This Health Hazard Evaluation (HHE) report and any recommendations made herein are for the specific facility evaluated and may not be universally applicable. Any recommendations made are not to be considered as final statements of NIOSH policy or of any agency or individual involved. Additional HHE reports are available at http://www.cdc.gov/niosh/hhe/reports

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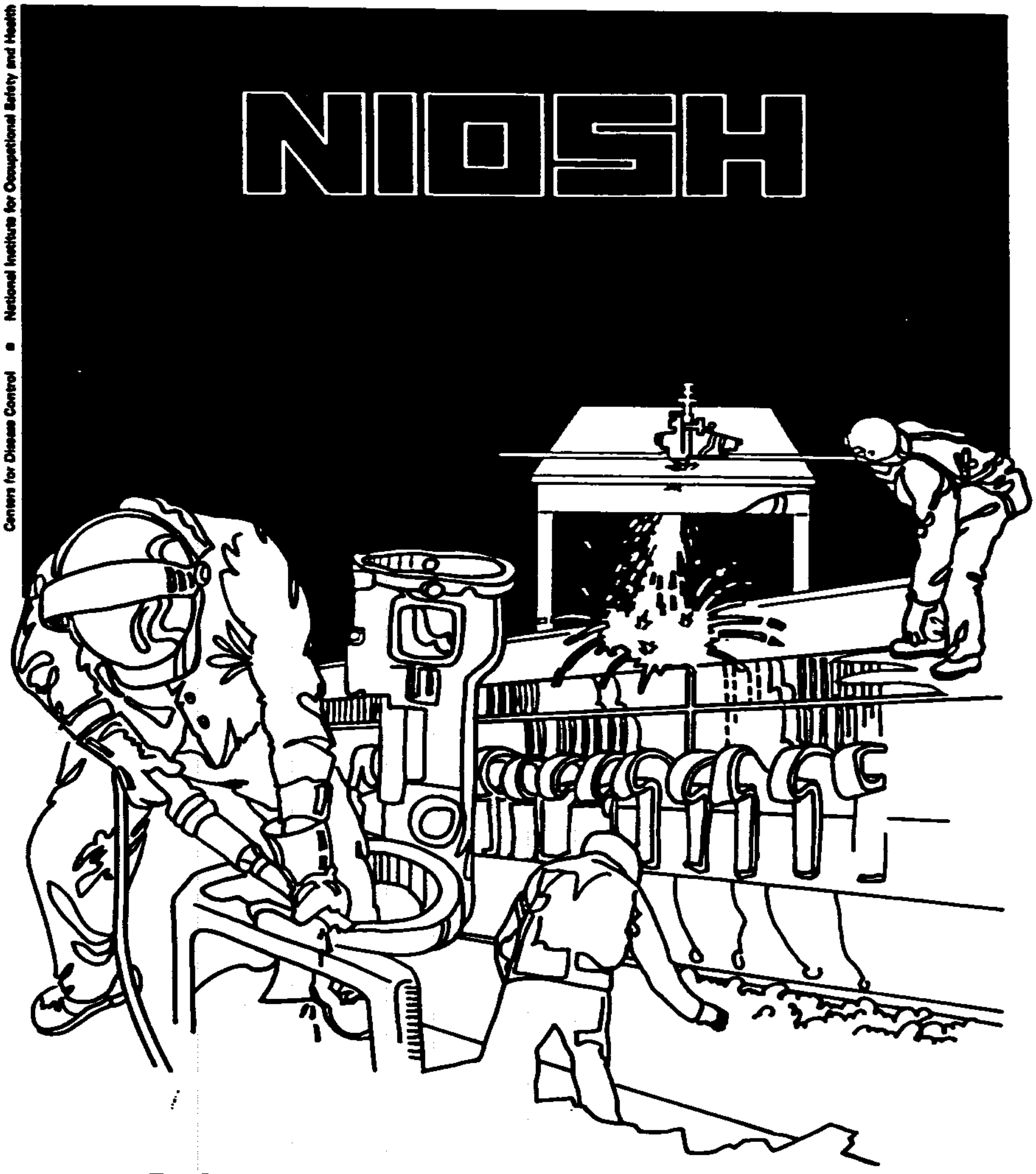

Health Hazard Evaluation Report

HETA 90-370-2107
MOORE BUSINESS FORMS
ANGOLA, INDIANA

PREFACE

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

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

Mention of company names or products does not constitute endorsement by the National Institute for Occupational Safety and Health.

HETA 90-370
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Moore Business Forms
Angola, Indiana

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I. SUMMARY

In August 1990 the National Institute for Occupational Safety and Health (NIOSH) received a request from Moore Business Forms to evaluate reports of nausea, headaches, throat irritation, eye irritation, and aching joints in the Preliminary department, and their possible association with workplace exposures to unidentified chemical or biological agents. About 40 employees work in this department, where photolithographic plates are designed and prepared for business forms. Portions of the area consist of office spaces, and other areas are used for photolithographic plate preparation.

On November 5-6, 1990, and December 19, 1990, NIOSH investigators monitored carbon dioxide levels, respirable particulates, and temperature and relative humidity. The ventilation and local exhaust systems were also inspected and evaluated, and since sections of the Preliminary area involve the chemical processing of photolithographic plates, area air monitoring for organic solvents, aminoethanol compounds, ammonia, and ozone was conducted. Confidential personal interviews were conducted with 17 employees (42% of the staff) from the first and third shifts to determine the nature and extent of symptoms experienced by the employees.

Carbon dioxide levels were between 450 and 825 parts per million (ppm) during the November NIOSH visit. Relative humidities ranged from 36 to 50 percent, and temperatures ranged from 69 to 76 ^{o}F. Lower relative humidities (28 to 34 percent) were observed during the December 19, 1990, NIOSH visit. Temperatures ranged from 69 to 76 ^{o}F.

The Preliminary area was found to be under negative pressure relative to the adjacent Press area. Fresh air intakes serving the Preliminary area were close to ammonia exhausts and plumbing vents on the roof, resulting in possible re-entrainment of contaminated air. A source of possible biological contamination was discovered within a large air conditioner unit serving the Preliminary area. Several of the canopy exhausts were found to have inadequate capture efficiency.

No ozone or aminoethanol compounds were detected. Ammonia, xylene, 1,1,1 trichloroethane, methylene chloride, and C-7 hydrocarbons were present in low levels. Methylene chloride levels ranged from 1.81 to 9.69 ppm. NIOSH recommends that exposures to methylene chloride, a possible occupational carcinogen, be reduced to the lowest feasible limit. The source of the organic solvent contamination in the Preliminary area resulted from extensive use of "type cleaner" solvent in the adjacent Press area.

The most prevalent symptoms reported were headache, metallic taste in mouth, fatigue, nausea, and joint pain. The symptoms could not be related to specific job descriptions. Furthermore, the identified chemical exposures were probably not related to the reported symptoms.

A number of conditions were found in the Preliminary area that may be contributing to the reported employee symptoms. Several recommendations are offered to improve the air quality in the Preliminary department. These include increasing make-up air and humidification in the Preliminary department, relocating the exhausts and intakes on the roof, maintenance or replacement of an air conditioner unit, and modifications to some of the exhaust hoods. The best option in reducing exposures to methylene chloride, a potential occupational carcinogen, is to use alternative solvents. A potential health hazard exists from exposures to methylene chloride. A complete discussion of recommendations may be found in section VII of this report.

KEYWORDS: SIC 2752 (commercial printing, lithographic), photolithography, indoor air quality, methylene chloride.

II. INTRODUCTION

In August 1990 the National Institute for Occupational Safety and Health (NIOSH) received a request for a Health Hazard Evaluation (HHE) from the Moore Business Forms facility located in Angola, Indiana. The request concerned a suspected problem with indoor air quality in which several employees employed in the "Preliminary Area" reported nausea, headaches, eye and throat irritation, and aching joints.

In response to the request, NIOSH investigators visited the plant on November 5, 1990, and conducted a walk-through inspection of the Preliminary area, which included both office-like areas and photolithographic plate-making areas.

On the following day, a more thorough inspection of possible exposure sources was conducted, the ventilation system was reviewed, and employees working in the Preliminary area were interviewed. Carbon dioxide levels, respirable particulates, and temperature and humidity were monitored throughout the day. Potential chemical contamination existed in some areas, so air sampling was performed for organic chemicals and ammonia. On December 19, 1990, NIOSH investigators returned to further evaluate the possibility of air contamination by aminoethanol compounds and methylene chloride. Further investigation of the ventilation system was performed by removal of various sections of ductwork.

An interim letter, discussing the November NIOSH visit, was sent to Moore Business Forms on November 30, 1990.

III. BACKGROUND

Approximately 400 employees are employed at Moore Business Forms, which manufactures forms for a variety of customers. About 40 employees (5 men, 35 women) are employed in the Preliminary (pre-press) area over three shifts. Most of the employees work in areas which are considered to be office-like areas. The facility at Moore consists of a 23,000 square foot single floor, brick structure, built in 1957 with additions in 1976. The Preliminary area is located within the section built in 1957.

A. Process Description

Photolithographic plates, used to print business forms, are designed and prepared in the Preliminary area. A layout of the Preliminary area can be found on Figure 1. In the Map room, layouts for business forms, similar to paper photocopies, are produced on computers. A darkroom, located adjacent to the Map room, contains an automated laser graphic system that produces negatives from the layouts. The Planning room is used to coordinate the processes that a particular order will follow. The Camera room and an associated darkroom ("Film room") are used to produce negatives from layouts that a customer may have supplied. In the Step/Repeat room, multiple images of a particular form can be placed on a single negative. Both the plates and the negatives are checked at various stages of the process in the Proofreading room. The open area throughout the Preliminary area is know as General Department 12 and is used for exposing plates with ultraviolet light. The plates are then developed in the Plate Making area. A Customer Service area is also located in the Preliminary area. The men's and women's restrooms are located adjacent to the Preliminary area. A boiler room is located near the men's restroom.

The Map room, Proofreading room, Customer Service room, and the Planning rooms are open office space, and most of the Preliminary department's employees work in these areas.

The lithographic process is based on the chemical treatment of a printing plate to make it selectively water repellent (i.e. ink receptive) and water receptive (i.e. ink repellent). Two types of plates are produced at Moore Business forms: lithoplates and flexoplates. The lithoplates consist of thin anodized aluminum sheets, pre-coated with various photosensitive mediums. The flexoplates, used to print adhesive labels and forms, are photopolymer plates presensitized with acrylate and methacrylate esters and monomers that are sandwiched between polyester films.

The plates are exposed by placing them under an ultraviolet light source (special box-like units) while covered by the negative. Following the exposure, the plates are chemically developed; the lithoplates are processed in an self-contained, automated Howson-Algraphy Auto Neg machine® (no local exhaust) and the flexoplates are processed in an Flex-light® Aqueous Process Washer.

The Howson-Algraphy Auto Neg® uses a Developer (containing butyrolacetone, polyoxyethylene lauryl ether, phosphoric acid) and a gum solution. The plate is simply fed into the machine, is developed internally, and exits after a few minutes. The machine is not equipped with local exhaust.

The Flex-light® Aqueous Process Washer, consisting of two tanks (a replenishing unit and a washout unit) contains water, diethylene glycol monobutyl ether, and soda flake. The solution washes away areas of the flexoplates that were not exposed to the ultraviolet light. Two canopy hoods are situated above the units. Plastic has been placed around the washout unit and hood to increase the capture efficiency of the hood. The unit is self-contained and closed, except when plates are being placed into or taken out of the tanks, or when additional fluid is added to the system. One employee, wearing safety glasses and rubber gloves, periodically develops batches of flexoplates. An electric, exhausted oven, located next to the washout unit, is used to gently dry the developed flexoplates.

The negatives produced in the Step/Repeat room are processed in an automated Ammonia Developer, containing aqua ammonia. The Ammonia Developer contains an internal exhaust that is piped outside through the roof. The Step/Repeat unit is equipped with a canopy hood, which was intended to capture ozone or other products that might be released during processing.

The Camera room and associated darkroom are used to produce negatives from layouts that a customer may have supplied. The layouts are photographed, and the film is processed in the adjacent dark room. The film processing is an automated, self-contained process, which utilizes several developing chemicals. One employee works in the area on an as-needed basis. The room is equipped with an independent exhaust which maintains the room at a negative pressure (determined by smoke tube tests) with respect to the rest of the Preliminary area.

Exhausts and canopy hoods have been added to various processes in an effort to reduce the possibility, however small, of chemical contamination within the Preliminary area.

Other products are used in the Press area, which is adjacent to the Preliminary area. These include a variety of inks and other chemicals. Warsaw Chemical item #92207 "type cleaner" solvent is used extensively in the Press area to clean equipment. This product contains as much as 30% xylene, 30% methylene chloride, and 50% tolusol (a toluene derivative).

B. Ventilation, Heating and Cooling System

The Preliminary area is served by separate heating and cooling systems. A baseboard recirculating hot water heating system runs along the outside wall of the Preliminary area. Hot water is supplied from a gas-fired boiler located near the men's restroom. While in operation, the boiler is "blown-down" periodically to reduce pressure, and the steam is exhausted through a chimney on the roof. Several chemical additives are used in the boiler. These include diethylaminoethanol (3 quarts daily), sodium metabisulfite (2½ ounces daily), and Chemtrec Water Treatment® (5 quarts daily, contains sodium hydroxide, diethylaminoethanol, sodium sulfite, and polymaleic acid polymer).

Humidification is provided solely to the Map Room by a single steam humidifier installed within an air conditioning supply duct located in the Plate Making area of Department 12. The humidifier is reportedly in operation only during the winter, when the air conditioning is off and the air is recirculated and filtered through the ventilation system. Water is piped up to the humidifier. No additives are reportedly used in this humidifier.

Most of the cooling in the Preliminary area is provided by two large air conditioners equipped with roof-top condensers. Air from both air conditioners is distributed throughout the preliminary area by interconnected ductwork. One of the units is located near the Camera room; the other is located outside the Plate Making area (servicing the Map room). Only the unit near the Camera room (Carrier model 38R28-209), equipped with an economizer, supplies fresh air year round (reportedly not tempered in the winter, minimum 10%) to the Preliminary area. The two systems are interconnected. The systems recirculate air continuously 24 hours per day.

The darkroom adjacent to the Map room is equipped with its own air conditioner, which operates to maintain the laser graphic equipment below 70 °F. The air conditioner is similar to a residential wall unit and is located in the wall between the darkroom and the Planning Room. The intake is connected to the outside; the condenser drain pipe runs to a floor drain outside the darkroom.

The fluorescent lights in the Preliminary area are covered with filters to reduce ultraviolet light emission. These filters cause the light to appear yellow. The flooring is tile. Reportedly, there have been periodic roof leaks in the past. Leakage in the entrance area to the plant was observed on the first NIOSH visit. Evidence of water leaks in the Preliminary area was not observed.

Adjacent to the Preliminary area is an office area that accommodates 20-30 people. The offices, some of which are shared, are cubicals with partitions. A commercial grade carpet is utilized throughout the area. The type of work performed in the office (work processing, typing, filing) is typical of most office environments. Smoking is allowed in the office area; however, no smoking is permitted in the Preliminary area.

IV. EVALUATION DESIGN AND METHODS

A. Environmental

1. Ventilation System A visual inspection of the air conditioners, heating system (including boiler room), ductwork, interior rooms, and exterior structure (including roof) of the Preliminary area was conducted. Several diffusers were removed to permit inspection of the interior ductwork. Additionally, the filters and drip pans on the air conditioners were inspected, along with the air intakes and exhausts on the roof. The canopy exhaust hoods and pressure relationships between rooms were examined by the use of smoke tubes.

2. Carbon Dioxide (CO_2) Real-time CO_2 levels were determined using a Gastech Model RI-411A, portable CO_2 meter on the November NIOSH visit. This portable, battery-operated instrument monitors CO_2 by non-dispersive infrared absorption with a sensitivity of 25 parts per million (ppm). Instrument zeroing and calibration were performed prior to use with zero air and a 800 ppm CO_2 span gas. CO_2 levels were measured on November 6, 1990.

3. Temperature and Relative Humidity (RH) Real-time temperature and RH measurements were conducted using a Vista Scientific, Model 784, battery-operated psychrometer. Measurements were taken on November 6, 1990, and December 19, 1990.

4. Respirable Suspended Particulates (RSP) Real-time RSP concentrations were measured using GCA Environmental Instruments Model RAM-1 monitors. This portable, battery-operated instrument measures changes in particle concentration via an infrared detector, centered on a wavelength of 940 nanometers. The levels were measured on November 6, 1990.

5. Airborne Vapors and Gases On the initial NIOSH visit of November 6, 1990, fourteen area air samples for organic vapors and gases were taken at various locations by drawing air through charcoal tubes (SKC 150 milligram (mg) coconut shell charcoal) at a rate of 200 milliliters per minute (ml/min). Area samples were taken since the reported symptoms were non-specific and not related to any particular job description or work activity. Ten samples were collected from the Preliminary area, and one was taken from each of the following locations: women's restroom, boiler room, press

area, and outside. Four charcoal tube samples and four bulk liquids were submitted for qualitative analysis for volatile organic compounds by gas chromatography-mass spectrometry (GC/MS). Results of samples taken from non-complaint areas (press area and outside) were compared to those from the Preliminary area. Based on the results of the GC/MS analysis, the remaining ten charcoal tubes were quantitatively analyzed for xylene isomers, 1,1,1 trichloroethane, and total seven carbon (C7) hydrocarbons (n-heptane as a standard), using a combination of NIOSH methods 1003, 1500, and 1501. Additional analytical information, including desorption methods, detection methods, and limits of detection and quantitation, may be found in Table 1.

On the second NIOSH visit to Moore, area air sampling was performed for methylene chloride, which was collected on two 150 mg coconut charcoal tubes connected in series (sampling rate of 20 ml/min), according to NIOSH method 1005. Ethanolamine and diethylaminoethanol were collected on silica gel tubes at a flow rate of 200 ml/min. These chemicals, which are not used in any processes within the Preliminary area, were thought to be migrating into the Prelimary area from other locations in the plant. The two analytes were then determined separately under different conditions by gas chromatography, according to NIOSH method 2007. Additional analytical information may be found in Table 1.

Ammonia and ozone were measured with Draeger® indicator tubes. The range of measurement for the ammonia 5/a tubes was 5 to 70 ppm. For the ozone 0.05/b tubes, the range of measurement was 0.05 to 0.7 ppm ozone.

B. Medical

Confidential personal interviews were conducted with 17 persons (42% of the staff) from the first and third shifts. Participants had a mean age of 40 years, and had worked at Moore Business Forms 11 years (mean 11.4 years).

V. EVALUATION CRITERIA

A significant portion of the Preliminary area is considered office space, including the Map room, Proofreading room, Planning rooms, and the Customer Service room. The methods used to evaluate the Preliminary area were those developed by NIOSH for use in the indoor environment, typically commercial office buildings. However, there are also special use areas which needed to be considered separately because of the known presence of potential sources of environmental contaminants, including areas where photolithographic plates are exposed and developed. These areas were evaluated using more traditional industrial hygiene methods.

A. <u>Indoor Environment</u>

NIOSH investigators have responded to approximately 700 complaints of indoor air quality problems in a wide variety of settings. The majority of these investigations have been conducted since 1979, paralleling the "energy efficiency" concerns of building operators and architects.

Commonly, the symptoms and health complaints reported by building occupants have been diverse and not suggestive of any particular medical diagnosis or readily associated with a causative agent. A typical spectrum of symptoms has included headaches, varying degrees of itching or burning eyes, irritation of the skin, sinus problems, dry and irritated throats, and other respiratory irritations. The workplace environment typically has been implicated because symptoms reportedly disappear when the workers' are away from the office or work environment.

The causes of comfort and health problems related to indoor air quality are typically multifactorial, which makes determination difficult. The investigations NIOSH has conducted have been classified by the primary type of problem found: inadequate ventilation, contamination from inside the building, contamination from outside the building, microbiological contamination, contamination from building materials, and "unknown." The predominant problems identified in the NIOSH indoor environment investigations can be placed into the following three general categories listed in order of decreasing frequency: inadequate ventilation, chemical contamination, and microbiological contamination. Inadequate ventilation, a category which includes shortages of outside air, poor distribution, and short circuiting of supply air, is reported most commonly in the NIOSH building investigations (greater than 50% of cases). These ventilation problems make it difficult to control heating and cooling, and allow the accumulation of contaminants in the occupied space. The resulting conditions may cause occupants to become uncomfortable or experience adverse health effects.

Standards for indoor air quality in office areas do not exist. NIOSH, the Occupational Safety and Health Administration (OSHA), and the American Conference of Governmental Industrial Hygienists

(ACGIH) have published regulatory standards and recommended limits for occupational exposures.[1,2,3] With few exceptions, pollutant concentrations observed in the office work environment fall well below these published occupational standards or recommended exposure limits. The American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) has published recommended building ventilation design criteria, and thermal comfort guidelines.[4,5]

The basis for monitoring carbon dioxide, temperature, relative humidity, and respirable suspended particulates are presented below. A discussion of microorganisms is also included.

Carbon Dioxide CO_2 is a normal constituent of exhaled breath and, if monitored, can be used as a screening technique to evaluate whether adequate quantities of fresh air are being introduced into an occupied space.

Indoor CO_2 concentrations are normally higher than the generally constant ambient CO_2 concentration (range 300-350 ppm). When indoor CO_2 concentrations exceed 1000 ppm in areas where the only known source is exhaled breath, inadequate ventilation is suspected. Elevated CO_2 concentrations suggest that other indoor contaminants may also be increased. Above 1000 ppm comfort and health complaints may be more frequent.

Temperature and Relative Humidity The perception of comfort is related to an individual's metabolic heat production, the transfer of heat to the environment, physiological adjustments, and body temperatures. Heat transfer from the body to the environment is influenced by factors such as temperature, humidity, air movement, personal activities, and clothing. ANSI/ASHRAE Standard 55-1981 specifies conditions in which 80% or more of the occupants will find the environment thermally comfortable.[5] The ASHRAE "comfort chart" is presented in Figure 2. The acceptable ASHRAE humidity range for sedentary people is a dew point temperature between 35 and 62 °F. This is generally equivalent to a relative humidity between 30 and 50%.

Relative humidities below 30 percent may be associated with increased discomfort and drying of the mucous membranes. High relative humidities (above 70%) may promote the amplification of fungal populations.[6]

Respirable Suspended Particles (RSP) In contrast to fibrogenic dusts which cause scar tissue to be formed in lungs when inhaled in excessive amounts, the so-called "nuisance" dusts are stated to have little adverse effects on lungs and do not produce significant organic disease or toxic effects when exposures are kept under reasonable control.

The greatest contributor to indoor RSP is environmental tobacco smoke (ETS).[6] In buildings where smoking is not allowed, RSP levels are influence by outdoor particle concentrations with minor contributions from other indoor sources. In buildings with oil, gas, or kerosene heating systems, increased RSP concentrations associated with the heating source may dominate.

The Environmental Protection Agency (EPA) has an ambient air quality standard for respirable particulate matter (PM_{10} standard, 150 ug/m^3 for 24 hours). It should be noted that the EPA PM_{10} standard is an ambient air quality standard, which was not specifically developed for office environments. This standard is cited for perspective to help interprete the results of this survey. PM_{10} concentrations (particles smaller than 10 microns in diameter) combine combustion, soil, dust, and mechanical source particle contributions. The larger particles are associated with outdoor particle concentrations, mechanical processes, and human activity. When indoor combustion sources are not present, indoor particle concentrations generally fall well below the EPA ambient PM_{10} standard.[6]

Microorganisms Most building-related antigens are thought to be of fungal or bacterial origin. Endotoxins, mycotoxins, and other microbial products can affect indoor air quality and cause immunologic (allergic) reactions in some individuals. For example, most fungi produce spores which are transported through the air.

In previous NIOSH investigations, microbiological contamination has commonly resulted from water damage to carpets or furnishings, or standing water in or near ventilation system components. Stagnant water, leaves, soil or vegetation near heating, ventilation, and air conditioning (HVAC) units or air intakes can permit the growth of bacteria or fungi, which can be taken up by the HVAC unit and enter occupied areas of the building. Air filters containing organic dusts may become moist depending on environmental conditions, allowing growth of bacteria or fungi on the filter itself.

If plausible sources are found where biological growth may be growing or if visible growth is identified, the sources should be removed as a preventative measure. After removal further field investigation is not required unless there is positive medical evidence of disease related to bioaerosols, such as humidifier fever, hypersensitivity pneumonitis, or Legionnaire's Disease.[6]

B. Special Use Areas

Since there are several known potential exposures to contaminants in special use areas of the Preliminary area, the following criteria were applied for perspective. As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for assessment of chemical and physical agents, which are generally intended for industrial environments. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours/day, 40 hours/week for a working lifetime without experiencing adverse health effects. It is important to note, however, that not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy). In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the levels set by the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus the overall exposure may be increased above measured airborne concentrations. Evaluation criteria typically change over time as new information on the toxic effects of an agent become available.

The primary sources of evaluation criteria for the industrial workplace are the following: NIOSH Criteria Documents and Recommended Exposure Limits (RELs) [1], the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLVs) [2], and the Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs).[3] These values are usually based on a time-weighted average (TWA) exposure, which refers to the average airborne concentration of a substance over the entire 8 to 10-hour workday. Concentrations are usually expressed in parts per million (ppm) or milligrams per cubic meter (mg/m^3). In addition, for some substances there are short-term exposure limits or ceiling limits which are intended to supplement the TWA limits where there are recognized toxic effects from short-term exposures.

The evaluation criteria for methylene chloride, 1,1,1 trichloroethane, xylene isomers, ethanolamine, diethylaminoethanol, C7 hydrocarbons, ammonia and ozone can be found in Table 2.

VI. RESULTS and DISCUSSION

A. Environmental

1. Ventilation System The locations of the exhausts and intakes on the roof were examined. Some of the exhausts are very close to the fresh air intakes, which may cause contaminant re-entrainment problems. The ammonia exhaust and the Camera room exhaust are located close (within a couple feet) to the fresh air intake of the large air conditioner located above the Camera room. In addition, the exhaust from the wall area between the men's and women's restrooms and the plumbing vents are located close (1-2 feet) to the fresh air intake above the men's restroom. Depending on wind direction and speed, steam from the boiler stack, containing the additive diethylaminoethanol, might also be re-entrained into the fresh air intake above the men's restroom. Corrosion-inhibiting chemicals, such as diethylaminoethanol, have been reported to cause a variety of symptoms including nausea, vomiting, dizziness, skin rashes, headache, chest tightness, and eye, nose and throat irritation.[7]

2. Hoods The hoods throughout the Preliminary area were qualitatively checked by smoke testing. The canopy hoods over the Step/Repeat unit, Printite® Washout Unit, and Replenishing tank for the Flex-light® Washout unit have poor capture efficiency. The use of portable fans and the air currents produced by the ventilation system further disrupt the ability of the hoods to perform adequately.

   The Flex-light® washout unit is equipped with a canopy hood surrounded by plastic. The hood appears to capture contaminants and prevent contamination of the work area; however, the workers are forced to work under the hood, causing vapors from the open tank to flow past their breathing zone before entering the hood.

3. Make-up Air As a result of the volume of air exhausted through hoods and other exhausts, the Preliminary area is at a negative pressure with respect to the rest of the building. This was determined by observing the direction of air movement at windows and doors using smoke tube tests. In this situation, chemically contaminated air can infiltrate into the Preliminary area from other areas of the plant. Currently, the only designated source of make-up air is from the air conditioner located over the Camera room (Carrier model 38R28-209), which recirculates air and brings in fresh air, the percentage (minimum 10%) depending on the outdoor temperature.

The boiler room fluctuated between negative and positive pressure with respect to the Press area on November 6, 1990.

4. Air conditioner The drip pan on the air conditioner unit (Carrier model 38R28-209) located above the entrance to the camera room was coated with a dry layer of dust and rust. The rust in the pan indicates that there is a problem with standing water at times.

   Microorganisms and fungi can grow in the stagnant water that results when drain pans are inadequately pitched toward the drain or when the drain is blocked. Endotoxins, mycotoxins, and other microbial products can cause immunologic reactions and other health effects in some individuals. Most fungi produce spores that are transported through the air.[6]

   A large section (10-12 square feet) of water damaged fibrous insulation was discovered above the drip pan on the Camera room air conditioner. Because of the dark color of the insulation, it was not possible to determine whether biological growth was present.

5. Carbon Dioxide CO_2 levels on November 6, 1990, ranged from 450 to 825 ppm. Within the Preliminary area (operating 24 hours per day), most measurements indicated carbon dioxide levels less than 600 ppm. The highest carbon dioxide levels (825 ppm) were found in the general office area adjacent to the Preliminary area at 3:00 p.m. Outdoor ambient levels were found to be 350 ppm. CO_2 levels in the range of twice the outdoor concentration or less are generally considered acceptable. ASHRAE recommends that the ventilation rate be set so the 1000 ppm CO^2 is not exceeded in occupied areas.[4] The specific CO_2 levels can be found in Table 3.

   Considering that the area is occupied over only one shift, the CO_2 levels in the adjacent office area (i.e. accounting area) were elevated at the beginning of the work shift (550 ppm range). This indicates that the office may need increased ventilation over night. The concentrations of CO_2 rose steadily throughout the day peaking at 825 ppm in the accounting area.

6. Temperature, Relative Humidity (RH), and Respirable Suspended Particulates (RSP) RSP were measured twice on November 6, 1990 at various locations around the Preliminary area. All the RSP levels were well below the EPA PM_{10} standard of 150 ug/m^3, and ranged from 18 ug/m^3 in the office to 38 ug/m^3 in

the Map room and General Department 12. Outside levels were in the range of 40 to 42 ug/m^3. These RSP values are typical of those found in other office-like environments.

On November 6, 1990 temperatures ranged from 69 to 76 ^oF, and RH ranged from 36 to 44 percent. On December 19, the temperatures ranged from 65 to 74 ^oF and RH ranged from 28 to 36 percent. The temperature and humidity values were generally within the ASHRAE ranges specified in Figure 2. The measured values at various locations can be found in Table 4.

The humidifier within the ductwork supplying the Map room was not inspected because of its inaccessible location.

7. Gases and Vapors Several organic gases and vapors were detected in the Preliminary area. GC/MS analysis indicated that the primary chemical contamination in the Preliminary area is identical to Press area. The analysis also indicated that the spectra of the contaminated air was nearly identical to the chemical constituents found in Warsaw solvent #92207, "type cleaner." This solvent is not presently used in the Preliminary area, however, contaminated air migrates from the Press area to the Preliminary area as a result of negative pressure in this area. The concentrations of methylene chloride, 1,1,1-trichloroethane, xylene isomers, various C7 hydrocarbons are listed in Tables 5 and 6.

In the Preliminary area, the average concentration of methylene chloride was 4.52 parts per million (ppm). The level in the Press area was 9.69 ppm. On the basis of carcinogenic and tumorigenic responses in animals, NIOSH recommends that methylene chloride be regarded as a potential occupational carcinogen. Exposure to methylene chloride is a potential health hazard. NIOSH has not identified thresholds for carcinogens. Therefore, NIOSH recommends that occupational exposure to methylene chloride be controlled to the lowest feasible limit. The current Occupational Safety and Health Administration (OSHA) Permissible Exposure Limit (PEL) for methylene chloride is an 8-hour time weighted average (TWA) concentration of 500 ppm; however, OSHA is currently in the process of rule-making to lower the PEL.[3]

For 1,1,1 trichloroethane and xylene, the average concentrations in the Preliminary area were 0.45 ppm and 1.78 ppm, respectively. The average concentration of C7 hydrocarbons was 23.91 mg/m^3. The NIOSH REL for n-heptane, a representative C7 hydrocarbon, is 350 mg/m^3 (85 ppm). Some investigators, however, suggest that symptoms may occur well below traditional limits applied to industrial environments. Tentative dose-response relationships for discomfort resulting from low exposures to volatile organic compounds (VOCs) have been discussed in the literature.[8] Lars Molhave of Denmark reports that levels of VOCs between 0.2 and 3.0 mg/m^3 may be related to increased building occupant irritation of the eye, nose, and throat. At levels over 3.0 mg/m^3, occupant complaints and symptoms are common. Molhave suggests that the threshold for headaches and neurotoxic symptoms is between 3 and 25 mg/m^3.[8] The levels of C7 VOC fraction found in the Preliminary department are well within these proposed ranges.

No ozone, ethanolamine, or diethylaminoethanol were detected at any location in the Preliminary area on the days of our visits. No glycol ethers were detected near the Flex-light® aqueous process washer. Low levels of ammonia (<5 to 12 ppm) were detected in certain locations; these are listed in Table 7.

B. Medical

The symptoms reported and the percent of participants affected include the following: headache 14 (82%), metallic taste in mouth 8 (47%), fatigue 7 (41%), nausea 7 (41%), joint pain 6 (35%), swelling of the hands and feet 5 (29%), shortness of breath and chest tightness 5 (29%), muscle aches 5 (29%), rash 5 (29%), burning eyes 3 (18%), dizziness 3 (18%), and stomach cramps 3 (18%). Participants were asked to describe symptoms they were experiencing as a result of conditions at work.

The number and severity of symptoms varied between individuals. Persons complaining of headache and fatigue indicated these symptoms were severe and required, at times, days to resolve. A visible rash (though dissimilar in appearance and location) was noted on 2 of the 5 persons reporting rashes.

The symptoms, which have persisted since March 1990, could not be directly associated with a chemical or a procedural change in the work area. The symptoms could not be associated with a specific job description. Many of these symptoms are non-specific and could be due to a variety of causes. Three persons, two supervisors and one employee, were self-selected and approved by the company for a complete clinical, toxicologic, and neurologic evaluation at the University of Michigan. The results of the evaluation did not identify any medical condition that was related to a worksite chemical exposure.

VII. RECOMMENDATIONS

The following recommendations are offered as prudent measures to reduce or prevent possible work-related health symptoms.

1. The HVAC system should be evaluated, at a minimum, by a ventilation professional (outside company). Complete redesign or substantial changes to the current system are necessary. Attention should be placed on proper balancing of the air supply and exhaust systems. The HVAC system should be modified so that additional tempered make-up is available to the Preliminary area. Maintaining a slight positive pressure with respect to the rest of the plant will prevent the migration of contaminants into the Preliminary area. This should be done after any modifications are made to the exhausts in the Preliminary area. Since a number of potentially irritating chemicals are used in the darkrooms, these areas should be maintained at a negative pressure with respect to the remainder of the Preliminary area.

2. In office areas, any modification to the HVAC system should maintain a minimum fresh air intake of 20 cubic feet per minute (cfm) per occupant, as recommended by ASHRAE.[4] Relative humidities and temperatures should be monitored on a regular basis. If the values fall outside the ASHRAE criteria specified in Figure 2, further adjustment or modification of the system is needed. As part of the HVAC modifications, a humidification system for the entire Preliminary area may be necessary. The humidification system should be independent of the current boiler heating system. After installation, maintenance and routine inspections of the system should be instituted.

   The current humidifier supplying the Map room should be visually inspected on a regular basis for water build-up and mold or other biological growth.

3. The residue on the drip pan of the Carrier air conditioner near the camera room should be removed. The drain should be checked to ensure that it is not blocked. If the water still does not drain completely, the slope of the pan should be adjusted. After removal of the debris, the drip pan should be disinfected by rinsing the pan with a biocide such as 1-5% aqueous sodium hypochlorite, followed by several water rinses.[6]

4. The insulation within the Carrier® air conditioner should be removed and replaced. A manufacturer's service representative should be contacted to determine if the moisture build-up on the insulation can be prevented. If not, the air conditioner should be replaced.

5. Several exhausts (ammonia exhaust, plumbing vents, etc.) on the roof should be relocated so that they are at least 25 feet from any fresh air intake. Additionally, the exhausts should be elevated with respect to the intakes. ASHRAE provides recommendations for calculating stack height to avoid exhaust reentrainment.[9] A tight cluster of exhausts or a combined single exhaust will allow the fresh air intakes to be placed as far as possible from the exhausts.[9] A ventilation engineer should be consulted before actual modifications are initiated.

   The ammonia processors should be located in a separate, exhausted room that is maintained under negative pressure. In addition, increased exhaust flow from the interior of the machines might reduce fugitive ammonia emissions. Some of the ammonia vapor, however, is probably released from the negatives exiting the machine.

6. As a preventative measure to stop possible odor migration, consideration should be given to maintaining the boiler room at a slight negative pressure with respect to the adjacent areas. This might be accomplished by installing a small exhaust controlled by a static pressure gauge. However, care should be taken not to create a strong negative pressure in this room as this might disrupt the functioning of the boiler stack.

7. The Flex-light® washout unit is equipped with a canopy hood surrounded by plastic. Although the hood appears to have adequate capture efficiency, the worker is forced to work under the hood, causing potential vapors from the open tank to flow past his breathing zone before entering the hood. This hood should be removed and replaced with a slotted exhaust, as described in Figure 3.[10]

   The blockage in the exhaust ductwork leading from the Replenishing tank should be removed. In addition, the canopy hood should be lowered so that it closer to the source. Specifications for canopy hoods can be found in Figure 4.[10] Portable fans should not be placed near any of the canopy hoods in the Preliminary area.

8. Methylene chloride containing solvents, including Warsaw Chemical solvent blend 44-53-2 (type cleaner) used for general cleaning of machinery or printing plates in the Press area, should be discontinued, and replaced, if possible, with safer solvents. In the interim, solvent usage should be reduced to a minimum. If possible, installation of engineering controls, such as local exhausts, may be considered to reduce methylene chloride exposures in the Press area. Substituting methylene chloride containing solvents, however, is probably the best option. A potential health hazard exists from exposure to methylene chloride.

9. No eating or drinking should be allowed in the Preliminary department. These practices may pose an added health risk, as chemicals present on the hands or other surfaces may be transferred to the mouth. These activities should be restricted to designated areas away from process areas.

10. Personal protective clothing and gloves should continue to be used by employees who have potential skin contact with developing solutions. Hand and body washing should be practiced by all employees who have potential skin exposures to these solutions.

11. Although not directly related to air quality, the cylindrical ultraviolet lamp located in the Plate Making area should be shielded, for example, by means of black curtaining. Ultraviolet light can cause eye and skin damage.

12. An evaluation of potential workplace factors that could induce physical stress should be evaluated, specifically in the Map room where employees work continuously with specialized computers. This might involve ergonomic or anthropometric evaluations of the relationships of the employees to the equipment that they use.

If further evaluation or technical expertise is needed to resolve any indoor air problems, on-site assistance is available from the following sources. The expertise, availability and cost of these consultants vary with locality and state.

1. A list of engineering firms certified by the National Environmental Balancing Bureau (NEBB) can be obtained from the following address:

   National Environmental Balancing Bureau
   8224 Old Courthouse Road
   Vienna, Virginia 22180

2. A list of industrial hygiene ventilation consultants who are members of the American Industrial Hygiene Association (AIHA) is available from the following address:

   American Industrial Hygiene Association
   345 White Pond Drive
   Akron, Ohio 44311-1087

VIII. REFERENCES

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IX. AUTHORSHIP AND ACKNOWLEDGEMENTS

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1. Moore Business Forms
2. Employee representatives
3. OSHA, Region V

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

Table 1
Analytical Information
Moore Business Forms
Angola, Indiana
HETA 90-370

Analyte	Desorption Method	Analytical Method (NIOSH)	LOQ (mg)	LOD (mg)
Qualitative Analysis	Carbon Disulfide	GC/FID/MS	N/A	N/A
1,1,1 TCE	Carbon Disulfide	GC/FID (1003, 1500, 1501)	0.005	0.002
Xylene	Carbon Disulfide	GC/FID (1003, 1500, 1501)	0.010	0.003
C7 HC	Carbon Disulfide	GC/FID (1003, (1500, 1501)	0.010	0.003
Diethylamino-ethanol	Methanol/water	GC/NPD (2007)	0.03	0.01
2-amino-ethanol	Methanol/water	GC/NPD (2007)	0.09	0.03
Methylene Chloride	Carbon Disulfide	GC/FID (1005)	0.03	0.01

1,1,1 TCE = 1,1,1-trichloroethane
C7 HC = Seven carbon hydrocarbons, heptane as standard
LOQ = Limit of Quantitation (mg per sample)
LOD = Limit of Detection (mg per sample)
GC = Gas Chromatography
MS = Mass Spectrometry
FID = Flame Ionization Detector
NPD = Nitrogen-Phosphorous Detector

Table 2

Environmental Evaluation Criteria
Moore Business Forms
Angola, Indiana
HETA 90-370

Chemical			REL/PEL/TLV®			Effects [7,11,12]
1,1,1 trichloroethane	(ppm)	TWA	NC	350	350	Headache, lassitude, CNS Depression;
		STEL	350 C	450	450	High conc. causes eye irritation
Xylene	(ppm)	TWA	100	100	100	Dizziness, excitement, drowsiness; eye,
		STEL	150	150	150	nose, and throat irritant
2-ethanolamine	(ppm)	TWA	3	3	3	Eye, skin, and respiratory irritant
		STEL	6	6	6	
2-diethylaminoethanol	(ppm)	TWA	10	10	10	Eye, skin, and respiratory irritant
		STEL	NC	NC	NC	
Ammonia	(ppm)	TWA	25	35	25	Eye, nose, and throat irritant
		STEL	35	NC	35	
Ozone	(ppm)	TWA	NC	0.1	NC	Irritant to the eyes, nose, and throat.
		STEL	0.1C	0.3	0.1C	Can cause pulmonary edema and long term respiratory disease
Methylene Chloride	(ppm)	TWA	Ca	500	50	Fatigue, weakness, sleepiness; eye, skin,
		STEL	Ca	1000	NC	and respiratory tract irritant
		Peak*	Ca	2000	NC	
n-heptane‡	(mg/m^3)	TWA	350	1600	1600	CNS depression-- dizziness, drowsiness,
		STEL	1800C	2000	NC	incoordination; nausea

TWA = Time Weighted Average
STEL = Short Term Exposure Limit
C = Ceiling
Ca = Because this substance is a potential occupational carcinogen, the NIOSH policy for exposure is lowest feasible limit.
REL = NIOSH Recommended Exposure Limit, 10-hour TWA
PEL = OSHA Permissible Exposure Limit, 8-hour TWA
TLV® = ACGIH Threshold Limit Value, 8-hour TWA
ppm = parts per million
mg/m^3 = milligrams per cubic meter
NC = No Criteria
† = In the process of 6(b) rulemaking, CFR 1910.1000, Table Z-2.
‡ = There are no criteria for C-7 hydrocarbons, the criteria listed here are for n-heptane.
* = Peak of 5 minutes in any 2 hours.

Table 3
Carbon Dioxide Levels
Moore Business Forms, Preliminary Area
Angola, Indiana
HETA 90-370

November 6, 1990

Location	Time:	Carbon Dioxide Levels (ppm) 0700-0730	1200-1230	1450-1515
Outside		350	350	350
Office, Accounting		575	775	750
Office, General		550	775	825
Map Room		575	650	675
Planning		500	575	575
Dep't 12, general		500	575	500
Plate Making Area		500	575	500
Camera Room		500	575	425*
Film Dark Room		500	575	450
Step/repeat		500	625	500*
Women's restroom		500	575	550
Press Area		450	500	500
Proofreading Room		550	650	625

* Windows were opened

Table 4
Temperatures and Relative Humidities
Moore Business Forms, Preliminary Area
Angola, Indiana
HETA 90-370

	Temperature (°F)/Relative Humidity (%)			
Date:	11/06/90	11/06/90	11/06/90	12/19/90
Location Time:	0720-0745	1200-1225	1500-1525	0800-0848
Outside	41/88	42/78	42/72	35/60
Map Room	75/38	76/37	76/37	74/28
Gen. Dep't 12	73/39	76/37	74/38	69/34
Proofreading	74/37	76/37	76/36	70/28
Camera Room	69/44	73/40	62/50*	69/34
Press Area	72/40	73/40	72/40	74/34

* opened window

Table 5
Methylene Chloride
Moore Business Forms
Angola, Indiana
HETA 90-370

December 19, 1990

Location	Sampling Time (minutes)	Sample Volume (liters)	Concentration (ppm)
Step/Repeat Room	463	9.26	4.28
General Area 12	456	9.13	9.13
Boiler Room	458	9.18	6.17
Flex-Light Washer	459	9.18	5.25
Womens' Restroom	458	9.16	3.09
Planning Room	469	9.37	1.81
Office, Accounting	469	9.38	3.32
Map Room	467	9.35	3.94
Proofreading Room	467	9.34	3.67
Press Area	467	9.35	9.69

Table 6
Xylene, 1,1,1 Trichloroethane, and C-7 Hydrocarbons
Moore Business Forms, Preliminary Area
Angola, Indiana
HETA 90-370

November 6, 1990

Location	Sampling Time (minutes)	Xylene (ppm)	1,1,1 TCE (ppm)	C-7 HC (mg/m^3)
Office, Accounting	482	1.38	0.41	19.0
Office, Central	482	1.51	0.42	20.2
Map Room	479	1.74	0.43	23.7
Planning Area	478	1.45	0.36	19.8
Proofreading	474	1.72	0.44	23.2
Dep't 12	474	2.26	0.54	28.7
Customer Service	471	1.75	0.44	23.6
Camera Room	467	2.02	0.50	27.3
Film Dark Room	469	1.82	0.45	24.7
Women's Restroom	461	2.17	0.52	28.9

ppm: parts per million
mg/m^3: milligrams per cubic meter of air
Sampling Rate: 200 milliliters per minute
NIOSH methods: 1003, 1500, and 1501.

Table 7
Ammonia Measurements
Moore Business Forms, Preliminary Area
Angola, Indiana
HETA 90-370

Location	Concentration (ppm)
Over Ammonia Processor - 11/6/90 (1100)	<5
Near Ammonia Processor - 12/19/90 (1001)	5
Near Ammonia Processor - 12/19/90 (1250)	12
Press Area, aisleway - 12/19/90 (1022)	<5

Figure 1: Preliminary Department

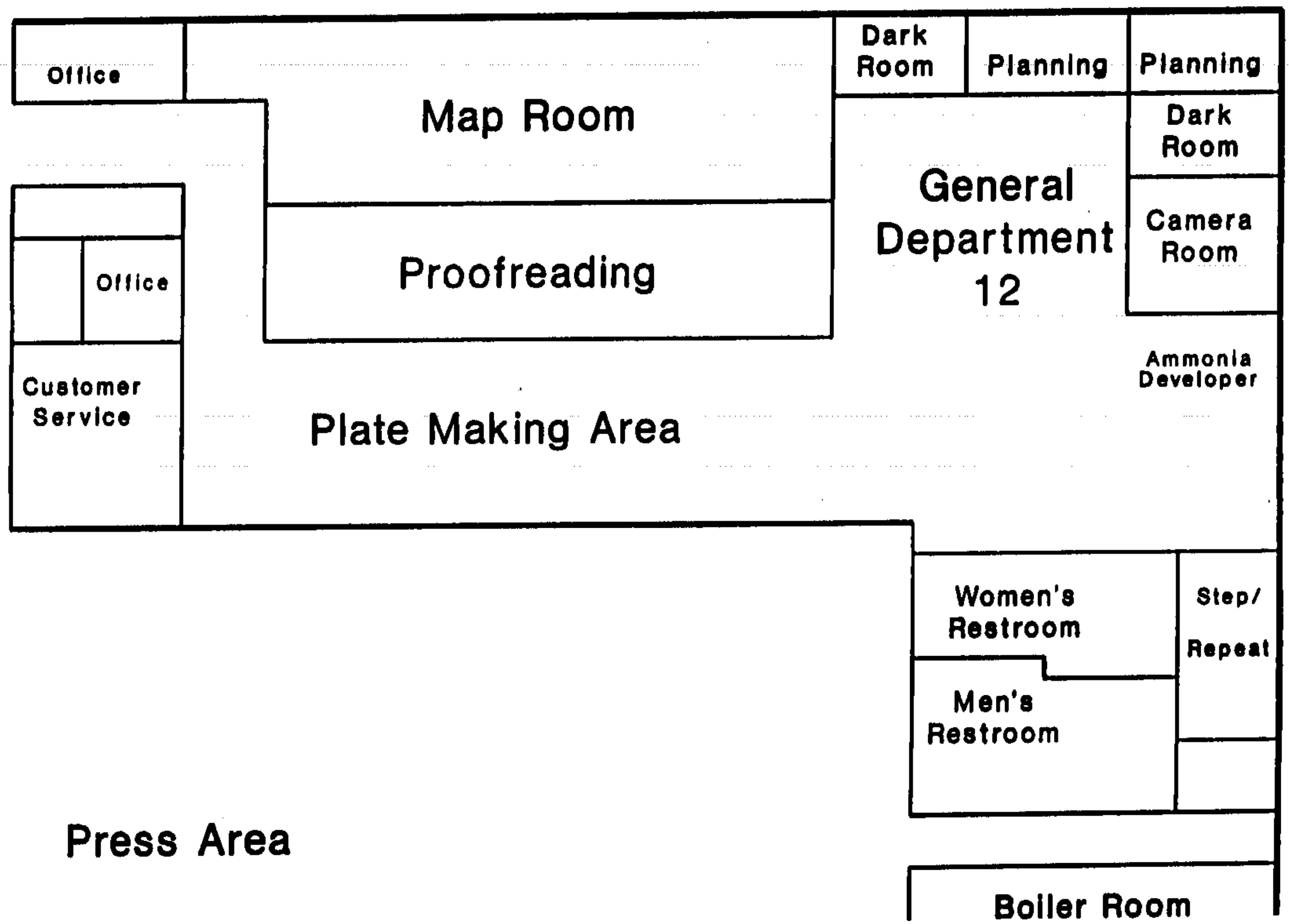


Figure 2

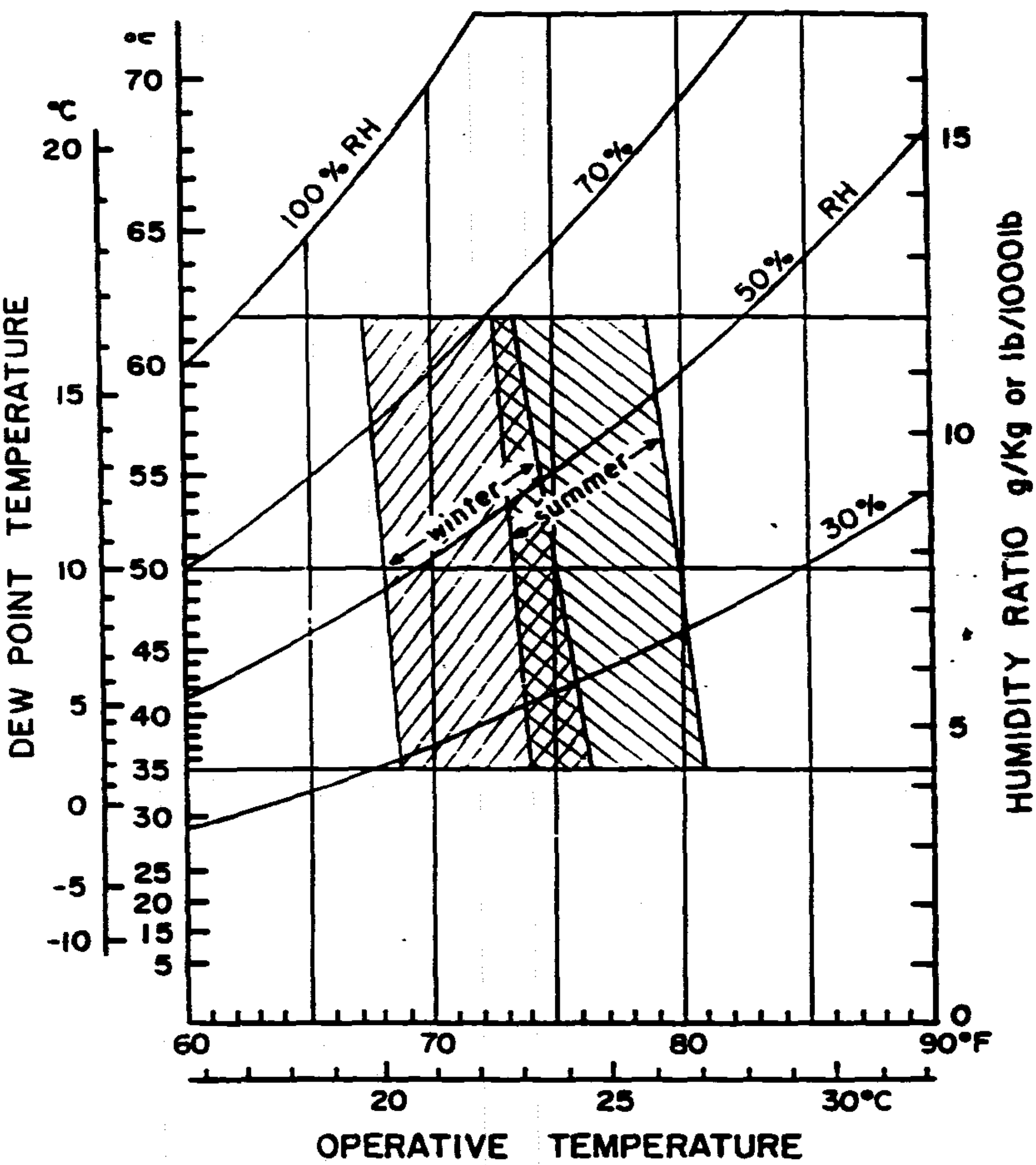
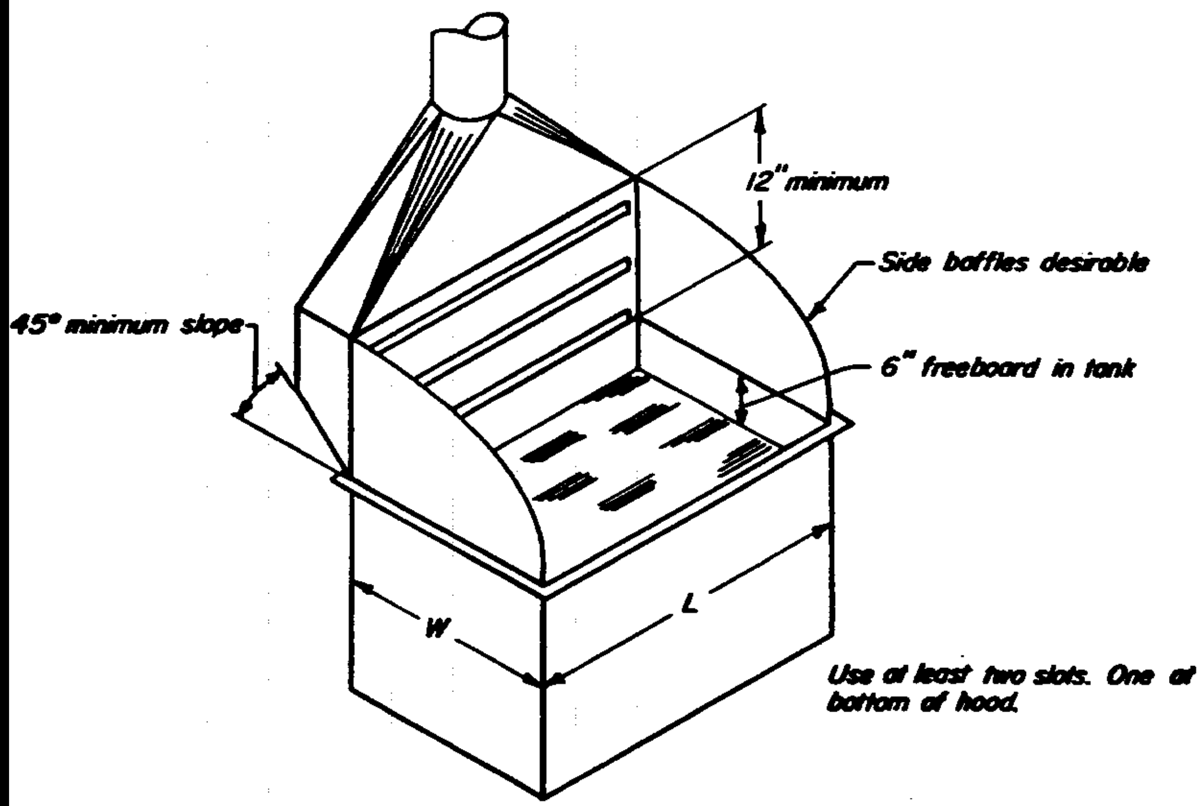


Table courtesy of: The Amercan Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.
Standard 55-1981, "Thermal Environmental Conditions for Human Occupancy"

Figure 3



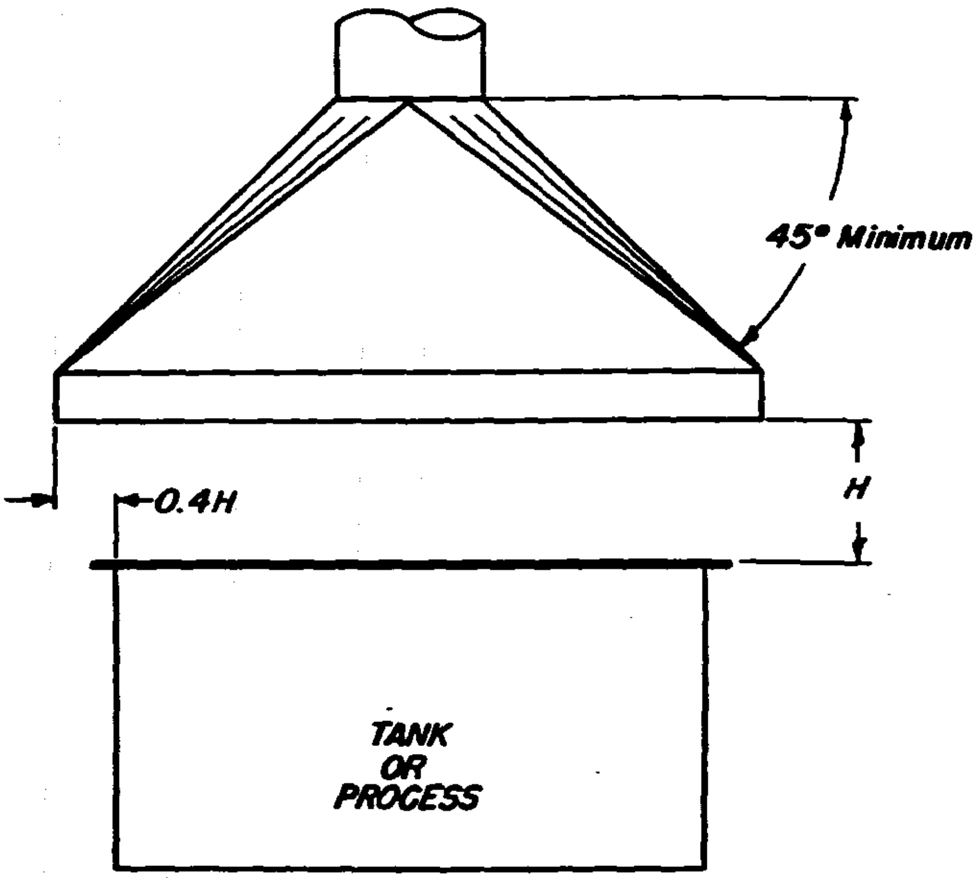
Q = 150 cfm/sq ft of bed (150LW)
Slot velocity = 2000 fpm
Entry loss = 1.78 slot VP + 0.25 duct VP
Duct velocity = 2500 - 3000 fpm
W not to exceed 36"

For circular beds or other hood designs, see VS-303, VS-504
Free board must be maintained to prevent material carryout.

AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS	
FLUIDIZED BEDS	
DATE 1-70	VS-915

Figure courtesy of: American Conference of Governmental Industrial Hygienists, Industrial Ventilation, 19th Ed., 1986

Figure 4



Not to be used where material is toxic and worker must bend over tank or process.
Side curtains are necessary when extreme cross-drafts are present.

Q = 1.4PHV	for open type canopy. P= perimeter of tank, feet. V= 50-500 fpm. See Section 4
Q =(W+L)HV	for two sides enclosed. W & L are open sides of hood. V = 50-500 fpm. See Section 4
Q = WHV or LHV	for three sides enclosed. (Booth) V= 50-500 fpm. See Section 4

Entry loss= .25 duct VP
Duct velocity= 1000-3000 fpm

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CANOPY HOOD

DATE 1-70	VS-903

Figure courtesy of: American Conference of Governmental Industrial Hygienists, Industrial Ventilation, 19th Ed., 1986