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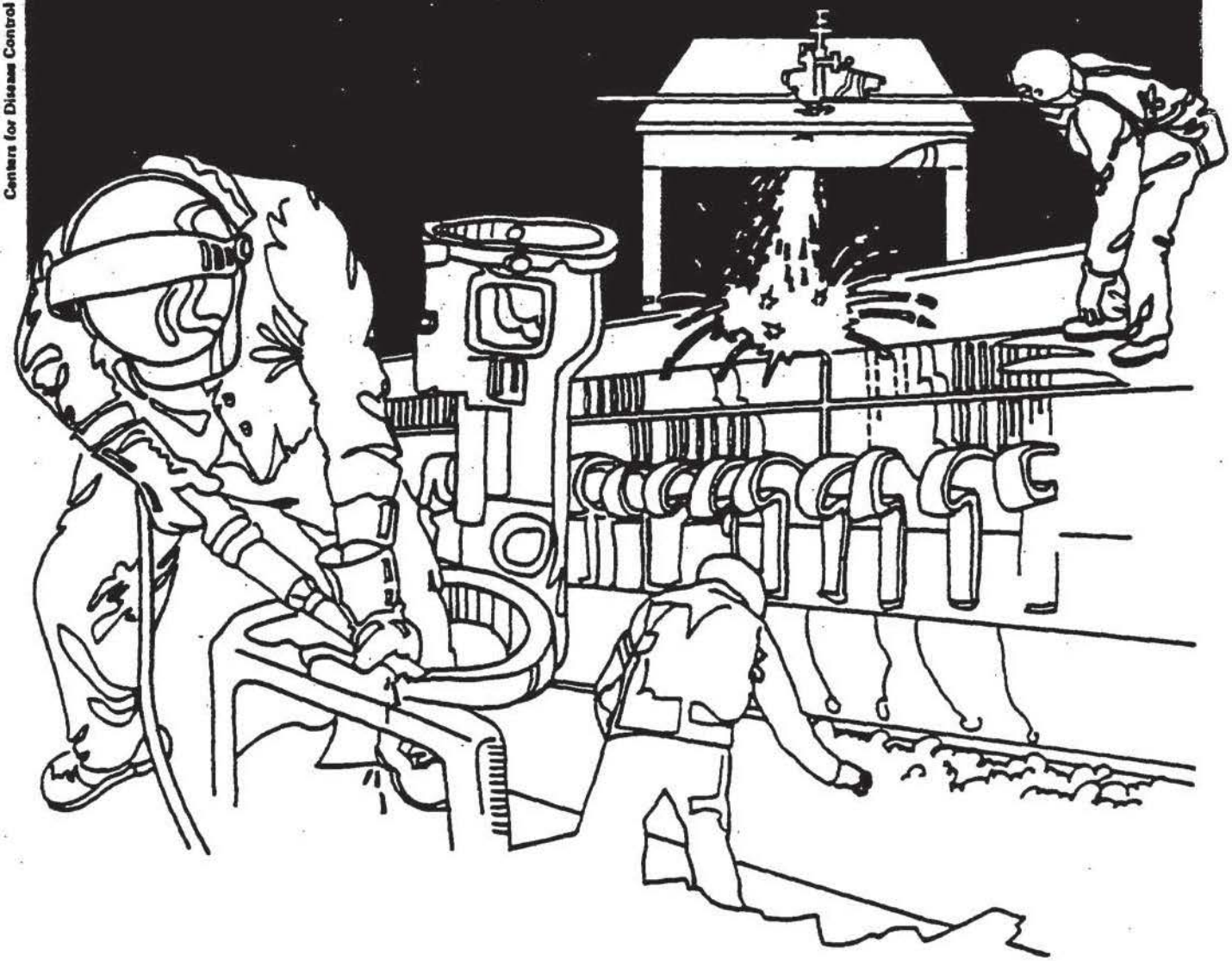

Health Hazard Evaluation Report

HETA 84-155-1489
CLARA MAASS MEDICAL CENTER
BELLEVILLE, NEW JERSEY

PREFACE

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

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, 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.

HETA 84-155-1489
JULY 1984
CLARA MAASS MEDICAL CENTER
BELLEVILLE, NEW JERSEY

NIOSH INVESTIGATOR:
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I. SUMMARY

On February 10, 1984, the National Institute for Occupational Safety and Health (NIOSH) was requested to evaluate reported symptoms of skin, eye, and throat irritation, headaches, light-headedness, and lethargy among technicians and pathologists in the Histopathology Laboratory at the Clara Maass Medical Center, Belleville, New Jersey. Lab personnel attributed these symptoms to formaldehyde and xylene exposure.

On March 20-22, 1984, a NIOSH investigator conducted an environmental evaluation of the Histopathology Laboratory. To characterize exposures to formaldehyde and xylene vapors, both long-term and short-term personal (breathing zone) air samples were collected from pathologists and technicians. In addition, the ventilation in the laboratory was evaluated by obtaining air flow measurements at exhaust and supply vents, and by observing air patterns using smoke tubes.

Formaldehyde was detected in all 21 air samples collected. The highest levels were present during grossing (visual inspection and dissection of formalin-preserved tissue specimens). During this operation the pathologist was exposed to levels of 2.79 and 4.08 parts per million (ppm) with peak levels ranging from 7 to in excess of 10 ppm. The technicians had exposures ranging from 1.07 to 1.55 ppm (peak up to 7 ppm) during grossing. These exposure levels exceeded the ceiling limit of 1 ppm currently proposed by the American Conference of Governmental Industrial Hygienists. No exposures exceeded the OSHA standard of 3 ppm as an 8 hour TWA; however peak levels during grossing exceeded the OSHA ceiling limit of 5 ppm. NIOSH recommends that occupational exposure to formaldehyde be reduced to the lowest feasible limit because of its carcinogenic potential.

Average daily exposures to xylene vapors for the technicians were measured at 8.6 and 7.1 ppm, well below the NIOSH and OSHA standard of 100 ppm. Short-term exposures to vapors during manual slide preparation procedures ranged from 100 to 200 ppm. Three of eight samples collected either met or approached the NIOSH ceiling limit of 200 ppm.

Airflow measurements and observations indicated deficiencies in both the general and local ventilation systems. General ventilation, although providing an adequate air exchange rate (10 per hour), was unacceptable because the laboratory was under positive pressure. This meant that contaminants generated in the lab would enter other non-contaminated areas of the hospital. The local exhaust system, consisting of a canopy-type hood above the grossing table, is an inappropriate hood design for controlling formaldehyde vapors during grossing because these vapors had to pass through the pathologist's breathing zone before exhausted by the hood.

On the basis of the data obtained in this investigation, NIOSH has determined that histopathology laboratory personnel are exposed to formaldehyde at levels capable of causing irritation effects. Recommendations concerning improvements in ventilation and work practices are presented in Section VIII of this report.

KEYWORDS: SIC 8062 (General Medical and Surgical Hospitals) formaldehyde, xylene, histopathology laboratory, eye and throat irritation, ventilation.

II. INTRODUCTION

On March 20-22, 1984 the National Institute for Occupational Safety and Health conducted a health hazard evaluation at Clara Maass Medical Center, Belleville, New Jersey. The survey was conducted to evaluate formaldehyde and xylene exposures to technicians and pathologists in the histopathology laboratory during tissue grossing and staining procedures. Health complaints reported by the workers consisted of eye and upper respiratory tract irritation, headaches, light-headedness, and lethargy.

III. BACKGROUND

Clara Maass Medical Center is a 575 bed hospital with a staff of about 1450 employees. Six workers are assigned to the Histopathology Lab including three pathologists and three technicians. The pathologists are responsible for visual examination and dissection of 10% formalin-preserved surgical and post-mortem tissue samples (hereafter referred to as grossing) and microscopic evaluation of stained tissue sections for cellular abnormalities. Grossing is routinely done in the afternoon for less than an hour by one of the pathologists, who rotate on a daily basis. Microscopic evaluation of stained tissue specimens is conducted by the pathologists on a daily basis in their respective offices and typically occupies most of their time when away from the lab.

The technicians are responsible for assisting the pathologist during grossing, preparing tissue samples for microscopic evaluation (includes cutting, mounting, and staining of tissue specimens), and cytology. These duties were divided between two of the technicians; i.e., one technician was responsible for assisting in grossing and cutting paraffin-encased tissue specimens while the other technician was responsible for staining and cytology. The third technician was mostly involved in administrative duties in a separate area away from the lab.

Tissue cutting and staining are done in the morning while grossing and cytology are done in the afternoon. The staining process requires the use of xylene and ethanol; these solvents and other staining solutions are kept in 27-500 ml capacity covered glass containers on the lab bench. During the staining procedure the technician manually dips a tray of slides with tissue sections on them from one solution to another. Xylene is also used when coverslips are manually placed over the stained tissue sections (coverslipping). No toxic chemicals are used in cytology or during cutting of paraffin-encased tissue specimens.

IV. DESIGN AND METHODS

On March 21 and 22, the NIOSH industrial hygienist collected personal and general area air samples for formaldehyde and personal samples for xylene. The air monitoring on March 21 was repeated on March 22.

Formaldehyde exposures were evaluated by collecting: (1) long-term and short-term breathing zone air samples from the pathologists and technicians and (2) general area air samples. The long-term samples were collected on Supelco ORBO-22 sorbent tubes containing 2-(benzylamino)ethanol-coated Chromosorb 102 resin. These tubes were connected to battery operated personal sampling pumps calibrated at 80 cubic centimeters per minute (cc/min). Samples were analyzed by gas chromatography according to NIOSH Method 2502 (formerly designated P&CAM 354).[1]

Different sampling strategies were used to evaluate the pathologists' and technicians' exposures. The pathologists were monitored only during the grossing process since this was the only time they were present in the lab. The one technician who cut tissue and assisted the pathologist during grossing had separate samples taken during each of these operations. The samples were used to differentiate between background formaldehyde exposure levels (prior to grossing) and exposure levels present during grossing. The other lab technician, although not directly involved in grossing either day, also had separate air samples taken during the work shift to show to what extent her exposure to formaldehyde increased during the afternoon when grossing was done. The remaining technician, who was involved in other activities away from the lab, was not included in the air monitoring.

The short-term formaldehyde samples were collected with direct-reading Draeger indicator tubes. These air samples were collected in the grossing area at various intervals up until the time grossing started to document background formaldehyde levels. Measurements were also taken in the breathing zone of the pathologist and technician during grossing.

Long-term and short-term breathing zone air samples for xylene were collected from the technician who stained tissue specimens. The long-term samples were collected on charcoal tubes using sampling pumps calibrated at 50 cc/minute and analyzed for total xylenes by NIOSH Method 1501 (formerly P&CAM 5318).[2] The short-term air samples were collected with direct reading Draeger indicator tubes during phases of the staining procedure where xylene was used; e.g., rinsing/cleaning slides and coverslipping.

No air samples for ethanol were collected because this compound is relatively non-toxic.

Ventilation measurements were taken to determine whether the system conformed to recommended minimum ventilation requirements. Air flow measurements were taken at each exhaust and supply vent in the laboratory using a Shortridge Model CFM-83 Flowhood and/or a Kurz velometer. Direction of air movement was observed using smoke generated from smoke tubes.

V. EVALUATION CRITERIA

A. Environmental Evaluation Criteria

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for 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 if 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 evaluation criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: 1) NIOSH Criteria Documents and recommendations, 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLV's), and 3) the U.S. Department of Labor (OSHA) occupational health standards. Often, the NIOSH recommendations and ACGIH TLV's are lower than the corresponding

OSHA standards. Both NIOSH recommendations and ACGIH TLV's usually are based on more recent information than are the OSHA standards. The OSHA standards also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH-recommended standards, by contrast, are based primarily on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is legally required to meet only those levels specified by an OSHA standard.

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 or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high short-term exposures.

B. Formaldehyde

The health effects of formaldehyde can result from acute or chronic exposure. The effects of acute exposure are primarily mucous membrane irritation (burning, tearing eyes; nose and throat irritation). These symptoms can occur as low as about 0.1 parts per million (ppm).[3] Dermatitis associated with formaldehyde vapor, solutions or formaldehyde-containing resins has been documented.[3,4] Formaldehyde is a primary skin irritant but may also cause allergic dermatitis at concentrations below those likely to cause primary irritant effects.

Allergic effects include skin sensitization and possibly asthma or asthma-like symptoms.[5,6] There is considerable evidence that formaldehyde can produce skin sensitization in man, especially in persons occupationally exposed through skin contact.[7] Eczematous contact dermatitis, when acute, is characterized by redness, swelling, vesiculation and oozing with itching. In the chronic form, affected areas of the skin may become dry, thickened and fissured.[8]

A recent study conducted by the Chemical Industry Institute of Toxicology (CIIT), in which rats and mice exposed to formaldehyde vapors developed nasal cancer, has raised concern about its carcinogenic potential in humans.[4]

The Federal (OSHA) standard for formaldehyde exposure is 3 ppm as an 8-hour TWA, with a ceiling level of 5 ppm and an acceptable maximum peak level of 10 ppm for 30 minutes.[9] On the basis of the CIIT study, ACGIH and NIOSH currently recommend that formaldehyde be treated as a potential human carcinogen. ACGIH currently proposes a TLV of 1 ppm as a ceiling limit.[10] NIOSH recommends that exposures be reduced to the lowest feasible level.[3]

C. Xylene

Xylene (xylol) is a common industrial solvent containing any one or a mixture of its isomers (i.e., ortho-xylene, meta-xylene, para-xylene).

Typical of many other organic solvents, exposure can cause varying degrees of anesthesia, with low level exposures causing headaches, and greater exposures causing light-headedness, "drunkeness", and even unconsciousness. Xylene may also cause irritation to the eyes, mucous membranes, and respiratory tract. Skin contact, particularly on a prolonged or repeated basis, may cause dermatitis.

The OSHA standard for xylene is 100 ppm as an 8-hour TWA.[11] NIOSH currently recommends that xylene exposures be controlled so that workers are not exposed to xylene at a concentration greater than 100 ppm as a 10-hour TWA with a ceiling concentration of 200 ppm.[12]

D. Ventilation

Recently, the Health Resources and Services Administration published guidelines for construction and equipment of hospitals and other health care facilities.[13] In this document they recommend that certain criteria be met with respect to ventilation in a number of hospital areas including histopathology laboratories. In terms of general ventilation requirements, histopathology labs should be ventilated to provide at least six room air changes per hour. This requirement is based on comfort, as well as asepsis and odor control and does not account for control of toxic contaminants. The general ventilation should also provide for movement of air into the lab from surrounding areas, i.e., the lab should be under negative pressure. Because of potential buildup of odors and/or contaminants the air should not be recirculated but rather exhausted directly outdoors (away from air intakes).

In situations where toxic contaminants are generated, local exhaust hoods should be used to remove the contaminant at the source. The type of hood to use would depend primarily on the process or operation; the more complete the hood enclosure the more economical and effective the system will be.

VI. RESULTS AND DISCUSSION

A. Environmental

The long-term and short-term air sampling results for formaldehyde are presented in Tables 1 and 2, respectively. As anticipated, the pathologists had the highest exposure during grossing, being exposed to levels of 2.79 and 4.08 ppm with peak levels ranging from 7 to in excess of 10 ppm. The technician who assisted the pathologist during grossing had exposures of 1.53 and 1.07 ppm with a peak level of 7 ppm. The other technician who was performing cytological assays near the grossing area during grossing was exposed to formaldehyde at a concentration of 1.55 ppm. During other operations (tissue staining, cutting) the technicians were exposed to 0.10 to 0.35 ppm formaldehyde. These levels are probably representative of background levels present in the lab. The combined daily exposure for the technicians ranged from 0.22 to 0.62 ppm, as a time-weighted average. Four area samples taken at the grossing table showed formaldehyde levels of 0.65 and 0.27 ppm with peak levels ranging up to 2 ppm for the 6-7 hour period preceeding grossing. The average levels during grossing increased to 2.64 and 3.42 ppm.

The levels of formaldehyde present during grossing exceeded the proposed ACGIH ceiling limit of 1 ppm. Although none of the samples exceeded the OSHA standard of 3 ppm as an 8-hour TWA the peak levels measured during grossing exceeded the OSHA ceiling limit of 5 ppm. The pathologist and assisting technician as well as the technician who was working nearby complained of eye and throat irritation.

Tables 3 and 4 present the long-term and short-term air sampling results for xylene. Two long-term air samples obtained from the technician (responsible in part for staining tissue slides) indicated exposure levels of 8.6 and 7.1 ppm, well below the evaluation criteria of 100 ppm. Short-term measurements taken during the slide staining process ranged from 100 to 200 ppm (Table 4), and were highest during rinsing/cleaning of slides. Three of four air samples taken during this operation either met or approached the NIOSH ceiling limit of 200 ppm.

B. Ventilation

The histopathology lab occupies approximately 575 sq. ft. of floor area. General ventilation consists of two supply air vents and one return (exhaust) vent, all located on the ceiling. Local ventilation consists of one canopy-type exhaust hood which is located above the grossing table.

Air flow measurements and observations indicated deficiencies in both the general and local exhaust systems. Regarding general ventilation, there was more air supplied to the lab than exhausted (700 cfm versus 530 cfm) which indicated that the lab was under positive pressure. Air flow patterns, visualized by generating smoke at the entrances to the lab corroborated these measurements; prevailing air movement was from the lab into the corridor. As a result, any contaminants generated in the lab can enter other non-contaminated areas of the hospital. Based on the amount of air supplied to the lab (not including the air entering the lab from the adjacent pathologists offices) there were at least 10 room air changes per hour in the lab. According to the hospital engineering staff, none of the air entering the lab was recirculated.

The canopy-type hood (dimensions 35" x 29"), apart from the fact that it did not exhaust very well (less than 30 feet per minute average face velocity) is an inappropriate hood design to use to control formaldehyde vapors during the grossing process. These hoods are almost exclusively used to control hot processes where vapors rise naturally through convective forces to the hood. They are not suited for operations where workers need to position themselves directly above their work (as in grossing) because the flow of air would be directed into the workers breathing zone before it is exhausted by the hood.

C. General Observations

Aside from lab coats, latex surgeon-type gloves are the only other protective equipment used by the lab personnel. The gloves are used during grossing but not during tissue staining. According to the workers these gloves readily deteriorate when handling xylene.

During manual transfer of slide trays from one container of solvent to another the liquid would spill onto the lab bench where it would evaporate. Covers were removed from all of the containers during staining even though only a few are used at any given time.

VI. CONCLUSIONS

The concentrations of formaldehyde measured in the personal breathing-zone air samples obtained during grossing were excessive (four times greater than ceiling limit of 1 ppm) and at levels which produced symptoms of eye and throat irritation among exposed lab personnel. These symptoms are consistent with the acute health effects reported in the literature for formaldehyde. Although there is no way of determining whether the laboratory workers are at an increased risk of developing cancer at these exposure levels, the presence of symptoms and the fact that formaldehyde is a suspect human carcinogen underlie the need for improvements in the local and general ventilation systems.

Although xylene exposures were below the 8 hour TWA, short-term excursions were measured at the NIOSH recommended ceiling limit of 200 ppm. Brief exposures at this concentration not only can produce mucous membrane irritation but also narcotic effects which may affect attention, judgement, or perception sufficiently to cause a worker to be non-responsive in an emergency situation. Since gloves were not worn during handling of slides wet from xylene it is very likely that this worker was also exposed percutaneously.

VIII. RECOMMENDATIONS

1. In order to effectively control formaldehyde vapors during grossing, a local exhaust ventilation system with a hood that physically encloses the operation as much as possible should be used. Probably the most effective type of hood to use in this particular operation would be a laboratory hood similar to that shown in Figure 1.

2. The general ventilation in the lab, although providing an acceptable air exchange rate, should also maintain the lab under negative pressure to keep contaminants from entering other work areas.

3. All formalin-preserved tissue samples kept in the lab should be stored in a ventilated cabinet to keep ambient formaldehyde levels in the lab to a minimum.

4. To control xylene vapors staining and coverslipping of slides should be conducted under a laboratory hood (see Figure 1).

5. Work practices (staining operation) should be improved with the goal of minimizing exposures during transfer of slide tray from one solution to another. Care should be taken to keep spillage to a minimum. If spills occur they should be removed immediately. The

practice of removing all of the container covers at the same time and leaving them off until the slides are processed should be discontinued. Solvent resistant gloves should be worn to minimize skin absorption of solvents.

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XI. DISTRIBUTION AND AVAILABILITY OF REPORT

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1. Clara Maass Medical Center
2. Requestors
3. NIOSH, Region II
4. OSHA, Region II

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.

Table 1

Formaldehyde Concentrations in Personal and Area Samples

Clara Maass Medical Center
Histopathology Laboratory
Belleville, New Jersey
HETA 84-155

March 21-22, 1984

Date	Sample Description	Work Activity	Sample Time (min)	Sample Volume (liters)	Formaldehyde Concentration Over Individual Sampling Period (ppm)	Formaldehyde Concentration Combined Exposure (ppm)
3-21-84	Pathologist, BZ	Grossing	47	3.8	2.79	
3-21-84	Lab Technician, BZ	Cutting paraffin encased tissue	277	21.1	0.35	
		Assist grossing	49	4.8	1.53	
		Cutting tissue/grossing	326	25.9		0.53
3-21-84	Lab Technician, BZ	Tissue Staining	227	17.1	ND*	
		Cytology	147	10.9	ND*	
		Staining/cytology	374	28.0		ND*
3-21-84	Stationary Sample, at Grossing Table	Before Grossing	362	26.3	0.65	
		During Grossing	72	5.3	2.64	
3-22-84	Pathologist, BZ	Grossing	33	2.6	4.08	
3-22-84	Lab Technician, BZ	Cutting paraffin tissue	338	25.8	0.10	
		Assist grossing	49	3.8	1.07	
		Cutting tissue/grossing	387	29.6		0.22
3-22-84	Lab Technician, BZ	Tissue Staining	224	15.1	0.16	
		Cytology	111	8.4	1.55	
		Staining/cytology	335	23.5		0.62
3-22-84	Stationary Sample, at Grossing Table	Before Grossing	426	33.4	0.27	
		During Grossing	51	3.8	3.42	
Evaluation Criteria:					**	**

Abbreviations: ppm = parts per million; BZ = breathing zone; ND = non detectable (less than 0.09 ppm)

* These results are questionable because all of the other samples had detectable levels including the samples taken from the same technician while doing the same work the following day.

** NIOSH recommends that exposures be reduced to the lowest feasible level (see Section IV).

Note: The combined TWA exposure was calculated by using the following formula:

$$\frac{C_1(T_1) + C_2(T_2)}{T_1 + T_2}$$

, where C1 is the contaminant concentration over time period T_1 and C_2 is the contaminant concentration over time period T_2.

Table 2

Short-term Formaldehyde Concentrations Before and During Grossing

Clara Maass Medical Center
Histopathology Laboratory
Belleville, New Jersey
HETA 84-155

March 21-22, 1984

Date	Time	Sample Description	Formaldehyde Concentration (ppm)
3-21-84	8:10a	Grossing Area, Before Grossing	1.0
3-21-84	9:50a	Grossing Area, Before Grossing	1.2
3-21-84	12:30p	Grossing Area, Before Grossing	2.0
3-22-84	7:50a	Grossing Area, Before Grossing	1.5
3-22-84	12:35p	Grossing Area, Before Grossing	1.5
3-22-84	2:30p	Pathologist's Breathing Zone, During Grossing	>10
3-22-84	2:41p	Pathologist's Breathing Zone, During Grossing	7
3-22-84	2:50p	Pathologist's Breathing Zone, During Grossing	10
3-22-84	2:53p	Technician's Breathing Zone, During Grossing	7

Evaluation Criteria: *

* NIOSH recommends that exposures be reduced to the lowest feasible level (see Section IV).

Table 3

Long-Term Xylene Concentration in Breathing Zone of Lab Technician

Clara Maass Medical Center
Histopathology Laboratory
Belleville, New Jersey
HETA 84-155

March 21-22, 1984

Date	Sample Description	Sampling Time (min)	Sample Volume (liters)	Xylene Concentration (ppm)
3-21-84	Lab Technician	335	15.2	8.6
3-22-84	Lab Technician	374	17.5	7.1

Evaluation Criteria: 100

Table 4

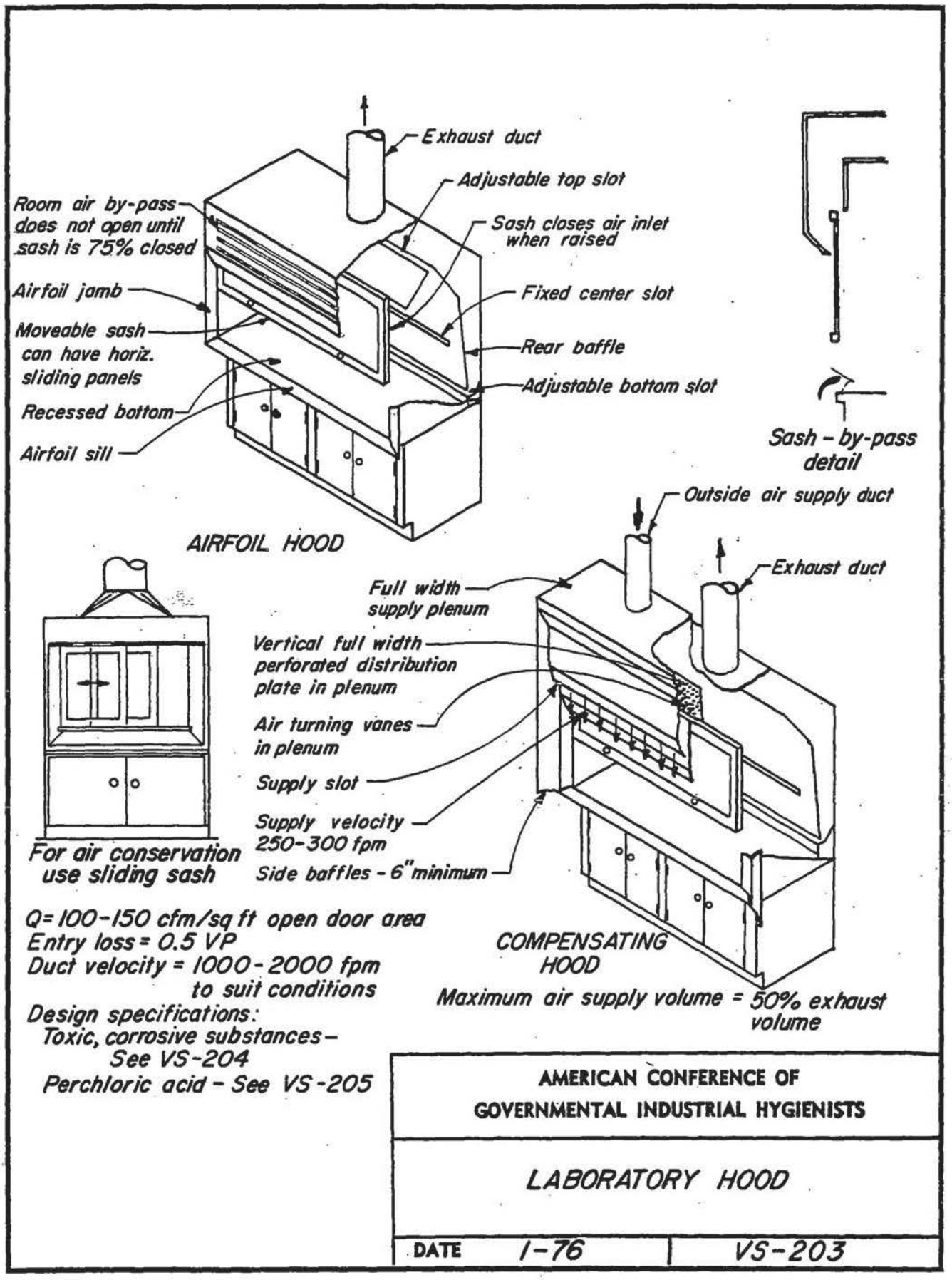
Short-Term Xylene Concentration in the Breathing Zone of Lab Technician
During Slide Staining Procedure

Clara Maass Medical Center
Histopathology Laboratory
Belleville, New Jersey
HETA 84-155

March 21-22, 1984

Date	Operation	Time	Xylene Concentration (ppm)
3-21-84	Rinsing/Cleaning Slides	9:25a	180
3-22-84	Rinsing/Cleaning Slides	9:50a	190
3-22-84	Rinsing/Cleaning Slides	11:00a	150
3-22-84	Rinsing/Cleaning Slides	12:00n	200
3-21-84	Cover Slipping Slides	9:30a	100
3-22-84	Cover Slipping Slides	9:55a	125
3-22-84	Cover Slipping Slides	11:05a	125
3-22-84	Cover Slipping Slides	12:06p	100
Evaluation Criteria:			200

Figure 1



Source: see Reference 14