria commonly used for evaluating LEV systems is from the ACGIH publication, Industrial Ventilation: A Manual of Recommended Practice.[16] In general, laboratory hoods or other controls are necessary when there is a likelihood of employee overexposure to contaminants generated by the laboratory activity.[17]

Respiratory Protection

NIOSH recommends that respiratory protection be used for worker protection only when engineering controls are not technically feasible, during the interim while the controls are being installed or repaired, or when an emergency and other temporary situations arise.[18] Respirators are the least preferred method of worker protection to air contaminants because an effective respiratory protection program must be implemented to increase the reliability of the protection and the cooperation of the workers to adhere to the elements of the program is critical for respirators to afford adequate protection.

There are two general classes of respiratory protection, **air–purifying respirators** which remove contaminants from the ambient air before it is inhaled, and **air-supplied respirators** which deliver an independent source of respirable air (other than the surrounding atmosphere).[19] Both types of respirators can be subclassified based on the type of inlet covering (facepieces, helmet/shroud, suit, etc.) and the mode of operation. Regardless of the subclassification, air–purifying respirators only remove contaminants from the air and air-purifying respirators must not be used in oxygen deficient atmospheres. It is essential to fully characterize the hazardous atmosphere that respirators will be used in, including the identity and concentration of the air contaminants and the oxygen level.

RESULTS

Attention by management and line employees to safety and health was at a high level in all areas evaluated. Written procedures (respiratory protection, chemical hygiene, etc.) were comprehensive and easily understood. An effective safety program with a management safety committee, area safety officers, and a program to identify and evaluate hazards has been established.

Air Sampling – Vermiculite

Activity–specific personal breathing zone (PBZ) and area air samples for vermiculite were collected on September 18–19 in the Sterile Fly facility. On September 18, sampling was conducted in the Larvae #2 room for a 50–minute period during the removal of a larvae/vermiculite mix, the addition of new vermiculite to the larvae trays, and the preparation of vermiculite (mixing with water). Both employees conducting this task wore 3M 8710 disposable dust/mist (DM) respirators when working with the vermiculite.

On September 19, sampling was conducted in the Pupae room during the mixing of vermiculite with water, and the addition of the prepared vermiculite to trays. The trays were then stacked into racks, and the area swept with a push broom. This activity took approximately 50 minutes to complete. A PBZ sample was also collected from the same employee during the sieving operation to separate the pupae from the vermiculite. This entails removing each tray, dumping the contents into the front of the rotary sieve, and brushing out the tray. The employee stands on a small stepladder during this task, and also wears a 3M 8710 DM respirator. After 2–3 trays are placed in the sieve, the employee moves to the back of the sieve, removes the pupae, and records the volume recovered. This activity took 90 minutes to complete. There is no local exhaust ventilation system for the sieving operation. Area samples for respirable and total particulate were obtained at a workstation at the back of the sieve. The results of the sampling are shown in the following table:

Sampling Results: Particulates Not–Otherwise Classified
FDACS – Sterile Fly Facility
September 18–19, 1996

Date	Task Sampled	Sample Type	Sample Time (min)	Concentration Detected (mg/m^3)	
				Respirable Particulate	Total Particulate
Sept. 18	Replenishing and Mixing Vermiculite in Larvae #2 Room	Personal	15:14–16:04 (50)	<0.25	NA
		Personal	15:12–16:04 (52)	0.68	NA
		Area	15:17–16:05 (48)	NA	1.24
Sept. 19	Mixing Vermiculite and Preparing Trays in Pupae Room, Sweeping	Personal	08:52–09:41 (49)	<0.24	NA
	Sieving Pupae, Cleaning Sieve	Personal	09:43–09: 58, 10:18–11:29 (86)	**5.9**	NA
		Area	09:45–11:31 (106)	0.9	NA
		Area	09:44–11:30 (106)	NA	1.5
ACGIH TLV–TWA for PNOC				**3**	**10**

Mg/m^3 = milligrams of contaminant per cubic meter of air sampled for the duration of the activity monitored

As noted in the above table, the personal sample collected during the sieving process exceeded the ACGIH TLV–TWA for PNOC for the 86–minute sampling period. This suggests that if the worker conducted this activity for an entire work–shift, the full–shift exposure would exceed the TLV–TWA. The TLV–TWA is the time–weighted average concentration for a normal 8–hour workday to which it is believed nearly all workers may be exposed without adverse effect.[6] As such, TLV–TWAs permit excursions above the TLV provided they are compensated by equivalent excursions below the TLV during the workday. The amount of excursion which is acceptable is dependent on a number of factors including the nature of the contaminant, whether very high concentrations produce acute effects, the frequency of occurrence, and the duration of the excursion. The employee monitored at the sieving operation was also the same employee monitored during the mixing of vermiculite in the Pupae room. No other work with vermiculite was conducted by this employee during the work–shift. As such, his average concentration for comparison with the TLV–TWA was calculated using the following formula:

$$TWA = \frac{C_1T_1 + C_2T_2 ... + C_nT_n}{8 \text{ hours}}$$

Where: C= concentration of contaminant detected during time T

Using this formula, the full–shift time–weighted average exposure for the worker conducting the sieving operation was **1.1 mg/m^3.** The respirable dust results from the sieving activity were somewhat unexpected based on observation of this task. As such, followup monitoring may be worthwhile to verify exposure levels.

No crystalline silica (quartz or cristobalite) was detected in the bulk sample of vermiculite. The bulk sample was analyzed using x–ray diffraction. The limit of detection for this method is 0.8 %.

Solvent Sampling Results

Entomology Slide Lab

On September 18, three PBZ samples were collected from two workers (Lab Tech 4) in the Entomology Slide Laboratory to assess exposure to solvent vapors during the preparation of samples. Exposure to isopropyl alcohol (70% solution) and ethyl alcohol (95% solution) was monitored for both workers. One of the workers used xylene in some sample processing steps and wore an extra sampling device to monitor for this solvent. Samples are prepared in a batch process in plexiglass hoods. During the monitoring, most solvent work took place directly outside the hood in petri dish adjacent the worker's microscope. Small (e.g., 5–10 ml) volumes were used during the sample preparation process. Hood ventilation was operational during the sampling. Sampling was conducted for most of the work shift and it was reported to be a "normal work load day." The results of the sampling are shown in the following table:

Personal Sampling Results: Isopropyl Alcohol, Ethyl Alcohol, Xylene
FDACS – Entomology Slide Laboratory
September 18, 1996

Task Description	Sample Time (min)	Concentration Detected (ppm)		
		Isopropyl Alcohol	Ethyl Alcohol	Xylene
Sample Prep. at Hood #3. Processed 7 sample sets and cover slips	07:50–11:26 12:49–14:26 (313)	4.4	1.3	Not Measured
Sample Prep. at Hood #1. Used Xylene for some sets.	09:26–11:55 13:00–14:26 (235)	6.2	3.8	0.16
NIOSH REL		400	1000	100

These results show that worker exposures to the measured solvents were well below NIOSH criteria for the monitoring period.

Sterile Fly Facility

A PBZ and area sample was collected during the use of isopropyl alcohol to disinfect the Diet Prep Room in the Sterile Fly facility. This activity, which entails washing down the walls and ceiling with a 30% isopropyl alcohol/water solution, is conducted daily. During the monitoring, the employee washing the walls with isopropyl alcohol wore a NIOSH certified full–face air–purifying respirator with a combination organic vapor/acid gas cartridge. The employee also wore rubber gloves and a hat. This employee indicated he had been trained and fit–tested; however, he was not clean shaven and facial hair was present in the face to facepiece seal area. This task, which takes approximately 5–6 minutes to complete, had not been previously monitored.

The isopropyl alcohol/water solution is mixed in a small tank with a hand–wand sprayer and is dispensed at approximately 40 psi. Prior to spraying the alcohol solution, the worker places a warning sign on the outside of the Diet Prep room to notify personnel not to enter. The sign is kept in place for 15–20 minutes after spraying. After washing down the room, the worker immediately leaves and does not enter again for 15 minutes.

The area sample was collected in the center of the Diet Prep room during the spraying and 15–minute waiting period. Personal monitoring began with the preparation of the alcohol solution and continued until the worker left the Diet Prep room.

The PBZ monitoring results (11–minute sample) from the worker conducting the spraying showed a concentration of **258 ppm** isopropyl alcohol. The 22–minute area sample showed a concentration of **206.6 ppm** isopropyl alcohol. Both samples were below the NIOSH REL of 400 ppm as a 10–hour TWA and 500 ppm as a 15–minute Short–Term Exposure Limit (STEL). Because this task is of short duration and only takes place once a day, the STEL is the most appropriate criteria for assessing this task.

Chemical Storage and Handling

Each laboratory has a separate chemical storage area with a flammable liquids storage cabinet, and shelving for reagents and other laboratory–scale chemicals. Inspection of these storage areas identified several chemicals that appeared outdated, and were no longer (or rarely) used. Some of these chemicals are of particular concern because of their toxic properties. These included: carbon tetrachloride, benzene, methyl cellosolve, and formaldehyde. In one area, nitric acid (oxidizer) was stored in the flammable storage cabinet. Incompatible chemicals such as oxidizers and flammable solvents should not be stored together

Isopropyl alcohol is obtained from a bulk distribution system with two fill stations in the Entomology Department. Fill stations were located in other areas but have been shut–down because of safety concerns. Personnel from other DPI areas, including the Sterile Fly facility, obtain isopropyl alcohol from this system. In some cases personnel must transport 2–gallons (e.g., Sterile Fly facility) of isopropyl alcohol through the building and across parking lots. Excessive manual transport of chemicals is undesirable because of the potential for spillage.

Improperly stored chemicals were noted in some of the other areas inspected. A 1–gallon container of formalin was found on top of the flammable storage cabinet in Nematology, and waste flammable solvents in open containers were inside the plexiglass hoods in the Entomology Slide Laboratory. Chemicals in the Entomology Slide Laboratory are stored under the cabinet.

In general, container labeling was excellent throughout the DPI complex. A system using chemical identity and a hazard ranking has been implemented. However, a few exceptions were noted in both the main laboratories and individual office work areas. Several 100–milliliter to 1–liter jars of chemicals were found with no labels, and the contents could not be identified.

DPI is considering implementing a common chemical storage area outside the facility, and eliminating the satellite storage areas in each laboratory. Centralized chemical storage systems have both advantages and disadvantages. Some of the advantages include:

- Enhanced management for inventory, access control, and security.
- The bulk of the chemicals would be outside the occupied building.
- Emergency response in the event of an accident (bulk of chemicals in one location)
- There may be fire or building code advantages

Disadvantages include:

- Additional chemical handling and transport necessary to move chemicals to use locations.
- Tendency to "stockpile" chemicals in use areas to ensure sufficient volumes are on–hand and to reduce administrative delays.
- There may be fire or building code disadvantages (e.g., large quantity requirements, transport through egress corridors)

Indoor Environmental Quality

In response to concerns about general air quality, a limited assessment was conducted that entailed measurement of standard indoor environmental quality (IEQ) parameters (CO_2, temperature, relative humidity [RH]) and a brief inspection of the Plant Pathology HVAC system. Specific ventilation parameters (e.g., air exchange rates, outside air volumes, etc.) were not measured. Appendix A contains background information regarding IEQ, including the rationale for monitoring CO_2 and other IEQ indices. Appendix B provides information on microbial contamination in indoor environments, as well as general recommendations regarding contaminated HVAC systems. A guidance document, *NIOSH/EPA, Building Air Quality: A Guide for Building Owners and Facility Managers* was provided to DPI during the site visit. The results of the IEQ monitoring conducted on September 18, 1996, are shown in the following table:

Location	Time	RH %	Temp. °F	CO_2 (ppm)
PP–101	07:50	66	73	575
	10:45	65	72	475
Outside	07:05	89	77	375
	11:10	71	85	350
E–121	10:50	52	74	600

RH% = relative humidity ppm = parts per million

The CO_2 monitoring suggests that sufficient outside air is being provided to occupied areas. Temperatures were also within recommended ranges. The relative humidity in Plant Pathology room 101, however, was above the recommended maximum level of 60 RH%.

Outside air (OA) is obtained from roof–mounted intakes and provided to each air–handler unit (AHU). Return air (RA) is obtained through large wall–mounted grilles located in corridors adjacent the mechanical room housing the AHU. RA and OA are mixed in a plenum, filtered and conditioned, and distributed via ductwork to occupied areas. Smoking is not allowed in the building.

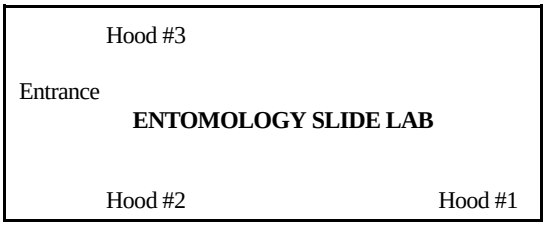
Some tenants have blocked supply vents in an attempt to alter air flow in their work areas. This practice affects ventilation in other areas serviced by the same system. Discussions with tenants indicated that recent duct–cleaning efforts have shown favorable results (less odor and debris complaints).

Local Exhaust Ventilation

Low (lab–scale) quantities of solvents (isopropyl alcohol, ethyl alcohol, xylene, phenol) are used in the Entomology Slide Lab and three table–top plexiglass backdraft exhaust hoods have been installed for this use. Flexible duct connects the back of the hood to an exhaust fan. On all three hoods the laboratory worker uses a microscope that is outside the hood envelope. Each hood is equipped with a rheostat (unlabeled) that controls fan speed, and there are wall–mounted electrical outlets inside each hood for connection to stirrers, hot plates, and the microscope.

Waste solvent stored in open glassware was observed in the hoods. One of the waste solvent beakers was immediately below the electrical outlet inside the hood. This potential fire hazard was pointed out and the beaker relocated. Except for the employee conducting the procedures using phenol, disposable gloves were worn by employees during their work in the hood. Skin absorption represents a major route of entry for phenol (both vapor, liquid, and solid phenol), as phenol will rapidly penetrate the skin.[4] Significant systemic toxic effects (lung, central nervous system damage) have occurred following percutaneous absorption of phenol.[4] Because of the small volumes of chemicals used, the potential for dermal contact appeared to be minimal.

Hood measurements in the Entomology Slide Lab were as follows:



Hood	Dimensions	Avg. Velocity (fpm)	Volume (cfm)
#1	18"X21" = 2.6 ft^2	44	114
#2	18"X33" = 4.1 ft^2	43	176
#3	13"X33" = 2.8 ft^2	35	98

fpm = feet per minute
cfm = cubic feet per minute

Face velocity alone is not sufficient to assess hood performance, as other factors such as location, traffic patterns, and turbulence may affect air patterns. For instance, a 60 fpm face velocity may be sufficient, but only under ideal conditions and work practices, while extremely high face velocities may be less efficient due to increased eddy currents and poor air distribution.[16,17] In general, if local exhaust ventilation is necessary to control exposure during laboratory activities, an average face velocity of 80-120 fpm is usually sufficient.[16,17]

Respiratory Protection

Respirator use is limited to certain specific tasks, including: addition of hydrochloric acid to the sterile fly diet mix; preparation of cyanide–containing insect traps; certain pesticide applications; washing down walls with isopropyl alcohol in the sterile fly facility; mixing and handling of vermiculite in the sterile fly facility. A written respiratory program has been established, and respirator users are trained and fit–tested. Individuals needing respiratory protection are issued their own respirator, and are responsible for cleaning and maintenance. Exposure monitoring has been conducted for some, but not all, tasks where respiratory protection is used.

During the addition of hydrochloric acid to the sterile fly diet mix, the employee wore a NIOSH certified half–mask air purifying respirator with a combination organic vapor/acid gas/HEPA filter cartridge. Additional protective equipment worn during this task included rubber boots, goggles, face–shield, and gloves. DPI personnel indicated that this activity had been monitored with direct–reading colorimetric detector tubes; however the results were not available for review.

Disposable respirators (e.g., 3M 8710 dust/mist) are available for any DPI employee who desires to use one, and users are not required to participate in the respiratory protection program. Some employees working with vermiculite used these disposable respirators. Although disposable respirators are commonly referred to as "dust masks," they are considered respirators and their use should be included in the facility respiratory protection program.

As previously noted, the employee conducting the isopropyl alcohol washdown in the Diet Prep room wore a full–face respirator but was not clean shaven. Facial hair in the face to facepiece seal prevents a proper seal, results in considerable leakage, and can create a false sense of security where the worker believes he/she is protected. Even if respirator use is optional (i.e., exposure during the isopropyl alcohol washdown was below the REL and respiratory

protection is therefore not mandatory), users should adhere to the requirements of a respiratory protection program.

Sound Level Monitoring

Sound levels were monitored in the Herbarium (N–116) and in the Personnel Office (A–113) in response to concerns about noise generated from nearby mechanical rooms housing HVAC units. The monitoring was conducted with a calibrated Quest Type II sound level meter operating in the slow–response mode. All measurements were obtained with conversation at a minimum. Monitoring was conducted using different frequency–weighting scales – A and C. The A–scale is the most commonly used weighting curve, and is used for regulatory purposes because this scale approximates the frequency response of human hearing. As such, the A–scale discriminates against lower frequency noises (e.g., less than 500 hertz). The C–weighting scale is much "flatter" (does not discriminate much at the lower frequencies). Although the information obtained is limited, comparing successive C– and A–scale readings can help determine if a noise source has significant low–frequency components (the C–scale values will be greater than the A–scale values). Appendix C contains additional information, including occupational exposure criteria for noise. A noticeable "rumbling" sound was present in both areas monitored, with the obvious source the adjacent mechanical room.

The results of the sound level monitoring were as follows:

Room	dB(A)	dB©
N–116	50–52	80
A–113	53–54	76

dB(A) = decibels, A–scale,
dB© = decibels, C–scale

The sound level monitoring confirms that there is low–frequency noise present, and that the source is likely machinery in the mechanical room. Although the sound levels in these office areas are well below occupational exposure criteria or levels sufficient to cause hearing damage, employees were concerned about the annoyance effect of this noise. Non–auditory effects of noise are somewhat subjective and difficult to quantitate, but distraction and interference with speech have been reported.[20]

Soil Sampling

In the Nematology department, soil samples are routinely received (approximately 15,000 soil samples annually are processed by FL DACS) for nematode inspection by laboratory personnel. The samples are processed by filtering and spraying with high–pressure water at wash stations in the Nematology laboratory. This results in water mist and spray droplet generation at these stations. Laboratory workers estimated they spend approximately 3.5 hours a day processing soil samples. Information about the soil (e.g., what pesticides, etc. it may have been treated with) is often lacking, and there is concern that exposures may occur when processing the soil. Most (but not all) employees wear disposable (surgical latex) gloves when handling the soil. The nematologists indicated that maximum dexterity is necessary for this process and the use of more cumbersome gloves would not be possible. Written procedures have been developed and standard policy is to discard the sample and speak with the inspector who collected it if a problem is suspected (e.g. odor, visible residue). Plant inspectors have been instructed to notify Nematology of any known contamination.

Miscellaneous Findings

In some areas (e.g., africanized bee slide preparation, electrophoresis) laboratory activities are conducted in former office or other locations not originally intended for laboratory applications. As such, chemical use, which may entail volatile and odorous

compounds, takes place without local exhaust ventilation, and in areas supported by the same general ventilation system that services non–lab spaces.

Most areas inspected had designated areas with chemical spill cleanup supplies. Emergency shower and eyewash facilities were also present throughout the DPI complex. One exception noted was the electrophoresis laboratory where eyewash/emergency shower facilities were not located in this area.

During the addition of HCL to the diet mix, the mechanical pump and hose from the 55–gallon drum of HCL is used for dispensing the final measured amounts into a 1–liter graduated cylinder. This is an awkward arrangement as fine control with this mechanical pump is difficult.

DISCUSSION

A good safety and health program has been established, reflecting the effort and resources dedicated to safety in the DPI organization. Major safety and health issues (e.g., program development, safety officer establishment, etc.) have been addressed and resolved. Most of the employee safety and health concerns at this time seemed to involve unknown or uncertain situations (e.g., what is the potential risk and is it acceptable), or intractable issues due to facility limitations (e.g., HVAC system improvements).

Ideally, laboratories should be serviced by a dedicated HVAC system operating in a single–pass mode (100% make–up air, general exhaust air is not recirculated), and under negative pressure with respect to other areas. Many new laboratory facilities use this type of design criteria. Older existing laboratories, such as the DPI complex, were constructed prior to the development of these specifications and are functioning as dual–occupancy facilities. Appendix A of the Occupational Safety and Health Administrations (OSHA) regulation 29CFR 1910.1450, *Occupational Exposure to Hazardous Chemicals in Laboratories* contains provisions specifying the amount of general ventilation recommended for laboratories. Noting that general ventilation should not be relied on for protection against toxic substances released into the laboratory, OSHA indicates that a rate of 4–12 room air changes per hour (Ach/Hr) is normally adequate.

In general, local exhaust ventilation should be provided for operations where volatile chemicals are routinely used. However, the potential hazard (toxicity, volatility, volumes used, maximum credible accident concentrations, etc.) should be considered when determining specific requirements. Another important factor regarding the need for and extent of ventilation is the potential for unwanted migration of odorous chemicals (even if the concentrations are below exposure limits). With some possible exceptions, most chemical use in the Nematology, Plant Pathology, and Entomology labs is on a very small scale, and entails compounds of a relatively low order of toxicity.

CONCLUSIONS

A review of general safety and health programs and procedures at the FDACS DPI complex did not identify any immediate hazards. A good safety and health program has been established that incorporates both employees and management input. Although a comprehensive exposure assessment was not conducted for all areas, monitoring in the Entomology Slide Lab did not identify any concerns with overexposure to the compounds assessed. One personal sample obtained during the pupae sieving operation in the Sterile Fly facility found a higher than desirable concentration of respirable dust, and recommendations to improve this operation are made in this report. Areas where improvements in the safety and health program should be implemented include respiratory protection, ventilation, chemical storage and handling, and labeling.

RECOMMENDATIONS

Chemical Storage, Handling, and Use

1. With some exceptions, the volumes of chemicals used at DPI are relatively low. Large volumes of chemicals were not being stored (each areas 30–gallon flammable storage cabinet seemed adequate) and each area had chemical spill response capability. As such, with some exceptions, there were no obvious safety and health problems associated with the current chemical storage system.

Having access to chemicals that are used on a daily basis in each laboratory will significantly reduce the need to continually transport chemicals throughout the building, and thus reduce the potential for accidents. Any decisions to implement a common chemical storage area should carefully consider the impact of limited access and increased chemical handling for laboratory workers.

2. All chemicals should be properly stored in the appropriate cabinet after use. Laboratory hoods should not be used for chemical storage. Spent chemicals should be stored in designated, labeled, and sealed containers prior to final disposal. Incompatible chemicals (e.g., oxidizers and flammables) should not be stored in the same cabinet or space. Acetic acid is a flammable organic acid and should not be stored with oxidizers (e.g., nitric acid, hydrogen peroxide).

3. Each laboratory should include chemical container labeling as an item for inspection during routine safety reviews. Any identified deficiencies should be immediately corrected.

4. Consider obtaining a small table–top flammable (e.g. 3–5 gallon capacity) liquids storage cabinet for the Entomology Slide Laboratory to ensure that the solvents used/stored in this room are properly secured.

5. Protective gloves should be worn by all laboratory workers handling chemicals (e.g., phenol use in the Entomology Slide Laboratory). Because the chemical use is lab–scale and not continuous, disposable gloves are an option for some of these tasks. There are several types of disposable gloves available commercially that could be used (e.g., nitrile). Note that the use of this type of glove is only for immediate protection against incidental contact; if chemical does contact the glove, the hands should be immediately washed and the gloves discarded.

6. A source for obtaining isopropyl alcohol should be provided at the Sterile Fly facility to eliminate the need for transporting this chemical from the Entomology Department.

7. Routine hazard reviews should be conducted for all new and established chemical use procedures to ensure the appropriate precautions are implemented. However, because of their particular hazard properties, all procedures requiring the use of formaldehyde (formalin), benzene, carbon tetrachloride, chloroform methyl cellosolve, mercury, cyanides, and phenol should be specifically reviewed, and the need for continued use of these materials determined. For those procedures where less–toxic substitutes are not available, a comprehensive assessment including evaluating the potential for exposure during use should be conducted. Note that the above list is based on my review of chemicals in each laboratory's storage cabinet and may not be complete. This list is not intended to exclude other chemicals used at DPI. Prudent practices for work with all laboratory chemicals include minimizing exposures, using less–toxic materials where feasible, and providing adequate ventilation. DPI has a well–written Chemical Hygiene Plan and efforts should continue to ensure the program is fully implemented.

Respiratory Protection

1. Ensure the no–facial hair policy is enforced for respirator users.

2. Include the "dust–masks" in the DPI respirator program and ensure that access to these respirators is restricted to trained and authorized users.

3. To ensure that the proper respirator is selected, exposure assessments should be conducted and documented for all activities where respiratory protection is required.

4. PBZ air sampling for vermiculite during the pupae sieving operation found exposure to respirable dust in excess of the ACGIH TLV for the duration of the task, although the full–shift TWA exposure (assuming no vermiculite exposure for the remainder of the workday) is less than the TLV–TWA for respirable PNOC. The worker conducting this task wore a 3M 8710 (TC–21C–132) particulate dust/mist (DM) respirator. These respirators were certified under old regulations (30 CFR 11) that have since been revised and replaced with new respirator certification regulations (42 CFR 84). However, until they are phased out, respirators certified under the old regulations will still be available and on the market until July 1998.

Research has shown that particles sized 2 micrometers (2 µmd) or less can penetrate some DM filters certified under 30 CFR 11, and these filters should only be used if the particle size of the aerosol present in the workplace has been characterized, and the mass median aerodynamic diameter (MMAD) is known to be greater than 2 µmd.[21] Under the new regulations, particulate filters are tested under much more demanding conditions, using the most penetrating aerosols. As such, these filters are effective against any size aerosol

Because the particle size of the vermiculite dust is not known, until effective ventilation controls can be implemented, personnel conducting this operation should use a DM respirator certified under the new NIOSH respirator certification regulations. The minimum protective filter that should be used is N95. These respirators will have a certification label with the NIOSH and Department of Health and Human Services (DHHS) emblem, with a numbering sequence of TC–84A–xxxx.

Soil Sampling

Traditional exposure monitoring is not applicable to this activity as each soil sample received is unique and, with few exceptions, the presence of contaminants (pesticides, herbicides, fertilizers, etc.) is not known. As such, assessing the hazard associated with this activity is difficult. Procedures have been developed for handling suspected contaminated samples. However, these are based on the presence of visible residue or an unusual odor when the soil sample bag is opened. Although these are prudent precautions, pesticide contamination can still be present without odor or visible residue, and the senses should not be used for determining when precautions should be taken.

Because of the issues noted above, a "universal precautions" approach for handling soil samples is recommended, and reasonable efforts to reduce the potential for aerosolizing soil/water during processing should be taken. Gloves should be worn when handling the soil (there are several types of disposable gloves that would provide sufficient dexterity) at all times. Until aerosol–reducing procedures are implemented, faceshields should be worn to reduce the potential for direct contact. Alternative soil processing methods should be identified; employees conducting this activity should be asked to provide ideas on this issue.

Ventilation

1. The integrity of the hoods in the Entomology Slide lab should be reviewed from an electrical/fire safety standpoint to ensure they are intrinsically safe. Laboratory fume hoods should be constructed of non–combustible, nonporous material. Criteria for laboratory hoods are available from a number of sources.[17] Flammable solvents are used in these hoods and any potentially spark–producing equipment (switches, outlets) should be outside of

the hood. Switches (e.g., fan speed controller) should be labeled.

2. Although the flow rates in the Entomology Slide lab hoods were below typical hood face velocities (60–120 fpm), exposures to the chemicals measured were well below their respective RELs. In general, an exhaust hood is considered adequate if, in combination with good laboratory practice, worker exposures are below the applicable criteria.[17] However, future activities, or more extensive procedures may take place in these hoods. The presence of a laboratory hood suggests that chemical handling activities can be safely conducted within the hood. As such, the hoods should be re–designed and configured to provide a minimum face velocity of 80 fpm. The hoods should be included in routine laboratory fume hood ventilation assessments.

3. Employees should be instructed not to tamper with the ventilation system (e.g., blocking supply vents), and to contact facilities maintenance if problems with the ventilation system are encountered.

4. Future upgrades and modifications to the HVAC system should incorporate current laboratory design practices as much as possible. These include maintaining laboratory areas under negative pressure with respect to the rest of the building, and controlling recirculated air. Increased humidity control capability should also be incorporated into any future upgrades.

5. Provide local exhaust ventilation control at the front end of the rotary sieve to control vermiculite dust during use. The design should encompass capturing the contaminant as close to the source of generation as possible while still allowing room for the work to be conducted. This will maximize the efficiency of the system and minimize the amount of exhaust air. The system should be designed or reviewed by a qualified industrial hygienist or engineer with experience in local exhaust ventilation systems.

There was some discussion regarding the use of portable "ductless" lab hoods as a means for controlling emissions where laboratory activities take place in areas not originally intended for laboratory use and without local exhaust ventilation capacity. Examples include the Africanized Bee Slide Preparation room and the Electrophoresis laboratory, where small volumes of chemicals are used, some of which are volatile. Ductless hoods typically are equipped with a particulate (e.g., HEPA) or gas/vapor (e.g., activated charcoal) filter that must be monitored and replaced after some period of use.

In general, ductless hoods should only be used for activities that could normally take place on an open bench without presenting an exposure hazard.[17] Additionally, they should only be used for materials of relatively low toxicity that have good warning properties (odor) to provide an early indication if the filter is not operating properly. There are limited applications in laboratories because of the wide variety of chemicals used. However, they can be useful for controlling odors during limited solvent use – such as slide preparation, provided that the adsorbent filter properties are effective for the compound(s) in use. They may also be appropriate if the contaminant is particulate, and provisions are made for changing the filters routinely.

Miscellaneous Recommendations

1. Spill control supplies and emergency eyewash facilities should be provided for the Electrophoresis Laboratory.

2. In addition to the other PPE routinely worn during the addition of HCL to the diet mix, a chemical resistant apron should also be worn for additional splash protection. An alternative means to better control the volume of HCL added to the graduated cylinder should be used. One suggestion is to use a secondary container (e.g., 1–gallon bottle) to add HCL to the graduated cylinder.

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APPENDICES

Appendix A – Indoor Environmental Quality

A number of published studies have reported a high prevalence of symptoms among occupants of office buildings.[1,2,3] NIOSH investigators have completed over 1200 investigations of the indoor environment in a wide variety of settings. The majority of these investigations have been conducted since 1979.

The symptoms reported by building occupants have been diverse and usually not suggestive of any particular medical diagnosis or readily associated with a causative agent. A typical spectrum of symptoms has included headaches, unusual fatigue, varying degrees of itching or burning eyes, irritations of the skin, nasal congestion, dry or irritated throats, and other respiratory irritations. Typically, the workplace environment has been implicated because workers report that their symptoms lessen or resolve when they leave the building.

Scientists investigating indoor environmental problems believe that there are multiple factors contributing to building–related occupant complaints.[4,5] Among these factors are imprecisely defined characteristics of HVAC systems, cumulative effects of exposure to low concentrations of multiple chemical pollutants, odors, elevated concentrations of particulate matter, microbiological contamination, and physical factors such as thermal comfort, lighting, and noise.[3,1,2,4] Reports are not conclusive as to whether increases of outdoor air above currently recommended amounts ($\geq$15 cubic feet per minute per person) are beneficial.[6] However, rates lower than these amounts appear to increase the rates of complaints and symptoms in some studies.[7] Design, maintenance, and operation of HVAC systems are critical to their proper functioning and provision of healthy and thermally comfortable indoor environments. Indoor environmental pollutants can arise from either outdoor or indoor sources.[8]

There are also reports describing results which show that occupant perceptions of the indoor environment are more closely related to the occurrence of symptoms than the measurement of any indoor contaminant or condition.[9] Some studies have shown relationships between psychological, social, and organizational factors in the workplace and the occurrence of symptoms and comfort complaints.[10,11]

Less often, an illness may be found to be specifically related to something in the building environment. Some examples of potentially building–related illnesses are allergic rhinitis, allergic asthma, hypersensitivity pneumonitis, Legionnaires' disease, Pontiac fever, carbon monoxide poisoning, and reaction to boiler corrosion inhibitors. The first three conditions can be caused by various microorganisms or other organic material. Legionnaires' disease and Pontiac fever are caused by *Legionella* bacteria. Sources of carbon monoxide include vehicle exhaust and inadequately ventilated kerosene heaters or other fuel–burning appliances. Exposure to boiler additives can occur if boiler steam is used for humidification or is released by accident.

Problems that NIOSH investigators have found in the non–industrial indoor environment have included poor air quality due to ventilation system deficiencies, overcrowding, volatile organic chemicals from office furnishings, machines, structural components of the building and contents, tobacco smoke, microbiological contamination, and outside air pollutants; comfort problems due to improper temperature and relative humidity conditions, poor lighting, and unacceptable noise levels; adverse ergonomic conditions; and job–related psychosocial stressors. In most cases, however, no cause of the reported health effects could be determined.

Standards specifically for the non–industrial indoor environment do not exist. NIOSH, the Occupational Safety and Health Administration (OSHA), and the American Conference of Governmental Industrial Hygienists (ACGIH) have published regulatory standards or recommended limits for occupational exposures.[12,13,14] With few exceptions, pollutant

concentrations observed in the office work environment fall well below these published occupational standards or recommended exposure limits. The ASHRAE has published recommended building ventilation design criteria and thermal comfort guidelines.[15,16] The ACGIH has also developed a manual of guidelines for approaching investigations of building–related symptoms that might be caused by airborne living organisms or their effluents.[17]

Measurement of indoor environmental contaminants has rarely proved to be helpful, in the general case, in determining the cause of symptoms and complaints except where there are strong or unusual sources, or a proved relationship between a contaminant and a building–related illness. However, measuring ventilation and comfort indicators such as carbon dioxide (CO_2), temperature, and RH is useful in the early stages of an investigation in providing information relative to the proper functioning and control of HVAC systems.

Carbon Dioxide

Carbon dioxide is a normal constituent of exhaled breath and, if monitored, can be used as a screening technique to evaluate whether adequate quantities of outside air are being introduced into an occupied space. ASHRAE's most recently published ventilation standard, ASHRAE 62-1989, Ventilation for Acceptable Indoor Air Quality, recommends outdoor air supply rates of 20 cubic feet per minute per person (cfm/person) for office spaces, and *15 cfm/person for reception areas, classrooms, libraries, auditoriums, and corridors*.[16] Maintaining the recommended ASHRAE outdoor air supply rates when the outdoor air is of good quality, and there are no significant indoor emission sources, should provide for acceptable indoor air quality.

Indoor CO_2 concentrations are normally higher than the generally constant ambient CO_2 concentration (range 300-350 parts per million [ppm]). Carbon dioxide concentration is used as an indicator of the adequacy of outside air supplied to occupied areas. When indoor CO_2 concentrations exceed 1000 ppm in areas where the only known source is exhaled breath, inadequate ventilation is suspected. Elevated CO_2 concentrations suggest that other indoor contaminants may also be increased. It is important to note that CO_2 is not an effective indicator of ventilation adequacy if the ventilated area is not occupied at its usual level.

Temperature and Relative Humidity

Temperature and RH measurements are often collected as part of an indoor environmental quality investigation because these parameters affect the perception of comfort in an indoor environment. The perception of thermal comfort is related to one's metabolic heat production, the transfer of heat to the environment, physiological adjustments, and body temperature.[18] Heat transfer from the body to the environment is influenced by factors such as temperature, humidity, air movement, personal activities, and clothing. The American National Standards Institute (ANSI)/ASHRAE Standard 55-1992 specifies conditions in which 80% or more of the occupants would be expected to find the environment thermally acceptable.[15] Assuming slow air movement and 50% RH, the operative temperatures recommended by ASHRAE range from 68–74ºF in the winter, and from 73–79°F in the summer. The difference between the two is largely due to seasonal clothing selection. In separate documents, ASHRAE also recommends that RH be maintained between 30 and 60% RH. Excessive humidities can support the growth of microorganisms, some of which may be pathogenic or allergenic.

Monitoring Methodology

A. Carbon Dioxide (CO_2)

Instantaneous measurements of CO_2 concentrations were obtained using a Gastech Model RI–411A Portable (direct reading) CO_2 monitor. The principle of detection is non–dispersive infrared absorption. The instrument was zeroed (zero CO_2 gas source) and calibrated prior to use with a known CO_2 source (span gas). The monitor provides CO_2

concentrations in 25 parts per million (ppm) increments with a range of 0 – 4975 ppm. Measurements were obtained at various intervals and locations throughout the building. Outdoor readings were taken to determine baseline CO_2 levels.

B. **Temperature and Relative Humidity (RH)**

Dry bulb temperature and RH levels throughout the building were determined at various intervals. Outdoor readings were obtained for comparison purposes. Instrumentation consisted of a TSI, Inc. model 8360 VelociCalc® meter with a digital readout. This unit is battery operated and has humidity and temperature sensors on an extendable probe. The temperature range of the meter is 14 to 140° F and the humidity range is 20 – 95%. Temperature and RH, as determined via standard dry bulb, wet bulb, and psychrometric chart correlated well with levels determined via the VelociCalc® meter.

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Appendix B – Microbial Contaminants

Microorganisms (including fungi and bacteria) are normal inhabitants of the environment. The saprophytic varieties (those utilizing non–living organic matter as a food source) inhabit soil, vegetation, water, or any reservoir that can provide an ample supply of a nutrient substrate. Under the appropriate conditions (optimum temperature, pH, and with sufficient moisture and available nutrients) saprophytic microorganism populations can be amplified. Through various mechanisms, these organisms can then be disseminated as individual cells or in association with soil/dust or water particles. In the outdoor environment, the levels of microbial aerosols will vary according to the geographic location, climatic conditions, and surrounding activity. In a "normal" indoor environment, the level of microorganisms may vary somewhat as a function of the cleanliness of the HVAC system and the numbers and activity level of the occupants. Generally, the indoor levels are expected to be below the outdoor levels (depending on HVAC system filter efficiency) with consistently similar ranking among the microbial species.[1,2]

Some individuals manifest increased immunologic responses to antigenic agents encountered in the environment. These responses and the subsequent expression of allergic disease is based, partly, on a genetic predisposition.[3] Allergic diseases typically associated with exposures in indoor environments include allergic rhinitis (nasal allergy), allergic asthma, allergic bronchopulmonary aspergillosis (ABPA), and extrinsic allergic alveolitis (hypersensitivity pneumonitis).[4] Allergic respiratory diseases resulting from exposures to microbial agents have been documented in agricultural, biotechnology, office, and home environments.[5,6,7,8,9,10,11,12]

Individual symptomatology varies with the disease. Allergic rhinitis is characterized by paroxysms of sneezing; itching of the nose, eyes, palate, or pharynx; nasal stuffiness with partial or total airflow obstruction; and rhinorrhea (runny nose) with postnasal drainage. Allergic asthma is characterized by episodic or prolonged wheezing and shortness of breath in response to bronchial (airways) narrowing. Allergic bronchopulmonary aspergillosis is characterized by cough, lassitude, low–grade fever, and wheezing.[13] Heavy exposures to airborne microorganisms can cause an acute form of extrinsic allergic alveolitis which is characterized by chills, fever, malaise, cough, and dyspnea (shortness of breath) appearing four to eight hours after exposure. In the chronic form, thought to be induced by continuous low–level exposure, onset occurs without chills, fever, or malaise and is characterized by progressive shortness of breath with weight loss.[14]

Acceptable levels of airborne microorganisms have not been established, primarily because allergic reactions can occur even with relatively low air concentrations of allergens, and individuals differ with respect to immunogenic susceptibilities. The current strategy for on–site evaluation of environmental microbial contamination involves an inspection to identify sources (reservoirs) of microbial growth and potential routes of dissemination. In those locations where contamination is visibly evident or suspected, bulk samples may be collected to identify the predominant species (fungi, bacteria, and thermoactinomycetes). In limited situations, air samples may be collected to document the presence of a suspected microbial contaminant. Air sample results can be evaluated epidemiologically by comparing those from the "complaint areas" to those from non–complaint areas, or by relating exposure to immunologic findings.

Microbial Decontamination in HVAC Systems – Recommendations

1. All sources of moisture in or near the AHU, including the leaks in the foundation, standing water in the condensate drain pans of the cooling coils, and standing water in the sumps located in the ventilation system, should be identified and repaired.

2. Contaminated or moisture–damaged fiberglass sound liners should be discarded and replaced,

preferably with a smooth–surfaced insulation to prevent the collection of microbial contaminants. Subsequent to the removal of the insulation, all surfaces (nonporous and porous) should be dried and cleaned with a high–efficiency particulate air (HEPA)–filtered vacuum to remove dirt, debris, and microorganisms before removal. The surface of the insulation should not be damaged by vacuuming. All remedial activities should be performed when the building is vacant and when the HVAC system is decommissioned. All materials should be discarded appropriately according to state and local regulations.

During renovation, the spread of contaminants (e.g., bioaerosols, debris, and fiberglass fibers) through recirculation of air to occupied spaces needs to be controlled. This may be accomplished by: (1) isolating areas being renovated from the rest of the building (including negative pressurization to prevent exfiltration of contaminated air), (2) exhausting air contaminants from the area undergoing renovation directly to the outdoors, and (3) sealing off ductwork to prevent the redistribution of contaminated air and contamination of ductwork.

3. During the removal of any damaged materials, precautions should be taken to minimize exposures to the remediation workers performing the abatement. Remediation efforts should include provisions for the proper protection of the individuals conducting the remediation work. Workers should wear respiratory protection consisting of high efficiency particulate air (HEPA) filters and adequate skin and eye protection.

4. A formal written preventative maintenance schedule for the AHU should be implemented in consultation with the manufacturers of the equipment. Preventative maintenance on the equipment should be documented and the documentation kept in a file to assure continuity between mechanical personnel. The HVAC cooling coils and condensate drip pans should be kept free of standing water and visible microbial growth. Throughout the year, coils, condensate pans, and drains should be inspected monthly and, if necessary, cleaned. Pill packs should not be used to keep the drip pans free of debris or biological growth. These tablets are not effective unless a sufficient pool of water in the pan enables the tablet to dissolve evenly throughout the pan. The floor of the fan room should be kept free of debris which could become entrained into the supply air stream.

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Appendix C – Occupational Noise Criteria

Noise–induced loss of hearing is an irreversible, sensorineural condition that progresses with exposure. Although hearing ability declines with age (presbycusis) in all populations, exposure to noise produces hearing loss greater than that resulting from the natural aging process. This noise–induced loss is caused by damage to nerve cells of the inner ear (cochlea) and, unlike some conductive hearing disorders, cannot be treated medically.[1] While loss of hearing may result from a single exposure to a very impulse noise or explosion, such traumatic losses are rare. In most cases, noise–induced hearing loss is insidious. Typically, it begins to develop at 4000 or 6000 Hz (the hearing range is 20 Hz to 20000 Hz) and spreads to lower and higher frequencies. Often, material impairment has occurred before the condition is clearly recognized. Such impairment is usually severe enough to permanently affect a person's ability to hear and understand speech under everyday conditions. Although the primary frequencies of human speech range from 200 Hz to 2000 Hz, research has shown that the consonant sounds, which enable people to distinguish words such as "fish" from "fist," have still higher frequency components.[2]

The A–weighted decibel [dB(A)] is the preferred unit for measuring sound levels to assess worker noise exposures. The dB(A) scale is weighted to approximate the sensory response of the human ear to sound frequencies near the threshold of hearing. The decibel unit is dimensionless, and represents the logarithmic relationship of the measured sound pressure level to an arbitrary reference sound pressure (20 micropascals, the normal threshold of human hearing at a frequency of 1000 Hz). Decibel units are used because of the very large range of sound pressure levels which are audible to the human ear. Because the dB(A) scale is logarithmic, increases of 3 dBA, 10 dBA, and 20 dBA represent a doubling, tenfold increase, and 100-fold increase of sound energy, respectively. It should be noted that noise exposures expressed in decibels cannot be averaged by calculating a simple arithmetic mean.

The OSHA standard for occupational exposure to noise (29 CFR 1910.95) specifies a maximum PEL of 90 dB(A)-slow response for a duration of eight hours per day.[3] The regulation, in calculating the PEL, uses a 5 dB time and intensity trading relationship, or exchange rate. This means that a person may be exposed to noise levels of 95 dB(A), for no more than 4 hours, to 100 dB(A) for 2 hours, and so on. Conversely, up to 16 hours of exposure to 85 dB(A) is allowed by this exchange rate. NIOSH, in its Criteria for a Recommended Standard, proposed a recommended exposure limit of 85 dB(A) for 8 hours, 5 dB less than the OSHA standard.[4] The 1972 NIOSH criteria document also used a 5 dB time/intensity trading relationship in calculating exposure limits. However, in 1995, NIOSH changed its official recommendation for an exchange rate of 5dB to 3dB.[5] The ACGIH also changed its TLV in 1994 to a more protective 85 dB(A) for an 8–hour exposure, with the stipulation that a 3 dB exchange rate be used to calculate time–varying noise exposures.[7] Thus, a worker can be exposed to 85 dB(A) for 8 hours, but to only 88 dB(A) for 4 hours or 91 dB(A) for 2 hours.

The duration and sound level intensities can be combined to calculate a worker's daily noise dose according to the following formula:

$$\text{Dose} = 100 \text{ X } (C_1/T_1 + C_2/T_2 + ... + C_n/T_n),$$

where C_n indicates the total time of exposure at a specific noise level and T_n indicates the reference duration for that level as given in table G–16a of the OSHA noise regulation.[3] During any 24–hour period, a worker is allowed up to 100% of his daily noise dose. Doses greater than 100% are in excess of the OSHA PEL.

The OSHA regulation also has an action level of 85 dB(A), which stipulates that an employer shall administer a continuing, effective hearing conservation program when the TWA value exceeds the action level. The program must include monitoring, employee notification, observation, audiometric testing, hearing protectors, training

programs, and recordkeeping. All of these requirements are included in 29 CFR 1910.95, paragraphs © through (o).[3]

Finally, the OSHA noise standard requires that when workers are exposed to noise levels in excess of the OSHA PEL of 90 dB(A), feasible engineering or administrative controls shall be implemented to reduce the workers' exposure levels. However, in 1983, a compliance memorandum (CPL 2–2.35) directed OSHA compliance officers to not cite employers for lack of engineering controls until workers' TWA levels exceeded 100 dB(A), so long as the company had an effective hearing conservation program in place. Even when TWA levels are in excess of 100 dB(A), compliance officers are to use their discretion in issuing fines for lack of engineering controls.

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