U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
CENTER FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
CINCINNATI, OHIO 45226

# HEALTH HAZARD EVALUATION DETERMINATION REPORT NO. 75-12-321

COOPER UNION SCHOOL OF ART
NEW YORK, NEW YORK



AUGUST 1976

## I. TOXICITY DETERMINATION

Environmental investigations were conducted at the Cooper Union School of Art in April and December, 1975 and in March, 1976. The purpose of these investigations was to evaluate the exposures of students, faculty, and technical assistants at the art school to materials used by artists and craftspersons. On the basis of environmental data collected during these surveys, observation of work practices, and available literature relevant to the toxicity of substances used in these work areas, it has been determined that exposures to crystalline silica, benzene, methyl cellosolve acetate, and lead are potentially toxic at concentrations measured during this evaluation. Although exposures to these substances are brief and sporadic in nature, it is believed that even short-term exposures to concentrations in the ranges of those measured during this investigation, may produce adverse health effects. Recommendations are included herein for the amelioration of these hazards and for the interim control of student or employee exposures until such engineering control is installed.

Mineral spirits, Lithotine®, Benzine®, toluene, xylene, acetone, acetic acid, nitric acid, and styrene, as found in the printmaking areas and plastics molding room, were determined to be non-toxic. Although capable of producing transient sensory irritation, they are not believed to be capable of producing any long-term health effects at the concentrations measured during this evaluation.

Concentrations of wood dust as found in the woodworking shop are also believed to be capable of producing transient irritation of the upper respiratory tract. Recommendations pertaining to ventilation control have been offered for consideration.

Exposures to fumes of copper, tin, and zinc in the metals casting area have been determined to be non-toxic at concentrations measured during this evaluation.

## II. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this Determination Report are available upon request from NIOSH, Division of Technical Services, Information Resources and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. Copies have been sent to:

a) Cooper Union School of Art, New York, N. Y.
b) U.S. Department of Labor - Region II
c) NIOSH - Region II

For the purpose of informing the approximately 300 affected employees and students, the Determination Report shall be posted for a period of 30 calendar days in a prominent place(s) near where exposed persons work.

## III. INTRODUCTION

Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6), authorizes the Secretary of Health, Education, and Welfare, following a written request by an employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The National Institute for Occupational Safety and Health (NIOSH) received such a request from the Dean of the School of Art, Cooper Union, to evaluate the exposures of faculty, technical assistants, and students, to various art materials used at the School of Art. Artists and craftspersons are exposed to a great number and variety of chemical substances. The requester expressed concern over the fact that there is little knowledge as to appropriate safe handling and use of these materials and that many symptoms are experienced by artists, such as "headaches, skin reactions, (and) lung problems".

## IV. HEALTH HAZARD EVALUATION

### A. Materials and Processes

The Cooper Union School of Art occupies a six-story building in downtown New York City. Artists' studios and work areas are located on the upper three floors, with the fourth floor reserved primarily for sculpture, the fifth floor for printmaking, and the sixth floor for painting and drawing. Students have scheduled classes in these areas but spend most of their time working on individual projects. The amount of time spent on any given project varies from day to day and week to week, and a student may work on more than one project at a time. The types of materials used and the quantities are very variable and unpredictable. Faculty and technical assistants are more likely to be exposed to the same substances on a daily basis, but the quantities of materials used are still quite variable.

1. Fourth Floor - Sculpture

The largest single work area on the fourth floor is that set up for woodworking. Sanders, planers, various types of saws, and drills are available for student use. The types of wood used vary, and much of it is scrap material which has been scavenged. During the NIOSH surveys, from one to five students were observed to be actually using the automatic tools at any one time. There were often other students present in the work area, some of whom were using hand tools, gluing, or doing other non-bench work. There was no local exhaust ventilation provided on any of the machines; general room ventilation consisted of two very large vents (approximately 4 feet by 6 feet each) covered by HEPA filters, which appeared to be heavily coated with dust.

Adjacent to the wood working area, metal sculptures are cast. Metal which is to be cast (usually bronze) is melted in a crucible in a ceramic high temperature kiln then poured into a mold. The molds also are formed in this area. A wax model of the desired form is made, then a slurry consisting of plaster and silica flour in water is poured over the model. Chicken wire coated with a hardened mixture of plaster, pulverized volcanic rock, and water, is used to contain the mold. This is then put into the burnout kiln where the invested wax becomes liquid and flows out the mold. Molten metal can then be poured into the mold to form the final metal sculpture. This entire process is called the lost-wax or investment-casting method. The potential hazards in this area include exposure to metal fumes during melting and pouring, and the inhalation of free silica and other dusts while mixing investment castings. Metal casting is only done on the average of one time per week, for a few hours at a time. Therefore, these exposures are intermittent and infrequent. The person who has the highest potential exposure is the Shop Assistant, who does the actual melting and pouring. There are hoods over the burnout kiln and a parabolic refractory kiln.

There is also a Plastics Shop on the fourth floor in which modeling of polyester resins and polyurethanes may be done, aerosol spray adhesives are used, and Plexiglass® sheets or blocks are cut or heated. During the three NIOSH visits, some polyester resin casting was observed and aerosol spray adhesives were used intermittently. In polyester resin casting, the raw material is principally a polyester carried in styrene which acts as the solvent and cross-links with the polyester. The cross-linking or curing is catalyzed by the addition of an organic peroxide. The polyester then hardens to a hard finish. Exposures were usually very short. For example, a student would stay in the room only long enough to combine the resin polyester and catalyst, then would leave while the mixture hardened.

2. Fifth Floor - Printmaking

Silk screen printing, etching, lithography, and various photographic processes are print-making methods used on the fifth floor. In one set of rooms etching and lithography work stations are located. With etching, acid is used to etch a design in a metal plate, usually copper or zinc, and the plate is subsequently used to produce a number of prints on paper. Hydrochloric and nitric are the acids used for biting copper and zinc plates, while sulfuric acid is occasionally used for biting steel plates. Acid baths are located within a hood in the etching rooms. Lithography differs from etching primarily in that the design is cut in a large, flat stone instead of a metal plate. A variety of solvents is used in this area, most of which are aliphatic hydrocarbons similar to mineral spirits. Alcohol (ethanol) is also used in the plate washup area, acetic acid is used as a degreaser, and powdered rosin (highly pulverized magnesium carbonate) is used to coat plates as part of the etching ground. While working on a specific project, a student might spend an entire day in the etching/lithography area, and faculty and technical assistants may have daily exposures in this area.

Silk screening and photographic processes are situated on the opposite side of the hallway on the same floor as etching and lithography. In silk screening, the design to be reproduced on paper is transferred from a piece of fabric stretched across a frame. The primary chemical to which artists are exposed during silk screening is mineral spirits, used to wash the screens. This is poured liberally from a can onto the screen, then wiped across the screen with hands and/or rags. There is no local exhaust ventilation in the silk screening area.

Photo etching is a print making technique used occasionally by students, in which photosensitive chemicals are used. Students are potentially exposed to ethyl acetate, ethylene glycol, monomethyl ether acetate (methyl cellosolve acetate), benzene, xylene, and toluene. Photo etching is performed in a small room equipped with a separate ventilation system, but at the time of the survey, this was not in operation.

There is one large photographic darkroom and several smaller ones, adjacent to the silk screening area. Students working in these rooms are potentially exposed to chemicals contained in the developer, stop bath, or fixer.

3. Sixth Floor - Painting

Several large studios are used for painting and drawing on this floor. A variety of painting media is used including both oil paints and synthetics, especially the acrylic media. Solvents, diluents, or thinners are used daily, and most of these are turpentine or mineral spirits based. There is a separate ventilation system for the sixth floor, designed to move 400 cfm from each of the vents. Up to 30 persons may be painting at any one time, but with the exception of scheduled classes, no more than a few students were ever observed to be working on the sixth floor at any one time.

B. Evaluation Design

An initial screening survey was conducted by NIOSH industrial hygienists on April 7, 1975 in order to better define the alleged hazards and areas in which potentially toxic materials are used. Due to the very large variety of chemicals used by artists and the limited scope of hazard evaluations, it was determined that an evaluation would be conducted only for those substances used regularly or for which there were identified health complaints from students or faculty.

Following the walk-through survey of the fourth floor, it was concluded that the greatest potential exposures on this floor were from dust generated during woodworking, metal fumes during casting, from silica during investment molding, and from styrene and solvents in the plastics molding room.

On the fifth floor, the greatest potential exposures appeared to be from various solvents and acids used in printmaking. Turpentine and mineral spirits were judged to present the greatest potential exposures on the sixth floor.

Because of the unscheduled and sporadic usage of all materials, it was not possible to estimate which chemicals were actually used with sufficient frequency and quantity that they would be sources of airborne contamination. In order to determine which chemicals were actually present in the workplace atmosphere, bulk air samples were obtained on December 1 and 2, 1975. (This follow-up survey had been delayed because of summer recess.) The samples were qualitatively analyzed by a combination of gas chromatography/mass spectrometry. In March, 1976, a third and final survey was conducted in order to quantitate the exposures to those chemicals which were identified from the bulk air samples of the December survey as possible airborne contaminants.

C. Evaluation Methods

1. Initial Environmental Sampling

a) Sculpture (fourth floor)

On December 1 and 2, MSA Model G personal sampling pumps were set in various locations around the woodworking shop. Air was pulled at a flow rate of 1.7 liters per minute through pre-weighed VM-1 filters. Two filters were connected in series with 10-mm nylon cyclones so that only respirable dust was collected on the filters. Filters were subsequently re-weighed at the NIOSH laboratories in Salt Lake City. Samples also were collected in the metal casting area during the melting of bronze (85% copper, 5% tin, 5% lead, 5% zinc) using MSA Model G personal sampling pumps and HA filters. These were analyzed by atomic absorption spectroscopy for lead, copper, tin, and zinc. During the time that one student was preparing an investment mold using silica flour and pulverized volcanic rock (approximately one hour), a personal breathing zone and an area sample were obtained on pre-weighed FWSB filters connected to MSA Model G personal sampling pumps. These samples were analyzed by X-ray diffraction for quartz and cristobalite as well as for total weight gain. A bulk sample of the silica flour was collected, to be analyzed by X-ray diffraction for percent free (crystalline) silica.

In the plastics molding room, a bulk air sample was collected by drawing air through a charcoal tube at a flowrate of 1.3 liters per minute. This sample was submitted for qualitative gas chromatography/mass spectrometry analysis.

b) Print making (fifth floor)

Charcoal tubes and MSA Model G personal air sampling pumps were used to collect bulk air samples at various locations throughout the etching and lithography rooms and silk screening area. These tubes, along with bulk samples of the six liquids which were used most frequently in these areas, were analyzed by gas chromatography and mass spectrometry at the NIOSH laboratory in Cincinnati. They were specifically screened for low boiling aromatics (benzene, xylene, toluene) and for chlorinated hydrocarbons.

Sampling pumps and impingers were placed near the acid baths in the etching and lithography rooms and in the large darkroom near the developing solution, stop bath, and fixer. Air was bubbled through sodium hydroxide contained in the impingers. These solutions were titrated with standardized hydrochloric acid to determine the equivalent of total acid present (in mg of hydrogen ion per ml of impinging solution).

c) Painting (sixth floor)

No samples were taken on the sixth floor since there was no work being done there at the time of the survey.

2. Follow-up Environmental Sampling

a) Sculpture (fourth floor)

Pre-weighed VM-1 filters were again used to collect dust samples in the woodworking shop on March 24. MSA Model G sampling pumps were either worn by students to obtain breathing zone samples or placed at various work stations around the shop as area samples. Students wore the pumps for the entire time that they were sanding, sawing, or planing. The filters were analyzed gravimetrically for total particulate.

Personal sampling pumps also were worn by persons working in the metal casting area while 85 pounds of bronze were being melted. The pumps drew air at a flowrate of 1.5 liters per minute through AA filters which were subsequently analyzed by atomic absorption spectroscopy for lead, copper, tin, and zinc.

Two students who were making investments with silica flour, plaster, and pulverized volcanic rock were monitored for exposure to crystalline silica. MSA Model G pumps were used to draw air at a flowrate of 1.7 liters per minute through pre-weighed PVC filters worn on the shirtfronts of the students. Each person wore one sampler which had a 10 mm nylon cyclone in line with the filter so that only respirable dust was collected; in addition, one student wore a filter sampler which was to be analyzed for total amount of free silica. All samples were re-weighed and analyzed by X-ray diffraction for quartz and cristobalite.

One person was molding with polyester resin in the plastics room. His exposure to styrene, acetone, methyl ethyl ketone, toluene, and methylene chloride was measured by drawing air through a charcoal tube at a flow-rate of 200 cc per minute. This tube was analyzed by gas chromatography/ mass spectrometry.

b) Print Making (fifth floor)

Environmental air samples were collected in the etching and lithography area on March 23 and 24, in the silk screening area on March 24, in the photo etching area on the 23rd, and in the dark rooms on both days.

Sipin pumps, set at a flowrate of 200 cc per minute, pulled air through charcoal tubes worn on the shirtfronts of students and faculty in the etching and lithography area. The samples were analyzed by gas chromatography and mass spectrometry techniques in order to identify the air contaminants. Specifically, analysts looked for those substances provided as bulk samples of the chemicals used in this area (Lithotine®, Kerosine®, and Benzine®) and aromatics such as benzene, toluene, and xylene.

Concentrations of nitric acid were measured near the acid baths in the etching room by drawing air at the rate of 1 liter per minute through 15 ml of 0.1 N sodium hydroxide contained in impingers. The solutions were analyzed spectrophotometrically.

Charcoal tube samples were obtained in the silk screening area and were analyzed by gas chromatography and mass spectrometry, specifically looking for mineral spirits as well as any other major peaks that appeared on the chromatograph. One student was photo etching; his exposure to components of the KPR® developer, dye, and photo resist were monitored using a Sipin pump drawing air through a charcoal tube at a rate of 200 cc per minute. Analysis of bulk samples of the three compounds by gas chromatography/mass spectrometry techniques indicated the presence of toluene, xylene, 2-methoxyethyl acetate, and benzaldehyde. Therefore, charcoal tube analysis was directed specifically toward detection of these chemicals.

In the darkroom, MSA Model G sampling pumps were set up to draw air at a flowrate of 1 liter per minute through 15 ml of 0.1 N sodium hydroxide contained in impingers. These solutions were analyzed by gas chromatography for acetic acid.

c) Painting (sixth floor)

Personal breathing zone exposures of students working on the sixth floor, to paint solvents and diluents were monitored with Sipin pumps and charcoal tubes. The samples, along with bulk samples of four of the compounds used most often, were analyzed by gas chromatography and mass spectrometry to identify and quantitate the major air contaminants.

3. Medical Investigation

Non-directed medical questionnaires were administered to approximately 40 students, faculty, and technical assistants to determine the type and extent of symptoms being experienced that were attributable to their exposures to materials used at the School of Art.

## D. Evaluation Criteria

### 1. Environmental Standards

Several types of standards have been selected for use as criteria in evaluating the limitations of exposure to substances used at the Cooper Union School of Art. One set of standards are those standards of occupational exposure that have been developed and recommended by NIOSH. A second set of standards is that promulgated by the U.S. Department of Labor, designed to protect the health and safety of workers exposed to any of approximately 400 chemical substances for an 8-hour workday, 40-hour week, over a working lifetime (29 CRF 1910.1000, Tables G-1, G-2, and G-3). The third type of criteria is the threshold limit value (TLV), as recommended by the American Conference of Governmental Industrial Hygienists. The TLV's represent airborne concentrations of substances under which it is believed "nearly all workers" may be exposed without adverse effect. The following table presents those standards applicable to the substances evaluated during this survey.

| Substance | Federal Standard | ACGIH TLV | NIOSH Recommendations |
|---|---|---|---|
| Acetic Acid | 10 ppm (25 mg/M$^3$) | 10 ppm (25 mg/M$^3$) | |
| Acetone | 1000 ppm (2400 mg/M$^3$) | 1000 ppm (2400 mg/M$^3$) | |
| Benzene | 10 ppm (30 mg/M$^3$) | 10 ppm (30 mg/M$^3$) | 10 ppm (30 mg/M$^3$) |
| Copper fume | 0.1 mg/M$^3$ | 0.2 mg/M$^3$ | |
| Ethylene glycol monomethyl ether acetate (methyl cellosolve acetate) | 25 ppm (120 mg/M$^3$) | 25 ppm (120 mg/M$^3$) | |
| Lead | 0.2 mg/M$^3$ | 0.15 mg/M$^3$ | 0.15 mg/M$^3$ |
| Mineral spirits (stoddard solvent) | 500 ppm | 100 ppm (175 mg/M$^3$) | |
| Nitric acid | 2 ppm (5 mg/M$^3$) | 2 ppm (5 mg/M$^3$) | 2 ppm (5 mg/M$^3$) |
| Silica (crystalline) | | | |
| total | $\frac{30\ mg/M^3}{\%\ SiO_2+2}$ | $\frac{30\ mg/M^3}{\%SiO_2+3}$ | |
| respirable | $\frac{10\ mg/M^3}{\%\ SiO_2+2}$ | $\frac{10\ mg/M^3}{\%SiO_2+2}$ | 50 µg/M$^3$ |
| Styrene | 100 ppm (420 mg/M$^3$) | 100 ppm (420 mg/M$^3$) | |
| Tin | 2 mg/M$^3$ | 2 mg/M$^3$ | |
| Toluene | 200 ppm (750 mg/M$^3$) | 100 ppm (375 mg/M$^3$) | 100 ppm |
| Turpentine | 100 ppm (560 mg/M$^3$) | 100 ppm (560 mg/M$^3$) | |
| Wood dust | -- | 5 mg/M$^3$ | |
| Xylene | 100 ppm (435 mg/M$^3$) | 100 ppm (435 mg/M$^3$) | 100 ppm |
| Zinc oxide fume | 5 mg/M$^3$ | 5 mg/M$^3$ | 5 mg/M$^3$ |

2. Toxicologic Effects

a) Aliphatic and Alicyclic Hydrocarbons

Most of the solvents used in the print making and painting departments are primarily aliphatic and alicyclic hydrocarbons, some of which have low percentages of aromatic hydrocarbons, halogenated hydrocarbons and possible non-hydrocarbon additives. Most of the aliphatic and alicyclic hydrocarbons can produce central nervous system depression if sufficient quantities are inhaled, but the more common health complaints arise from their ability to irritate the mucous membranes of the eyes, nose, and upper respiratory tract. As liquid solvents, they have a tendency to dehydrate and defat the skin, causing irritation and possibly dermatitis.

The Lithotine®, Benzine®, Kerosine®, Streakless®, Mineral Spirits®, and turpentine are included in this category of hydrocarbons.

b) Aromatic Hydrocarbons

Several of the chemicals used in the etching and lithography, photo etching, and plastics molding contain small quantities of aromatic hydrocarbons, such as benzene, xylene, toluene, and styrene. Generally, the aromatic hydrocarbons are potentially more toxic than the aliphatic and alicyclic hydrocarbons. The vapors are more irritating to the mucous membranes and systemic injury is more likely to result from inhalation of aromatic hydrocarbon vapors. As the aliphatic and alicyclic hydrocarbons, the aromatics are primary irritants and can dehydrate and defat the skin following repeated or prolonged contact with the liquids. Benzene is unique in its ability to produce leukemia,[1,2] aplastic anemia,[3,4] and other blood dyscrasias. Several reports in the literature have associated leukemia with chronic exposures to benzene. The NIOSH recommended environmental limit of 10 ppm as a time-weighted average for up to a 10-hour workday, 40-hour work week,[5] is based upon borderline hematological changes which have occurred in man and animals following chronic exposures to concentrations as low as 20-25 ppm.[6,7,8,9]

Toluene and xylene are primarily mucous membrane irritants and may produce some central nervous system depression, with symptoms including changes in muscular coordination and reaction time, and narcosis. These or other adverse effects have not been reported in the literature for toluene or xylene exposures of 100 ppm or less in industrial workers or experimental subjects.[10,11]

Styrene vapors have a transient irritating effect on the eyes and mucous membranes of the nose at concentrations of 200-400 ppm.[12] Exposures to concentrations of 800 ppm have produced other adverse health effects including drowsiness, listlessness, muscle weakness, and unsteadiness.[13] The current TLV is based upon experiments which found no untoward effects to humans at concentrations below 100 ppm.[14] Under ordinary room conditions, styrene does not vaporize sufficiently to produce life-threatening vapor concentrations. Styrene is excreted both in exhaled air and in the urine, as hippuric acid.

c) Methyl Cellosolve Acetate (ethylene glycol monomethyl ether acetate)

There is very little data relating to occupational exposures to methyl cellosolve acetate, however, evidence from animal experiments indicated that chronic inhalation of 500 and 1000 ppm resulted in kidney damage in guinea pigs, rabbits, cats, and mice. Single and repeated exposures to a concentration of 4500 ppm of methyl cellosolve acetate caused mucous membrane irritation in mice, guinea pigs, and cats after one hour; guinea pigs and cats died of bronchopneumonia following 3-hour exposure to the same concentration.[15]

d) Crystalline Silica

The crystalline forms of silica can cause severe tissue damage when inhaled. Silicosis is a form of pulmonary fibrosis caused by the deposition of fine particles of crystalline silica in the lungs. Symptoms usually develop insidiously, with cough, dyspnea, chest pain, weakness, wheezing, and non-specific chest illnesses.[16,17] Silicosis usually occurs after years of exposure, but may appear in a shorter time if exposure concentrations are very high. This latter form is referred to as rapidly-developing silicosis, and its etiology and pathology are not as well understood.[17] Silicosis is usually diagnosed through chest roentgenograms, occupational exposure histories, and pulmonary function tests. The manner in which silica affects pulmonary tissue is not fully understood, and theories have been proposed based on the physical shape of the crystals, their solubility, cytotoxicity to macrophages, or their crystalline structure. There is evidence that cristobalite and tridymite, which have a different crystalline form from that of quartz, have a greater capacity to produce silicosis.[16]

e) Metals

Emissions generated during the melting and pouring of bronze could include metal fumes of copper, zinc, tin, and lead. Many metal fumes, including zinc and copper, are capable of producing metal-fume fever with symptoms including chills and fever, nausea, vomiting, dryness of the throat, coughing, fatigue, and weakness. This is sometimes accompanied by mental confusion, convulsions, and decreased vital capacity of the lungs.[12] The condition is usually temporary, and never fatal. Copper fume also has been associated with congestion of the nasal mucous membranes, ulceration of the nasal septum, and sometimes pharyngeal congestion. Chronic exposure can lead to irritation of the upper respiratory tract, a metallic or sweet taste, nausea, discoloration of the skin and hair, and more seriously, damage to the liver, kidneys or spleen.[12]

The fume of tin has produced stannosis, a benign form of pneumoconiosis. This is usually diagnosed by roentgenogram, since pulmonary tissue reaction and symptoms of pulmonary function interference are usually absent. One case in the literature reports that a person employed as a smelter and bagger of $SnO_2$ for 22 years did eventually develop dyspnea and reduced vital capacity.[18]

The primary site of action for lead has been shown to be the outer surface of the cell membrane, and therefore the important toxic effects of lead are membrane effects.[19] Anemia is a prominent finding, resulting from the inhibition of hemoglobin synthesis and a shortening of the life span of circulating erythrocytes. Neurologic effects include lead encephalopathy which may be either acute or chronic and is characterized by cerebral edema, theorized to be due to impairment of biochemical metabolic reactions in the brain cells. Progressive symptoms may include subtle changes in mental attitude, losses of memory and ability to concentrate, restlessness, headache, vertigo, and tremor, and later, vomiting, drowsiness, stupor, and coma. Lead palsy, characterized by aching and tenderness of the muscles and joints and a fine tremor, is another possible effect of occupational lead exposure. Renal damage also has resulted from lead exposure. There is usually a progressive impairment of renal function which may result in irreversible renal disease. Other effects of lead poisoning may include gastrointestinal symptoms such as loss of appetite and digestive disturbances with colicky abdominal pain and constipation in more severe cases. Lead exposure also produces a bluish line on the gums (called the Burtonian lead line) caused by precipitated lead sulfide.[20]

f) Acids

The most important effects of exposure to an acid result from the direct contact of the acid on the skin, eyes, or mucous membranes of the upper respiratory tract. Acetic acid, a widely used organic acid, has been found to cause conjunctivitis, bronchitis, and pharyngitis as well as erosion of the teeth in workers exposed for seven to twelve years to concentrations of 80-200 ppm as peak concentrations. Except for local effects, there is no evidence of cumulative toxicity, and the TLV of 10 ppm is believed to prevent undue irritation.[12,21] Nitric acid vapor or mist also had been reported to produce chronic bronchitis, and chemical pneumonitis from more severe exposures. Exposure to the TLV of 2 ppm is believed to be sufficiently low to prevent irritation of the respiratory tract and corrosion effects on teeth.[22]

g) Wood Dust

Increased incidences of adenocarcinoma of the nasal cavity and accessory sinuses have been reported among woodworkers in the furniture industry in Great Britain and Sweden.[23,24] Cancers of the larynx, tonsils, tongue and lung also have been reported to have resulted from inhalation of wood dust.[25,26] The associated dust levels are unknown but are believed to be high since exposures occurred during a period of advanced mechanization with the absence of environmental controls. Other respiratory diseases and dermatoses have been associated with specific types of wood. A survey of woodworkers in Great Britain indicated that nasal mucociliary function was impaired in workers exposed to wood dust in the furniture industry for more than 10 years.[27] The ACGIH has recommended a TLV of 5.0 $mg/M^3$ to minimize the risk of wood dust disease, recognizing the lack of evidence associating health effects with quantitative data on occupational exposures.

E. Evaluation Results

1. Initial Environmental Sampling

Results of analyses of area air samples obtained in the woodworking area showed 0.22 and 0.95 mg/$M^3$ of respirable dust and 0.29 and 2.58 mg/$M^3$ of total dust. No metals were detected on any of the filters. The lower limits of detection were 0.003 mg per sample for lead, 0.001 mg for copper, 0.020 mg for tin, and 0.002 mg for zinc. Total particulate levels in the investment molding area were 0.16 mg/$M^3$, 1.78 mg/$M^3$, and 24.75 mg/$M^3$. The latter two samples contained 0.11 and 1.34 mg/$M^3$ of quartz respectively, both considerably higher than the NIOSH recommended concentration of 0.05 mg/$M^3$. The filter containing 1.34 mg/$M^3$ was from a personal breathing zone sample worn by a student while he was mixing silica flour with pulverized volcanic rock and plaster. He was observed to be wearing a single-use type respirator for protection against dusts.

Samples taken on the fifth floor indicated measurable amounts of total acid, ranging from 1.6 to 2.1 mg/$M^3$ of hydrogen ion. Gas chromatography/mass spectrometry analyses of charcoal tube bulk air samples from the printmaking areas showed a varying level of contaminants with most compounds resembling mineral spirits and other aliphatic type hydrocarbons. No benzene or chlorinated hydrocarbons were detected on any of the samples.

Toluene, styrene, and traces of xylene were detected on the charcoal tube sample obtained in the plastics molding room.

2. Follow-up Environmental Sampling

The results of analyses for total particulate in the woodworking area, metals, crystalline silica, nitric acid, acetic acid, and organics are presented in tables I, II, III, IV, V, and VI.

Total particulate weights in the woodworking shop ranged from 0.87 to 24.18 mg/$M^3$ with a mean concentration of 5.5 mg/$M^3$ and a median of 3.9 mg/$M^3$. Three of the ten samples exceeded the recommended exposure limit of 5 mg/$M^3$. In the metal sculpting area, the concentrations of copper, tin, and zinc were all below recommended limits of exposure. However, one of the three samples showed a lead concentration of approximately twice the NIOSH recommended standard and ACGIH TLV. This level was measured on a breathing zone sample of the Shop Assistant who works full time in this area.

Silica concentrations measured while two students were molding investments, were 0.57 mg/$M^3$, 0.78 mg/$M^3$ and 1.70 mg/$M^3$ of quartz. The two lower concentrations were respirable dust samples while the highest was a total dust sample. Cristobalite concentrations were 0.03 and 0.12 mg/$M^3$; one of the respirable samples had no detectable amount of cristobalite on it. The concentrations of quartz greatly exceed all recommendations for 8-hour time weighted average exposure limits. It is not expected that this represents a daily exposure since the exposure time was three hours, and no other investment molding was performed on any of the days that the NIOSH team was there for a follow-up survey. Also, it is not likely that the same student would be exposed except on an occasional basis.

Concentrations of nitric acid and acetic acid were all quite low, the highest being 1.15 mg/$M^3$ of nitric acid, measured in the etching room. Most of the impinger solutions from the darkroom samples, showed no detectable amounts of acetic acid.

Concentrations of Lithotine®/Benzine®, solvents comprised primarily of substituted aliphatics such as pentanes, hexanes, and heptanes, ranged from 6.7 mg/$M^3$ to 50 mg/$M^3$. Mineral spirits concentrations measured in the silkscreening area were 34.1 and 163.2 mg/$M^3$. These levels are all below the proposed TLV of 175 mg/$M^3$ for Stoddard Solvent, which is similar in composition to these solvents. Acetone was found in samples from several different areas. In the photo etching area, 91.5 mg/$M^3$ were measured and in the plastics molding room, 25.0, 43.3, and 56.2 mg/$M^3$ were found on three samples. These levels are considerably less than the standard, 2400 mg/$M^3$.

Three of the five charcoal tubes showed barely detectable amounts of toluene on them, and the two others, one from the silkscreening area and one from the plastics molding room, had 10.4 and 2.3 mg/$M^3$, respectively. (The ACGIH recommended TLV is 375 mg/$M^3$). Xylene concentrations also were very low, with trace quantities detected on one sample from the silkscreening area and 2.6 mg/$M^3$ on the other. Styrene was barely detectable on one sample, and was found to be 2.0 and 10.0 mg/$M^3$ on the other two, all from the plastics molding room. The standard for an 8-hour time-weighted average exposure to styrene is 420 mg/$M^3$.

Analysis of the charcoal tube sample from the breathing zone of a student in the photo etching area indicated a concentration of 176.1 mg/$M^3$ of methyl cellosolve acetate (the 8-hour time weighted average exposure limit is 120 mg/$M^3$) and 112.7 mg/$M^3$ of benzene (the standard for benzene is 30 mg/$M^3$).

Concentrations of turpentine, measured on the sixth floor, ranged from 8.3 mg/$M^3$ to 63.4 mg/$M^3$ with an average concentration of 29.1 mg/$M^3$. The major component of turpentine - pinene - was found in concentrations ranging from 3.3 to 30.8 mg/ $M^3$. The federal standard and recommended TLV are both 560 mg/$M^3$.

3. Medical Investigation

Forty-two people were interviewed to determine the extent and range of adverse health effects attributable to the use of artists' materials. Seventeen persons felt that they had some health problem which was related to their work at the Art School. Most of the complaints were related to the use of solvents on the printmaking and painting floors. "Headaches" was the most common symptom (about 10 persons), eye and skin irritation were reported by five people, and upper respiratory tract irritation was reported by two students. Dizziness, tiredness, disorientation, and a feeling of being 'high' was associated with exposures during photo etching by one student.

F. Conclusions and Recommendations

It is believed that most of the chemicals and processes to which students, faculty, and technical personnel at the Cooper Union School of Art are exposed, have no serious and long-lasting health effects. This is primarily due to the fact that exposure times are usually brief and sporadic in nature. However, there are a few exceptions to this, notably the exposures to silica, benzene, and lead. Although exposures to these substances also are occasional, it is believed that even short-term exposures to concentrations in the ranges of those measured during this investigation, may have potentially toxic effects.

Several substances used at Cooper Union may produce transient irritation of the eyes, nose, and throat, and may dry and defat the skin. The solvents used in etching, lithography, silk screening, and painting are in this category. Concentrations of mineral spirits, lithotine/benzine, toluene, xylene, acetone, and styrene are not judged to be a health hazard at the concentrations measured during this evaluation. It is recognized that concentrations may be higher at times of increased activity in these areas, however, since these exposures are short-term and occur intermittently, they are not believed to be capable of producing any long-term health effects.

Concentrations of wood dust encountered in the sculpture area also are believed to be capable of producing transient irritation of the upper respiratory tract. Although long-term health effects are not likely with limited exposure times, the evidence from woodworking industries that more serious disease may result from chronic exposures suggests that it would be prudent to reduce exposures to the lowest practicable levels. Improved dilution (general room) ventilation is recommended. Measurements of air movement using an Alnor Velometer indicated very little air movement in the room in spite of the fact that two large filtered vents were present. Both were observed to be heavily coated with dust, which may be one explanation for the absence of air flow. Periodic cleaning of the filters is recommended to prevent the restriction of air flow. Another possibility is that the exhaust fan capacity is not sufficient to exhaust the large number of cubic feet of air present in a room of that size. It is also recommended that machine guarding is added to the woodworking machinery which is not already so-equipped.

Local exhaust ventilation is recommended over the small kiln, in which bronze is melted. This could be similar in design to that over the large kiln. Although concentrations of copper, tin, and zinc are not likely to reach levels capable of producing toxic effects, the concentrations of lead measured during this investigation are potentially toxic. Until such a time that ventilation is installed, exposures which are likely to be several hours at a time, especially that of the Shop Assistant who is exposed routinely, should be controlled through the use of personal protective equipment. There are several respirators that have been approved by NIOSH for use in atmospheres containing metal fumes, any of which would be appropriate.

It has further been determined that concentrations of acetic acid and nitric acid are not toxic at the concentrations measured during this investigation.

Potentially toxic exposures do exist during photo etching, as determined from environmental sampling data, observation of work practices, and non-directed medical questionnaires. The concentration of methyl cellosolve acetate found in the breathing zone of one student was approximately one and a half times the current standard (both the OSHA standard and the ACGIH TLV). Although his exposure was not for eight hours, it is possible that a student could be exposed for an entire day if his or her project demanded that much work. Benzene was found to be 112.7 mg/$M^3$ in the breathing zone of this same student, which is greater than the federal standard for an acceptable ceiling concentration (75 mg/$M^3$) for a maximum exposure of ten minutes. Furthermore, of two students interviewed who were involved in photo etching, one reported frequent headaches and the other described dizziness, tiredness, disorientation and a feeling of being high. The small rooms in which photo etching chemicals were used, were equipped with ventilation. However, it was observed that the exhaust vents were not connected to any exhaust fan. Local exhaust ventilation is necessary wherever these photo etching chemicals are used. In the interim period before ventilation is installed and in operation, students' and faculty exposure should be limited, either through the use of appropriate respiratory protection or by restricting the amount of time anyone may work with these chemicals. A chemical cartridge respirator designed for respiratory protection against organic vapors would be appropriate.

Based upon results of environmental sampling for free silica, it has been determined that students are exposed to excessive concentrations of crystalline silica during mixing of materials for making investments. Even though exposures are not continuous for eight hours nor are they daily exposures, it is believed that there is a serious health hazard in this area. NIOSH has recommended that no worker be exposed to crystalline silica in concentrations exceeding 50 ug/$M^3$, determined as an 8-hour time weighted average daily exposure. The concentrations measured at Cooper Union were 110 and 1340 ug/$M^3$ on the first survey (total crystalline silica) and 570, 780 (both respirable fraction of crystalline silica), and 1700 ug/$M^3$ (total) on the follow-up survey. One student was wearing an approved respirator for use in atmospheres containing up to ten times the recommended standard. However, several of the values obtained were greater than ten times this standard, and the respiratory protection which would thus be appropriate consists of a full facepiece respirator with a replaceable dust filter or a Type C supplied air respirator with a full facepiece. It is believed that respiratory protection is not a suitable alternative to ventilation control, and that local exhaust ventilation must be installed in this area. It is further believed that until such time that engineering control is in operation, no exposure in this area is free from toxic potential. Although acute onset of silicosis is rare, there have been reports of rapidly developing silicosis in the literature.

A further recommendation would be the installation of eye wash fountains in any area where solvent or acid splashes are likely. Also, barrier cream or neoprene gloves are recommended where skin exposure to solvents is excessive. This might be appropriate in the silk screening area when mineral spirits is liberally poured on the screens and spread by hand for cleaning.

Information pertaining to the selection and use of appropriate respirators can be obtained from the respiratory protection devices manual published by the AIHA and ACGIH in 1963 or from the NIOSH publication of certified personal protective equipment.

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## VI. AUTHORSHIP AND ACKNOWLEDGMENTS


| | |
|---|---|
| Report Prepared By: | Beth S. B. Levy<br>Industrial Hygienist<br>Cincinnati, Ohio |
| Originating Office: | Jerome P. Flesch, Acting Chief<br>Hazard Evaluation and<br>Technical Assistance Branch<br>Cincinnati, Ohio |



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| | |
|---|---|
| Environmental Evaluation: | Jerome P. Flesch, Acting Chief<br>Hazard Evaluation and<br>Technical Assistance Branch |
| | Irving Kingsley,<br>Regional Industrial Hygienist<br>Region I |
| | Eileen Philbin,<br>Nurse Consultant, |
| | Robert E. Rosensteel,<br>Chief, Industrial Hygiene Section |
| | Raymond L. Ruhe<br>Industrial Hygienist |
| Chemical Analysis: | Ardith Grote,<br>Chemist |
| | Utah Biomedical Test Laboratory<br>Salt Lake, Utah |

Table I

Total Particulate Concentrations in the Woodworking Shop

Cooper Union School of Art

March 23 and 24, 1976

| Operation | Sample Period | Concentration ($mg/M^3$) |
|---|---|---|
| Sawing, sanding | 1415-1500 | 5.04 |
| Sanding | 1410-1526 | 6.75 |
| Planing, sanding, welding | 1440-1830 | 2.29 |
| Sanding | 1435-1521 and 1730-1830 | 4.28 |
| Sawing | 1526-1700 | 1.06 |
| Sawing, sanding | 1520-1930 | 0.87 |
| Sawing | 1525-1722 | 3.42 |
| Planing, cutting | 1515-1650 and 1705-1915 | 24.18 |
| Area | 1449-1950 | 2.46 |
| Cutting plastic | 1430-1900 | 4.59 |
| | | |
| Environmental Criteria | | 5 $mg/M^3$ |

Table II

Concentrations of Metals

Cooper Union School of Art

March 23 and 24, 1976

| Sample Description | Sample Period | Concentration ($mg/M^3$) Lead | Copper | Tin* | Zinc |
|---|---|---|---|---|---|
| Melting - supervisor | 1405-1628 | 0.32 | 0.04 | 0.02 | 0.84 |
| Melting - student | 1407-1620 | 0.14 | 0.02 | ND | 0.29 |
| Melting - student | 1419-1620 | 0.13 | 0.02 | ND | 0.32 |
| Lower Limit of Detection (mg/sample) | | 0.003 | 0.001 | 0.004 | 0.001 |
| Environmental Criteria | | 0.15 | 0.1 | 2 | 5 |

*One blank was found to contain 0.012 mg of tin, 3 times the lower limit of detection.

ND = none detected.

Table III

Concentrations of Particulate and Crystalline Silica

Investments Molding Area

Cooper Union School of Art

March 24, 1976

| Sample Description | Sample Period | Particulate (mg/M$^3$) | Quartz (mg/M$^3$) | Cristobalite* (mg/M$^3$) |
|---|---|---|---|---|
| Breathing zone - respirable | 1515-1840 | 3.15 | 0.57 | 0.03 |
| Breathing zone - total | 1555-1835 | 8.00 | 1.70 | 0.12 |
| Breathing zone - respirable | 1555-1835 | 4.84 | 0.78 | ND |

*One blind blank was 3 times the lower limit of detection for cristobalite.

ND = none detected.

Table IV

Concentrations of Nitric Acid and Acetic Acid in the Printmaking Areas

Cooper Union School of Art

March 23 and 24, 1976

| Sample Location | Sample Period | Nitric Acid ($mg/M^3$) | Acetic Acid ($mg/M^3$) |
|---|---|---|---|
| Etching - breathing zone | 1005-1110 | 1.15 | - |
| Etching - breathing zone | 1547-1607 | 0.50 | - |
| Etchine - area | 1544-1843 | 0.06 | - |
| Film developing-breathing zone | 1021-1158 | - | ND |
| Film developing-breathing zone | 1017-1341 | - | ND |
| Film developing-breathing zone | 1553-1730 | - | ND |
| Film developing-breathing zone | 1537-1733 | - | 0.09 |
| Film developing - area | 1534-1847 | - | 0.05 |
| Film developing - area | 1534-1847 | - | ND |

ND = none detected.

Table V

Concentrations of Organic Vapors in the Printmaking Areas and Plastics Mold Room

Cooper Union School of Art

March 23 and 24, 1976

| Sample Description | Substance | Concentration (mg/M$^3$) |
|---|---|---|
| Etching - BZ** | Lithotine/Benzine* | 6.7 |
| Etching - BZ | Lithotine/Benzine | 50.0 |
| Etching - BZ | Lithotine/Benzine | 20.8 |
| Photoetching - BZ | Acetone | 91.5 |
| | Benzene | 112.7 |
| | Methyl Cellosolve Acetate | 176.1 |
| Silkscreening - BZ | Mineral Spirits* | 163.2 |
| | Toluene | 10.4 |
| | Xylene | 2.6 |
| Silkscreening - BZ | Mineral Spirits | 34.1 |
| | Toluene | trace |
| | Xylene | trace |
| Etching-BZ | Lithotine/Benzine | 16.8 |
| Etching-Area | Lithotine/Benzine | 13.8 |
| Plastics Molding-BZ | Acetone | 25.0 |
| | Toluene | trace |
| | Styrene | 2.9 |
| Plastics Molding-Area | Acetone | 56.2 |
| | Toluene | trace |
| | Styrene | trace |
| Plastics Molding-Area | Acetone | 43.3 |
| | Toluene | 2.3 |
| | Styrene | 10.0 |

* Lithotine®, Benzine®, and Mineral spirits® are the trade names of the bulk liquids used in these areas.

** BZ = Breathing Zone

Table VI

Breathing Zone Concentrations of Organic Vapors in the Painting Department

Cooper Union School of Art

March 23 and 24, 1976

| Sample Description | Substance | Concentration (mg/M3) |
|---|---|---|
| Painting | Turpentine - total | 37.9 |
| | Major component - Pinene | 27.6 |
| Painting | Turpentine - total | 8.3 |
| | Major component - Pinene | 4.2 |
| Painting | Paint thinner/Turpentine | 61.1 |
| | Major component - Pinene | 5.6 |
| Painting | Turpentine - total | 9.4 |
| | Major component - Pinene | 6.3 |
| Painting | Turpentine - total | 38.5 |
| | Major component - Pinene | 30.8 |
| Painting | Paint thinner/Turpentine | 63.4 |
| | Major component - Pinene | 8.6 |
| Painting | Turpentine - total | 17.0 |
| | Major component - Pinene | 11.4 |
| Painting | Turpentine - total | 37.5 |
| | Major component - Pinene | 25.0 |
| Painting | Turpentine - total | 6.7 |
| | Major component - Pinene | 3.3 |
| Painting | Turpentine/Varnish | 22.2 |
| | Major component - Pinene | 8.9 |
| | Paint thinner/Turpentine | 45.3 |
| | Major component - Pinene | 5.7 |
| Painting | Turpentine - total | 13.0 |
| | Major component - Pinene | 7.4 |
| Painting | Turpentine - total | 32.4 |
| | Major component - Pinene | 18.8 |
| Painting | Turpentine - total | 33.8 |
| | Major component - Pinene | 22.6 |
| Painting | Turpentine - total | 10.0 |
| | Major component - Pinene | 5.0 |
| Painting | Turpentine - total | 29.7 |
| | Major component - Pinene | 18.6 |