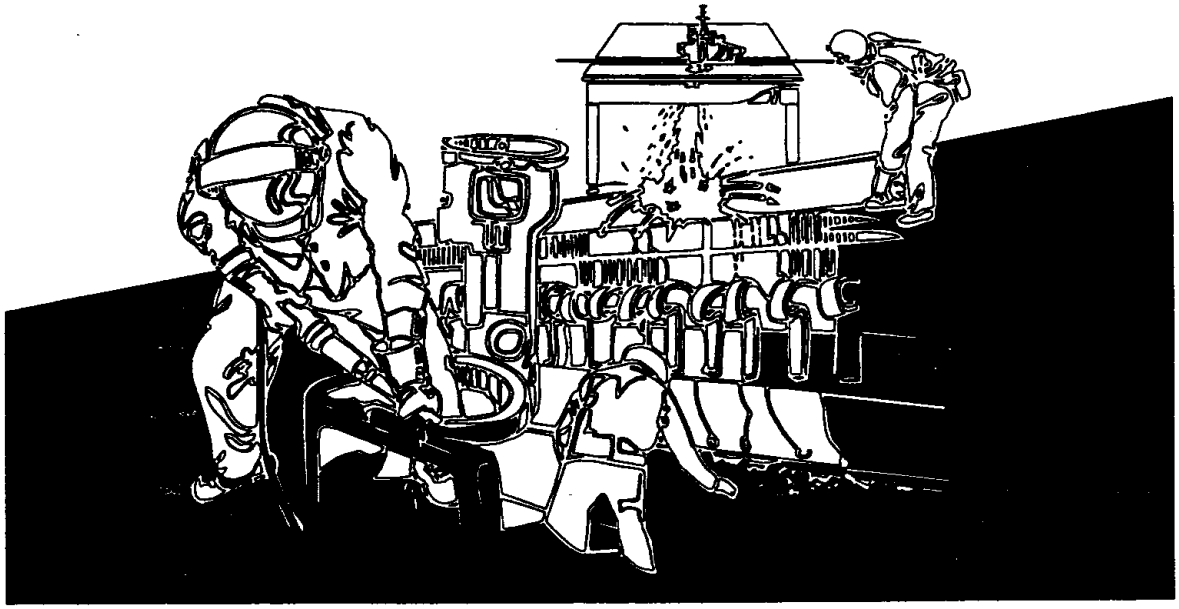
NIOSH

HEALTH HAZARD EVALUATION REPORT

HETA 92-171-2255
ONONDAGA COUNTY MEDICAL EXAMINER'S OFFICE
SYRACUSE, NEW YORK



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

CDC
CENTERS FOR DISEASE CONTROL

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 and authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to federal, state, and local agencies; labor; industry; and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

Table of Contents

LIST OF TABLES

LIST OF FIGURES

HETA 92-171-2255
SEPTEMBER 1992
ONONDAGA COUNTY MEDICAL EXAMINER'S OFFICE
SYRACUSE, NEW YORK

NIOSH INVESTIGATORS
Teresa A. Seitz, M.P.H, C.I.H.
John A. Decker, R.Ph., M.S.

SUMMARY

In March 1992, at the request of the National Center for Infectious Diseases (NCID), Centers for Disease Control (CDC), the National Institute for Occupational Safety and Health (NIOSH) conducted an evaluation at the Onondaga County Medical Examiner's Office in Syracuse, New York. This evaluation was conducted in conjunction with the CDC EPI-AID investigation (EPI 92-39-1) which was requested by the New York State Department of Health. Concerns regarding the potential for tuberculosis (TB) transmission in the Medical Examiner's Office resulted from the performance of autopsies on inmates from a State Correctional Facility who had active multidrug-resistant TB at the time of their death. Positive tuberculin skin tests were documented for five of the 18 employees who were tested. Two employees were not included in the skin testing program as they were known to be positive, and one employee declined participation. Two of the staff with positive skin tests were apparent converters who had a negative skin test a few months prior to the follow-up testing. Baseline skin test data was not available for the three other employees who tested positive. NIOSH was asked to evaluate environmental conditions and procedures used to prevent TB transmission at this facility.

On March 10-12, 1992, NIOSH personnel evaluated the ventilation systems serving the morgue and office areas, observed work practices and use of personal protective equipment during an autopsy, and made ultraviolet (UV) radiation measurements in areas where germicidal UV (GUV) lamps were used to "disinfect" potentially contaminated air.

The ventilation evaluation indicated that the autopsy room is under positive pressure with respect to the adjacent hallway which connects the morgue and office areas. As a result of this and the fact that the return air plenum for the ventilation systems serving the morgue and the adjacent office area is open, there is air mixing between these two areas. A fog-generating device and ventilation smoke tubes used to visually assess airflow patterns demonstrated the potential for air movement out of the morgue and into surrounding areas.

Ultraviolet radiation levels in the morgue were high, due to the use of six ceiling-mounted GUV lamps providing direct irradiation of the area below; louvers and baffles were not used on these lamps. The UV levels measured at a height of 5 feet

from the floor, facing the lamps, resulted in permissible exposure times less than 20 minutes for workers with unprotected skin and eyes (5-60 microwatts per square centimeter [$\mu W/cm^2$]). While personal protective equipment was worn to protect against UV overexposures, neck areas were not adequately protected from UV. Erythema was observed at the end of the day on the neck of one of the staff who had been in the room approximately 2 hours. UV radiation levels in the ducts were also high (approximately 660-950 $\mu W/cm^2$ at a distance of three feet from the lamps) as a result of the use of duct-mounted GUV lamps to "disinfect" recirculated air. This presents a potential UV-exposure hazard to maintenance personnel and other workers who have contact with these lamps.

A potential hazard exists for workers exposed to aerosols containing *Mycobacterium tuberculosis* organisms resulting from autopsies on cadavers which had active tuberculosis (TB) at the time of death. The use of high-speed tools and other aerosol generating procedures which encounter collections of TB-infected material presents a potentially high-risk exposure situation. While many changes have been made at this facility to minimize the potential for TB transmission, additional changes are needed to further reduce the potential for TB exposure. Recommendations are made in the report to correct existing ventilation deficiencies, including isolation of the morgue ventilation system, use of personal protective equipment, safe use of germicidal UV lamps, and the provision of separate clean and dirty change areas for morgue personnel.

KEYWORDS: SIC 9199 (Government not elsewhere classified), autopsy, morgue, tuberculosis, *Mycobacterium tuberculosis*, germicidal ultraviolet radiation, ventilation.

INTRODUCTION

On March 3, 1992, the National Institute for Occupational Safety and Health (NIOSH) received a request for technical assistance from the Division of Bacterial and Mycotic Diseases (DBMD), National Center for Infectious Diseases, Centers for Disease Control. This request was made to complement the EPI-AID investigation (EPI 92-39-1) conducted by DBMD and the Division of Tuberculosis Elimination, National Center for Prevention Services. Specifically, NIOSH was asked to evaluate environmental conditions and procedures for preventing tuberculosis (TB) transmission in the Onondaga County Medical Examiner's Office, Syracuse, New York. The CDC investigation identified apparent tuberculin skin test (TST) conversions among two of 18 employees tested. Three additional employees tested positive, however, there was no baseline data available on these workers. Two employees were not tested as they were known to have positive TSTs, and one employee declined participation. It was hypothesized that the TST conversions may have resulted from exposure to *Mycobacterium tuberculosis* during autopsies on inmates from a New York State Correctional Facility who had active TB, including some with multidrug-resistant TB (MDR-TB), at the time of their death. The autopsies were conducted from March to November 1991.

On March 10-12, 1992, NIOSH conducted an environmental evaluation at the Medical Examiner's Office which included work practice observations during an autopsy, informal discussions with employees, an evaluation of the ventilation systems serving the morgue and office areas, a visual assessment of airflow patterns within the facility, and measurements of ultraviolet (UV) radiation from germicidal UV (GUV) lamps located in the morgue and in the supply/mixed air ducts. NIOSH personnel were assisted by an industrial hygienist from the New York State Department of Health, Bureau of Occupational Health/Industrial Hygiene. This report describes the findings and recommendations from the NIOSH evaluation. Preliminary findings and recommendations were made at the closing meeting held on March 12, 1992. A separate EPI-AID report was issued on August 5, 1992, concerning the epidemiologic evaluation.

FACILITY AND PROCESS DESCRIPTION

At the time of the NIOSH survey, approximately 18 persons were currently employed at the Onondaga County Medical Examiner's (ME's) Office as medical examiners, morgue technicians, morgue attendants, case researchers, and clerical and secretarial staff. The ME's office is in a one-story concrete building which also houses a Red Cross organ transplant clean room. Approximately 600-700 autopsies are conducted yearly, with the

autopsies performed at two work stations in the morgue. A floor plan of the facility is shown in Figure 1 (please see below).

This single story facility was built in 1973, and contains approximately 8000 square feet. There are two main heating, ventilating and air-conditioning (HVAC) units located on the roof which service the morgue and office areas. No information was available on the specifications or capacity of the HVAC units. One unit supplies conditioned air to the morgue, garage, and cooler area, while the second unit supplies conditioned air primarily to the office space. Air from the morgue and office areas is recirculated, with the space above the suspended ceiling acting as the return air plenum. This plenum is open throughout the facility, allowing for air mixing between the two systems. There are

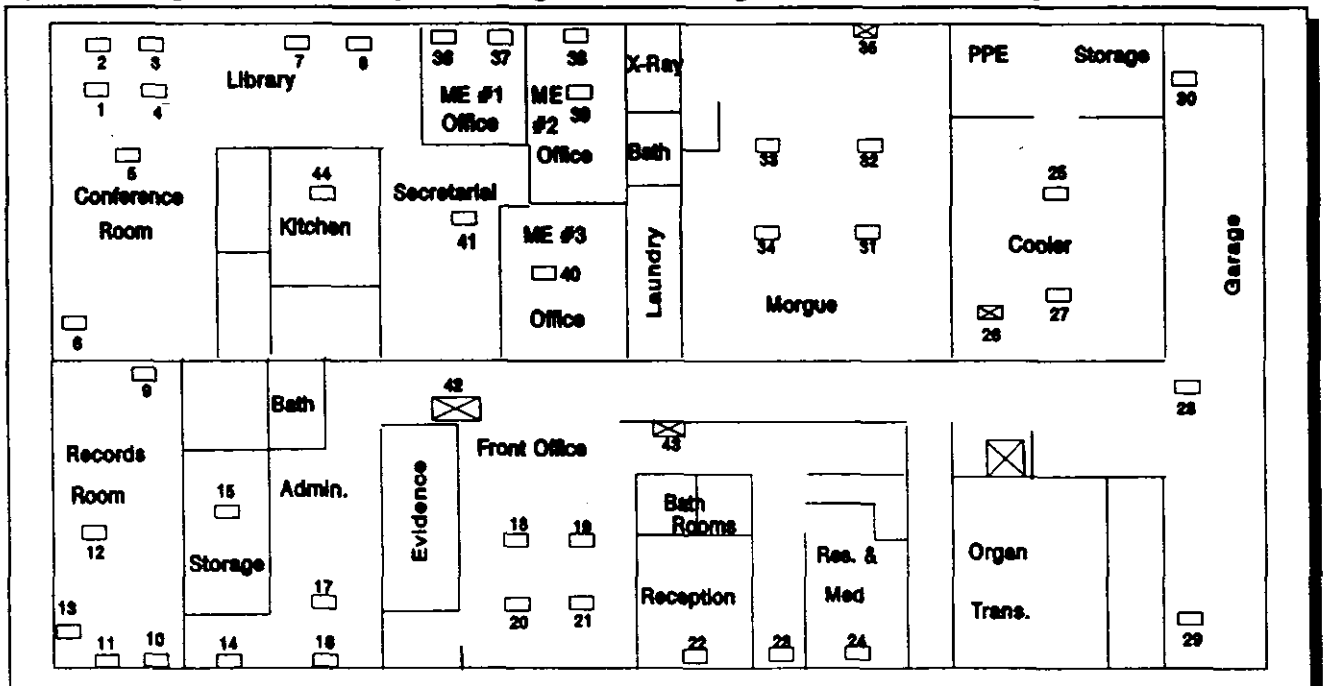


Figure 1. Floor plan of the Onondaga County Medical Examiner's Office showing supply diffusers and exhaust grills.

three wall mounted returns and a few egg-crate type ceiling panels which are open to the return plenum. The Red Cross clean room is served by a separate ventilation system; however, air from the ME's office is brought into this room after passing through particulate filters (reportedly high efficiency particulate air (HEPA) filtration). The unit which serves this area is located in the hallway between the morgue and the clean room. There are two exhaust units (air ejectors) located in the cooler room in addition to the bathroom/kitchenette exhausts which are vented directly to the outside. A

supplemental fan which exhausts air directly to the outside was recently installed in the morgue in an effort to maintain this room under negative pressure with respect to surrounding areas.

VENTILATION EVALUATION

To evaluate air distribution within the morgue and office areas, the volume rate of airflow (in cubic feet per minute [CFM]) was measured at the supply air diffusers and exhausts using a Shortridge Airdata Multimeter/Flowhood Model 860/8405. Due to obstructions which would not allow the use of the flowhood, it was necessary in a few locations to determine the air velocity at the supply diffuser directly using an Alnor Compuflow Thermoanemometer Model 8565. Each HVAC system has one thermostat which controls air supply to the space. The thermostats are located on the morgue wall and on the wall separating the front office and secretarial areas. The thermostats have settings for heating and cooling, as well as an automatic setting and fan mode. To make airflow measurements it was necessary to place the systems in the fan mode, rather than in the automatic mode as they were found, so that there was continuous air supply. In the automatic mode, air is supplied only when the thermostat calls for heating or cooling; when the thermostat is satisfied, there is no air delivered to the space.

The American Society for Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) has published ventilation criteria for office environments. ASHRAE Standard 62-1989, Ventilation for Acceptable Indoor Air Quality,[1] specifies outdoor air supply rates of 20 CFM/person for general office space and conference rooms, and 15 CFM/person for reception areas. We were not able to determine the amount of outside air being brought into the building by the HVAC systems for comparison with these guidelines due to the configuration and location of the outside air intakes. However, it was noted that the outside air intake for HVAC unit which supplies the office area was closed. Some outside air (OA) may have entered the office area from the morgue HVAC system due to the mixing of the recirculated air or from leaks in the building envelope and through doors. There were no design specifications or estimates of the amount of OA supplied by this system.

Office Ventilation System

Airflow measurements are shown in Table 1 (please see next page). All supply air diffusers were operational; however, the air ejector in the cooler was not working. The office HVAC system did not appear to be balanced properly, as three single-person offices of similar size had supply airflows ranging from 44 to 369 CFM. In addition, a

few supply diffusers appeared to be blocked (ME office #2 and storage room), as very low air flow-rates were measured in these areas. Since there were no design criteria available for these ventilation systems, a comparison of the measured values with design or "as-built" specifications was not possible. In addition, because there was no information on the amount of OA which was being brought into this facility by the morgue HVAC unit, a comparison of measured values with guidelines specific for morgues was not possible.

Table 1

Airflow Measurements

March 11, 1992

Area	Location No.[1]	Supply (CFM)[2]	Exhaust (CFM)
Conference Rm.	1-6	100, 123, 133, 103, 98, 82	
Library	7-8	177, 190	
Records	9-13	83, 245, 98, 81, 180	
Hallway	14	252	
Storage	15	35	
Administrative Office	16-17	94, 98	
Front Office	18-21	88, 82, 134, 95	
Reception Area	22-23	100, 105	
Res/Med Students	24	118	
Cooler	25-27	255, 266	not working
Garage	28-30	320, 236, 327	
Morgue	31-35	287, 305, 462, 497	646
ME Office #1	36-37	199, 170	
ME Office #2	38-39	51, 11	
ME Office #3	40	44	
Secretarial	41	284	
Hallway Register	42		15
Hallway Register	43		150
Kitchen	44	109	

[1] Location numbers correspond with markings on the floor plan in Figure 1. Airflow measurements listed are in sequential order.

[2] CFM = cubic feet per minute.

Morgue Ventilation System

ASHRAE,[2] the State of New York,[3] and the American Institute of Architects (AIA)[4] have published ventilation guidelines specific for health facilities. With the exception that the AIA guidelines do not recommend that a minimum amount of OA be provided to autopsy areas, the three guidelines are the same in all other respects. These guidelines recommend that autopsy areas be provided with 12 total air changes per hour (ACH), with a minimum of two air changes of outdoor air per hour supplied to the room. Using the air flow-rates from Table 1 (above), the number of ACH in the morgue were calculated. Considering a total supply air flow-rate of 1551 CFM, the estimated ACH ranged from 11-13, depending on the air volume used in the calculation. The lower ACH takes into consideration the volume of air in the X-ray/laundry area in addition to the morgue space. While the X-ray and laundry areas are not physically separated from

the morgue, there are partial wall dividers in these areas. Because the morgue HVAC unit does not supply air to this area when the thermostat is in the automatic mode and temperature is satisfied, or when the system is manually turned off (as is reportedly the case during perceived high-risk procedures), the ACH was also calculated considering only the flow-rate of the air which is exhausted from this area by the supplemental fan. This corresponds to a rate of 4-5 ACH, well below existing guidelines for morgues. It should also be noted that the ACH calculations assume perfect mixing of room air, a situation which is not likely given the location of the morgue exhaust and the partially enclosed X-ray and laundry areas.

The guidelines described above also recommend that autopsy areas be under negative pressure with respect to adjacent areas, and all room air be exhausted directly to the outdoors, with no recirculation within the room. Although a dedicated exhaust to the outside was recently installed in this room, some air from the morgue is recirculated into other areas within the building through the mechanical HVAC system. As previously noted, the space above the suspended ceiling acts as a return air plenum shared by both the morgue and office HVAC units. In addition, under all conditions of measurement, (with the morgue HVAC system on and off), the morgue was under positive pressure with respect to the adjacent hallway. While this would not have been anticipated during times when the morgue HVAC system was off due to the use of the supplemental exhaust fan (which exhausted 646 CFM), smoke tubes and a fog-generating device confirmed this to be the case. The fog-generating device was placed in the morgue, in the area near the autopsy tables, and allowed to release a fog for visualization of airflow patterns. Smoke tubes were used to visually assess the air pressure differential at the morgue door. With the morgue HVAC system off, there was air movement out of the morgue and into the hallway in the direction of the air intake for the organ transplant room.

GERMICIDAL ULTRAVIOLET RADIATION EVALUATION

At the end of 1991, GUV lamps were installed in a short section of return air ductwork for the two HVAC units in an effort to "disinfect" the recirculated air. The fixtures and lamps were manufactured by American Ultraviolet (G36T6L). Two banks of GUV lamps were located in a new section of ductwork for the morgue HVAC unit, each containing four 39 Watt lamps. One set of four 39 Watt GUV lamps was located in the ductwork serving the office HVAC unit. In both cases, the bulbs were placed perpendicular to the direction of airflow. An access panel was installed to allow access to the lamps for maintenance, cleaning, and replacement. In addition, six ceiling-mounted 30 Watt GUV lamps manufactured by General Electric (G30T8) were installed in the morgue, with direct irradiation of the area below. The ceiling height in the morgue is 8.6 feet and the

room dimensions are approximately 26 X 39 feet. The GUV lamps do not contain louvers or reflectors which are used in GUV systems for indirect irradiation of the upper room air. Warning signs were placed outside the areas where the lamps were used, and a warning light was installed outside the morgue entrance to indicate when lamps were in use. However, the on/off switches did not have locking mechanisms.

The UV lamps used at the ME's office are low-pressure mercury vapor lamps which are primarily a line rather than broad band source, and which emit UV and visible radiation at specific wavelengths. The manufacturer of the American Ultraviolet fixtures reports that the lamps allow 90% of the radiant emissions at 254 nanometers (nm); hence, they are considered GUV lamps. These lamps have been used for many years to aid in the control of TB by "disinfecting" the air. This evaluation addressed only occupational exposure concerns; UV efficacy issues were not addressed.

There is a potential hazard resulting from overexposure to GUV radiation emitted from these lamps. The critical organs of exposure for the 254 nm 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).[5] 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.[6,7]

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 2 (at right), 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

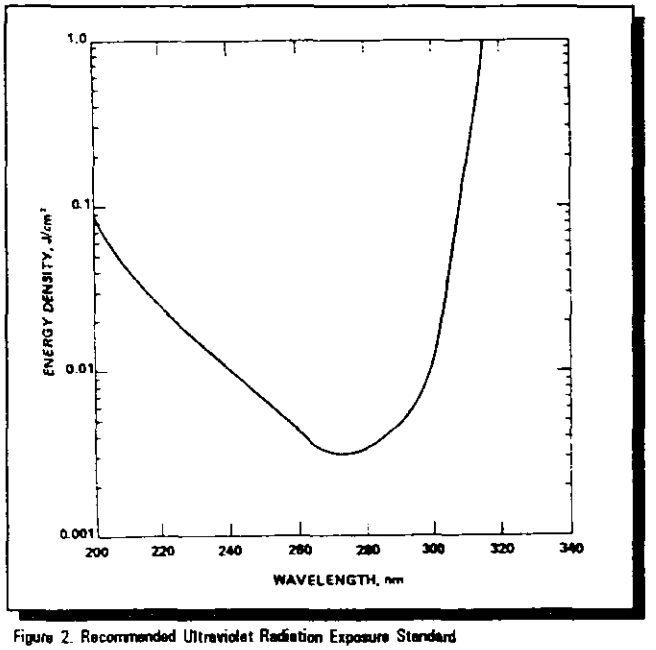


Figure 2. Recommended Ultraviolet Radiation Exposure Standard

erythema and keratoconjunctivitis from both human and animal studies. At 254 nm, the predominant UV wavelength for germicidal lamps,[8] the REL is 0.006 Joules per square centimeter (J/cm^2). 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 2 (please see previous page). 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 measured UV irradiance in $Watts/cm^2$.

The measurement system used to evaluate occupational exposures consisted of a calibrated model 1400A International Light (IL) radiometer connected to a SEL 240 detector that permitted the system to read UV levels directly in units of watts per square centimeter (W/cm^2). The measurement range is 0 to 1 milliwatt per square centimeter (mW/cm^2) for emissions in the 200 to 320 nm range. The radiometer used in this evaluation was calibrated within six months of use by the manufacturer.

Duct-Mounted Germicidal Ultraviolet Lamps

Ultraviolet (UV) radiation measurements were made in front of the duct-mounted germicidal ultraviolet (GUV) lamps in the morgue and office HVAC ductwork to evaluate lamp output and the potential UV hazard to maintenance or other personnel who have exposure to these lamps. All lamps were in operation and dust build-up was observed on all lamps. To gain access to the fixtures, ceiling panels immediately below the units were removed. Measurements were made at a distance of approximately 3 feet from the lamps with the detector facing the lamps. UV radiation levels emitted by the office GUV lamps ranged from 825 to 950 microwatts per square centimeter ($\mu W/cm^2$). Permissible exposure times (in seconds) were then calculated using the 8-hour REL of 0.006 J/cm^2 for UV exposures at 254 nm, the predominant wavelength for GUV lamps, and dividing this value by the measured irradiance in W/cm^2. The resulting permissible exposure time ranged from 6 to 7 seconds indicating that even very brief exposures may result in serious skin or eye burns for workers who are not adequately protected. Despite precautions taken by the NIOSH investigators, transient erythema was observed on one member of the NIOSH survey team (wrist and neck where protective clothing had lapsed or was not protective enough) later in the evening after making UV measurements in the ducts. UV radiation levels measured at 3 feet from the GUV lamps in the morgue HVAC duct ranged from 660 to 710 $\mu W/cm^2$, which corresponds with permissible exposure times (for unprotected skin and eyes) of 8 to 9 seconds. At distances closer than 3 feet, much higher exposures would be obtained. Due to a concern regarding the generation of ozone by some UV lamps, ozone measurements were made in each of the ducts approximately 3 feet from the bank of GUV lamps using

Draeger direct-reading detector tubes specific for ozone. Ozone was not detected above a limit of detection of 0.05 parts per million. This finding is in agreement with the manufacturer's literature. While making the UV measurements, relative humidity (RH) and temperature levels were obtained. The RH measured in the office HVAC duct was 21% and the temperature was 71°F.

When the ceiling panels were replaced, no detectable UV levels were measured in the work area immediately below the duct-mounted GUV lamps. UV exposures would occur, however, if the ceiling panels were dislodged, because the section of ductwork where the lamps are located is not enclosed. This section of ductwork is open to allow return air to enter the duct. Visible radiation emitted by these lamps was seen in other areas above the ceiling where panels were removed, indicating that this represents a UV exposure hazard to anyone who may be working in the space above the suspended ceiling.

Ceiling-Mounted Germicidal Ultraviolet Lamps

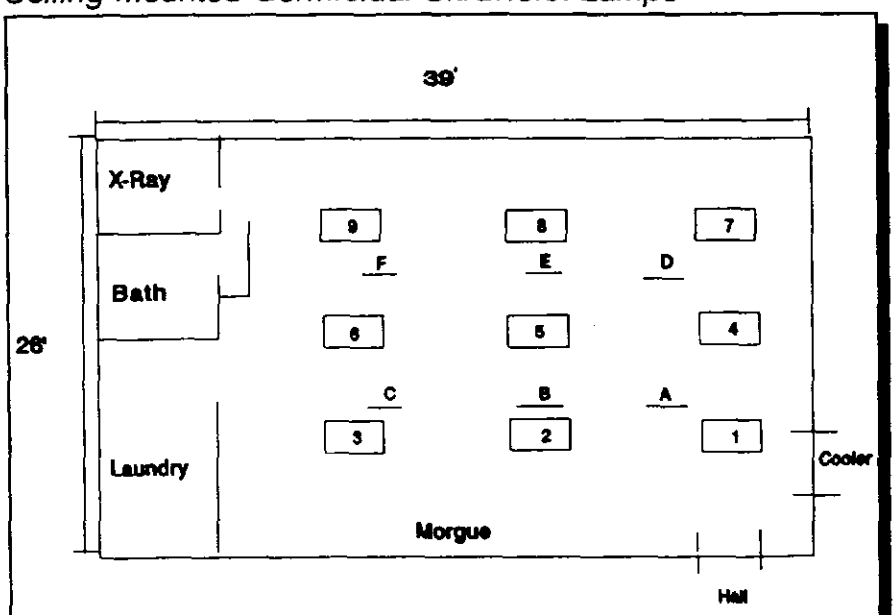


Figure 3. Morgue floorplan showing UV lamp placement and measurement locations.

Ultraviolet (UV) radiation measurements were made at several locations in the morgue where the ceiling-mounted GUV lamps are located (see Figure 3 left). GUV lamp placement is shown at locations A through F. Locations 1 through 9 represent sampling locations below fluorescent light fixtures. All lamps were in operation at the time the measurements were made, but bulb "C" was flickering. Measurements were made at a distance of 4 inches below the center of each lamp, at 5.5 feet from the floor, immediately below each lamp, and at nine other locations in the morgue. Results are shown in Table 2 (please see next page).

Table 2

Ultraviolet Radiation Levels and Permissible Exposure Times at Different Distances from Germicidal Lamps in the Morgue

March 11, 1992

Lamp Location[1]	4" From Lamp ($\mu W/cm^2$)[2]	Permissible Exposure Time (seconds)[3]	5.5' From Floor ($\mu W/cm^2$)[2]	Permissible Exposure Time (seconds)[3]
A	480	12	42.9	140
B	765	8	60.6	99
C[4]	350	17	27.2	220
D	520	11	39.3	153
E	840	7	61.5	98
F	475	13	31.1	193

[1] Locations correspond with markings on the morgue plan shown in Figure 3.

[2] UV levels are reported in microwatts per square centimeter ($\mu W/cm^2$). Measurements were taken at 4" from the lamp in the center of the lamp, and at 5.5' from the floor (maximum UV levels reported).

[3] The permissible exposure time is for exposure to UV radiation at 254 nm incident upon the unprotected skin or eye.

[4] Bulb was flickering.

At a distance of 4 inches from the lamp, which may represent an exposure received by a maintenance worker, the UV levels ranged from 350 to 840 $\mu W/cm^2$, showing a wide variation among the six lamps. It is unclear if this variation represents a variation in individual lamp characteristics or other factors. Permissible exposure times were again calculated, with times ranging from 7 to 17 seconds. UV radiation levels measured at 5.5 feet from the floor were made to estimate the exposure received at about eye height for a standing worker. The UV levels measured directly below the lamps, with the detector facing the ceiling, ranged from 27.2 to 61.5 $\mu W/cm^2$, corresponding with permissible exposure times of 98 to 220 seconds, or about 1.5 to 4 minutes. These very short permissible exposure times for unprotected workers indicates the importance of personal protective equipment in preventing skin and eye burns.

To further evaluate potential UV exposures, UV radiation levels were measured at 9 other locations in the morgue at a height of 5.5 feet from the floor, with the detector facing each of the nine lamps. Table 3, on the next page, lists the results of these measurements. The permissible exposure times (unprotected) were again low, on the order of 2 to 21 minutes. It should be noted that workers move extensively while performing their duties and it would be impossible to estimate their actual daily exposure. In addition, the amount of time spent in the morgue on a given day can vary tremendously based on the case load. It should also be noted that due to the many reflecting surfaces in the morgue, such as thesupplemental exhaust duct, the mirror, and

the metal rolling tables, higher UV levels could be present in areas which were not measured. The RH in the morgue was 25% and the temperature was 58°F.

PERSONAL PROTECTIVE EQUIPMENT AND WORK PRACTICE ISSUES

About 600-700 autopsies are performed yearly at this facility. Typical autopsies last approximately 30-90 minutes, with some special cases lasting an entire workshift or longer. Medical examiners, morgue technicians, medical students, residents, police officers, and other investigative agency representatives may be present during the autopsy. The autopsy we observed was attended by a medical examiner, morgue technician and medical resident. There was significant potential for aerosolization of tissue/fluids during the use of some high speed power tools. The personal protective equipment (PPE) worn included scrub pants, Tyvek®/polypropylene gown, surgical latex gloves, polycarbonate flip-up face shield, surgical hood (for neck protection), and either dedicated morgue shoes and/or shoes with Tyvek® covers. Designated "clean" and "dirty" change areas were not available. PPE was commonly donned in the PPE storage area behind the adjacent cooler room, and in some cases it was removed before leaving the morgue.

Table 3

Ultraviolet Radiation Levels and Permissible Exposure Times at Various Locations in the Morgue

March 11, 1992

Location No.†	Range of UV Exposure Levels at 5.5' from floor ($\mu W/cm^2$)‡	Permissible Exposure Time (minutes)#
1	7.2 - 11.9	8 - 14
2	7.4 - 32.0	3 - 13
3	6.7 - 9.3	11 - 15
4	8.3 - 9.9	10 - 12
5	5.6 - 20.0	5 - 18
6	4.7 - 6.6	15 - 21
7	8.2 - 11.5	9 - 12
8	6.1 - 40.1	2 - 16
9	6.9 - 8.1	12 - 14

† Location numbers correspond with markings on Figure 3 (Morgue floor plan).

‡ UV exposure levels are reported in microwatts per square centimeter ($\mu W/cm^2$). Measurements were taken at the listed locations with the detector facing each of the 9 lamps. The reported values represent the range of minimum and maximum measurements made at each location.

The permissible exposure time is for exposure to UV radiation at 254 nm incident upon the unprotected skin or eye.

Because the autopsy we observed was considered "low risk" i.e., there was no known or suspected exposure to TB, only surgical masks were worn by employees. For "high

risk" autopsies, the current policy is to wear either NIOSH-approved disposable dust and mist respirators or, for one employee with a beard, a loose-fitting powered air-purifying respirator (PAPR) equipped with high efficiency particulate air (HEPA) filters. Fit testing and training of workers has been performed; however, there was no written respiratory protection program at the time of our visit. The chief medical examiner was in the process of consulting with a respirator manufacturer to have a respirator designed or modified to include a loose fitting PAPR with HEPA filters, a reusable polycarbonate face shield to protect against UV exposures, and a disposable (attached) UV opaque hood. Other specifications desired include a long battery life and a low battery alarm.

The current policy is to use the GUV lamps during all autopsies. However, during the autopsy we observed, a worker turned off the lamps to enter the morgue for a short period of time to relay a message and forgot to turn the lamps back on. Consequently, the GUV lamps remained off for a period of time during the autopsy.

Some employees reported erythema and blistering when the GUV lamps were initially installed and PPE was not adequate. Photokeratitis has not been reported by workers. While health effects have reportedly decreased since initial GUV installation, erythema was observed on one worker's neck after spending approximately 2 hours in the morgue. This may have been due to poor coverage of the neck by the neck hood and/or poor protection of the hood against GUV radiation. New hoods had been ordered, but were not available at the time of our survey. To evaluate the protection afforded by some of the protective clothing materials used by workers, UV radiation measurements were made with and without the clothing material covering the UV detector. Results are shown in Table 4 (at right margin).

Table 4

Transmission of GUV Radiation Through
Protective Clothing Materials Worn in the Morgue

March 11, 1992

Clothing	UV level (μW/cm²) With Clothing	UV level (μW/cm²) Without Clothing	Reduction Factor
Becton Dickinson Surgical Glove Cat #376189 (talc free)	0.006	35.0	5833
Perry Surgical Glove, Latex Style #42	0.008	19.2	2400
Baxter Triflex Latex Glove #2d7152	0.005	18.8	3760
White Surgical Hood	5.2	40.0	8
Blue Hood	4.0	21.5	5
Hair net	15.5	21.8	1

The two hoods available did not provide adequate protection against the GUV lamps, as evidenced by significant UV transmission through the protective material. The UV levels which penetrated the hoods would allow a permissible exposure

time of only 20-25 minutes at the location tested before overexposures would occur. All glove materials tested provided adequate UV protection as evidenced by low UV penetration levels. Corresponding permissible exposure times exceeded 8-hours. The hairnet which was evaluated would afford very little protection against the GUV lamps for top-of-head exposures.

DISCUSSION

The focus of the NIOSH evaluation was to assess the current environmental conditions and procedures used to minimize TB transmission at the Onondaga County ME's Office. Although infectious disease transmission from cadaver to autopsy workers is well documented,[9] including TB-infections,[10] there is little information available regarding the viability of infectious agents in tissues and biologic fluids after death or of the droplet nuclei once airborne. One autopsy procedure studied for its potential to generate aerosols is the removal of the skull cap using high speed oscillating saws operating at 20,000 to 30,000 RPM.[11] High concentrations of respirable bone dust and liquid aerosols were documented along with large droplets of blood and cerebrospinal fluid, posing a risk to autopsy workers for inhalation and mucous membrane exposure from various infectious agents. The use of high speed tools or other aerosol-generating activities in areas where collections of TB-infected material are present represents a potentially high-risk exposure situation.

NIOSH supports the Occupational Safety and Health Administration (OSHA) policy on the use of a "hierarchy of controls" in controlling exposures to hazardous agents in the workplace.[12,13,14] The logic of the hierarchy is to minimize the likelihood that preventive measures will fail, resulting in a hazardous exposure. This policy states that efforts should first be made to substitute or eliminate the hazardous agent or source of exposure. Because autopsies are often required for legal or medical reasons, eliminating the source of exposure may not be possible; however, this should be further evaluated. The use of hand tools, as opposed to power tools, may be one method of eliminating (or reducing) the generation of respirable aerosols. However, the feasibility of using hand tools in a given situation would require further evaluation.

The next control in the hierarchy is to prevent or contain the hazardous emissions at their source. Examples of source control devices include local exhaust ventilation and the use of tools which have been modified to remove emissions locally before being released into the general work environment (e.g., high velocity and low volume exhaust systems). Downdraft ventilation autopsy tables are available and may have some applicability in these settings; however, their effectiveness in preventing the spread of TB aerosols has not been studied. Research is clearly needed to design and evaluate

source control devices for use in removing potentially-infectious aerosols generated during autopsy procedures. One procedural technique we observed at the ME's office which has the potential for reducing the spread of aerosols is the bagging of body parts, such as the head, prior to utilizing aerosol generating tools.

The remaining controls in the hierarchy include the removal or treatment of hazardous emissions from the pathway between the source and the workers (e.g., general dilution ventilation, negative pressure, air cleaning devices such as GUV radiation, and administrative controls), and lastly, the control of exposures by placing barriers between the worker and the hazardous work environment (e.g., PPE, such as respirators). These last two control strategies were primarily used at the ME's office to control TB transmission and will be discussed further.

ASHRAE and the AIA have established ventilation guidelines specific for health facilities, including autopsy areas. The guidelines are provided in terms of air pressure relationships to adjacent areas, minimum OA and minimum total ACH, and recirculation restrictions. The morgue did not meet existing guidelines for the following reasons: (1) air from the morgue was recirculated to other areas of the facility through the mechanical HVAC system, (2) the morgue was not under negative pressure with respect to surrounding areas, and (3) with the mechanical HVAC system off and the supplemental exhaust fan on (as may be the case during high risk procedures or when the thermostat is satisfied in the automatic mode), only 4-5 ACH were measured, well below the 12 ACH recommended. In addition, with the mechanical HVAC system off, there is no supply of OA to this area; the current guidelines recommend that 2 of the 12 ACH be from OA.

In an effort to "disinfect" potentially-contaminated air, GUV lamps were installed in the morgue and in the return air ducts for the two mechanical HVAC systems. NIOSH personnel addressed only health and safety issues related to the use of these lamps; efficacy issues are beyond the scope of this evaluation. Other groups within NIOSH have plans for evaluating efficacy issues in the future, looking at issues such as the UV output characteristics of these lamps, the minimum effective dose for killing under given conditions, and the optimum design and ventilation conditions for their use.

For the duct-mounted UV systems, high levels of UV radiation were measured in the return air ducts. Permissible exposure times for workers with unprotected skin and eyes were calculated resulting in permissible exposure times of only a few seconds. This clearly emphasizes the need for adequate skin and eye protection when workers must be present in these areas when the lamps are on, such as may be the case when workers are checking to see if the lamps are in operation or when making UV measurements. Obviously, the lamps should always be turned off before working above

the suspended ceiling in all other situations. The use of a locking mechanism on the switches would be beneficial to prevent the lamps from being accidentally turned on or off. In addition, this would prevent accidental UV exposures to people working in the office area below the duct-mounted lamps, all ceiling tiles should be promptly replaced after removal.

High levels of UV radiation also were measured in the morgue as a result of the use of six ceiling-mounted GUV lamps in this area. These lamps allow direct irradiation of the area below. Permissible exposure times (for unprotected workers) of approximately 20 minutes or less were calculated based on the UV levels measured in several representative areas at a height of 5.5 feet. Again, this clearly emphasizes the need for adequate eye and skin protection to prevent erythema and photokeratitis. Measurements of the UV radiation penetrating some clothing materials worn in the morgue indicated that some materials, such as the hoods, were not protective enough. Similar measurements should be made for all other existing and new protective clothing materials worn in the morgue. We also noted that the polycarbonate shields worn by morgue personnel may not provide sufficient facial protection in some areas due to the curvature of the face shield. This should be a consideration in the selection of appropriate respiratory protection. Additionally, observations of exposed workers should be made to ensure adequate coverage by the face shield; the chin area may be most affected.

The ME's office was in the process of developing respiratory protection guidelines for use during autopsies. At the time of the NIOSH evaluation, surgical masks were worn by workers during routine, "low risk" autopsies and either disposable dust and mist respirators or PAPR respirators with HEPA filters were worn during autopsies on known or suspected TB cases. There needs to be a consistent policy regarding respirator use during autopsies. The use of respiratory protection should be considered during low risk autopsies for protection against unsuspected TB exposure other potential inhalation hazards. Surgical masks do not meet the requirements specified by NIOSH in 30 CFR 11, Respiratory Protective Devices,[15] and may not provide adequate protection to the wearer due to poor face fit characteristics or leakage of small particles through the filter media.

For exposure to aerosols containing TB organisms, the respirator offering the highest level of protection should be selected that is consistent and feasible with the tasks to be performed by the workers. The use of high speed power tools (or other aerosol generating procedures) which can encounter collections of TB-infected material can create a potentially high risk situation. Efforts should continue to be made to obtain PAPR respirators that meet the needs of the wearers in this unique setting (concomitant UV exposures) or to the use of positive pressure air-line respirators to supplement

the use of engineering controls and work practices. When used in conjunction with a respirator program which meets the OSHA requirements (29 CFR 1910.134)[16] and NIOSH recommendations,[17] the air-line respirator has an assigned protection factor (APF) of 1000 (for half-facepiece types) or 2000 (for full-facepiece types), as compared with loose-fitting PAPR respirators which have an APF of 25, and dust and mist respirators which have an APF of 10. The APF is a rating system used to indicate the level of protection provided by each type of respirator. An APF of 10 means that performance tests have estimated that, for the majority of users, the given respirator reduces the contaminant concentration inside the respirator to one tenth of the ambient concentration. Caution should be used in interpreting the APF information; however, as the NIOSH APFs are based on the performance of the respirator under ideal lab or field conditions. Therefore, they do not assure that every user will achieve the level of protection indicated by the APF.

CONCLUSION

While it is not possible to determine the effectiveness of each of the control methods discussed above, every effort should be made to control emissions at their source and to remove emissions from the pathway between the source and the workers. This includes the isolation of the morgue area from the office area, maintaining negative pressure in the morgue with respect to surrounding areas, and exhausting all air from the morgue to the outside. Because TB exposure in these settings cannot be completely controlled by these preferred methods, the entire hierarchy of preventive measures is likely needed to minimize the risk of exposure to TB bacteria. This includes the use of appropriate respiratory protection.

In 1990, the CDC produced *Guidelines for Preventing the Transmission of Tuberculosis in Health-Care Settings, with Special Focus on HIV-Related Issues*. In this document, CDC recommended that particulate respirators be used by workers exposed to tuberculosis patients in certain situations. NIOSH is presently updating the guidance for respiratory protection of health-care-facility workers. Various alternatives for respiratory protection are being considered by NIOSH staff. When new NIOSH respirator recommendations are completed, copies will be sent.

RECOMMENDATIONS

1. Isolate the morgue ventilation system from the office area so there is no recirculation of morgue air into other areas of the facility. In addition, negative air pressure should be maintained in the morgue with respect to surrounding areas at

all times, and current ASHRAE and AIA guidelines for airflow rates should be met (i.e., 12 total ACH with 2 ACH of outside air). If a new HVAC system is installed which must recirculate some portion of air in the morgue, the use of HEPA filtration should be considered.

2. Restrict access in the morgue to personnel adequately protected against UV, TB, blood-borne pathogens and other hazards encountered during autopsies. The use of an intercom system to relay messages to morgue personnel is encouraged.

3. Provide for separate clean and dirty change areas for morgue personnel.

4. Incorporate a means of locking-out the on/off switches for the duct and ceiling mounted GUV lamps.

5. All personal protective equipment worn in the morgue should provide adequate protection against the high UV radiation levels encountered. Further evaluation of the hoods and faceshields is needed. The use of indirect vs. direct UV irradiation in the morgue would also serve to reduce worker UV exposures and should be considered.

6. A UV radiometer should be purchased to allow UV radiation measurements to be made whenever new bulbs are installed or changes are made in the location or design of the fixtures. This meter can also be used to assess the adequacy of protective clothing in protecting against the UV radiation. Equipment used to measure GUV radiation should be maintained and calibrated on a regular schedule. Also, a preventive maintenance program should be established outlining the schedule and procedures for cleaning and replacing UV lamps.

7. There should be a consistent policy regarding respirator use during autopsies. For exposure to aerosols containing TB organisms, the respirator offering the highest level of protection should be selected that is consistent with the tasks to be performed by the workers. The use of different types of respirators having varied assigned protection factors should be discontinued. In addition a respirator program should be established which meets the requirements of the OSHA Respiratory Protection Standard[15] and recommendations established by NIOSH.[16]

8. Tuberculin skin tests should be performed periodically on workers potentially exposed to TB, following existing CDC guidelines for testing and follow-up of positive cases.[18]

9. Medical surveillance of workers potentially exposed to UV radiation should include a review of the worker's past medical history to determine if there may be any condition that is exacerbated or aggravated by exposure to UV radiation. The use of any drugs or medications by workers that may cause hypersensitivity to UV radiation also should be evaluated. Any suspicious lesion that appears on skin exposed to UV should be examined by a physician.

10. A handwashing station should be installed in the cooler room.

11. Training and education should be provided for all workers potentially-exposed to TB, UV radiation, and blood-borne pathogens. The training should include information on the hazards encountered in this particular setting and procedures used in protecting workers against these hazards. The completion of the revised standard operating procedures (SOPs) for various tasks performed at the ME's office is encouraged.

12. Outside air (OA) should be provided at all times during occupancy as recommended by ASHRAE. The current recommendation is to provide 20 CFM of OA for general office space. Other deficiencies noted in the ventilation system should be corrected. This includes the repair of the exhaust fan in the cooler room and the balancing of the office HVAC ventilation system.

13. Efforts should be made to verify that the type of filtration used on the air intake for the clean room is capable of removing droplet nuclei.

REFERENCES

1. ASHRAE [1989]. Ventilation for acceptable indoor air quality. American Society for Heating, Refrigerating and Air-Conditioning Engineers. ANSI/ASHRAE Standard 62-1989.

2. ASHRAE [1991]. Health facilities. In: ASHRAE applications handbook. American Society for Heating, Refrigerating and Air-Conditioning Engineers: Atlanta, GA. Chapter 7.

3. State of New York [1988]. Medical facilities. In: Codes, rules and regulations of the State of New York, 9 Executive (B). Title 10, 712.31.

4. AIA [1987]. Guidelines for construction and equipment of hospital and medical facilities. American Institute of Architects. Waldorf, MD.

5. 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.

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

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

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

9. Collins CH [1983]. How laboratory infections are acquired. In: Laboratory acquired infections, pp. 26-35. C.H. Collins, Ed. Butterworths, London.

10. Lundgren R, Norrman E, Asberg I [1987]. Tuberculous infection transmitted at autopsy. Tubercule 68:147-150.

11. Green FHY, Yoshida K [1990]. Characteristics of aerosols generated during autopsy procedures and their potential role as carriers of infectious agents. App Occ Environ Hyg 5(12):853-858.

12. NIOSH [1989]. NIOSH comments on the Occupational Safety and Health Administration proposed rule on health standards; methods of compliance: 29 CFR Part 1910, October 2, 1989, OSHA Docket No. H-160. NIOSH policy 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.

13. NIOSH [1990]. NIOSH testimony on the Occupational Safety and Health Administration proposed rule on health standards; methods of compliance: 29 CFR Part 1910, May 31, 1990, OSHA Docket No. H-160. NIOSH policy 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.

14. NIOSH [1990]. NIOSH posthearing comments on the Occupational Safety and Health Administration proposed rule on health standards; methods of compliance: 29 CFR Part 1910, October 9, 1990, OSHA Docket No. H-160. NIOSH policy

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.

15. NIOSH. 30 CFR Part 11-respiratory protective devices; tests for permissibility, fees. Code of Federal Regulations. Washington, DC: U.S. Government Printing Office, Office of the Federal Register.

16. Code of Federal Regulations [1984]. Respiratory protection. 29 CFR 1910.134. Washington, DC: U.S. Government Printing Office, Federal Register.

17. NIOSH [1987]. A NIOSH guide to industrial respiratory protection. 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. 87-116.

18. CDC [1990]. Guidelines for preventing the transmission of tuberculosis in health-care settings, with special focus on HIV-related issues. U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control: Atlanta, GA. MMWR 1990;39(no. RR-17).

AUTHORSHIP AND ACKNOWLEDGEMENTS

Report Prepared by:

Teresa A. Seitz, M.P.H., C.I.H.
Industrial Hygienist
Industrial Hygiene Section

Field Assistance Personnel:

John A. Decker, R.Ph., M.S.
Industrial Hygienist
Industrial Hygiene Section

Report Formatted by:

Donna M. Humphries
Office Automation Assistant

Originating Office:

Hazard Evaluations and Technical Assistance Branch
Division of Surveillance, Hazard Evaluations and Field Studies

DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report may be freely reproduced and are not copyrighted. Single copies of this report will be available for a period of 90 days from the date of this report from the NIOSH Publications Office, 4676 Columbia Parkway, Cincinnati, Ohio 45226. To expedite your request, include a self-addressed mailing label along with your written request. After this time, copies may be purchased from the National Technical Information Service, 5285 Port Royal Rd., Springfield, Virginia 22161. Information regarding the NTIS stock number may be obtained from the NIOSH publications Office at the Cincinnati address. Copies of this report have been sent to:

1. Onondaga County Medical Examiner's Office
2. Civil Service Employees Union, Local 1000
3. State of New York, Department of Labor
4. OSHA Region II
5. New York State Department of Health
6. Centers for Disease Control
7. Onondaga County Health Department
8. Central New York Occupational Health Clinical Center

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