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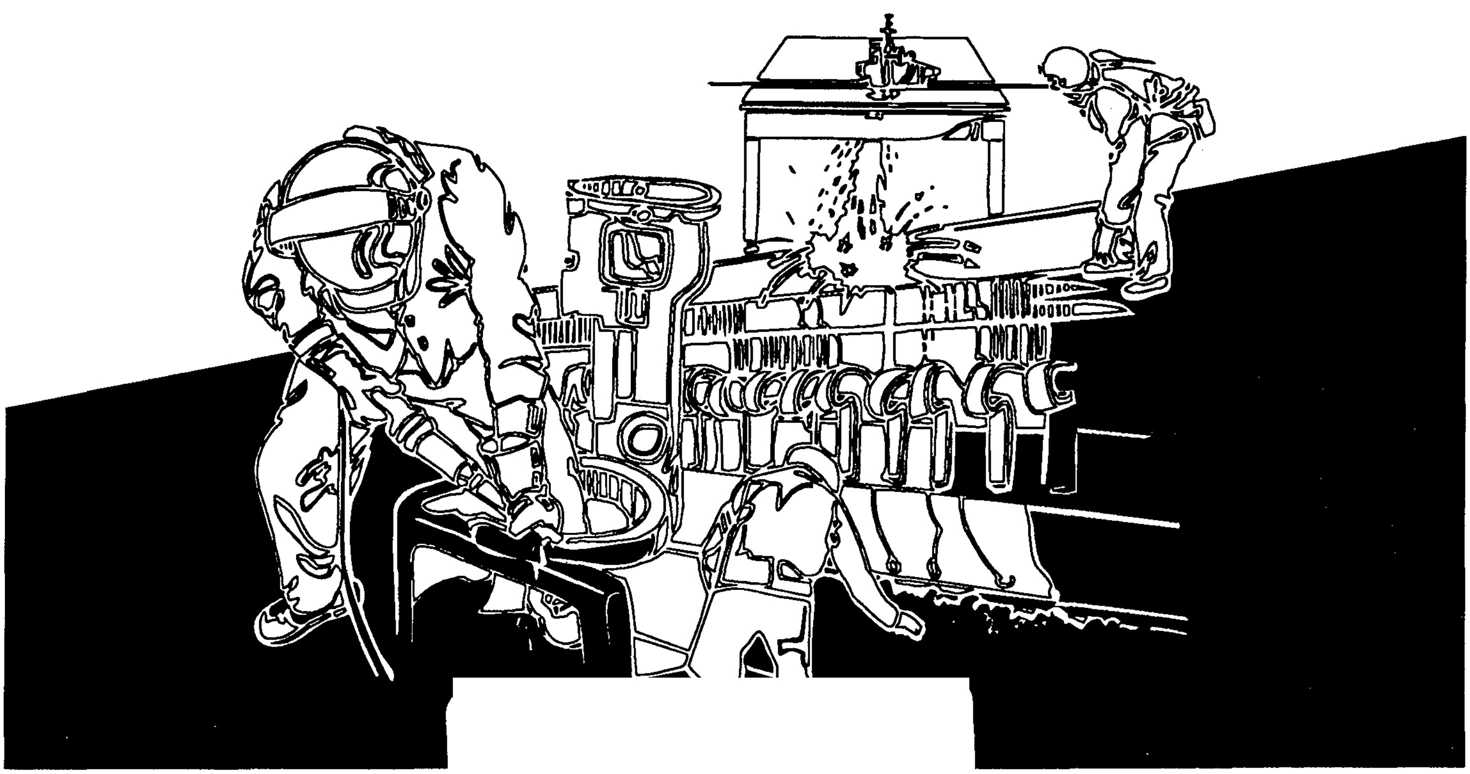
NIOSH HEALTH HAZARD EVALUATION REPORT

HETA 97–0189–2668
Valley High School
West Des Moines, Iowa

Max Kiefer, CIH



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

Preface

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Acknowledgments and Availability of Report

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

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Health Hazard Evaluation Report 97–0189–2668
Valley High School
Des Moines, Iowa
December 1997

Max Kiefer, CIH

SUMMARY

On September 16-17, 1997, the National Institute for Occupational Safety and Health (NIOSH) conducted a site visit at Valley High School in West Des Moines, Iowa, in response to a management request for a health hazard evaluation (HHE). The request asked NIOSH to assess indoor air quality and measure exposures to crystalline silica in the art rooms at this school. The source of crystalline silica was clay and various glazes used during ceramics courses in art room 403. The request was initiated following an employee complaint filed with the Iowa Department of Labor Services, Occupational Safety and Health (IOSH) Division, regarding potential exposure to dust and silica from clays. The IOSH administrator recommended that school officials request a NIOSH HHE. Adverse health effects reported in the IOSH complaint included respiratory difficulties, dizziness, nausea, and chronic sneezing.

Upon receipt of the HHE request on May 12, 1997, additional information about the materials used in the art rooms and reported health problems was obtained. Because the school year was almost over, it was decided to postpone the NIOSH site visit until the beginning of the fall, 1997 school year.

During the NIOSH site visit, full-shift personal breathing zone (PBZ) air sampling for respirable crystalline silica was conducted on two art instructors in Room 403. Bulk area air samples, for both respirable and total silica analysis and bulk samples of settled dust were also collected. Standard indoor environmental quality (IEQ) parameters (Temperature [°F], relative humidity [%RH], and carbon dioxide [CO_2]) were monitored at various times throughout the day in rooms 403, 409, 410, the main hallway, and outside. The ventilation systems supporting this area of the school (both local and general ventilation systems) were inspected.

All measured concentrations of respirable crystalline silica were below the NIOSH recommended exposure limit (REL) of 0.05 milligrams per cubic meter (mg/m^3) during the monitoring period. A respirable crystalline silica (quartz) concentration of 0.03 mg/m^3 was detected on a high-volume bulk air sample collected at the wedging table, and one respirable PBZ sample collected from an art instructor showed a detectable level of crystalline silica. Two bulk samples of settled dust collected from a cabinet shelf adjacent the door in room 403, and on top of glaze hood #1, were found to contain 24% and 14% crystalline silica (quartz), respectively.

Except for room 403, the measured temperatures were within acceptable comfort ranges. The temperature in room 403 averaged 67° F throughout the day, which is below the range recommended by the American Society for Heating, Refrigerating, and Air-conditioning Engineers (ASHRAE). Temperatures in rooms 409 and 410 were within acceptable ranges. RH levels (50-60%) were at the high end of the ASHRAE recommended range. The CO_2 concentrations varied throughout the day, but in all areas were below the 1000 parts per million (ppm) ASHRAE guideline. Two afternoon measurements in Room 403 (975 ppm) and main hallway (800 ppm) were at or above a proposed guideline of 800 ppm. CO_2 is used as one index for assessing the adequacy of outside air provisions in an HVAC system, and not for determining the presence of a health problem.

A limited visual inspection of air handling units (AHUs) D-8 (room 403) and D-12 (room 410) identified some items in need of improvement, from both a maintenance and operational standpoint. Excessive moisture damage and inadequate drainage of the AHUs condensate pans were found. No source of contaminants were noted near the outdoor air intake vents for these AHUs, and they appeared sufficiently distant from building exhaust. The filters on AHU D-7 (room 409) were clean and this unit appeared to be functioning properly.

Exposures to crystalline silica in room 403 were below applicable occupational limits during the monitoring period. The presence of crystalline silica in settled dust samples indicates continued adherence to appropriate housekeeping practices (wet cleaning) are necessary. Additional investigation and modifications of the ventilation system are needed to address the low temperatures measured in room 403, and to ensure adequate conditioned OA is provided to all areas. Deficiencies, primarily maintenance related, were identified in the HVAC systems supporting rooms 403 and 410. Water-damaged porous material, and noticeable odor in the mechanical areas housing the HVAC system are likely sources for the moldy odors reported in some art rooms. The reported automobile exhaust odors in room 410 are probably due to the proximity of the main return air intake for AHU D-12 to the automotive repair classroom. A cause-effect relationship between these identified HVAC system deficiencies and the reported health symptoms could not be determined. Recommendations include maintenance and operational improvements in the ventilation system and establishing an indoor environmental quality program.

Keywords: 8211 (Elementary and Secondary Schools): crystalline silica, quartz, cristobalite, ceramics, art, indoor environmental quality, IEQ, IAQ, mold, ventilation, carbon dioxide, relative humidity, temperature, respiratory, sneezing, dizziness.

TABLE OF CONTENTS

INTRODUCTION

In response to a request from school administrators, NIOSH conducted a site visit at Valley High School in West Des Moines, Iowa, on September 16-17, 1997. The request asked NIOSH to assess faculty exposure to crystalline silica in the art room and evaluate general indoor environmental quality (IEQ). The request was submitted following an employee complaint filed with the Iowa Department of Labor Services, Occupational Safety and Health (IOSH) Division, regarding concerns with exposure to dust and silica from clays. IOSH recommended that school officials request a NIOSH HHE. Health complaints reported in the IOSH complaint included respiratory difficulties, dizziness, nausea, and chronic sneezing.

During the site visit, a meeting was held to discuss specific employee concerns in the art rooms (403, 409, and 410), followed by a walkthrough inspection to review activities in these rooms, obtain descriptive information regarding the materials in use, and finalize the environmental sampling strategy. The heating, ventilating, and air-conditioning (HVAC) systems supporting the complaint areas were inspected, and the performance of the glaze-hoods in Room 403 were evaluated. Environmental monitoring was conducted to assess exposure to respirable crystalline silica. Standard IEQ parameters (Temperature [°F], relative humidity [%RH], and carbon dioxide [CO_2]) were monitored at various times throughout the day. Upon completion of these activities, a meeting was held with management and employee representatives to discuss preliminary findings and recommendations. Information on IEQ, and health hazards associated with the arts, were provided to management and employee representatives.

BACKGROUND

Valley High School was originally constructed in 1964 and has been renovated and expanded several times; the last addition was in 1989. The art rooms (403 - ceramics, 409 - photography, 410 - jewelry, painting) are part of the original construction. The school supports approximately 1700 students in grades 10-12. Core school hours are 7:45 a.m. - 3:00 p.m., although the school is generally occupied from 6:00 a.m. to 10:00 p.m. by maintenance, faculty, and attendees of community courses. There are 5 faculty supporting the art program. Smoking is not permitted in the school.

Room 403 typically has about 19 students (there are 10 potting wheel stations and several sculpting stations) per class. Students are responsible for their own art pieces, and retrieve their art work at the beginning of the period and store it prior to the end of class. After discussing objectives at the beginning of class, the art instructor(s) move from station to station providing individual assistance and demonstrating various sculpting techniques. One or two student-assistants are usually available in each class to help provide hands-on instruction. Three electric-fired kilns are located in a separate room with a dedicated exhaust system.

Room 410 is approximately twice the size of room 403 and can accommodate up to 35 students. This room can support two classes, with one area dedicated for jewelry-making and the other for painting. Local exhaust ventilation is present in both the jewelry (buffing, torch), and painting (aerosol painting) areas. Room 409 contains both a classroom area and a darkroom. The number of students in this room will vary depending on the class. There is a small hood in this room that is used when air-brushing photographs.

During the fall 1996 school year, concerns with indoor air quality in the art rooms were noted by some faculty and students. These concerns were primarily associated with exposure to dust in the ceramic room. In response to these concerns, school officials arranged for environmental surveys of these areas by the school insurance carrier and an industrial hygiene consultant. These investigations did not, however, resolve occupant concerns and a complaint was filed with the Iowa Department of

Labor Services, Occupational Safety and Health Division (IOSH). In response to this complaint, and upon the recommendation of IOSH, a NIOSH HHE was requested.

According to school officials, actions taken in response to the health complaints included increasing the cleaning schedule, installing more efficient filters in the HVAC systems, and reviewing all materials used in the art class. A safety and health professional specializing in art hazards was also consulted. At the time of the NIOSH site visit, occupant concerns included the potential for exposure to crystalline silica, temperature differences between rooms 410 (too warm) and 403 (too cold), occasional "stagnant" air in room 410, and mold and automobile exhaust odors.

HVAC Description

The air-handler units (AHUs) supporting the art rooms are dual-duct (hot deck and cold deck) variable-air-volume (VAV) systems. Thermostats control pneumatic dampers, which adjust the mix (hot or cold) of air at the VAV or mixing boxes, located in the false ceiling in various areas. Supply air (SA) is provided to each room via ceiling diffusers. Only facility maintenance personnel are authorized to adjust the thermostat control. Return air (RA) from each room passes into the hallway through louvers located above the room doors, and is conveyed back to the AHU through main RA grilles in the hallway and ducted to the AHU. Outdoor air (OA) is obtained from roof-mounted intakes and ducted to each AHU. The mixed air (RA & OA) passes through pleated filters and then cooling or heating coils prior to being distributed to occupied areas. OA dampers are controlled by economizers designed to allow more OA into the system if outside conditions are favorable, and less if conditions are unfavorable. Valley High personnel indicated the dampers were equipped with a minimum stop to ensure sufficient (15%) OA is always provided. The system is designed to provide a cold-deck discharge air temperature of 55°F and a hot-deck discharge temperature of about 80°F. For energy management purposes, each AHU is cycled on a staggered schedule to turn off beginning at 5:30 p.m. and turn on at 5 a.m.. The systems also cycle off on the weekends.

Various parameters of each AHU are continuously monitored and logged, and can be accessed by facility personnel for diagnostic purposes, and verify adherence to set-points. Parameters monitored include temperature (room air, mixed air, RA, cold deck, hot deck, chilled water, hot water supply), mixed air relative humidity, fan operation, and damper pneumatics.

AHU D-8 (serves room 403 and 4 other rooms) is mounted in a penthouse located in the plenum space. AHU D-12 (serves room 410) is located in a ceiling-level mechanical room in room 411 (automotive shop). The main RA intake grille for AHU D-12 is located in the hall adjacent the automotive shop. AHU D-7 is located in the plenum space in the hallway adjacent the photography classroom (room 409). A ceiling-mounted exhaust fan was installed in room 403.

METHODS

Upon arrival at the school, an opening meeting was held with 11 management and employee representatives. During this meeting information about NIOSH was provided, and the HHE request was discussed, including specific employee concerns in rooms 403, 409, and 410. Following the meeting, a walkthrough inspection was conducted to review activities in these rooms and obtain descriptive information about the materials in use. Design parameters of the school ventilation systems were discussed with the West Des Moines Community Schools Energy Manager, and AHUs D-7 (Room 409), D-8 (Room 403), and D-12 (Room 410) were inspected. Printouts of the operational set-points and current operating conditions (temperature, relative humidity) for these HVAC systems were reviewed, and the outside air intakes for these units inspected. Ventilation measurements were taken to assess the performance of the glaze-hoods in Room 403.

On September 17, full-shift personal breathing zone (PBZ) air sampling for respirable crystalline silica was conducted on two art instructors in room 403. Bulk area air samples, for both respirable and total silica analysis, as well as a bulk sample of settled dust were also collected. Standard IEQ parameters (Temperature [°F], relative humidity [%RH], and carbon dioxide [CO_2]) were monitored at various times throughout the day in rooms 403, 409, 410, the main hallway, and outside.

Upon completion of these activities, a closing meeting was held with management and employee representatives to discuss preliminary findings and recommendations.

Crystalline Silica

Personal breathing zone (PBZ) air sampling for respirable crystalline silica (quartz and cristobalite) in room 403 was conducted using Gilian Gil-Air 5 air sampling pumps. A flow rate of 1.7 liters per minute (l/m) was used to draw sample air through an MSA Dorr-Oliver cyclone with a tared, 37 millimeter, 5-micron pore size, polyvinyl chloride filter. The cyclone removes the non-respirable fraction of particulate so the filter will collect only that portion of the dust (<10 micrometers aerodynamic diameter particulate) that penetrates to the deeper areas of the lung. Full-shift samples were collected (average sample time was approximately 400 minutes).

Bulk air samples were also collected using a high-volume electric powered vacuum pump configured to draw air at 9 l/m through a pair of filter cassettes. Each filter in the pair was connected via tubing to a "T" connector. One filter was equipped with a cyclone designed to collect only respirable dust, while the other filter had no cyclone and collected total airborne dust. Bulk air sampling is often utilized for crystalline silica exposure assessments because a larger volume of air is sampled. This increases the chance that the quantity of dust collected will contain sufficient free silica to exceed the analytical limit of detection (LOD) for the x-ray diffraction (XRD) analysis. By collecting both a "total" and a "respirable" sample, the percentage of crystalline silica in each fraction can be determined. The bulk air samples were collected adjacent the "wedging" table in room 403. Analysis was conducted by the NIOSH contract laboratory (DataChem, Salt Lake City, Utah) according to NIOSH 7500 and 0500.

Two bulk samples of settled dust taken from the work area was submitted to the NIOSH contract laboratory to determine the percent and type of silica present, and identify potential analytical interferences. The samples were analyzed by XRD according to NIOSH method 7500.

Carbon Dioxide

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 parts per million (ppm). Measurements were obtained at various intervals and locations in the art rooms and adjacent hallways. Outdoor readings were taken to determine baseline CO_2 levels.

Temperature and Relative Humidity

Dry bulb temperature and RH levels were measured at the same times and locations as the CO_2 readings. 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%.

Local Exhaust Ventilation

The performance of 3 hoods in the glaze room, adjoining room 403, was assessed by measuring air velocity at the exhaust hood opening (face velocity). Hood size was measured, and descriptions of the work practices of employees using these systems were obtained. The hoods were not in use on the day of the monitoring.

Air velocity measurements were obtained with a TSI VelociCalc® model 8360 anemometer (the same instrument used for the temperature and RH measurements). This instrument measures air velocity in feet-per-minute (fpm). For each system evaluated, multiple measurements were obtained and the results averaged to obtain the mean velocity.

EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff use established environmental evaluation criteria for a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects even though their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy). In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: (1) NIOSH Recommended Exposure Limits (RELs)[1], (2) the American Conference of Governmental Industrial Hygienists' (ACGIH®) Threshold Limit Values (TLVs®)[2] and (3) the U.S. Department of Labor, OSHA Permissible Exposure Limits (PELs)[3]. In July 1992, the 11th Circuit Court of Appeals vacated the 1989 OSHA PEL Air Contaminants Standard. OSHA is currently enforcing the 1971 standards which are listed as transitional values in the current Code of Federal Regulations; however, some states operating their own OSHA-approved job safety and health programs continue to enforce the 1989 limits. NIOSH encourages employers to follow the 1989 OSHA limits, the NIOSH RELs, the ACGIH TLVs, or whichever are the more protective criterion. The OSHA PELs reflect the feasibility of controlling exposures in various industries where the agents are used, whereas NIOSH RELs are based primarily on concerns relating to the prevention of occupational disease. It should be noted when reviewing this report that employers are legally required to meet those levels specified by an OSHA standard and that the OSHA PELs included in this report reflect the 1971 values.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8-to-10-hour workday. Some substances have recommended short-term exposure limits (STEL) or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from higher exposures over the short-term.

Specific evaluation criteria, including health hazard information and recommended limits are provided in *Appendix A* (crystalline silica), *Appendix B* (indoor environmental quality), and *Appendix C* (microbial contaminants and HVAC systems).

Local Exhaust Ventilation

Local exhaust ventilation (LEV) is commonly used to control contaminants at the point of generation to reduce the potential for employee exposure. Ventilation assessments, in conjunction with exposure monitoring results, help determine the adequacy of controls at a workstation. This information also assists with deciding if additional controls, or modification of existing controls, is warranted. The principle design parameter for LEV systems is capture velocity. Capture velocity is the velocity necessary to overcome opposing air currents and capture contaminated air by causing it to flow into the exhaust hood. Recommended capture velocities will vary depending on the contaminant's toxicity and volatility, the manner in which the material is used (e.g., heated, agitated), and room conditions (e.g., air currents). Criteria commonly used for evaluating LEV systems is from the ACGIH publication, *Industrial Ventilation: A Manual of Recommended Practice*.[4]

RESULTS

Observations

Good housekeeping practices have been established to reduce classroom dust from dry clays in room 403. Students in each class were required to clean their work area, including tables and chairs, using wet mops and cloths before leaving. All clay scraps are removed and stored in a reclaim area. During the lunch break a janitorial service also cleans the room. Student and faculty work practices, including only working with moist clay and using pre-mixed clay and glazes, are effective measures to control dust. Students were instructed to moisten the potters wheel prior to use to reduce dust from dried clays. In the glaze room (adjoining room 403), a process to reclaim clay has been established using a screw-type mixer; students conduct reclaim activities using only moistened clay. Water-based, lead-free glazes are applied using an aerosol spray in the glaze hoods. Art faculty indicated that this practice will be replaced with a new procedure that eliminates spraying (dipping).

In room 403, activities considered by faculty to have the highest potential for generating clay dust are conducted at the "wedging" table. This table is located under an out-of-service canopy hood that had been originally installed for soldering operations that are no longer conducted. At this table, students and instructors work with clay in a manner similar to "kneading" bread. All potting wheel and sculpting activities were conducted with moistened clay.

The grille providing a return air path from classroom 403 into the hallway was dirty. Ceiling tiles in various areas showed evidence of moisture damage.

A building safety committee responsible for resolving health and safety issues has been established for each area. Issues specific to IEQ have not been addressed by this committee, and an IEQ program has not been established.

Silica Monitoring

A review of several material safety data sheets (MSDSs) for the clays (calcined fireclay) used in the ceramic art room indicated these contained an average of 10-30% crystalline silica as quartz or cristobalite. Other than two students who worked for approximately 20 minutes reclaiming clay, there was no work in the glaze room during the monitoring. On the day of the monitoring, two art instructors worked in room 403. Each art instructor taught 2 classes and spent additional time assisting students in this room while the other instructor taught class. These instructors occasionally went to the other art rooms, and each had a 60-minute planning period and 30-minute lunch break. The canopy hood over the wedging table and the ceiling-mounted exhaust in room 403 were not operational during the monitoring.

Air Sampling Results

The results of the personal and area air samples collected in room 403 are shown in Table 1. All measured concentrations of respirable crystalline silica were below the NIOSH REL during the monitoring period. As shown in the table, a respirable crystalline silica (quartz) concentration of 0.03 milligrams per cubic meter (0.03 mg/m^3) was detected on the high-volume bulk air sample collected at the Wedging Table. Analysis of one respirable PBZ sample collected from art instructor #1 showed a detectable level of crystalline silica. The concentration measured, however, was between the analytical limit of detection (LOD) and the limit of quantification (LOQ). The values reported are time-weighted average (TWA) concentrations for the duration of the monitoring period and includes the entire classroom work-shift of the Art Instructors. These values would be somewhat lower if the non-monitored time period (assuming zero crystalline silica exposure) were factored in to calculate a full 8- or 10- hour TWA concentration. Cristobalite was not detected in any of the air samples.

The gravimetric sampling results also show that the measured concentrations are below applicable exposure limits for total "particulate not-otherwise classified" (PNOC). PNOC is a general category for dusts, or mixtures of dusts, considered to be physical irritants for which no substance-specific toxicological data are available are generally placed in this category by OSHA for enforcement purposes.[5]

The OSHA PEL for respirable particulate not-otherwise regulated (PNOR) is 5 mg/m^3. NIOSH has not established an REL for PNOC. The gravimetric results also indicate, when compared with the silica-specific sampling results, the silica- and non silica-containing fractions of the measured concentration.

Table 1
Air Sampling Results: Crystalline Silica (Quartz) and Gravimetric Analysis
Valley High School
September 17, 1997

Sample #	Sample Description	Sample Time (min)	Crystalline Silica (mg/m3)		Gravimetric (mg/m3)	
			Respirable	Total	Respirable	Total
97-1823	Bulk Respirable Area Sample collected at Wedging Table	07:43-14:25 (402)	0.03	N/A	0.07	N/A
97-1871	Bulk Total Area Sample collected at Wedging Table	07:43-14:25 (402)	N/A	0.06	N/A	0.19
97-1877	Personal Sample: Art Instructor #1	0:739-14:33 (414)	(0.03)	N/A	0.06	N/A
97-1876	Personal Sample: Art Instructor #2	0:802-14:31 (388)	<0.02	N/A	<0.03	N/A
97-1819	Respirable Area Sample: Instructors Desk	0:802-14:31 (388)	<0.02	N/A	<0.03	N/A

The NIOSH REL for respirable crystalline silica is 0.05 mg/m^3

Notes: All results are time-weighted average concentrations for the duration of the monitoring period.
N/A = not applicable
mg/m^3 = milligrams of contaminant per cubic meter of air sampled.
< = less than
Values in parentheses indicated the concentration measured was between the analytical limit of detection (LOD) and the limit of quantification (LOQ)

Bulk Sampling Results

Two bulk samples of settled dust were collected for crystalline silica analysis. Bulk 1, collected from a cabinet shelf adjacent to the door in room 403, was found to contain 24% quartz. Bulk 2, collected from the top of glaze hood #1, was found to contain 14% quartz. As with the air samples, no cristobalite was detected in either bulk sample.

Temperature, Relative Humidity, and Carbon Dioxide

The results of the temperature, RH, and CO_2 measurements are shown in Table 2. Except for room 403, the measured temperatures were within acceptable comfort ranges. The temperature in room 403 averaged 67°F throughout the day, which is below the ASHRAE recommended range for both summer and winter conditions (Figure 1). The temperature in rooms 409 and 410 were within acceptable ranges. A review of the parameters recorded by the HVAC monitoring system showed that there was generally a 3°F difference between rooms 403 and 410. RH levels in all areas monitored were at the high end of the acceptable ranges.

The CO_2 concentrations varied throughout the day, but in all areas were below the 1000 parts per million (ppm) ASHRAE guideline.[6] Two afternoon measurements in room 403 (975 ppm) and main hallway (800 ppm) were at or above a proposed guideline of 800 ppm.[7] It is important to note that CO_2 is used only as an index for assessing the adequacy of outside air provisions in an HVAC system, and not for determining the presence of a health problem. All classrooms were fully operational with normal occupancy levels during the monitoring.

Table 2
Temperature, Relative Humidity, Carbon Dioxide Monitoring Results
Valley High School
September 17, 1997

Location	Carbon Dioxide (PPM)			Relative Humidity (%)			Temperature °F		
	08:15	10:15	13:00	08:15	10:15	13:00	08:15	10:15	13:00
Room 403	425	575	975	57	59	60	67	67	67
Room 410	525	525	675	58	59	53	72	73	73
Room 409	525	NA	500	58	NA	49	73	NA	73
Main Hallway	500	575	800	58	61	55	71	72	74
Outside	325	325	325	70	55	35	67	75	86

Notes: PPM = Parts of gas or vapor per million parts air
NA = room was not accessible during this monitoring period
Outdoor conditions were sunny, with mild-to-no breeze

HVAC System Inspection

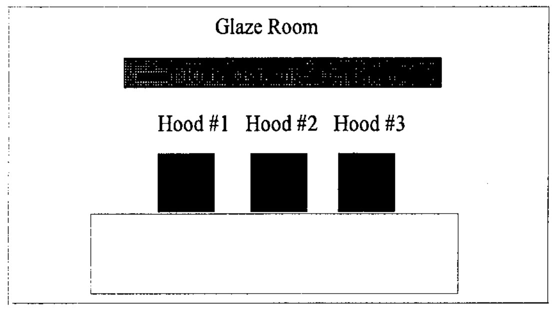
A limited visual inspection of AHUs D-8 (room 403) and D-12 (room 410) identified some items in need of improvement, from both a maintenance and operational standpoint. No source of contaminants were noted near the OA intake vents for these AHUs, and they appeared sufficiently distant from building exhaust. The filters on AHU D-7 (room 409) were clean and this unit appeared to be functioning properly.

The condensate pan drain line from AHU D-8 was discharging onto the concrete slab of the penthouse approximately 2.5 feet from the floor drain, creating a wet environment with standing water. Mold growth (visible and noticeable musty odor) was present in this area. The chilled water supply line insulation on this AHU was saturated and showed evidence of mold growth. Inspection of the interior of AHU D-8 found that the condensate pan was not draining properly and there was noticeable mold growth. The porous interior lining of this AHU also had moisture damage. Inspection of the OA dampers indicated they were completely closed and the minimum OA provisions could not be verified. The AHU filters were clean.

The access door on the supply side of AHU D-12 (room 410) was found in the full open position. As a result, conditioned air was discharging out the access door into the mechanical space above the automobile shop, instead of being delivered to room 410. It could not be determined how long this situation had existed. After closing the access door of this unit, occupants in room 410 later reported the room seemed cooler and less stagnant. As with AHU D-8, the OA dampers on D-12 appeared to be completely closed, and the minimum stop could not be verified. Considerable moisture was present in the system and the condensate pan was not draining properly. Mold growth was observed in the condensate pan and the internal insulation panels were wet. The fan belt cover had not been replaced and presented a safety hazard. The location of the RA intake for this system is such that the potential exists for entrainment of emissions from the automotive shop if the main overhead doors are open during class instructions entailing operating engines. The filters in this AHU appeared to be clean.

Local Exhaust Ventilation - Glaze Hoods

Three hoods (20" X 20" each) mounted on a table in the Glaze room are used when spraying glazes onto ceramic artwork. There is additional room exhaust via a plenum mounted above the glaze hoods with a 8" X 16" opening. Two of the hoods had a commercially available fabric filter placed in the back of the hood; there was no filter on the other hood. Six face velocity measurements from each hood were averaged to obtain the mean face velocity in feet per minute (fpm). The results are as follows:



Room Exhaust 2320 fpm
Hood #1: 250 fpm
Hood #2: 274 fpm
Hood #3: 337 fpm*

* = Hood #3 did not have filter in place.

DISCUSSION

Work and housekeeping practices by faculty and staff appear to be appropriate in reducing the potential for exposure to crystalline silica in room 403; all personal monitoring results were below NIOSH recommended limits. The bulk sample results showing the presence of crystalline silica in settled dust in this room indicate that continued vigilance is necessary to maintain safe conditions. Although the canopy hood over the wedging table was originally installed for a procedure no longer conducted, operating this hood while working in this area may further reduce the potential for exposure to airborne silica.

Deficiencies were noted during the inspection of AHUs D-8 (room 403) and D-12. Items noted included moisture damage, inadequate condensate pan drainage, and a possibly malfunctioning economizer system resulting in insufficient outside air into the system. A musty odor was also detected during the inspection of these air handlers, suggesting the presence of microbial growth.

Note that exposure standards for airborne microorganisms (bioaerosols) have not been established. Additionally, microbial organisms will be found throughout the environment (including buildings that are not experiencing IEQ problems) and their presence should not be construed as proof of the cause of health problems. However, obvious signs of bioaerosol reservoirs should be corrected to reduce the potential for these sources to cause health problems. These sources include the building's HVAC system (stagnant water in condensate pans, filters that become moist, porous acoustical liner in ducts), and water damaged carpet, ceiling tile or other furnishings. Health outcomes associated with bioaerosols include hypersensitivity pneumonitis (a potentially severe disease) or allergic rhinitis, which can be caused by bacteria, fungi, protozoa or other bioaerosols. Additional information is provided in *Appendix C.*

The difference in temperature between rooms 403 and 410 is considerable and noticeable by faculty and students who work in both areas. 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. Similarly, relative humidity levels were consistently at the high end of the desirable range.

It appears that sufficient outside air is being provided to occupied areas, although some improvements may be advisable. For example, the CO_2 levels in room 403 were in excess of a proposed 800 ppm guideline. While this is in itself not a health problem, it may be indicative of inadequate distribution of OA into this room. Similarly, the noticeably colder temperature in room 403 and the finding of OA dampers in the fully closed position indicates improvements are needed.

The perception of stagnant air in room 410 may be due to the condition of AHU D-12 (closed OA dampers, access door open resulting in loss of deliverable conditioned air). It is also possible that the practice of cycling the HVAC system heightens awareness of employees already uncomfortable with their work environment. The noticeable temperature swings, and possible stagnant conditions may have exacerbated these concerns. Although it is often difficult to identify specific contaminants or conditions associated with the occurrence of health complaints in a non-industrial setting, many researchers feel that the occurrence of symptoms among building occupants can be lessened by providing a properly maintained indoor environment. Adequate control of temperature and humidity are particularly important aspects of employee comfort.

The ventilation on all three glaze hoods is in excess of levels recommended for most local exhaust hoods (e.g. laboratory hoods). Note that in many cases higher face velocities do not result in greater protection.[4] At very high velocities, the indraft at the hood face created during activities where the operator stands at the face of the hood to work with materials in the hood can cause eddy currents which drag contaminants in the hood along the worker's body and up into the breathing zone.[4] Sufficient contaminant control for the activities conducted inside these hoods could be obtained with an average face velocity of 125-150 fpm.

CONCLUSIONS

An industrial hygiene HHE evaluation was conducted to assess faculty exposure to crystalline silica in room 403 and evaluate general indoor environmental quality(IEQ) in art rooms 403, 409, and 410. The results of this evaluation showed that all measured concentrations of silica were below recommended limits during the monitoring period. The presence of crystalline silica in settled dust samples indicates continued adherence to appropriate housekeeping practices (wet cleaning) are necessary.

Measured IEQ parameters of temperature, RH, and CO_2 indicate additional investigation and modifications of the HVAC system are needed to address temperature control problems and the adequacy of conditioned OA. Deficiencies, primarily maintenance related, were identified in the HVAC systems supporting rooms 403 and 410, and the proper function of the economizer system could not be verified. The water-damaged porous material, and noticeable odor in the mechanical areas housing the HVAC system are likely sources for the moldy odors reported in some of the art rooms. The reported odors of automobile emissions in room 410 are probably due to the proximity of the main RA intake for AHU D-12 to the automotive repair classroom. A contributing factor may be the closed OA dampers on this system.

The effect of these identified deficiencies on the reported health symptoms could not be determined. This is typical of most IEQ investigations. As the problems are likely mulitfactorial in nature, some or all of the potential building problems may have contributed to the occupant complaints. It is possible that IEQ problems may decrease as each potential explanation is addressed. This process is often referred to as a "solutions oriented" approach, and is the course of action recommended for Valley High School. Establishing a pro-active program to anticipate potential IEQ problems and ensure that preventive actions are taken is an essential element for resolving these types of concerns.

RECOMMENDATIONS

1. Implement an IEQ Management Plan for Valley High School. An IEQ manager or administrator with clearly defined responsibilities, authority, and resources should be selected. This individual should have a good understanding of the building's structure and function, and should be able to effectively communicate with occupants. The elements of a good plan include the following:

- Proper operation and maintenance of HVAC equipment.
- Overseeing the activities of occupants and contractors that affect IEQ (e.g., housekeeping, pest control, maintenance, food preparation).
- Maintaining and ensuring effective and timely communication with occupants regarding IEQ.
- Educating building occupants and contractors about their responsibilities in relation to IEQ.
- Pro-active identification and management of projects that may affect IEQ (e.g., redecoration, renovation, relocation of personnel, etc.).

The EPA package of information titled "Tools for Schools" provided during the NIOSH site visit should be utilized for developing and implementing the IEQ management plan.

2. Internal HVAC duct and air handler linings showing signs of deterioration or mold growth should be replaced. The water damaged ceiling tiles and pipe insulation should be replaced and the source of the moisture located and repaired. HVAC air supply duct linings should be inspected to determine if other areas are damaged or show signs of biological growth. Note that attempts to clean mold-contaminated porous material are generally unsuccessful. The condensate drain pans should be cleaned and adjusted to ensure they are draining properly. The condensate drain line for AHU D-8 should be hard-piped to the floor drain. These units should be routinely inspected to ensure that proper function. The return air grilles from classrooms into the main hallway should be cleaned and regularly maintained.

3. To optimize employee comfort, RH levels should be reduced and the temperature in room 403 adjusted to ensure these levels are within

recommended guidelines (Figure 1). This may be a ventilation balancing issue. The economizer systems on AHUs D-8 and D-12 should be inspected and adjusted to ensure proper performance and that sufficient OA is being provided to occupied areas at all times.

4. Ensure maintenance personnel replace fan belt covers to prevent safety problems.

5. Balance the local exhaust hoods in the glaze room to a uniform 125 fpm average face velocity. This should be sufficient to control contaminants generated in the hood during the application of glaze.

6. Ensure that the overhead doors at the end of the hallway adjacent room 410 and the automotive shop are closed when operating engines in this area. This may reduce the potential for emissions from this class entering the RA intake for AHU D-12.

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APPENDICES

Appendix A - Crystalline Silica

Silica exists in several forms, but only exposure to crystalline (as opposed to amorphous) forms can produce the pulmonary condition called silicosis.[8] Silicosis is a disabling, progressive, and sometimes fatal pulmonary fibrosis characterized by the development of silica containing nodules in the lung.[9] These nodules are thought to be formed by the death of macrophages laden with fine silica. The silica particles are ingested by new macrophages which are in turn killed, thereby releasing intracellular enzymes to promote further fibrosis; thus, the process becomes progressive even if exposure is terminated.[10] The exposure conditions can affect the occurrence and/or severity of silicosis. Silicosis usually occurs after 15 or more years of exposure; however, silicosis has developed after only a few years of exposure to high concentrations.[11] Initially, silicosis may not produce symptoms. However, as the disease progresses it is characterized by shortness of breath and a reduction in pulmonary function. Individuals with silicosis are also at increased risk of developing tuberculosis.

Quartz is the most common crystalline form of silica. Cristobalite and trydimite are other major forms of crystalline silica, and can be formed from quartz under certain temperature and pressure conditions. Tripoli is a naturally occurring microcrystalline form of quartz.[12] Cristobalite and trydimite are considered to have greater fibrogenic potential than quartz, and both the ACGIH and OSHA have set the TLV/PEL for these substances at one-half the value of quartz.[(8,12,13)] The NIOSH REL for respirable silica (all forms), is 0.05 mg/m^3.[14] The respirable fraction is considered to be that portion of inhaled dust which penetrates to the nonciliated portions of the lung.[11] In general, particles greater than 7-10 micrometers (µm) in diameter are all removed in the nasal passages and have little probability of penetrating to the lung. Particles smaller than this can reach the air-exchange regions (alveoli, respiratory bronchioles) of the lung, and are considered more hazardous.

The National Toxicology Program has concluded that respirable silica may reasonably be anticipated to be a carcinogen, based on laboratory animal studies which showed significant increases in lung cancer incidence in rats exposed to quartz via inhalation.[(15,16,17)] NIOSH is reviewing the data on carcinogenicity.[18]

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Appendix B - Indoor Environmental Quality

A number of published studies have reported a high prevalence of symptoms among occupants of officebuildings.[1-5] NIOSH investigators have completed over 1200 investigations of the indoor environment in a wide variety of settings since 1971. However, the great majority of these investigations have been conducted since 1979.

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

Scientists investigating indoor environmental problems believe that there are multiple factors contributing to building-related occupant complaints.[6,7] Among these factors are imprecisely defined characteristics of heating, refrigerating, 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.[4-8] Reports are not conclusive as to whether increases of outdoor air above currently recommended amounts are beneficial.[9] However, rates lower than these amounts appear to increase the rates of complaints and symptoms in some studies.[10] Design, maintenance, and operation of HVAC systems are critical to their proper functioning and provision of healthy and thermally comfortable indoor environments. Indoor environmental pollutants can arise from either indoor or outdoor sources.[11]

There are also reports describing results which show that occupant perceptions of the indoor environment are more closely related to the occurrence of symptoms than the measurement of any indoor contaminant or condition.[12] Some studies have shown relationships between psychological, social, and organizational factors in the workplace and the occurrence of symptoms and comfort complaints.[13,14]

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 irritant reaction to boiler corrosion inhibitors. The first three conditions can be caused by various microorganisms or other organic material. Legionnaires' disease and Pontiac fever are caused by *Legionella* bacteria. Sources of carbon monoxide include vehicle exhaust and inadequately ventilated kerosene heaters or other fuel-burning appliances. Exposure to boiler additives can occur if boiler steam is used for humidification or is released by accident.

Problems that NIOSH investigators have found in the non-industrial indoor environment have included poor air quality due to ventilation system deficiencies, overcrowding, volatile organic chemicals from office furnishings, office 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 (RH) conditions, poor lighting, and unacceptable noise levels; adverse ergonomic conditions; and job-related psychosocial stressors. In most cases, however, no environmental cause of the reported health effects could be determined.

Standards specifically for the non-industrial indoor environment do not exist. NIOSH, the Occupational Safety and Health Administration (OSHA), and the American Conference of Governmental Industrial Hygienists (ACGIH) have published regulatory standards or recommended limits for occupational exposures.[15,16,17] 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 and thermal comfort guidelines (Figure 1).[18,19] The ACGIH has also developed a manual of guidelines for approaching investigations of building-related symptoms that might be caused by airborne living organisms or their effluents.[20]

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

Carbon Dioxide

Carbon dioxide is a normal constituent of exhaled breath and, if monitored, can be used as a screening technique to evaluate whether adequate quantities of outside air are being introduced into an occupied space. ASHRAE's most recently published ventilation standard, ASHRAE 62-1989, Ventilation for Acceptable Indoor Air Quality, recommends outdoor air supply rates of 20 cubic feet per minute per person (cfm/person) for office spaces, and 15 cfm/person for reception areas, classrooms, libraries, auditoriums, and corridors.[19] 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 800 ppm in areas where the only known source is exhaled breath, inadequate ventilation is suspected.[21] 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.[22] 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 55-1981 specifies conditions in which 80% or more of the occupants would be expected to find the environment thermally acceptable.[18] 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. The difference between the two is largely due to seasonal clothing selection. ASHRAE also recommends that RH be maintained between 30 and 60% RH.[18] Excessive humidity can support the growth of microorganisms, some of which may be pathogenic or allergenic.

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Appendix C - Microbial Contaminants

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

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

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

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

Microbial Decontamination in HVAC Systems - Recommendations

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

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

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

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

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

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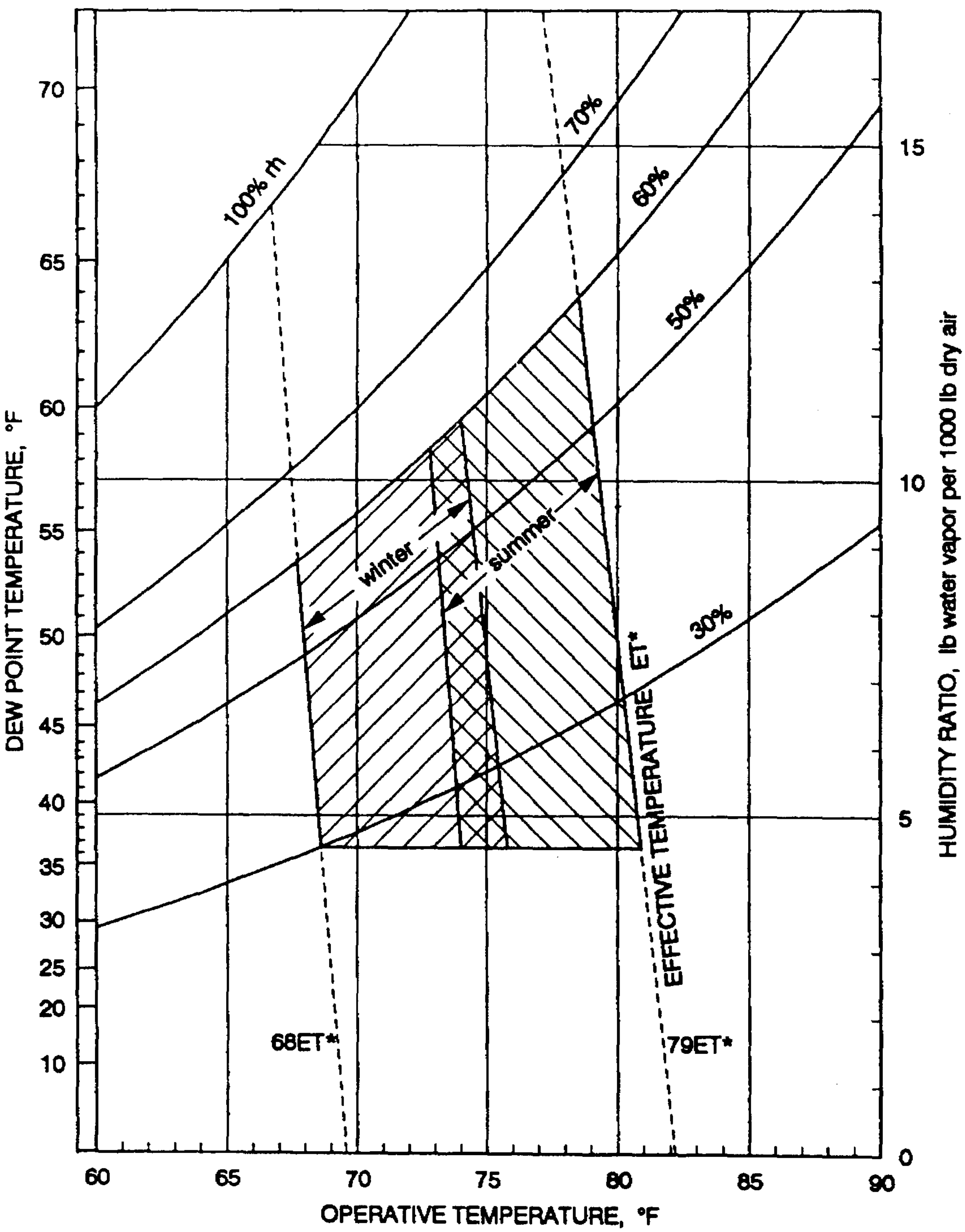
Figure 1
ANSI/ASHRAE Standard 55-1992
Thermal Environmental Conditions
for Human Occupancy



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