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SUMMARY

In response to an employee request, the National Institute for Occupational Safety and Health (NIOSH) conducted a health hazard evaluation (HHE) to evaluate possible exposures to formaldehyde, ethyl acetate, carbon dioxide (CO_2), and ultraviolet (UV) radiation in the microbiology laboratory at Manatee Memorial Hospital. Employees were also concerned about exposures to laboratory pathogens. The request stated that some employees were experiencing symptoms such as headaches, sinusitis, and drowsiness. In response to this request, a site visit was conducted on February 2, 1993.

Exposures to CO_2 from an incubator and germicidal ultraviolet (UV) radiation from a Class II Type A biological safety cabinet (BSC) were evaluated during the visit. Chemical usage had been moved to a laboratory hood in another area, so formaldehyde and ethyl acetate air sampling was not conducted. The ventilation performance of the biological safety cabinet was evaluated. All five employees present on the day of the NIOSH visit were interviewed, and selected work procedures were observed.

Room CO_2 concentration measured at 2:30 p.m. was 850 parts per million (ppm). This concentration is less than the NIOSH, the Occupational Safety and Health Administration (OSHA), and the American Conference of Governmental Industrial Hygienists (ACGIH) time-weighed average (TWA) criteria of 5,000 ppm. When the incubator door was opened, instantaneous personal breathing zone concentrations ranged from 1,600 to 5,000 ppm, which are less than the NIOSH, OSHA, and ACGIH short term exposure limit (STEL) of 30,000 ppm.

Ultraviolet radiation levels varied widely, depending on the location of measurement. At eye level directly in front of the BSC, irradiance was approximately 4.0 microwatts per square centimeter ($\mu W/cm^2$) (NIOSH/ACGIH permissible exposure time: 25 minutes). The UV irradiance at an adjacent computer terminal (eye level) was 0.8 $\mu W/cm^2$ (NIOSH/ACGIH permissible exposure time: 120 minutes). Levels at other work locations throughout the laboratory ranged from 0.1 to 0.2 $\mu W/cm^2$ (NIOSH/ACGIH permissible exposure time: $\geq$8 hours).

The performance of the BSC met the National Sanitation Foundation Standard #49 criteria. Face velocities exceeded 75 feet per minute (ft/min).

The employee interviews did not identify factors or exposures that could be specifically correlated to employees' symptoms. Reported symptoms included sleepiness, headaches, and sinusitis. Symptoms reportedly decreased when formaldehyde and ethyl acetate were moved from the BSC to the laboratory hood. The BSC would not have prevented exposures to formaldehyde and ethyl acetate vapors because it discharged air to the laboratory through a high efficiency particulate (HEPA) filter that is ineffective for filtering out gases and vapors.

CO_2 exposures do not present a health hazard to employees in the microbiology laboratory, and the potential for exposures to formaldehyde and ethyl acetate are decreased because procedures utilizing these chemicals have been moved to a laboratory hood. Exposure to UV radiation presents a potential health hazard for employees working near the biological safety cabinet. Recommendations related to the use of UV lamps, procedures and equipment to prevent transmission of airborne and bloodborne disease, and hazard communication training are provided.

KEYWORDS: SIC 8071 (Medical Laboratories), ultraviolet radiation, microorganisms, carbon dioxide, biosafety cabinets.

INTRODUCTION

On November 20, 1992, the National Institute for Occupational Safety and Health (NIOSH) received a request from an employee representative for a Health Hazard Evaluation (HHE) at Manatee Memorial Hospital. The specific health issues identified in the HHE request were headaches, sinusitis, and drowsiness in the microbiology laboratory and their hypothesized relationship to possible chemical exposures (ethyl acetate, carbon dioxide [CO_2], and formaldehyde). The request discussed concerns about exposures to laboratory pathogens. In response to this request, NIOSH conducted a site visit on February 2, 1993.

A NIOSH investigator evaluated exposures to CO_2 from incubators, germicidal ultraviolet radiation (UV) exposures, ventilation performance of a biological safety cabinet (BSC), general room ventilation, and the potential for ethyl acetate and formaldehyde exposures. Employees were interviewed, and the OSHA 200 logs were reviewed.

BACKGROUND

Manatee Memorial is a general medical and surgical hospital licensed for 500 beds. Five employees (medical technologists, technicians) work in the microbiology laboratory during the first shift, while only one works part-time on second and third shifts.

The microbiology laboratory consists of one room with a center work bench, incubators, a biological safety cabinet (BSC), and computer terminals.
The laboratory cultures most types of general bacterial, mycobacterial, and fungal microorganisms typically seen in community hospitals. However, no virology (hepatitis B, human immunodeficiency virus, etc.) is conducted in the laboratory; this work is contracted to an outside laboratory. The laboratory has four incubators, which are temperature and humidity controlled for culturing microorganisms. Elevated CO_2 concentrations can be used in two incubators to enhance microbial growth. During the NIOSH visit, one incubator was maintained with 8.5 percent (85,000 ppm) CO_2.

A Class IIA BSC equipped with a single General Electric #G30T8 30-watt UV lamp is used in the laboratory. The BSC is used for microbiological work having a potential for airborne microbiological transmission (e.g., acid fast bacilli [AFB] cultures). Air within the BSC is recirculated into the work area through a high efficiency particulate air (HEPA) filter. The UV lamp is left on for ½ to 1 hour after work in the BSC is completed. The UV lamp is not normally on while work is conducted inside the BSC.

A formaldehyde-containing product and ethyl acetate are used to prepare fecal ova parasite samples. These chemicals were handled previously within the BSC. Recently the procedures were moved to a laboratory hood in the chemistry laboratory because of employee concerns about exposures. The preparation procedure using these chemicals for a single sample takes less than five minutes. The hospital has a written hazard communication program, a chemical hygiene plan, and a laboratory safety manual.

Laboratory coats and gloves are required in the "non-clean" area of the laboratory. Faceshields are used when streaking culture plates. The counter tops are cleaned with Broadspec® cleaner (contains a quaternary ammonium amine) at least twice daily and more often when required. Bleach is used to clean spills. All employees have received or are currently receiving hepatitis B vaccine injections.

EVALUATION PROCEDURES

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.

CO_2 concentrations were measured throughout the laboratory and around the periphery of the CO_2 incubator. Additionally, personal breathing zone (PBZ) CO_2 measurements were taken with the incubator door open. Measurements were obtained at approximately 2:30 p.m. Outdoor readings were taken to determine baseline CO_2 levels.

Since the procedures having high potential for release of formaldehyde and ethyl acetate vapors were moved to a laboratory hood in the chemistry laboratory, the NIOSH investigator felt that the potential for significant exposure was remote. Therefore, air sampling for these chemicals was not conducted.

BSC and Laboratory Hood

Face velocities of the BSC were determined with thermal anemometer (TSI VelociCalc Plus Model 8360) at six points in the plane of the access opening. TSI VelociCalc Plus Model 8360 is an electronic meter with a digital readout. Velocity is measured by the cooling effect of air as it passes over a heated (hot-wire) sensor at the end of the probe. The instrument's accuracy is ± 2.5% of the reading.

Two rows of measurements were taken. One row was taken at a distance below the top of the access opening equal to 25% of the opening height (about 2 inches). The second row was taken at a distance below the top of the access opening equal to 75% of the opening height (about 6 inches). Face velocities of the laboratory hood were determined with the front sash in the full open position, half open, and approximately one-fourth (eight inches) open.

Ultraviolet Radiation

UV irradiance was measured with a calibrated model 1400A International Light (IL) radiometer connected to a SEL 240 detector that permitted the instrument to read UV levels directly in units of microwatts per square centimeter ($\mu W/cm^2$). The measurement range is 0 to 1000 $\mu W/cm^2$ for emissions in the 200 to 320 nm range. The radiometer was calibrated with a 254 nm UV source within six months of use by the manufacturer.

Occupational exposures to UV radiation were measured at a computer terminal adjacent to the biological safety cabinet, in front of the biological safety cabinet (eye level, 4 feet from floor), and at various work locations in the microbiology laboratory. UV irradiance was also measured inside the BSC.

Room Ventilation

Average air velocities from the supply vents were determined with the TSI VelociCalc Plus Model 8360, and the flow rate was calculated by multiplying this average velocity by the vent area using a correction factor to account for the effect of the vent's air diffuser.[1]

The measured values were then compared to guidelines in the ASHRAE 1991 Handbook, *Heating, Refrigerating, and Air-Conditioning Applications*, Chapter 7 "Health Facilities" and the 1993 Guidelines for Construction and Equipment of Hospitals and Medical Facilities, published by the American Institute of Architects (AIA).[2,3]

Heating, Ventilating, and Air-Conditioning System (HVAC)

The cooling coils, condensate pans, and filters in the HVAC unit serving the laboratory were visually inspected. Building air intakes and exhausts affecting the laboratory were reviewed. The outside air damper was also checked.

Employee Interviews

Five employees from the microbiology laboratory (all employees present on the day of the survey) were interviewed regarding symptoms and perceived causes of reported symptoms.

EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by work place exposures, NIOSH field staff use established environmental criteria for the assessment of a number of chemical and physical agents. These criteria 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 should be noted, however, that not all workers will be protected from adverse health effects if their exposures are below the applicable limit. A small percentage may experience adverse health effects due to individual susceptibility, pre-existing medical conditions, and/or hypersensitivity (allergy).

Some hazardous substances or physical agents may act in combination with other work place exposures or the general environment to produce health effects even if the occupational exposures are controlled at the applicable limit. Due to recognition of these factors, and as new information on toxic effects of an agent becomes available, these evaluation criteria may change.

The primary sources of environmental evaluation criteria for the work place are: 1) NIOSH Criteria Documents and recommendations, 2) the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs), and 3) the U.S. Department of Labor Occupational Safety and Health Administration (OSHA) standards.[4,5,6] Often, NIOSH recommendations and ACGIH TLVs may be different than the corresponding OSHA standard. Both NIOSH recommendations and ACGIH TLVs are usually based on more recent information than OSHA standards due to the lengthy process involved with promulgating federal regulations. OSHA standards also may be required to consider the feasibility of controlling exposures in various industries where the hazardous agents are found; the NIOSH recommended exposure limits (RELs), by contrast, are based primarily on concerns relating to the prevention of occupational disease.

Carbon Dioxide (CO_2)

At high concentrations, CO_2 is a simple asphyxiant, a respiratory stimulant, and both a stimulant and depressant of the central nervous system.[7] Respiratory ventilation is doubled at concentrations of 4% (40,000 ppm) CO_2. Increases in heart rate and blood pressure have been noted at 7.6% (76,000 ppm).[8]

CO_2 is a constituent of exhaled breath, and it is normally present in the atmosphere at concentrations of 350 to 400 ppm. Indoor CO_2 concentrations are usually higher than outdoor concentrations. If there are no sources other than exhaled breath, CO_2 concentrations are usually under 1,000 ppm in buildings with adequate outside air intake.[9]

The NIOSH REL for carbon dioxide is 5,000 ppm as a 10-hour time-weighted average (TWA) with a short term exposure limit (STEL, 15 minutes) of 30,000 ppm. Because of a recent court decision, the OSHA effective exposure limits are those specified as "Transitional Limits" in the air contaminant standard 29 CFR 1910.1000.[10] The OSHA Permissible Exposure Limit (PEL - legally enforceable) and ACGIH TLV currently is 5,000 ppm as an 8-hour TWA with a 30,000 ppm STEL.

BSCs and Laboratory Hoods

According to the National Sanitation Foundation Standard #49, Class II type A cabinets should maintain a minimum average inflow velocity of 75 feet per minute (ft/min) to protect personnel, HEPA-filtered vertical laminar airflow for product protection, and HEPA-filtered exhaust air for environmental protection.[11] Type A cabinets are suitable for microbiological work *in the absence* of volatile or toxic chemicals and radionuclides.[10,12]

The ACGIH recommends that laboratory hoods have a minimum air flow of 80 - 100 cubic feet per minute per square foot full open face area.[13] Additionally, a minimum duct velocity of 1000 - 2000 feet per minute (ft/min) is recommended. The AIA recommends that laboratory hoods have a minimum face velocity of 75 ft/min.[3]

UV Radiation

"Germicidal" UV lamps are low pressure mercury vapor lamps that emit UV radiation centered on a wavelength of 254 nanometers (nm). Although germicidal lamps have been used for many years, currently there are no standardized recommendations regarding effective UV intensity, exposure time, and optimal wavelength of germicidal UV radiation needed to inactivate microorganisms in the air.

Efficacy

The effectiveness of germicidal UV radiation to inactivate microorganisms depends on the intensity of the UV radiation, the duration of contact the organism has with the UV radiation, and the relative humidity.[14] The latest National Sanitation Foundation (NSF) Standard #49 does not recommend the use of UV lamps in BSCs.[10] The NSF Standard #49 states "UV lighting is not recommended in class II biohazard cabinetry. In a dynamic airstream, UV lighting is not penetrating and has limited effectiveness.... UV irradiation can cause erythema of skin and eye damage."

Limited research on germicidal UV radiation efficacy has been conducted in the area of tuberculosis control. In a study conducted more than 30 years ago, guinea pigs were completely protected from becoming infected with *M. tuberculosis* after exposure to air exhausted from infectious patients that had subsequently been treated with germicidal UV radiation.[15,16,17] Other studies cite the effectiveness of germicidal UV radiation in hospitals[18], military housing[19], and classrooms.[20,21,22] One recent study noted that use of germicidal UV lamps in a room reduced culturable airborne bacteria by 14 to 19 percent; the lamps did not reduce the concentration of gram-positive, rod-shaped bacteria, however.[23]

Occupational Exposures

The critical organs of occupational exposure to 254 nm UV radiation are the eyes and skin. At this wavelength, the radiation is absorbed by the outer surface of the eye, and overexposure can result in inflammation of the cornea (photokeratitis) and/or conjunctiva (conjunctivitis).[24]

Keratoconjunctivitis is a reversible injury, lasting 24-48 hours, but it is a debilitating condition while it runs its course. There is a latent period of a few hours, depending upon the dose, so it is sometimes not recognized as an occupational injury by the worker. Skin exposure to UV radiation also can result in erythema (reddening). This is also a reversible injury and the time course depends on the severity of the burn.

UV radiation in the UV-C range (100-290 nm) has been reported to cause sarcomas and squamous cell carcinomas in mice.[25,26] No epidemiological studies have been conducted to ascertain whether radiation in the UV-C range, such as that produced by germicidal lamps, causes cancer in humans. However, UV-C is known to induce DNA dimers in human cell cultures.[27] The carcinogenic effect of UV radiation in mammals is generally thought to be caused by the formation of pyrimidine dimers in cellular DNA that leads to errors in DNA replication and targeted gene mutations.[28]

Exposure Limits

In 1972 NIOSH formulated criteria for a recommended standard for occupational exposure to UV radiation.[5] Because the biological effects from exposure to UV radiation are dependent on the intensity and energy distribution of the source, as shown in Figure 1, the NIOSH recommended exposure limit (REL) is wavelength-dependent in the spectral region of interest (200-315 nm). The REL is based on an action spectrum derived from thresholds for acute effects of erythema and keratoconjunctivitis from both human and animal studies. The REL for 8-hour exposures has a minimum permissible dose level of 0.003 Joules per square centimeter (J/cm^2) at 270 nm. At 254 nm, the predominant UV wavelength for germicidal lamps[29], the REL is 0.006 J/cm^2, since the spectral effectiveness of 254 nm UV is 0.5.

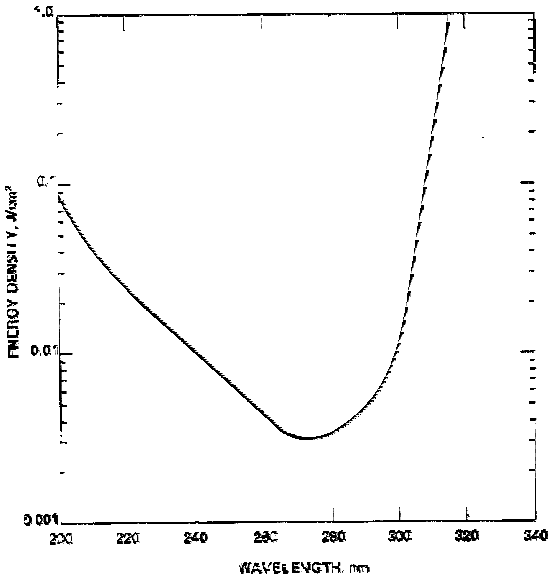

Figure 1: Recommended Ultraviolet Radiation Exposure Standard

If the UV energy is from a broad-band source, the effective irradiance relative to a 270 nm monochromatic source must be calculated using a formula described in the NIOSH criteria document.[5] If the UV energy is from a narrow-band or monochromatic source, permissible dose levels for a daily 8-hour period can be read directly from Figure 1. Permissible exposure times in seconds can be calculated by dividing the 8-hour dose level (i.e., 0.006 J/cm^2 for UV exposure to 254 nm) by the effective UV irradiance in Watts/cm^2).

Table 1
NIOSH Recommended Exposure Limits
Ultraviolet Radiation, 254 nm

Duration of Exposures per day	Effective Irradiance (μW/cm^3)	Irradiance at 254 nm (μW/cm^3)
8 hours	0.1	0.2
4 hours	0.2	0.4
2 hours	0.4	0.8
1 hour	0.8	1.6
30 minutes	1.7	3.4
15 minutes	3.3	6.6

The NIOSH and ACGIH occupational exposure limits, in terms of microwatts per square centimeter (μW/cm^3), are listed in Table 1. Since UV radiation at a wavelength of 254 nm has a spectral effectiveness of 0.5, the permissible exposure levels at 254 nm wavelength are twice the values listed as "effective irradiance." There are no OSHA limits for UV radiation.

HVAC System and Room Ventilation

The American society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) and the AIA have published ventilation guidelines for health care facilities.[2,3] These guidelines specify that microbiology laboratories should be supplied with a minimum of six total air changes per hour (ACH) and be under negative pressure relative to surrounding areas. All air should be exhausted to the outside. The State of Florida's Department of Health and Rehabilitative Services (HRS) ventilation requirements are identical to the ASHRAE and AIA recommendations.[30]
Air filters, coils, and condensate pans inside HVAC units should be free of debris and biological growth. The water inside the condensate pan should drain freely.

RESULTS AND DISCUSSION

CO_2 Concentrations

Room CO_2 concentration measured at 2:30 p.m. was 850 ppm, much less than the NIOSH and OSHA TWA criteria of 5,000 ppm. Instantaneous personal breathing zone concentrations of 1,600 to 5,000 ppm occurred when the incubator door was opened. These concentrations were less than the NIOSH and OSHA STEL criteria of 30,000 ppm. Measurements around the perimeter of the incubator door and the CO_2 inlet hose did not detect any leaks.

BSC and Laboratory Hood

The row of air velocity measurements taken at a distance below the top of the access opening equal to 25% of the opening height (about 2 inches) ranged from 75 to 85 ft/min. The second row, taken at a distance below the top of the access opening equal to 75% of the opening height (about 6 inches), ranged from 125 to 150 ft/min. All measurements were in excess of the NSF Standard #49 recommendation of 75 ft/min. The BSC had been certified on 12/23/92.

The NSF Standard #49 recommends that face velocities of Class II Type A BSCs be determined by measuring the cabinet's exhaust flow and calculating the inflow velocity based on front face opening area. Future measurements should be conducted in this manner.

Face velocities of the laboratory hood varied widely depending on the position of the front sash. When the sash was completely open, velocities ranged from 20 to 40 ft/min. When half open, velocities increased to 30 - 60 ft/min. With an eight inch opening, velocities ranged from to 60 - 120 ft/min. The laboratory hood requires additional evaluation to determine if the hood meets the ACGIH performance criteria. There are no records regarding performance certification of the hood.

UV Radiation

UV radiation levels ranged widely depending on location of measurement. Much of the UV radiation escaping from the BSC probably is reflected from the polished metal surface inside the BSC. At eye level while sitting directly in front of the BSC (about 4 feet from the floor), irradiance was approximately 4.0 $\mu W/cm^2$ (NIOSH/ACGIH permissible exposure time: 25 minutes). At eye level five feet from the BSC, the level was 0.6 $\mu W/cm^2$ (NIOSH/ACGIH permissible exposure time: 166 minutes). At the workstations in the laboratory and at the reception desk, levels ranged from 0.1 to 0.2 $\mu W/cm^2$ (NIOSH/ACGIH permissible exposure time: 8 hours or more). Irradiance at the computer terminal for the Bact T Alert, located immediately adjacent to the BSC, was 0.8 $\mu W/cm^2$ (NIOSH/ACGIH permissible exposure time: 120 minutes).

UV intensity of lamps decrease with age. However, substantial amounts of UV energy were being released from the lamp. On the bottom surface inside BSC (about 2 feet from the bulb), levels were approximately 200 $\mu W/cm^2$ (permissible exposure time: 30 seconds).

Laboratory workers normally do not work near the BSC while the UV lamp is activated. Even at the Bact T Alert computer terminal, workers are exposed for only two or three minutes at a time. All workers were aware that work inside the BSC should not be performed while the UV lamp was activated.

HVAC System and Room Ventilation

Based on the room exhaust and measured room volume, the laboratory had approximately seven air changes per hour (ACH). Fourteen ACH was calculated based on the total air supply to the room. These values are exceed the ASHRAE, AIA, and HRS recommendation of six ACH. Since nearly twice as much air is supplied as exhausted from the microbiology laboratory, the direction of air movement is from the laboratory to surrounding areas (positive pressure). To prevent the spread of contaminants to other parts of the hospital, it is generally recommended that the direction of air flow be from surrounding areas into the laboratory (negative pressure). Additionally, directional control optimally would require installation of a door to the laboratory.

The HVAC unit supplying the laboratory (#MZ-8) was installed in 1967. Chilled water is utilized for cooling. Heating and humidity control is achieved with reheat units. Outside air intake is controlled by an economizer (30% minimum outside air).
The coils had some scale deposits, but no biological growth. The condensate pan appeared clean and was draining properly. The filters were in good condition and had been changed about a month before the inspection. The interior supply ductwork was inspected between the coils and reheat units; a small amount of dust was present (normal condition) and no biological

growth was observed. The outside air intake is near a cafeteria exhaust, so food odor sometimes enters the laboratory. The exhaust is on the fifth floor.

Employee Interviews

Five employees were interviewed. One employee had no complaints. One employee reported occasional thermal comfort problems related to drafts from air vents directly above the work stations. Three employees reported health-related symptoms. One employee reported headaches only. One employee reported sleepiness and sinus problems (runny or stuffy nose), and another employee reported sinus problems, headaches, and job related stress. The sinus problems were thought to be related to formaldehyde and ethyl acetate. The symptoms were reduced when the chemicals were moved to a laboratory hood in the chemistry laboratory. The drowsiness was thought to be related to possible CO_2 exposures from incubators. Reportedly, the symptoms resolved when the employees left work. Four employees did not recall having had hazard communication training.

Injuries recorded on the OSHA 200 logs during the past two years included a needlestick injury while cleaning Bact T Alert needles, a hand laceration, a hand injury involving a door, and a kick by a patient.

CONCLUSIONS

Both ethyl acetate and formaldehyde vapor can cause irritation of sinuses and mucous membranes.[7] These chemicals previously were handled in the BSC. Since air in a Class II type A cabinet is returned to the room through a HEPA filter, non-particulates such as chemical vapors could escape into the laboratory. Possible exposures to these vapors may explain some of the symptoms, but a cause-effect relationship between reported symptoms and past exposures from procedures no longer practiced can not be established. CO_2 concentrations were well below all evaluation criteria and would not be expected to cause drowsiness or central nervous system effects.

Exposures to bioaerosols can cause allergic rhinitis (includes sinusitis and headaches) and asthma. Bioaerosols are airborne particles, that are living or were released from a living organism. The generally warm, damp climate in Florida has the potential to enhance the growth rate of bioaerosol reservoirs in HVAC units. The HVAC unit serving the laboratory was operating properly, and there was no evidence of biological growth. Another source of bioaerosols possibly could be microorganisms being cultured in the laboratory.

RECOMMENDATIONS

UV Lamps

Although no symptoms related to UV exposures were reported, employees should be aware that excessive exposures will result in photokeratitis and conjunctivitis. Often, these symptoms are not associated with UV exposures because of a latency between the time of exposure and the appearance of symptoms.

As a preventive measure, the UV lamp should be turned off if employees are working within 4 or 5 feet of the BSC. A sign should be posted on the BSC exterior and the entranceway to the laboratory indicating the presence of UV energy and the potential for eye and skin effects. Each worker in the microbiology laboratory should be trained in the hazards, relevant symptoms, and precautions concerning exposures. If necessary, exposure to UV 254 nm radiation can be controlled with sunscreens, clothing, gloves, goggles, or faceshields.

BSC and Laboratory Hood

The hospital has plans to convert the Class II Type A BSC into a Class II Type B BSC (all air is to be exhausted outside), so that chemicals can be used in the BSC. Until the conversion is completed, continue using the laboratory hood whenever formaldehyde or ethyl acetate are used. The performance of the laboratory hood should be improved and evaluated annually thereafter.

Airborne Disease

Some specimens sent to the laboratory have physician orders for both general bacterial and acid fast bacilli (AFB, e.g., *M. tuberculosis*) cultures. Currently, these samples are split on the bench, the general bacterial sample is processed on the bench, and the AFB culture is processed in the BSC. Whenever a AFB culture is ordered or suspected, *all* manipulations of the sample should be conducted inside the BSC.

Bloodborne Disease

Currently, workers are using tuberculin syringes for handling blood cultures. These syringes have non-locking needles. The Centers for Disease Control recommends that only needle-locking syringes or disposable syringe-needle units (i.e., needle is integral to the syringe) be used for injection of infectious materials because the likelihood of accidental exposure is less.[11]

At the present time, there are more than eighty Food and Drug Administration (FDA)-approved medical devices that employ risk-reduction technology (for example, resheathing needles) for bloodborne infections.[31] These devices should be considered by the hospital for the manipulation of blood products.

The acceptability and willingness of the staff to use a new device will depend on the amount of time it takes to become comfortable with a device, ease or difficulty of use, and the effect on basic technique. It has been suggested that up to 88% of percutaneous injuries could be eliminated by implementation of risk-reduction technologies.[32]

Training

Hazard communication training among employees in the microbiology laboratory appeared inadequate. Most workers could not recall that they had training, were not knowledgeable regarding the chemicals they used, and did not know where the biosafety manual was located. The laboratory should obtain the Centers for Disease Control/National Institutes of Health publication "Biosafety in Microbiology and Biomedical Laboratories," which was published in 1992.[11]

Room Ventilation

The microbiology laboratory is not isolated, from a ventilation standpoint, from the rest of the hospital. ASHRAE, AIA, and HRS recommend that microbiology laboratories be under negative pressure (more air is exhausted that supplied to the area). In order to achieve optimal directional control of air movement, a door would have to be installed at the entrance to the microbiology laboratory.

REFERENCES

1. ACGIH [1986]. Industrial ventilation, a manual of recommended practice, 19th ed. Lansing, MI: American Conference of Governmental Industrial Hygienists.

2. ASHRAE [1991]. Health facilities. In: ASHRAE Applications Handbook. Atlanta, GA: American Society for Heating and Air-Conditioning Engineers (ASHRAE), Chapter 7.

3. American Institute of Architects [1993]. Guidelines for construction and equipment of hospital and medical facilities. Washington, DC: American Institute of Architects.

4. NIOSH [1992]. NIOSH recommendations for occupational safety and health: compendium of policy documents and statements. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control; National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication No. 92-100.

5. ACGIH [1992]. Threshold limit values and biological exposure indices for 1992-1993. Cincinnati, Ohio: American Conference of Governmental Industrial Hygienists.

6. Code of Federal Regulations [1989]. OSHA Table Z-1. 29 CFR 1910.1000. Washington, DC: U.S. Government Printing Office, Federal Register.

7. Hathaway GJ, Proctor NH, Hughes JP, Fischman ML [1991]. Proctor and Hughes' chemical hazards in the workplace, 3rd ed. New York: Van Nostrand Reinhold.

8. NIOSH/OSHA [1981]. Occupational Health Guidelines for Chemical Hazards. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. DHHS (NIOSH) Pub. No. 81-123.

9. NIOSH [1989]. Indoor air quality, selected references. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control, National Institute for Occupational Safety and Health.

10. Bureau of National Affairs [March 24, 1993]. Occupational Safety and Health Reporter, Air Contaminants. 22(42): 1754.

11. NSF [1992]. NSF international standard 49, class II (laminar flow) biohazard cabinetry. Ann Arbor, Michigan: National Sanitation Foundation

12. CDC [1992]. Biosafety in microbiological and biomedical laboratories. Washington, DC: U.S. Government Printing Office. U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control. DHHS (CDC) Pub. No. 92-8395.

13. ACGIH [1992]. Industrial ventilation, a manual of recommended practice, 21st edition. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

14. Riley RL, Kaufman JE [1972]. Effect of relative humidity on the inactivation of airborne *Serratia marcescens* by ultraviolet radiation. App Microbiol 23:1113-1120.

15. Riley RL, Mills CC, O'Grady F, Sultan LU, Wittstadt F, Shivpuri DN [1962]. Infectiousness of air from a tuberculosis ward. Amer Rev Resp Dis, 85:511-525.

16. Riley RL, Nardill EA. Clearing the air: the theory and application of ultraviolet air disinfection. Am Rev Respir Dis. 139:1286-94.

17. Stead WW [1989]. Clearing the air: the theory and application of ultraviolet air disinfection [Letter]. Amer Rev Resp Dis. 140:1832.

18. McLean RL [1961]. General Discussion: the mechanism of spread of Asian influenza. Am Rev Resp Dis 83:36-38.

19. Willmon TL, Hollaender A, Langmuir AD [1948]. Studies of the control of acute respiratory diseases among naval recruits. A review of a four-year experience with ultraviolet irradiation and dust suppressive measures, 1943 to 1947. Am J Hyg 48:227-232.

20. Wells WF, Wells MW, Wilder TS. The environmental control of epidemic contagion. An epidemiologic study of radiant disinfection of air in day schools. Am J Hyg 35:97-121.

21. Wills MW, Holla WA [1950]. Ventilation in the flow of measles and chickenpox through a community. Progress report, January 1, 1946 to June 15, 1949. Airborne Infection Study, Weschester County Department of Health JAMA 142:1337-1344.

22. Perkins JE, Bahike AM, Silverman HF [1947]. Effect of ultraviolet irradiation of classrooms on spread of measles in large rural central schools. Am J Pub Health 37:529-537.

23. Macher JM, Alevantis LE, Chang L-L, Liu K-S [1992]. Effect of ultraviolet germicidal lamps on airborne microorganisms in an outpatient waiting room. App Occup Environ Hyg 7(8):505-513.

24. NIOSH [1972]. Criteria for a recommended standard: occupational exposure to ultraviolet radiation. Cincinnati, OH: U.S. Department of Health, Education, and Welfare, Public Health Service, Health Services and Mental Health Administration, National Institute for Occupational Safety and Health; DHEW (NIOSH) Publication No. HSM 73-11009.

25. Blum HF, Lippincott SW [1942]. Carcinogenic effectiveness of ultraviolet radiation of wavelength 2537 Å. J Nat Cancer Inst. 1:211-216.

26. Forbes PD, Urbach F. Experimental modification of carcinogenesis I: fluorescent whitening agents and shortwave ultraviolet radiation. Food Cosmetics Toxicol 13:335-337.

27. Enninga IC, Groenedijk RTL, Filon AR, van Zeeland AA, Simons JWIM [1986]. The wavelength dependence of u.v.-induced pyrimidine dimer formation, cell killing, and mutation induction in human diploid skin fibroblasts.

Carcinogenesis 7:1829-36

28. Ronai ZA, Lambert ME, Weinstein IB [1990]. Inducible cellular responses to ultraviolet light irradiation and other mediators of DNA damage in mammalian cells. Cell Biol Toxicol 6:106-126.

29. IES [1966]. Illuminating Engineering Society. IES lighting handbook, 4th ed. IES: New York. pp 25-27.

30. State of Florida [1991]. Minimum hospital ventilation rate table, general acute care hospitals. Tallahassee, Florida: Department of Health and Rehabilitative Services, HRS Plans and Construction.

31. Haney, J [1992]. FDA device regulatory responsibilities. Presentation at "Frontline Healthcare Workers: A National Conference on Prevention of Device-Mediated Bloodborne Infections." Washington, DC: Co-Sponsored by U.S. Department of Health and Human Services (Centers for Disease Control and Food and Drug Administration) and the U.S. Department of Labor. August 17, 1992.

32. Dowdle W [1992]. CDC disease prevention responsibilities. Presentation at "Frontline Healthcare Workers: A National Conference on Prevention of Device-Mediated Bloodborne Infections. Washington, DC: Co-Sponsored by U.S. Department of Health and Human Services (Centers for Disease Control and Food and Drug Administration) and U.S. Department of Labor. August 17, 1992.

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