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ST. VINCENT MEDICAL CENTER
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## SUMMARY

On May 4, 1995, the National Institute for Occupational Safety and Health (NIOSH) received a request for a Health Hazard Evaluation (HHE) at the St. Vincent Medical Center of Richmond in Staten Island, New York. The request asked NIOSH to assess indoor environmental quality (IEQ) and employee health concerns possibly associated with their work environment in the Labor and Delivery (L&D), Maternity, and Newborn Nursery (NBN) wards, located on the second floor of the Sister Loretta Bernard (SLB) building. Skin rashes, asthma, congestion, hives, itching and burning eyes, and throat irritation had been reported by some employees in these areas, and one employee had experienced a severe allergic (anaphylactic) reaction while at work. According to the request, potential environmental explanations included exposure to disinfectants used in these areas, corrosion inhibitors from boiler steam used for humidification, fiberglass, latex gloves, and poor ventilation.

In response to this request, NIOSH investigators conducted a site visit at St. Vincent Medical Center on June 21-23, 1995. The objectives of this visit were to inspect the areas of concern, interview employees, and review the heating, ventilating, and air-conditioning (HVAC) system supporting the SLB. Environmental monitoring for standard IEQ parameters (temperature, relative humidity [RH], and carbon dioxide [$CO_2$]), and instantaneous monitoring for non-specific volatile organic compounds (VOCs), was conducted on the day and evening work shifts. Integrated area air samples were collected on both shifts to qualitatively identify a wide range of VOCs. Personal air sampling was conducted to assess glutaraldehyde exposure of an employee cleaning medical devices in the endoscopy unit. The operation of Air Handler Units (AHU) #4 and #5, which support the second floor of the SLB building were reviewed and visually inspected. NIOSH medical officers conducted confidential interviews of day and evening shift employees in the L&D, Maternity, and NBN wards.

The $CO_2$ measurements varied, but in all areas and shifts were well below the 1000 parts per million (ppm) American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) guideline, indicating sufficient outside air is being provided and distributed to occupied areas on the second floor of the SLB building.

Temperatures were within acceptable ranges (69° - 75°F) on both the day and evening shifts. There were, however, fluctuations of up to 5°F throughout the second floor. RH levels were consistently found to be at the high end, or in excess of, the desirable range (30% - 60%). RH levels ranged from 58% to 62% throughout the second floor. Instantaneous measurements to assess relative levels of non-specific VOCs throughout the second floor showed only "trace" amounts present in ambient air; the levels detected were not appreciably different from outside concentrations.

The personal sample for glutaraldehyde showed an employee exposure of 0.06 ppm, which is below the NIOSH Recommended Exposure Limit (REL) of 0.2 ppm as a ceiling limit. Cleaning endoscopes with glutaraldehyde is conducted daily in a small room with a window at one end and supply fan at the other. During the cleaning, the worker wore rubber gloves and a splash apron. No eye protection was worn. A noticeable odor associated with the cleaning solution was present in the Endoscopy ward. A

135-minute area sample for glutaraldehyde, obtained in the suture room between the two operating rooms in the L&D ward, showed no detectable glutaraldehyde (detection limit = 0.004 ppm).

The integrated monitoring for VOCs was unremarkable and found typical indoor air contaminants such as components of cleaning solutions and disinfectants. Similar compounds were found on samples collected in other areas of the hospital.

Ongoing health concerns and complaints about the working environment have been reported by some employees on the second floor of the SLB building at the St. Vincent Medical Center. The symptoms (eye/nose/throat irritation, skin rashes/itching, headaches, congestion) began as early as 1990; consistent complaints have occurred since 1992, and span all shifts. A total of 24 employees elected to participate in the interviews (22 personal and 2 telephone interviews). Of the workers interviewed, all had at least one sign or symptom felt by the employee to be associated with the workplace, and occurring on more than one occasion in the previous year. Of the 24 workers interviewed, 11 (46%) had sought medical care for workplace symptoms. Diagnoses given to them by their physicians for conditions that were reported as caused or aggravated by the work environment included--asthma (four workers), asthma and latex allergy (two workers), and one each of latex allergy, anaphylaxis/ allergic reaction of unknown etiology, hives, sick building syndrome, and dry skin. The employee health complaint logbooks showed a variety of health concerns among employees of both the L&D and Maternity wards. The symptoms listed included headaches and eye and upper respiratory irritation. Log entries reflected health complaints on all shifts.

No obvious environmental explanation for the symptoms and complaints experienced was identified. Although some areas for improvement were noted, the ventilation system was in good condition and appeared to be operating properly. Sufficient outside air is being provided to the second floor of the SLB building; however there were considerable temperature swings and variations in humidity levels. Some employees appear to have experienced latex-related allergic reactions. Exposure to glutaraldehyde was below the NIOSH REL in the Endoscopy ward. Recommendations to address health concerns include improving employee communication, ventilation improvements, providing eye and face protection during the use of glutaraldehyde, and providing latex-free and powder-free gloves for personnel with latex allergies.

KEYWORDS: SIC 8062 (General Medical and Surgical Hospitals), indoor environmental quality, IAQ, latex allergy, VOCs, glutaraldehyde, anaphylactic reaction

## INTRODUCTION

NIOSH received a request from the St. Vincent Medical Center on May 4, 1995, to assess ongoing health complaints associated with indoor environmental quality (IEQ) among employees on the second floor of the Sister Loretta Bernard (SLB) building. The reported health complaints included skin rashes, asthma, congestion, hives, and throat irritation. Previous efforts by hospital staff members to resolve these issues had been unsuccessful, and NIOSH was asked to conduct an investigation.

NIOSH reviewed information provided by St. Vincent personnel regarding this facility and chemicals used in the complaint area. An initial site visit to the St. Vincent Medical Center was conducted on June 21, 1995. During this survey, NIOSH investigators met with St. Vincent and employee representatives and inspected the facility and heating, ventilating and air-conditioning (HVAC) systems supporting the complaint areas. Environmental monitoring for standard IEQ parameters, total volatile organic compounds (TVOCs), and glutaraldehyde was conducted. Confidential interviews were held with building occupants, and previously collected employee complaint logs were reviewed. IEQ investigation protocols, and information on latex allergies and anaphylactic reactions associated with latex, were provided to St.Vincent personnel during the site visit.

## BACKGROUND

### Facility Description

St. Vincent Medical Center is a 440-bed acute care teaching hospital that employs over 2100 workers. The hospital provides comprehensive inpatient services, including surgical, pediatric, cardiac, and obstetrical care. The SLB building, which opened in 1989, is the newest addition to St. Vincent Medical Center. The SLB building is a 7-story facility that is physically connected to the older main building and the Cardinal Spellman Pavilion. The main information desk, a waiting area, and a yogurt/bake shop are in an enclosed atrium at the back of the SLB building (windows on the back of the SLB building overlook the atrium). Elevators are also located in this area. The L&D ward employs 51 workers (3 shifts) and has two obstetrical surgery units. There are 35 employees in the Maternity ward and 31 workers in the 30-infant capacity NBN ward. The hospital averages approximately 3000 deliveries annually. Smoking is not permitted inside the building.

### Ventilation System

The HVAC system supporting the SLB building is located in a roof-top penthouse. All air-handling units (AHUs) are located in this mechanical room, and outside air (OA) is obtained at the roof level from a common louvered intake that faces Bard Avenue. This common OA intake is manifolded to many of the AHUs for this building.

AHU #4 (serves L&D) and AHU #5 (Maternity and NBN) are constant volume (CV) systems with terminal reheat units located in supply ducts above the false ceiling of the second floor. The terminal reheat units may serve up to four rooms per unit. There is one thermostat per reheat unit, which controls the valve supplying hot water to the systems. Supply air is distributed via unlined ducts to ceiling diffusers. Return air (RA) is obtained through ceiling mounted louvers and is conveyed back to the AHUs via ductwork (no common RA plenum). The AHUs, which operate continuously (no

cycling), are designed to provide 55°F air to the terminal reheat units. The AHUs have economizers designed to allow more OA into the system if outside conditions are favorable. St. Vincent Personnel reported that the OA dampers have a minimum stop set at 10% OA. Fire dampers installed in ductwork at fire-wall penetrations are designed to close upon activation of smoke detectors and the fire alarm. Direct injection of boiler steam ("live" steam) for humidification was used until late 1992, when, after concerns arose about the potential for exposure to corrosion inhibitor chemicals (diethylaminoethanol [DEAE], cyclohexylamine, morpholine), the humidification system was turned off. There is currently no provision for humidification. Each AHU is equipped with a 45% efficiency pre-filter and a 95% efficiency terminal filter. Recirculating fan coil units are located in perimeter rooms for additional comfort control. These units are equipped with a filter, a coil, and either hot or cold water supply (depending on the season). Operation is locally controlled, and the units are contained within laminated wooden cabinets.

**History of Health Complaints at St. Vincent**

Sporadic health complaints have occurred in the SLB building since 1990, primarily on the second floor. During 1992, increased numbers of complaints were reported from the Maternity ward, mostly on the night shifts. Initially, employees complained of itching, and then rashes, respiratory distress, odors, and allergic reactions. The complaints increased in L&D in January 1995, and one employee suffered a severe rash and allergic reaction in April 1995 and had to move to another area to work. Previously, employees on the fifth floor of the SLB building had reported health complaints. However, complaints diminished considerably on the fifth floor and remained a problem primairly of the second floor.

In response to these complaints, St. Vincent management took a number of actions to better characterize the scope of the problem, identify possible environmental explanations, and improve IEQ. These included adjusting the OA intake dampers to ensure sufficient OA is provided at all times, removing fiberglass lining from the HVAC system, cleaning the AHUs and ductwork, balancing AHU #5, replacing the filters in the AHUs, and discontinuing the use of the humidification system. A consulting firm was hired to evaluate standard IEQ parameters, and air sampling for fiberglass and formaldehyde was conducted. The chemicals used on the second floor were reviewed to identify potential sources. Some janitorial practices (use of Galahad® cleaner to wipe down the L&D nurses station) were halted or modified. Employee questionnaires were distributed to obtain additional information on the types of symptoms experienced and possible explanations. The potential for allergic reactions to latex gloves was also considered by St. Vincent personnel. Some health care workers with latex allergies have been identified, and some workers have less frequent symptoms when using powder-free gloves. In spite of these efforts, health complaints have continued to occur on the second floor. During the NIOSH visit, employees indicated that problems have diminished somewhat since the heating season ended.

## EVALUATION PROCEDURES

### Environmental

Thermal Desorption Tubes

Area air samples for qualitative VOC analysis were obtained in L&D, NBN, and the Maternity wards on both the day and night shifts. Reusable Carbotrap® 300 multi-bed thermal desorption (TD) tubes were used as collection media. These tubes are designed to trap a wide range of organic compounds for subsequent qualitative analysis via thermal desorption and gas chromatography/mass spectrometry (GC/MS). The air samples were collected using constant-volume SKC Model 223 low-flow sampling pumps at flow rates of 50-200 cubic centimeters per minute (cc/min). Sampling times ranged from 2 to 3 hours and field blanks and humidity controls were submitted with the samples. Pumps are equipped with a pump stroke counter and the number of strokes necessary to pull a known volume of air was determined during calibration. This information was used to calculate the air per pump-stroke "K" factor. The pump stroke count was recorded before and after sampling and the difference used to calculate the total volume of air sampled. A bulk sample of cleaning solution was submitted for qualitative analysis by GC/MS.

Glutaraldehyde

Personal and area air samples for glutaraldehyde were collected using constant-volume SKC Model 223 low-flow sampling pumps. Flow rates of approximately 200 cc/min were used to collect the samples. Sampling time ranged from 20 minutes to 2 hours. Treated silica gel sorbent tubes (SKC 226-119) were used as the collection medium, and analysis was conducted according to NIOSH 4th. ed. method 2532. Personal sampling was conducted to evaluate exposure during equipment cleaning in the Endoscopy ward. An area sample was collected in the suture room between the two obstetrical operating rooms in the L&D ward.

Non-specific VOC Monitoring

Instantaneous measurements to assess relative levels of VOCs were obtained in various indoor and outdoor locations. This monitoring was done with an HNu Systems Model DL 101 analyzer. This portable, non-specific, direct-reading instrument uses the principle of photoionization for detection. The sensor consists of a sealed ultraviolet light source that emits photons which are energetic enough to ionize many compounds. These ions are driven to a collector electrode where the current (proportional to concentration) is measured. A 10.2 electron volt lamp was utilized. This lamp will ionize a wide variety of organic compounds, yet exclude normal constituents of air such as nitrogen, oxygen, carbon dioxide, etc. Measurements were obtained with the instrument set on maximum sensitivity. This sampling was conducted to identify potential sources of solvent emissions or material that may be emitting VOCs.

Carbon Dioxide ($CO_2$)

Instantaneous measurements of $CO_2$ concentrations were obtained using a Gastech Model RI-411A Portable (direct reading) $CO_2$ monitor. The principle of detection is non-dispersive infrared absorption. The instrument was zeroed (zero $CO_2$ gas source) and calibrated prior to use with a known $CO_2$ source (span gas). The monitor provides $CO_2$ concentrations in 25 parts per million (ppm) increments with a range of 0 - 4975 ppm. Measurements were obtained at various intervals and locations throughout the SLB second floor. Outdoor readings were taken to determine baseline $CO_2$ levels.

Temperature and Relative Humidity (RH)

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

**Medical Evaluation Methods**

The medical evaluation consisted of the following components:

1. A review of symptom logs on L&D and the Maternity ward. In May 1995, logbooks for the self-recording of employee symptoms had been placed by the St. Vincent Environmental Health and Safety Department (EHS) in L&D and the Maternity wards. Employees were encouraged to record their symptoms and note concerns about environmental quality in this logbook.

2. A meeting with the physician at the St. Vincent Employee Health Department. Topics discussed included the types of symptoms experienced by employees and the medical work-ups conducted.

3. A review of the EHS employee questionnaire results. In May 1995, EHS distributed a questionnaire to employees of L&D, Maternity ward, and NBN to obtain the following information: types of signs and symptoms currently experienced by employees; the natural history of symptoms (onset and resolution); associated environmental factors; whether health care providers were consulted; and other comments regarding the work environment. The questionnaire had been analyzed by EHS; highlights are presented in the Medical Results section.

4. Voluntary, confidential interviews conducted with employees from L&D, Maternity ward, and NBN. All employees of L&D, Maternity ward, and NBN present on June 21 and 22 were asked to participate in an interview with a NIOSH medical officer. The interviews took place during all three work shifts. In addition employees were informed of the possibility of telephone interviews. The information obtained included the following:

    a. Demographic and work history (name, age, gender, work area, shift, job title, years worked at the job, extent of latex glove, and other exposures).

b. Medical history (history of asthma, allergies, skin problems, and cigarette smoking).
c. Current or past work-related health problems (eye/nose/throat irritation, skin rash or hives, fever, cough, wheezing, and shortness of breath).
d. Medical work-up of the health problems (physician visits, diagnoses, medications, and medical tests).

## EVALUATION CRITERIA

### A. Indoor Environmental Quality

NIOSH investigators have completed over 1100 investigations of occupational indoor environments in a wide variety of non-industrial settings. The majority of these investigations have been conducted since 1979.

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

A number of published studies have reported a high prevalence of symptoms among occupants of office buildings.[1-5] Scientists investigating indoor environmental problems believe there are multiple factors contributing to building-related occupant complaints.[6,7] Among these factors are imprecisely defined characteristics of heating, ventilating, and air-conditioning (HVAC) systems, cumulative effects of exposure to low concentrations of multiple chemical pollutants, odors, elevated concentrations of particulate matter, microbiological contamination, and physical factors such as thermal comfort, lighting, and noise.[8-13] Indoor environmental pollutants can arise from either outdoor sources or indoor sources.[14]

There are also reports describing results which show that occupant perceptions of the indoor environment are more closely related than any measured indoor contaminant or condition to the occurrence of symptoms.[15-17] Some studies have shown relationships between psychological, social, and organizational factors in the workplace and the occurrence of symptoms and comfort complaints.[17-20]

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

Problems NIOSH investigators have found in the non-industrial indoor environment have included poor air quality due to ventilation system deficiencies, overcrowding, volatile organic chemicals from office furnishings, machines, structural components of the building and contents, tobacco smoke, microbiological contamination, and outside air pollutants; comfort problems due to improper temperature and relative humidity conditions, poor lighting, and unacceptable noise levels; adverse ergonomic conditions; and job-related psychosocial stressors. In most cases, however, these problems could not be directly linked to the reported health effects.

Standards specifically for the non-industrial indoor environment do not exist. NIOSH, the Occupational Safety and Health Administration (OSHA), and the American Conference of Governmental Industrial Hygienists (ACGIH) have published regulatory standards or recommended limits for occupational exposures.[21-23] With few exceptions, pollutant concentrations observed in the office work environment fall well below these published occupational standards or recommended exposure limits. The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) has published recommended building ventilation design criteria and thermal comfort guidelines.[24,25] The ACGIH has also developed a manual of guidelines for approaching investigations of building-related complaints that might be caused by airborne living organisms or their effluent.[26]

Measurement of indoor environmental contaminants has rarely been shown to be helpful in determining the cause of symptoms and complaints except where there are strong or unusual sources, or a proven relationship between a contaminant and a building-related illness. The effects of exposure to the usual low-level concentrations of particles and variable mixtures of organic materials found are troublesome to understand. However, measuring ventilation and comfort indicators such as carbon dioxide ($CO_2$), temperature, and relative humidity, is useful in the early stages of an investigation in providing information relative to the proper functioning and control of HVAC systems.

Carbon Dioxide

Carbon dioxide is a normal constituent of exhaled breath and, if monitored, can be used as a screening technique to evaluate whether adequate quantities of outside air are being introduced into an occupied space. ASHRAE's most recently published ventilation standard, ASHRAE 62-1989, Ventilation for Acceptable Indoor Air Quality, recommends outdoor air (OA) supply rates of 20 cubic feet per minute per person (cfm/person) for office spaces, and 15 cfm/person for reception areas, classrooms, libraries, auditoriums, and corridors.[24] Recommended OA requirements for hospitals range from 30 cfm/person for operating rooms to 15 cfm/person for recovery, ICU, and medical procedure areas. Maintaining the recommended ASHRAE outdoor air supply rates when the outdoor air is of good quality, and there are no significant indoor emission sources, should provide for acceptable indoor air quality.

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

Temperature and Relative Humidity

Temperature and RH measurements are often collected as part of an indoor environmental quality investigation because these parameters affect the perception of comfort in an indoor environment. The perception of thermal comfort is related to one's metabolic heat production, the transfer of heat to the environment, physiological adjustments, and body temperature.[27] Heat transfer from the body to the environment is influenced by factors such as temperature, humidity, air movement, personal activities, and clothing. The American National Standards Institute (ANSI)/ASHRAE Standard 55-1992 specifies conditions in which 80% or more of the occupants would be expected to find the environment thermally acceptable.[25] Assuming slow air movement and 50% RH, the operative temperatures recommended by ASHRAE range from 68-74° F in the winter, and from 73-79° F in the summer (Figure 1). The difference between the two is largely due to seasonal clothing selection. ASHRAE also recommends that RH be maintained between 30 and 60% RH.[24,25] Excessive humidities can support the growth of microorganisms, some of which may be pathogenic or allergenic.

## B. Volatile Organic Compounds

Volatile organic compounds describe a large class of chemicals which are organic (i.e., contain carbon) and have a sufficiently high vapor pressure to allow some of the compound to exist in the gaseous state at room temperature. These compounds are emitted in varying concentrations from numerous indoor sources including, but not limited to, carpeting, fabrics, adhesives, solvents, paints, cleaners, disinfectants, waxes, cigarettes, and combustion sources.

Indoor environmental quality studies have measured wide ranges of VOC concentrations in indoor air as well as differences in the mixtures of chemicals which are present. Research also suggests that the irritant potency of these VOC mixtures can vary. While in some instances it may be useful to identify some of the individual chemicals which may be present, the concept of total volatile organic compounds (TVOC) has been used in an attempt to predict certain types of health effects.[28] The use of this TVOC indicator, however, has never been standardized.

Some researchers have compared levels of TVOCs with human responses (such as headache and irritative symptoms of the eyes, nose, and throat). However, neither NIOSH nor the Occupational Safety and Health Administration currently have specific exposure criteria for VOC mixtures in the non-industrial environment. Research conducted in Europe suggests that complaints by building occupants may be more likely to occur when TVOC concentrations increase.[10] It should be emphasized that the highly variable nature of these complex VOC mixtures can greatly affect their irritancy potential. Considering the difficulty in interpreting TVOC measurements, caution should be used in attempting to associate health effects (beyond nonspecific sensory irritation) with specific TVOC levels.

## C. Glutaraldehyde

Glutaraldehyde is used as a cold sterilant in hospitals and dental offices. It is used in pulmonary physiology units, at nurses' stations, and research laboratories to clean sputum mouthpieces, suction bottles, tubing, and other equipment.[29] Although glutaraldehyde is available in 50%, 25%, 10%, and

2% solutions, most health care facilities use 2% glutaraldehyde solutions buffered to pH 7.5-8.5. Glutaraldehyde solutions also contain surfactant to promote wetting and rinsing of surfaces, sodium nitrite to inhibit corrosion, peppermint oil as an odorant, and FD&C yellow and blue dyes to indicate activation of the solution.[29] One disadvantage of buffered glutaraldehyde solutions is that they are stable for less than 2 weeks, so solutions must be dated and made as needed.[30] Another disadvantage is that at 20° C (68° F), a 50% solution of glutaraldehyde has a vapor pressure of 0.015 mm Hg and can generate an atmosphere that contains as much as 20 ppm glutaraldehyde.[31] This concentration is well above that shown to cause adverse health effects in animals and humans.

Glutaraldehyde may be absorbed into the body by inhalation, ingestion, and skin contact. Extensive skin contact may cause allergic eczema and may also affect the nervous system. Glutaraldehyde has an odor threshold of about 0.04 ppm, is highly toxic, and is irritating to the skin and mucous membranes at concentrations of 0.3 ppm.[31] A NIOSH investigation determined that airborne glutaraldehyde concentrations of 0.4 ppm were responsible for symptoms of irritation in 9 of 11 (82%) exposed workers. Eye, throat, and lung irritation were reported among 45% of the workers. Other symptoms including cough, chest tightness, headache, skin irritation, and asthma symptoms, were also reported.[29]

In a study published by the National Toxicology Program (NTP) in 1993, groups of five rats and five mice of each sex were exposed to glutaraldehyde by whole-body inhalation at concentrations of 0, 0.16, 0.5, 1.6, 5, and 16 ppm for 6 hours per day, 5 days per week, for 2 weeks. All rats and mice exposed to 5 or 16 ppm glutaraldehyde died before the end of the studies; all mice exposed to 1.6 ppm also died. Deaths were attributed to severe respiratory distress. Mice appeared to be more sensitive than rats because the small airways of the nasal passage of mice were more easily blocked by cell debris and keratin. Lesions noted in the nasal passage and larynx of rats and mice included necrosis, inflammation, and squamous metaplasia. The no-observed-adverse-effect level (NOAEL) was 0.125 ppm for respiratory lesions in rats. An NOAEL was not reached for mice, as inflammation was found in the anterior nasal passage at concentrations as low as 0.0625 ppm.[32]

Glutaraldehyde exposure has also been associated with fetotoxicity in mice, DNA damage in chickens and hamsters, and mutagenicity in microorganisms.[33] The NIOSH recommended exposure Limit (REL) for glutaraldehyde is 0.2 parts per million (ppm) as a ceiling limit (the level that should not be exceeded at any time).[21]

### D. Latex

An occupationally-related rubber contact urticaria [RCU] in a nurse exposed to latex surgical gloves was first reported in 1980.[34] Numerous cases have since been reported, and allergic reactions to latex among health care workers is now a recognized occupational disease. Implementation of "universal precautions" in health care settings and the Occupational Safety and Health Administration (OSHA) bloodborne pathogen standard have substantially increased the use of disposable latex gloves, with a resultant increase in reports of latex sensitivity.

The symptoms associated with latex allergy can vary in type and severity. Non-specific complaints of itching, burning, or a history of hand eczema may be reported. Some patients have pronounced reactions within minutes at the site of contact, which gradually resolve after cessation of exposure.

Rhinoconjunctivitis, contact dermatitis, asthma, and anaphylactic shock have also occurred as a result of latex-related allergic reactions.[35-38] One severe anaphylactic reaction occurred in a health care worker who used latex gloves "specifically formulated for hands allergic to latex."[36] One prevalence study found 7.4% of physicians and 5.6% of nurses working in operating rooms to have RCU.[34] Another study, where 224 medical center employees were skin tested with extracts of four different latex gloves and one synthetic glove, found positive reactions to the latex extracts in 17% of the test subjects, while there were no reactions to the non-latex glove extract.[39] Time periods between exposure to latex allergens and onset of symptoms have been reported to range from six months to five years.[37] It has been estimated that some 500,000 health care workers may be affected by latex sensitivity.[40]

The agent thought responsible for the allergic reaction is a protein found in the rubber tree, the source of latex for most latex products. Latex is not a pure chemical but a complex mixture : latex gloves contain approximately 2-3% protein.[34] Apparently, gloves from different manufacturers vary widely in their ability to elicit allergic reactions. One study found that the rate of positive responses to skin prick tests (SPTs) using latex gloves from 19 different manufacturers ranged from 8% to 100% among those tested.[34]

A number of studies have shown that the latex allergen becomes airborne, primarily when powdered latex gloves are used.[41-43] There is evidence that the cornstarch powder used with latex gloves will bind with allergenic proteins in the latex.[41] The resultant airborne particles may present a significant hazard to latex sensitive persons, and mucosal exposures may be more apt to result in anaphylactic reactions.[34] One study showed that when a latex-sensitive laboratory technician's coworkers switched to powder-free latex gloves, her symptoms cleared.[42] Although there is evidence suggesting a truly allergen-free latex glove may not exist for latex-sensitive persons, the OSHA bloodborne pathogens standard (29 CFR 1910.1030) requires employers to provide "hypoallergenic gloves, glove liners, powderless gloves...to employees who are allergic to the gloves normally provided."[44]

Protection for latex-sensitive workers can be accomplished by substituting synthetic (e.g., vinyl) gloves, or when such gloves alone would not be adequately protective, wearing synthetic gloves underneath the latex gloves. Providing a latex-free environment, identification of high-latex use areas, and providing latex allergy assessments for employees should also be part of a health and safety plan for responding to this issue. In some cases, it may be necessary for workers to move to other areas or alter assume different job duties.

## RESULTS AND DISCUSSION

### Environmental

#### Temperature, Relative Humidity, and Carbon Dioxide

The results of the $CO_2$, temperature, and relative humidity monitoring are shown in Table 1. The $CO_2$ measurements varied, but in all areas and shifts were well below the 1000 ppm ASHRAE guideline. This indicates sufficient OA is being provided and distributed to occupied areas on the second floor of the SLB building. The highest $CO_2$ concentration measured was 850 ppm, detected during the day shift in the L&D breakroom when there were 7-8 employees present in this area. $CO_2$ concentrations

in most areas ranged from 400 - 575 ppm. The hospital was fully operational and normally staffed during the monitoring.

Temperature measurements indicated levels to be within acceptable ranges on both the day and evening shifts. There were, however, fluctuations of up to five degrees °F throughout the second floor, particularly on the day shift. Some of the temperature swings were found in the same area (e.g., L&D). Excessive variations in temperature may cause more discomfort than maintenance of higher or lower temperatures with less variation, and can exacerbate complaints. This finding is consistent with comfort concerns noted by employees.

Humidity control was less than ideal. Relative humidity levels were consistently found to be at the high end, or in excess of, the desirable range. RH levels ranged from 58% to 62% throughout the second floor. A contributing factor to the high RH levels may be the economizers in use in the HVAC system. Because OA temperatures were favorable, additional OA was brought into the AHUs, with less air being recirculated. The RH of this OA was relatively high (66 - 73%) which increased the overall RH levels in the building. This is likely to be a seasonal issue, with an opposite effect during the winter. During the hotter months, outdoor RH levels are much higher than during the winter. In the winter, RH levels are much lower, and, because there is currently no provision for humidifying ventilated air, are likely to fall below the recommended range.

Table 1
Temperature, Relative Humidity, and Carbon Dioxide ($CO_2$) Monitoring
St. Vincent Medical Center, Staten Island, NY
June 21-22, 1995
HETA 95-0239

| LOCATION | $CO_2$ (ppm) | | | | RH % | | Temperature °F | |
|---|---|---|---|---|---|---|---|---|
| | 23:00 | # Workers | 14:00 | # Workers | 23:00 | 14:00 | 23:00 | 14:00 |
| Outside | 300 | NA | 275 | NA | 73 | 66 | 66 | 76 |
| Nurse St. (Maternity) | 525 | 6 | 600 | 10 | 58 | 62 | 70 | 71 |
| West Hallway btwn Maternity and NBN | 450 | 2 | 525 | 3 | 58 | 62 | 70 | 72 |
| Nurse St. (NBN) | 400 | 7 | 475 | 3 | 58 | 59 | 71 | 75 |
| East Hallway, Outside L&D | 450 | 2 | 525 | 4 | 58 | 57 | 71 | 74 |
| Nurse St. (L&D) | 450 | 8 | 525 | 11 | 59 | 60 | 69 | 71 |
| L&D (adjacent 2A48) | 425 | 1 | 525 | 2 | 60 | 60 | 70 | 72 |
| L&D (outside Nurse Station) | NA | NA | 525 | 11 | NA | 60 | NA | 73 |
| L&D (Break Room) | NA | NA | 850 | 8 | NA | 59 | NA | 75 |

ppm =parts of gas or vapor per million parts air
NA = not applicable or sample not collected during that time period

Non-Specific Volatile Organic Carbon Monitoring

Instantaneous measurements to assess relative levels of VOCs throughout the second floor were obtained on both the day and evening shifts. This monitoring showed only "trace" amounts of VOCs present in ambient air; the levels detected were not appreciably different from outside concentrations. Measurements taken directly above "point sources" such as Galahad® or TBQ cleaning solutions elicited a response from the HNu meter, indicating these materials are VOC sources, although they did not appear to contribute to overall VOC levels on the second floor.

HVAC Inspection

A limited visual inspection of AHUs #4 and #5 showed these units to be clean and in good condition. The filter banks appeared clean and properly fitted (no evidence of filter bypass). Condensate drain pans were free of standing water or evidence of mold, indicating proper drainage. Both sides of the coils were clean. The OA damper modulator motors and linkage appeared to be secure and functional. Neither the supply nor the return ducts are internally insulated. Air balancing, volume measurements, and system cleaning had recently been conducted for AHU #5. However, there was no balancing or capacity information available for AHU #4, thus no verification that the system was operating as designed. St. Vincent personnel indicated that the AHUs are inspected daily by Facilities Engineering.

According to Facilities Engineering personnel, the economizers are designed to operate by an enthalpy controller, which monitors both temperature and RH, and modulates the OA and RA dampers accordingly to maximize efficiency. Inspection of the OA intakes showed the dampers on AHU #4 to be at the minimum stop position, while the OA damper on AHU #5 was approximately 25% open, and the OA dampers on an adjacent AHU (#7) were fully open. As the OA and RA dampers were in different positions on each AHU, this suggests the enthalpy controller was not functioning properly. No sources of contaminants were noted near the OA intake vents for these AHUs. Visual inspection of a representative terminal reheat unit and supply diffusers and duct work in L&D and Maternity indicated the duct work to be clean and free of microbiological growth. A small amount of very fine grey colored dust was noted in one of the terminal reheat units in the Maternity area.

The wooden framework around a perimeter fan-coil unit in room 2A24 was removed and the unit inspected. The fan-coil filter had considerable dust/dirt buildup, and the area enclosed by the framework was dirty, and contained discarded items (candy wrappers, clothing article), as well as a package of rat poison.

Observations

Cooking odors from the yogurt shop were noticeable in the L&D and East Hallway between Maternity and L&D. As the OA intakes are located at the roof level (west side), these intakes are not considered to be the source of the cooking odors infiltrating into the second floor. This suggests the L&D, and possibly the rest of the second floor is operating under negative pressure with respect to outside. This may be due to excessive exhaust or insufficient volume provided by one of the AHUs. Under these parameters, unconditioned OA, or air from the atrium will infiltrate into the building through doors and other leakage points. A common design goal is to operate a building under positive pressure to

allow for better control of temperature and humidity, conserve energy, and minimize the introduction of unfiltered air into the building.

In some areas (e.g., Maternity) there was evidence of water damage (discolored ceiling tiles). This may be due to spills on the third floor that leak through unsealed floor transitions. Visual inspection of the space above the false ceiling did not identify any obvious leak points.

The anesthetic gas delivery system in the L&D obstetrical operating room was inspected. Most sedation is by IV anesthetic agents, and not gas. the anesthetic gases (nitrous oxide, isoflurane, halothane, and enflurane) are rarely used (approximately once a month). The delivery system is closed-loop (gas is delivered via endotracheal tube and scavenged out), and is leak checked monthly.

Informal discussions with employees on all shifts indicated a general lack of awareness of proper HVAC operation and current status of the IEQ issues. Some employees were misinformed (e.g., one worker expressed concern about asbestos, another worker apparently was told that the itching problem was due to fiberglass coming out of the supply ducts).

Several employees commented that the IEQ problems had dissipated since the heat had been turned off in the spring. Employees in all areas indicated concern with the noticeable temperature swings that have been experienced (either too hot or too cold). Many staff members also felt that the problem worsens when the fire alarm goes off (occurs on a daily basis). Periodic odors described as "locker-room" and natural gas were reported by several workers.

Some employees readily acknowledged experiencing latex allergies of varying severity. Apparently some workers feel that the low-powder latex gloves are less allergenic. There are no "latex-free" areas in the hospital. Synthetic gloves are available for use for some workers.

Some concerns were noted about Galahad® disinfectant, a phenolic-based cleaning agent, that has been in use in all areas except the operating rooms at St. Vincent's for some time. It is used to wipe down tables and work stations. This task is now conducted by nurse assistants, and not the janitorial staff. If the solutions are mixed or used improperly (e.g., high concentrations, no protective gloves, etc.), a potentially harmful situation could develop.

Glutaraldehyde Monitoring

A personal sample (20 minutes) was obtained from an employee cleaning endoscopy tubes in the Endoscopy ward. A commercially available (Cidex®) 2.4% glutaraldehyde solution is used to soak the endoscopy tubes. Fresh Cidex® solution must be prepared every two weeks. This activity is conducted daily in a small room with a window at one end and supply fan at the other. There is no local exhaust and the door is kept closed. The cleaning procedure entails scrubbing the tubes with a soap solution and then soaking in one of two covered 3-gallon tubs of Cidex®. The endoscopy tubes are then removed from the Cidex® solution, manually shaken and rinsed in water. During the cleaning, the worker wore rubber gloves and a splash apron. No eye protection was worn. A noticeable odor associated with the cleaning solution was present in the Endoscopy ward. The results of this monitoring showed the employee was exposed to a glutaraldehyde concentration of 0.06 ppm. This value is an estimate as the glutaraldehyde detected on the sample (1.0 micrograms per sample

[µg/sample]) was between the analytical limit of detection (0.5 µg/sample) and the limit of quantification (1.7 µg/sample). The results indicate that employee exposure for the activity monitored was below the NIOSH REL of 0.2 ppm as a ceiling limit.

A 135 minute area sample for glutaraldehyde was obtained in the suture room between the two operating rooms in the L&D ward. Cidex® is used for soaking surgical instruments in this room. The Cidex® solution is kept in a shallow pan in this room. The pan is usually covered an the room is not routinely occupied. No detectable glutaraldehyde was found (detection limit = 0.004 ppm) on this sample.

Thermal Desorption Monitoring and Bulk Sample Results

Eleven thermal desorption tubes for qualitative VOC analysis were collected at nurses' stations in the L&D, Maternity, and NBN wards on both the day and evening shifts. For comparison purposes, control samples were collected at the fifth floor nurses' station (SLB-5) and in the Human Resources Manager's office, Villa Building A. Major compounds identified on the samples included isopropanol, acetone, ethanol, various $C_6$ - $C_{12}$ aliphatic hydrocarbons, siloxane compounds, toluene, and limonene. Other compounds present on some samples included benzaldehyde, butyl cellosolve, aliphatic esters, xylene, perchloroethylene, chlorofluorohydrocarbons, and naphthalene. Many of these compounds are typical of indoor air contaminants and can be components of cleaning solutions, disinfectants, or other common sources. Similar compounds were found on the control samples collected on SLB-5 and in the Villa Building A office.

Three major compounds were detected in the aqueous-based bulk sample of cleaning solution. These were isopropanol, p-tert-amyl phenol, and o-phenylphenol. These were all compounds identified on the material safety data sheet for the Galahad® cleaning solution. A small amount of triethanolamine was also detected in a sample that was directly injected into the GC/MS. Of these three compounds, only isopropanol was detected on the thermal desorption tube samples.

**Medical Results**

The employee health complaint logbooks revealed a variety of health complaints, from both the L&D and Maternity wards, on all shifts. The predominant symptoms listed included headaches and eye and upper respiratory irritation. The meeting with the employee health director revealed that few employees utilized the employee health department for the evaluation of these symptoms.

IEQ Questionnaire

The IEQ questionnaire was distributed by EHS to L&D, Maternity, NBN and four other areas (CCU, SLB5, VB A, and VB B). The response rate to the IEQ questionnaire distributed by EHS by ward were: L&D, 45/51 or 88%; Maternity, 23/35 or 66%; NBN, 22/31 or 71%; CCU, 32/37 or 86%; SLB5, 22/39 or 56%; VB A, 10/10 or 100%; and VB B, 7/7 or 100%. The most common symptoms reported by employees in each ward are listed in Table 2. Most employees on L&D, Maternity, and NBN noted that these symptoms resolved after they left the building. The most frequently cited environmental problem was dry and stagnant air.

Table 2.

Self-reported Symptoms by Ward
St Vincent Hospital Environmental Health and Safety Department
IEQ Questionnaire, May 1995

| Ward | % with 1 or more symptoms | Most Common Symptom (%) (> 10% of respondents) |
|---|---|---|
| L&D | 75% | congestion/stuffiness (34%); burning eyes (27%); itchy eyes (18%); dry eyes (14%); rash/hives (11%); headaches (11%); shortness of breath (11%) |
| Maternity | 91% | headaches (44%); burning eyes (35%); rash/hives (35%); itchy skin (14%); sneezing (13%); fatigue (13%) |
| NBN | 59% | burning eyes (14%); wheezing (14%) |
| CCU | 72% | headaches (34%); congestion/stuffiness (25%); sneezing (25%); sore throat (12%); sinus headaches (12%) |
| SLB 5 | 36% | sneezing (14%) |
| VB A | 100% | upper respiratory infection (60%); sinus headache (40%); dry skin (20%); congestion/stuffiness (20%); headaches (20%) |
| VB B | 85% | congestion/stuffiness (72%); fatigue (28%); watery eyes (14%); sneezing (14%); headaches (14%); shortness of breath (14%); dizziness/lightheaded (14%) |

**Medical Interviews**

A total of 24 employees elected to participate in the interviews (22 personal and 2 telephone interviews). The response rates by ward were: L&D, 4/51 or 8%; Maternity, 11/35 or 31%; NBN, 5/31 or 16%. In addition 2 staff members with current or past exposure to the wards were interviewed.

Because of the low interview participation rates, the results of the interviews may not be representative of all employees working on these wards. The mean age of those interviewed was 41 years (range: 22 to 67 years); all were females. The mean time assigned to the current job and current ward was 8 years (range: 1 to 26 years). The mean time worked at St. Vincent was 11 years (range: 3 to 32 years). Those interviewed represented a variety of job titles--13 were nurses, 3 nurses aids, 3 nurses assistants, 2 technicians, 2 clerks, and 1 staff physician. Of the workers interviewed, all had at least one sign or symptom felt by the employee to be associated with the workplace and

occurring on more than one occasion in the previous year. The specific signs or symptoms reported by the interviewed workers included--eye irritation, skin rash, nose irritation, cough, hives, throat irritation, wheeze, shortness of breath, lethary, headaches, and lightheadedness.

Of the 24 workers interviewed, 11 (46%) had sought medical care for workplace symptoms. According to the employees, the diagnoses given to them by their physicians for conditions that were reported as caused or aggravated by the work environment included asthma (4 workers), asthma and latex allergy (2), and 1 each of latex allergy, anaphylaxis/allergic reaction of unknown etiology, hives, sick building syndrome, and dry skin.

## CONCLUSIONS

Ongoing health concerns about the working environment have been reported by some employees at St. Vincent Medical Center. The problems appear to be concentrated on the second floor of the SLB building. The predominant symptoms (eye/nose/throat irritation, skin rashes/itching, headaches, congestion) reportedly began as early as 1990 and first appeared in the Maternity area. These concerns have persisted since 1992 and span all shifts. Following a facility inspection, observation of work practices, and limited environmental monitoring, no obvious environmental explanations for the reported health problems were identified.

Although some areas for improvement were noted, the ventilation system was in good condition and appeared to be operating properly. Sufficient outside air is being provided to the second floor of the SLB building; however, there are considerable temperature swings and variations in humidity levels (high in hotter months, low in colder months).

Anesthetic gases are not routinely used on the second floor, and a closed-loop gas delivery system has been installed. As such, exposure to waste anesthetic gases is not a likely cause of the continuing health complaints. Based on observation of use and the VOC monitoring, it appears unlikely that there is appreciable exposure to the Galahad® disinfectant on the second floor of the SLB building. Similarly, the glutaraldehyde monitoring did not indicate appreciable exposure in the L&D area.

Some employees may be experiencing latex-related allergic reactions of various intensities. This, however, probably does not account for most of the health complaints.

While it has been difficult to identify concentrations of specific contaminants that are associated with the occurrence of symptoms, many researchers in the field believe that the occurrence of symptoms among building occupants can be lessened by providing a properly maintained interior environment. Adequate control of temperature and RH is a particularly important aspect of employee comfort.

## RECOMMENDATIONS

1. Communication between management and employees to facilitate the exchange of concerns about environmental conditions at the building should be improved. Employees should be made aware of the problems with the building and decisions that must be made by building managers to address those problems. Therefore, St. Vincents should establish a forum for effectively communicating IEQ and other issues to employees. Employees should be briefed on how the ventilation system is designed to operate.

2. To optimize employee comfort, efforts to reduce RH levels during high humidity times of the year should be implemented. The enthalpy controller system should be inspected and adjusted to ensure proper performance. It is also likely that a mechanism to humidify the supply air is necessary during periods of low humidity. Humidification systems must be carefully planned and properly maintained to assure that indoor environmental quality is not adversely affected. From an indoor environmental quality perspective, steam humidifiers are the preferable method for commercial spaces, since the heating of the water kills nearly all of the microorganisms. Steam humidifiers should have a separate water supply which is free from potentially irritating anti-corrosion agents such as diethylaminoethanol [DEAE] and cyclohexylamine. Chemicals such as DEAE and cyclohexylamine, in sufficient concentrations, are irritants of the skin, mucous membranes, and eyes.

3. Ensure AHU #4 is providing sufficient capacity per design. L&D appears to be operating under negative pressure, allowing infiltration of unconditioned air, odors, etc.

4. Temperature swings should be controlled. This may be an HVAC balancing issue. These temperature swings may have heightened the awareness of environmental shortcomings among employees already uncomfortable in their work environment.

5. To reduce microbiological growth, replace water-damaged material (ceiling tile). Attempts to clean or decontaminate mold-contaminated porous material are generally unsuccessful. Transitions (piping, conduit, etc.) between floors should be sealed to prevent leakage.

6. The use of glutaraldehyde-based disinfectants in the Endoscopy ward needs to be improved. Eye and face protection should be worn when working with this solution. Although the results of the air monitoring showed that exposure levels were below the NIOSH REL, there may be more glutaraldehyde-intensive tasks conducted at this station that entail a higher potential for exposure, and there was a noticeable odor present during the use of the Cidex® disinfectant. Consider installing additional local exhaust ventilation at the cleaning station.

7. Cleaning inside the perimeter fan-coil housings should become a routine janitorial activity. Because of the enclosures around these units, it appears they have become a convenient receptacle for waste.

8. Employees with possible work-related medical problems should be encouraged to be evaluated by the employee health department or their own physicians. Employees should report diagnosed work-related or work-aggravated health conditions to the employee health department.

Employee health should work closely with EHS to determine possible etiologies of the work-related health problems. In particular, the employee health department should ensure that evaluations of possible latex allergy are available to employees. Employees with latex allergy who are unable to avoid allergic reactions by using hypoallergenic or non-latex gloves (which St. Vincents should provide) should be advised on the risks of continued exposure to airborne latex allergens and provided the opportunity to work in a latex-free area (i.e., areas where all latex gloves are hypoallergenic and powderless).

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Figure 1
ANSI/ASHRAE Standard 55-1992
Thermal Environmental Conditions
for Human Occupancy