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SUMMARY

On July 25, 1995, the National Institute for Occupational Safety and Health (NIOSH) received a management request for a health hazard evaluation (HHE) at the T.O. Vinson Health Center in Decatur, Georgia. The request asked NIOSH to assess indoor environmental quality (IEQ) and employee concerns about health problems possibly associated with their work environment. Symptoms including eye and throat irritation, difficulty breathing, headaches, malaise, and gastro-intestinal disorders had reportedly been experienced by some employees.

In response to this request, NIOSH investigators conducted a site visit to the T.O. Vinson Center on July 26-27, 1995. The objectives of this visit were to inspect the areas of concern, meet with employees, and review the heating, ventilating, and air-conditioning (HVAC) system supporting this facility. Environmental monitoring for standard IEQ parameters (temperature, relative humidity [RH], and carbon dioxide [CO_2]), plus instantaneous monitoring for non-specific volatile organic compounds (VOCs) was conducted. On July 28, a bulk sample of expansion joint material (soil and tar) was obtained from the maintenance dock for qualitative analysis via gas chromatography/mass spectroscopy (GC-MS) in an attempt to identify an odor detected on the dock. Air samples for suspected pesticides were collected in various areas of the building and on the maintenance dock. Because of concerns about potential employee exposure to pesticides, on July 31, T.O. Vinson Health Center officials vacated the building as a precautionary measure and relocated all employees. On August 4, NIOSH investigators collected bulk and surface wipe samples inside the T.O. Vinson Center to assess potential pesticide contamination. On August 10, another bulk sample of expansion joint material was obtained, and on August 30, integrated air sampling was conducted for VOCs using a sensitive and broad-spectrum monitoring technique to better characterize the indoor environment. In addition to the NIOSH investigation, on August 4, 1995, researchers from the Centers for Disease Control, National Center for Environmental Health (CDC-NCEH) initiated an epidemiologic study of the health problems among T.O. Vinson Center employees and collected blood and urine samples to analyze for evidence of pesticide exposure.

Most symptoms have been reported from occupants of the second floor clinic area; other areas have had few or no reports of symptoms. Areas of concern to occupants were the second floor X-ray developer room, a nearby incubator used by the STD program for microbiological cultures, and residue from past chemical spills. On the first floor, the carpeting in the former clinic/child care area (now unoccupied) was a concern because of its poor condition and appearance.

Indoor temperature (72° - 77° F) and RH (49% - 57%) levels were within acceptable comfort ranges throughout the facility. CO_2 measurements were within guidelines specified by the American Society for Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) and suggest that sufficient outside air is provided to occupied areas. A limited review of the HVAC unit servicing the majority of the building found the unit in good working condition. VOC monitoring conducted inside the building did not detect any unusual compounds; there was no measurable difference between indoor and outdoor VOC concentrations. The integrated VOC monitoring did not identify the compounds responsible for the odor present on the loading dock and first floor restroom.

Analysis of both bulk samples from the maintenance dock showed high (3% - 12%) concentrations of malathion (an organo-phosphate pesticide) and DDT. DDT is an insecticide that has not been used in the United States since 1972. In the past, both malathion (until 1987) and DDT (until 1972) had been used at the T.O. Vinson Center for the DeKalb County mosquito control program.

The results of a head space analysis of the bulk sample (to identify volatile airborne compounds) indicated the presence of sulfur compounds (dimethyl sulfide, dimethyl trisulfide) that are possible breakdown products of malathion. These sulfur compounds are likely responsible for the noticeable odor on the maintenance dock and first floor restroom. Malathion was not detected on air samples collected inside the T.O. Vinson Center.

Analysis of bulk samples collected inside the T.O. Vinson Center found trace amounts of malathion, diazinon, chlorpyrifos, DDT, and other chlorinated pesticides in some of the samples. The surface sampling indicated the floor in the former pesticides storage room is still contaminated with a variety of pesticides. Trace quantities of various pesticides were also found in several samples obtained in other areas inside the Vinson Center. Compounds detected were DDT, DDE, DDD, endrin, lindane, chlordane, dieldrin, endosulfan, diazinon, and chlorpyrifos. Criteria for evaluating surfaces contaminated with these pesticides have not been established.

Many recent changes to the HVAC system have been made to improve IEQ. The impact of these changes has not been ascertained.

Ongoing health symptoms and complaints have been experienced by some occupants of the T.O. Vinson Center. The effectiveness of recent ventilation modifications were not directly assessed by NIOSH investigators, but survey findings indicate the building and its HVAC systems are providing acceptable air quality. High levels of two pesticides (DDT and malathion) were detected on the back maintenance dock. Trace quantities of various pesticides were found in bulk and surface samples inside the T.O. Vinson Center. Standards or guidelines for surfaces contaminated with these pesticides have not been established, and it cannot be concluded that these materials are responsible for the health problems reported by Vinson Center occupants. Recommendations offered to address employee concerns include remediation of the maintenance dock pesticide contamination, implementation of an IEQ management plan, and housekeeping and HVAC system improvements.

KEYWORDS: SIC 9431 (Administration of Public Health Programs), Indoor air quality, IAQ, carbon dioxide, temperature, humidity, malathion, DDT, pesticides, fatigue, nausea, irritation.

INTRODUCTION

On July 25, 1995, NIOSH received a request from the DeKalb County Board of Health (DBOH) to investigate ongoing health complaints among employees at the T.O. Vinson Health Center. The reported health effects included eye and throat irritation, fatigue, nausea, and difficulty breathing. Previous efforts by DBOH and other investigators to resolve these complaints had been unsuccessful.

NIOSH investigators reviewed the results of previous indoor environmental quality (IEQ) investigations regarding this facility, as well as the results of an engineering evaluation of the facility's heating, ventilating, and air-conditioning (HVAC) system. NIOSH investigators conducted site visits on July 26-27, August 4, and August 30 to review the scope of the problems experienced; inspect the heating, ventilating, and air-conditioning (HVAC) system, and conduct environmental monitoring.

An initial response letter describing the actions taken by NIOSH, as well as preliminary findings and recommendations, was issued to DBOH officials on August 22, 1995. NIOSH presented the findings at employee forums on September 1, 1995. On October 11, 1995, the results of the August 30 air sampling were provided to DBOH.

BACKGROUND

Facility Description

The T.O. Vinson Health Center, constructed in 1963-1964, is a 3-story, 55,000 square foot facility located in the metro-Atlanta area. Approximately 60 employees work in the T.O. Vinson Health Center. The building serves as a DeKalb County community health clinic and, except for administrative and maintenance areas, the majority of the space is used for clinical services. The building is owned by the DeKalb County Public Works Department. Building mechanical systems are operated and serviced by DeKalb County Physical Plant Management (PPM) personnel. Smoking is not permitted in the building. There has been no recent construction activity or renovations at the T.O. Vinson Center.

The T.O. Vinson Center is serviced by three HVAC systems. The main air handling unit (AHU), located in a mechanical room on the first floor of the building, supports approximately 70% of the health center, including all of the complaint areas. This AHU is a dual-duct (hot deck and cold deck) variable-air-volume (VAV) system. Thermostats control pneumatic dampers which adjust the mix (hot or cold) of air at the VAV boxes; the design calls for a constant supply volume across all thermostat ranges. The VAV mixing boxes are located above the false ceiling in various areas. Supply air is provided to each room via ceiling diffusers. Return air (RA) is obtained through ceiling-mounted louvers and conveyed back to the AHU via unlined ductwork (no common RA plenum). At one time the HVAC system was cycled (shut down between 7 p.m. and 6 a.m.), but it now operates continuously. Bathrooms, located on each floor are exhausted directly outdoors. An exhaust vent has also been installed in the X-Ray developer room in the dental clinic. Outdoor air (OA) for the main AHU is ducted from a ground level louver at the rear of the building. The mixed air (RA and OA) passes through roll-type filters and then cooling coils before being distributed to occupied areas. OA dampers are controlled for indoor cooling by economizers designed to allow more OA into the system if outside conditions are favorable. PPM personnel indicated the dampers were equipped with a minimum stop to ensure sufficient OA is always provided. AHU #2 is located on the first floor near the main loading dock and serves the first and second floor hallways, the auditorium, and the vital records room. The third AHU is a small ceiling-mounted system that serves the computer room. This unit was not operational during the NIOSH visit.

From 1969 to 1987, the mosquito control program for DeKalb County was located in the T.O. Vinson Center. DDT was used until the Federal ban in 1972, and malathion was used until spraying as a mosquito control method ceased in 1987. However, DDT may still have been stored at the T.O. Center until the early 1980's. Between 1984-1986, all chemicals stored in the T.O. Vinson Center were relocated to a stand-alone concrete building behind the main facility. Prior to this, the pesticides were stored in a dedicated storage room located in the back of the facility on the first floor. This room was taken out of service when the pesticides were relocated. The rear door of this storage room opened onto the maintenance dock. Until the spraying program was halted, the pesticides were mixed and loaded on the maintenance dock.

Indoor Environmental Quality at the T.O. Vinson Center

Since 1992, employees had periodically complained of poor IEQ at the T.O. Vinson Center. In response to these complaints, DBOH personnel took a number of actions to better characterize the scope of the problem, identify possible environmental explanations, and improve the workplace environment. Two recent incidents (a May 2, 1995, algicide spill in the mechanical room, and a May 11, 1995 sewer odor) however, resulted in increased complaints of poor air quality among employees of the T.O. Vinson Center. After the May 11 incident, building occupants were relocated, and a consulting firm conducted an indoor air quality survey of the facility. HVAC problems noted by the consultant were addressed, the ventilation ducts were cleaned, adjustments were made to ensure proper air distribution to occupied areas, and the facility thoroughly cleaned. The building was reoccupied on July 17. However, employee health complaints associated with poor IEQ continued, and NIOSH was asked on July 25 to provide assistance and participate in a task force established by DBOH to address the IEQ problems. NIOSH investigators met with DBOH management and employees on July 25, and attended an employee forum on July 26 to: (1) provide information on IEQ, (2) discuss NIOSH investigative protocols, and (3) obtain information on the current health complaints.

On July 28, bulk samples of expansion joint material from the crevice between the outside wall and the back maintenance dock of the T.O. Vinson Center were collected by NIOSH and other investigators and found to contain the pesticides malathion and DDT. Also on July 28, the consultant repeated the air quality measurements they had previously conducted in May 1995. This consisted of sampling for carbon dioxide (CO_2), temperature, relative humidity (RH), VOCs, bioaerosols (bacteria and fungi), organophosphate pesticides, and respirable dust. All parameters monitored by the consultant were below established criteria or guidelines. On July 31, an informal survey conducted by DBOH management indicated employees were still experiencing symptoms. This survey found the majority of the health complaints were among employees on the second floor clinic area, and were less common in the administrative and first floor dental clinic. There were few or no symptoms reported on the third floor. On August 1, building operations were again suspended and all personnel were instructed to leave. On August 4, 1995, the Director of the DeKalb County Health Department requested assistance in evaluating potential employee exposure to pesticides from the Centers for Disease Control, National Center for Environmental Health (CDC-NCEH). CDC-NCEH agreed to collect and analyze blood and urine samples from employees. Approximately 100 samples were collected from employees beginning on August 5, 1995. Samples were analyzed for the presence (or metabolites) of malathion, DDT, and 20 other chlorinated pesticides. Blood samples were also analyzed to assess cholinesterase inhibition (an indicator or organophosphate pesticide exposure). Repeat cholinesterase monitoring was conducted for some employees approximately 6-8 weeks after the initial blood draw.

EVALUATION PROCEDURES

The NIOSH evaluation consisted of the following: (1) a review of the history of IEQ at the T.O. Vinson Health Center and actions taken by DBOH personnel to identify and resolve the IEQ problems; (2) an initial site visit to conduct a facility inspection, interview building occupants, and collect environmental samples; (3) followup site visits to conduct additional environmental monitoring, review findings with employees, and meet with DBOH personnel, and investigators from other State and Federal agencies, including the Georgia Environmental Protection Division (EPD), the Georgia Department of Human Resources (DHR), and the CDC-NCEH. The NIOSH environmental assessment was conducted in conjunction with the CDC-NCEH epidemiologic evaluation of health complaints among employees at the T.O. Vinson Center.

Monitoring Methods

Sampling and analytical methodology used during this evaluation were as follows:

Carbon Dioxide (CO_2)

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

Temperature and Relative Humidity (RH)

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

Non-specific VOC Monitoring

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

Bulk and Surface Sampling

The first bulk sample of expansion joint material obtained from the rear maintenance dock on July 28, 1995, was sealed in a glass vial and shipped to the NIOSH contract laboratory (Data Chem, Salt Lake City, Utah) for analysis. The sample was collected to identify the source of a sewer- or pesticide-like odor that was present on this dock. The sample was analyzed by two techniques. The first analysis was for compounds in the "head space" of the sample collection container to identify compounds volatilizing into the air from the sample. The second analysis consisted of a solvent extraction of the bulk material to identify compounds within the sample matrix. Both analyses used gas chromatography-mass spectroscopy (GC-MS) to identify and quantitate a wide range of possible compounds.

The second bulk sample of expansion joint material obtained on August 10 was also analyzed by the NIOSH contract laboratory. This sample was extracted with a solvent and specifically analyzed by gas chromatography for malathion (flame photometric detector), DDT, and the related compound DDE (electron capture detector).

On August 4, bulk samples of various materials inside the T.O. Vinson Center were collected and shipped to the NIOSH contract laboratory for analysis. Items sampled were carpet from the first floor (former WIC area), foam from wall display cases in the clinic area, a section of wall partition from the former WIC area, fiberglass insulation from above the false ceiling, ceiling tile from restroom R-104, polyfiber filter from the main AHU, and residue from the bag of a vacuum cleaner used for housekeeping. The samples were analyzed by two methods: (1) a semi-quantitative technique using solvent desorption and GC-MS analysis, utilizing a EPA/NIST/NBS mass spectral library for peak identification; and (2) a customized screening analysis for organo-chlorine pesticides using gas chromatography with electron capture detection. This latter technique used two mixes of organo-chlorine pesticides, at five concentration levels, for standards. Quantitation was by comparison of the sample response with that of curves derived from the standards. The two standard mixes were as follows:

MIX A: Aldrin, Lindane, Heptachlor, Heptachlor Epoxide, Endosulfan I, Endosulfan II, Dieldrin, 4,4'-DDT, Endrin Aldehyde, Methoxychlor, Dibutyl Chlorendate, Tetrachloro-m-xylene.

MIX B: α-BHC, β-BHC, δ-BHC, Endrin, 4,4'-DDD, 4,4'-DDE, Endosulfan Sulfate, Endrin Ketone, α-Chlordane, γ-Chlordane, Dibutyl Chlorendate, and tetrachloro-m-xylene.

Surface wipe samples were also collected on August 4, 1995, to assess residual pesticide contamination in various areas throughout the T.O. Vinson Center. The samples were collected with 3" X 3" pre-extracted cotton gauze moistened with 91% isopropyl alcohol. One hundred square centimeters (100 cm^2) of surface area were wiped with each gauze. After collection, the samples and blanks were placed in glass vials and shipped to the NIOSH contract laboratory for analysis. At the laboratory, the samples were screened for organo-phosphate pesticides utilizing a modification of NIOSH 4th. ed. method #5600. This included analyzing the samples against two mixes of organo-phosphate pesticides at six concentration levels. Quantitation was by comparison of the sample response with curves derived from the standards. The two standard mixes were composed of:

> MIX A: Dichlorvos, Demton O and S, TEPP, Sulfotep, Disulfoton, Ronnel, Trichloronate, Chlorpyrifos (Dursban®), Malathion, Tokuthion, Bolstar, and Azinphos-Methyl
>
> MIX B: Mevinphos, Ethoprop, Phorate, Naled, Diazinon, Monocrotophos, Dimethoate, Parathion Methyl, Merphos, Parathion, Fenthion, Tetrachlorovinphos, Fensulfothion, EPH, and Coumaphos

In addition to the organo-phosphate screen, the surface wipe samples were analyzed for organo-chlorine pesticides. Two standard mixes of organo-chlorine pesticides, similar to those utilized for the bulk samples, were used for this analysis (six concentration levels). The samples were also run against an individual mix of Chlordane and Toxaphene, as well as two pyrethroid pesticides (Baythroid and Fenvalerate). The results were quantified by comparison of the sample results with curves derived from the standards.

Organo-Phosphate Pesticide Air Sampling

Area air samples were collected on July 28, 1995, to assess for organo-phosphate pesticides identified in the bulk sample. The sampling was conducted because the odor present on the maintenance dock and restroom R-104 was similar to that associated with pesticides. Samples were collected inside the T.O. Vinson Center (former pesticide storage room, restroom R-104, room 231 - 2nd. floor clinic area), on the maintenance dock above the suspected source of the odor, and in the Eleanor Richardson building across the street from the health center. Calibrated air sampling pumps were placed in various areas and connected, via tygon tubing, to sample collection media. Monitoring was conducted for approximately 1 hour at a nominal flow rate of 1 liter per minute. The air samples were collected using OVS-2 (OSHA Versatile Sampler) sorbent tubes. After sample collection, the pumps were post-calibrated and the samples submitted to the NIOSH contract laboratory for analysis. Field blanks were submitted with the samples. At the laboratory, the samples were desorbed and analyzed for malathion and chlorpyrifos (Dursban®) according to the NIOSH 4th. ed. analytical method #5600.

Qualitative Volatile Organic Compounds - Thermal Desorption Tubes

Area air samples for qualitative VOC analysis were obtained with reusable Carbotrap® 300 multi-bed thermal desorption (TD) tubes as collection media. These tubes are designed to trap a wide range of organic compounds for subsequent qualitative analysis via thermal desorption and GC-MS. The air samples were collected using constant-volume SKC Model 223 low-flow sampling pumps. The pumps are equipped with a pump stroke counter and the number of strokes necessary to pull a known volume of air was determined during calibration. This information was used to calculate the air per pump-stroke "K" factor. The pump stroke count was recorded before and after sampling and the difference used to calculate the total volume of air sampled. Flow rates and sample times were standardized (100 cc/min, 100 minute sample, 6 liter volume) to allow for comparison of results. Three field blanks and one humidity control were submitted with the samples.

This sampling was conducted to better characterize the indoor environment and possibly identify compounds responsible for an odor present in restroom R-104, located on the first floor of the T.O. Vinson Center. Samples were collected in the following areas:

Sample Number	Location
AO3725	Room R-104 (odor still present)
AO4801	R-130 (former pesticide storage room)
AO4725	Second Floor Clinic, outside room 227
AO3393	Third Floor Reception Area, near 313
AO4468	Room 553, Richardson Building

EVALUATION CRITERIA

Indoor Environmental Quality

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

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

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

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

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

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

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

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

Carbon Dioxide

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

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

Temperature and Relative Humidity

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

Volatile Organic Compounds

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

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

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

Malathion

Malathion is a common, non-restricted use (can be purchased and applied by the public), organophosphate insecticide. Organophosphate chemicals are popular as insecticides because they are biodegradable as well as effective. Organophosphate chemicals (along with carbamate pesticides) belong to a class of compounds referred to as cholinesterase inhibitors. Acetylcholinesterase is an enzyme critical to normal control of nerve impulses from nerve fibers to other cells. Loss of this enzyme function allows for the accumulation of acetylcholine (the impulse-transmitting substance) at these junctions.[29-31] Signs and symptoms of acute poisoning can include the following:

increased sweating	chest pain	muscle weakness
blurred vision	breathing difficulty	muscle twitches
increased tears	wheezing	memory problems
increased saliva	nausea and vomiting	decreased concentration
increased nasal and lung secretions	abdominal cramps	diarrhea

Malathion has a low order of toxicity in comparison with other organophosphate pesticides, has only a slight direct inhibitory action on cholinesterase, and is regarded as the least toxic of this class of compounds.[29-30] The rapid metabolism of malathion is thought to be the reason for the lower toxicity associated with this insecticide. The relative safety of malathion to humans has been repeatedly demonstrated, and adverse health reports are usually the result of gross exposures involving skin absorption in agricultural settings.[29] Skin sensitization caused by malathion, and dermatitis under conditions of heavy field use, have been reported.[32] Malathion is not considered to be a carcinogen.[32] The NIOSH Recommended Exposure Limit (REL) for malathion is 10 milligrams per cubic meter (mg/m^3) as a 10-hour time-weighted average.[21]

Malathion degrades rapidly in soil. The persistence of malathion will vary depending on the type of soil, and the degradation rate is affected by exposure to UV-light, relative humidity, temperature, and concentration.[33] Reported half-lives in soil range from 4 to 18 days.[33-34] Malathion has, however, been shown to be stable for at least one year when stored in unopened drums at temperatures not exceeding 23°C.[33]

DDT

DDT is the common name for dichlorodiphenyltrichloroethane, a synthetic, chlorinated insecticide which has broad-spectrum insecticidal activity. Technical-grade DDT is a waxy solid that was extensively used to control insects on agricultural crops and insects that carry diseases like malaria and typhus.[35-36] In 1972, the U.S. Environmental Protection Agency banned all uses of DDT because of concern with build-up in the environment and possible effects on wildlife. DDT is currently not approved for use in the United States except in cases of public health emergencies.

Because of the extensive use and environmental persistence of DDT and its degradation products (dichlorodiphenyldichloroethylene [DDE], dichlorodiphenyldichloroethane [DDD]), potential human exposure is considered to be widespread.[36] The primary route of human exposure to DDT and its metabolites is by ingestion of food containing these compounds. Inhalation is another potential route of entry if DDT adheres to particles that become airborne and subsequently inhaled. Although skin absorption is a possible route of exposure, DDT, DDE, and DDD do not pass through the skin very easily.[35]

High doses of DDT affect the nervous system, and can result in tremor and convulsion.[29] Heavy exposure to DDT dust may cause eye or skin irritation. No effects were reported in human studies where people were given small daily doses of DDT for 18 months, and DDT has relatively low acute human toxicity.[35] Epidemiologic studies of workers exposed to DDT have been inadequate for determining whether it is carcinogenic in humans.[35] However, in animal studies DDT has caused liver, lung, and lymphatic cancer, and NIOSH recommends that DDT be considered a potential occupational carcinogen and that exposure should be kept as low as possible.[(21,36)]

Once DDT enters the environment, it will remain in the soil for a very long time; some studies have shown that it takes over 15 years for DDT to break down.[35] Even though it has not been used in the USA since 1972, DDT or its breakdown products are still present in some air, water, and soil samples, and DDT has been detected in animal and plant tissues and food.[35] In the early 1970's, national soil testing programs reported levels in soil from 0.2 to 6 ppm.[35]

Pesticide Residues

Pesticides are commonly used in commercial and residential buildings, and it is estimated they are used in over 90% of the households in the United States.[(37-38)] Detectable quantities of different pesticides are often found in ambient air and on surfaces in homes and various buildings.[(37,39-40)] In the past, chlorinated pesticides were commonly used (e.g., chlordane, DDT, dieldrin, etc.), and because of their persistence in the environment are frequently measured in buildings. Chlorpyrifos (Dursban®) is commonly used as a termiticide (especially since chlordane was banned by the EPA in 1988), and because of its popularity as an indoor insecticide has often been detected in air and surface samples indoors.[41]

Standards for surfaces contaminated with residual pesticides have not been established. Efforts to assess risks associated with residual pesticide contamination and determine "safe" levels have often involved determining the No Observable Adverse Effect Level (NOAEL), and making assumptions on skin contact, absorption, and transfer rate to estimate a potential dose received. These studies have usually been conducted to assess the risk to children (toddlers) in buildings. The risk is generally higher after recent application and will vary depending on the type of pesticide treatment (e.g., crack and crevice, broadcast, or fogging).

RESULTS AND DISCUSSION

Environmental

Temperature, Relative Humidity, and Carbon Dioxide

The results of the temperature, RH, and CO_2 measurements are shown in Table 1. Temperature (72° - 77° F) and RH (49% - 57%) levels measured inside the T.O. Vinson Center were within acceptable comfort ranges throughout the facility. No unacceptable fluctuations in temperature were noted. CO_2

measurements (575 - 850 ppm) suggest that sufficient outside air is provided to occupied areas; all measurements were below the 1000 ppm ASHRAE guideline. However, the afternoon measurements were taken when many employees had left the building to attend a staff meeting across the street in the Richardson Building. Therefore, this CO_2 monitoring may not be representative of normal afternoon conditions. The building interior was maintained at a positive pressure with respect to the outside, a desirable condition to prevent infiltration of unconditioned outside air into the building.

Table 1
Temperature, Relative Humidity, Carbon Dioxide Monitoring Results
T.O. Vinson Health Center
July 26, 1995

LOCATION	Carbon Dioxide (PPM)		Relative Humidity (%)		Temperature °F	
	11:30 am	2:30 pm	11:30 am	2:30 pm	11:30 am	2:30 pm
AHU #1 Mech. Room	675	650	53	52	75	76
First Floor Main Hallway	775	800	54	49	77	77
2nd. Floor Main Hallway	725	675	54	51	74	74
Clinic Waiting Room	775	825	55	54	74	76
Room 217 - Lab	775	675	55	53	72	73
Room 227	850	625	56	54	74	74
Room 232 Waiting Area	750	575	55	52	74	74
WIC Check-in Waiting Area	750	675	56	54	72	73
Admin 201A Waiting Room	725	575	57	53	73	74
219A WIC Administration	625	575	57	54	73	73
Hallway Outside 209A	650	550	57	55	73	74
Hallway Outside 312	675	575	57	54	72	73
Room 319	625	525	56	54	72	73
Outside	NM	400	NM	54	NM	86
Richardson Bldg: First Floor	NM	875	NM	48	NM	76

NM = Not Measured

Non-specific VOC monitoring

VOC monitoring conducted inside the building using direct-reading instrumentation did not detect any unusual volatile compounds or sources; there was no measurable difference between indoor and outdoor VOC concentrations. No indoor environmental contaminants were identified by this monitoring that could explain the reported symptoms from the building occupants.

HVAC Inspection

A variety of mechanical and operational problems in the HVAC system were identified by the LAW investigators; corrections and modifications were made prior to the building being reoccupied on July 17. The building was thoroughly cleaned prior to reoccupying the building, and a maintenance engineer was assigned to the facility. A limited evaluation of the HVAC unit servicing the majority of the building found the AHU in good working condition. The ductwork was not inspected (it was reported that the ducts had been cleaned and sealed prior to the building being reoccupied). Before/after renovation photographs of the HVAC system were reviewed, as well as the original as-built schematics. Access to the HVAC coils and condensate pan is difficult, requiring the AHU to be shutdown, and were therefore not observed during our evaluation. A spot check of one air supply vent serviced by this unit found air supply velocity was consistent under the full range of thermostat settings for this zone. A complete test and balance report for the HVAC system was not available. There is no mechanism for introducing moisture into the HVAC system to increase humidity levels (it was previously reported that boiler water was used for this purpose).

Observations

According to DBOH personnel, most symptoms have been reported in the second floor clinic area. Other areas have had few (administrative wing) or no (3rd. floor) reports of symptoms. The symptoms reported (headache, fatigue, nausea, throat/eye irritation) are similar to those NIOSH investigators have found in other investigations of non-industrial worksites. The reported symptoms seemed to vary in severity; at least one employee was no longer willing to work in the building because of the symptoms experienced. Employee symptoms at the T.O. Vinson Center reportedly improved when they left the building. There does not appear to be any seasonality to the symptoms. During the survey, NIOSH investigators noted a high level of concern and anxiety among employees regarding the symptoms experienced inside the T.O. Vinson Center.

During the walkthrough and employee meeting on July 26, areas of concern identified by occupants were: the second floor X-ray developer room, a nearby incubator used by the STD program for microbiological cultures, and residue from previous chemical spills. No unusual odors were initially reported by employees except for the two incidents in May (sewer, algicide). On the first floor, the carpeting in the former clinic/child care area (now unoccupied) was considered by employees to be a potential source of contaminants because of the carpet's poor condition and appearance. General concerns with building conditions, appearance, and janitorial services were noted. The X-ray unit is no longer used, however the developer and other equipment was still present. According to DBOH personnel, some developer chemicals had recently been removed, and stains remaining on the floor left by the containers were a source of concern to some workers. The incubator used for the STD program has since been removed. A copy machine on the second floor is located in a separate room with fabric padded walls.

An odor noted by DBOH personnel on the back maintenance dock of the T.O. Vinson Center, initially thought to be associated with a sanitary sewer line problem, prompted an investigation and collection of bulk and air samples. The odor appeared to be confined to the back dock and the first floor restroom (R-104). The pathway for the odor to penetrate into the restroom appears to be at an open area in a pipe chase. The concrete pipe chase has an approximate 2 foot opening between the top of the chase wall and the ceiling. This restroom contains a ventilation supply vent and an exhaust fan (no air returns from this room to the main HVAC). Compounds responsible for the odor that are present in the soil underneath the dock or chase could be pulled into the bathroom by the exhaust fan.

Management response to employee complaints, and efforts to communicate actions, have been timely and appropriate. Environmental sampling and consultant findings have been shared with employees, and written updates concerning this issue are provided to all occupants.

Expansion Joint Bulk Sample Results

The results of the extraction analysis from the bulk sample collected on July 28, 1995, on the back maintenance dock found very high concentrations of malathion, DDT, and DDE. DDE is a common contaminant and breakdown product of DDT. Concentrations detected were as follows:

malathion	*110,000 ug/gm of sample (11%)*
DDT (total isomers)	*24,000 ug/sample (2.4%)*

Bulk samples collected by DBOH and LAW Engineering also found high concentrations of malathion and DDT. Analysis of a subsequent sample of expansion joint material collected on August 10 in the same area as the first sample found:

malathion	*35,000 ug/gm of sample (3.5%)*
DDT (total isomers)	*120,000 ug/sample (12%)*

This analysis also showed the presence of approximately 0.7% DDE, but this was thought to be an artifact arising from the breakdown of DDT.

The results of the head space analysis indicated the presence of sulfur- (dimethyl sulfide, dimethyl trisulfide), and phosphorous-containing compounds that are possible breakdown products of malathion. It is likely that these sulfur compounds are responsible for the noticeable odor on the maintenance dock and first floor restroom (room 104-R). Many sulfur compounds have very low odor thresholds, and odors associated with the use of malathion and other organo-phosphate pesticides in commercial and residential settings have been attributed to sulfur-containing breakdown products.

As malathion has an environmental half-life of 4-6 days, (the half-life will vary depending on soil pH, sunlight, and microbiological activity), to find such a high concentration of malathion eight years after pesticides were removed from the building is highly unusual. The source of the malathion and the extent of the contamination has not been determined.

Malathion and Chlorpyrifos Air Sampling

Results of the July 28 air sampling included one air sample with a detectable quantity of malathion between the limit of detection and the limit of quantitation for the sampling method. This sample was collected on the back dock directly over the area with the most noticeable odor (one inch above the expansion joint). The concentration at this location is estimated at 0.005 milligrams per cubic meter (mg/m^3). No malathion was found on any of the other air samples collected inside the T.O. Vinson

Center or Eleanor Richardson building. This is not an unexpected finding as malathion is only slightly volatile and does not readily become airborne. The air samples were also analyzed for chlorpyrifos (Dursban®); no detectable amounts were found on any of the samples.

Bulk Samples from Inside the T.O. Vinson Center

Analysis of additional bulk samples collected at the T.O. Vinson Center on August 4 revealed trace amounts of various pesticides on all samples except one (fiberglass insulation from above the false ceiling, first floor). Low-level concentrations of various organo-chlorine pesticides were found. The highest concentrations detected were for 4,4'-DDT. The results are presented in Table 2.

Table 2
Bulk Sample Results
T.O. Vinson Health Center
August 4, 1995

Bulk Sample Description	Compounds Detected	micrograms/sample
Foam from Display Frame: 2nd. Floor Clinic Area, Childrens Immunization Section	Aldrin 4,4'-DDT Dieldrin Heptachlor	(0.02) (0.06) (0.07) (0.1)
Foam from Display Frame: Room 232	Aldrin Lindane 4,4'-DDT Heptachlor Heptachlor Epoxide	(0.1) 0.42 (0.23) 0.24 0.094
First Floor Carpet, Adjacent Room 123	Aldrin Lindane 4,4'-DDD 4,4'-DDE 4,4'-DDT Heptachlor Malathion	(0.1) (0.06) 4 µg/g 0.48 16, 5µg/g 0.12 1 µg/g
Wall Partition Adjacent Room 136	Fenvalerate	20 µg/g**
Fiberglass Insulation from above False Ceiling, First Floor	ND	N/A
Plaster Ceiling Tile from Panel Adjacent Pipe Chase, First Floor, Room R-104	Aldrin Lindane Heptachlor	(0.02) (0.02) (0.02)
Poly Fiber Roll Filter from Main AHU	Aldrin Lindane 4,4'-DDT Dieldrin Endosulfan II Heptachlor Epoxide Methoxychlor	1.3 0.20 1.3 1.5 0.49 0.069 (0.87)
Residue From Vacuum Cleaner	Aldrin Lindane 4,4'-DDE 4,4'-DDT Dieldrin Endosulfan I Endosulfan II Endrin Heptachlor Methoxychlor	0.82 (0.2) 0.72 11 3.3 0.63 1.1 0.97 1.8 2.7

NOTE: Results in parentheses indicate the concentration detected was between the limit of detection and the limit of quantification. µg/g = micrograms of contaminant per gram sample. ** = sample was consumed during GC-MS analysis and could not be analyzed for specific organo-chlorine compounds. ND = None Detected.

Surface Sampling Results

The surface sampling results from the T.O. Vinson Center are shown in Table 3. These results indicate the floor in the former pesticides storage room is still contaminated with a variety of pesticides. These include many chlorinated pesticides that are no longer commercially used, including DDT, Chlordane (used as a termiticide for many years), and others. Lindane, a component of some shampoos used for lice and scabies treatment was also detected in this room, as was the common pesticide Diazinon. Trace quantities of various pesticides were also identified in several wipe samples obtained from other areas inside the T.O. Vinson Center. Chlorpyrifos (Dursban®) is an organo-phosphate pesticide used for commercial and residential pest control and Diazinon is used for outdoor and household insect treatment. However, a review of records for the T.O. Vinson Center indicated that recent (since 1992) building pesticide treatment applications only involved pyrethroid-based insecticides. It is possible that some of the detected compounds were tracked inside the building by pedestrian traffic from the maintenance dock and other areas. Standards or guidelines for surfaces contaminated with these pesticides have not been established.

Table 3
Surface Sample Results
T.O. Vinson Health Center
August 4, 1995

Sample Description	Compounds Detected	µg/cm^2
Floor of Room 130 - Former Pesticide Storage Room	Lindane Chlordane DDT DDE Diazinon DDD Dieldrin Heptachlor Endrin	5.67 0.123 0.099 0.098 0.087 0.036 0.050 0.0088 0.0042
Vinyl Chair Seat, Rm. 227	DDD Endosulfan II Endrin	(0.0013) (0.0011) 0.0067
Foot Pad - Scale, Rm 228	DDD DDT	0.012 0.015
Computer Monitor (top), Rm 231	None Detected	NA
Blue Fabric Desk Chair, Rm 243	None Detected	NA
Top of File Cabinet, Rm 244	None Detected	NA
Blank	DDT	(0.0019)
Wall, near floor, under light switch in Rm 105 (Dental Office)	Delta BHC Alpha Chlordane DDD Dieldrin chlorpyrifos (Dursban®) Baythroid	(0.0022) (0.012) 0.016 (0.0016) 0.12 0.034
Wall (chase corner), Rm R-104 (1st floor bathroom)	DDE DDT DDD Diazinon Baythroid	(0.0012) 0.0035 (0.0013) 0.087 0.017
Blank	None Detected	NA

NOTE: Results in parentheses indicate the concentration detected was between the limit of detection and the limit of quantification.

Thermal Desorption Tube Monitoring

During the sampling at the T.O. Vinson Center the HVAC system was operational and the building was unoccupied. Copies of the reconstructed total ion chromatograms from the GC-MS analyses of the thermal desorption tubes are provided in Attachment 1. The chromatograms were all scaled the same for comparison. Compounds detected on the samples included toluene, p-dichlorobenzene, butyl cellosolve, terpenes, and various aliphatic hydrocarbons. These compounds are typical of indoor air contaminants and can be components of cleaning solutions, disinfectants, or other common sources. Similar compounds were detected in both the T.O. Vinson Center and the Richardson building. The sampling did not identify any specific compound that could be attributed to the odor present in Room R-104. Note that the odor is suspected to be a sulfur-containing compound, which generally have extremely low odor thresholds. The odors noted are therefore likely to be lower than the analytical limit of detection for this method.

DISCUSSION and CONCLUSIONS

The history of the odor present on the back dock and restroom 104-R is curious. The odor is very noticeable and objectionable. If residual malathion from 1987 or before was responsible, it is likely that it would have been detected and addressed by now. When the odor was first noted is difficult to ascertain, as recent problems with sewage odors (clogged line, broken wax seal) confound the reports. Additionally, malathion degrades rapidly in the environment and would not be expected to persist for the eight years since the last use. Possible explanations include recent applications that were unrecorded, or that malathion would not degrade as rapidly as anticipated due to adsorption of the compound with other materials that may stabilize it and retard the breakdown process.

Many recent changes have been made to the facility and the HVAC system in an attempt to improve air quality. The effectiveness of these changes has not been directly assessed by the NIOSH investigators, but a limited visual inspection of the system and monitoring for standard IEQ parameters indicate the building and its HVAC systems are providing acceptable IEQ.

Although trace levels of various pesticides were detected on bulk and surface samples inside the T.O. Vinson Health Center, the concentrations detected would not result in exposures sufficient to cause the adverse health symptoms reported, and biological monitoring of employees showed absorption was not occurring. CDC-NCEH investigators analyzed 99 blood samples for 20 pesticides known to persist in the body and no pesticide levels above those observed in the general population were found. No traces of malathion breakdown products were detected in the urine samples. Nevertheless the pesticide contamination detected on the maintenance loading dock is a concern. This finding will require more extensive evaluation by qualified hazardous materials personnel and the Georgia EPD to ensure the extent of the contamination is properly characterized and a remediation strategy is developed. However, other than possibly pedestrian traffic, a pathway for these compounds to contaminate inside the T.O. Vinson Center has not been observed, and it cannot be concluded at this time that these materials are responsible for the health problems reported by T.O. Vinson Center occupants.

Although pesticides are commonly used in residential and commercial buildings, and residues are routinely found inside buildings, the presence of chlorinated pesticides, albeit at very low levels, was unexpected and is difficult to interpret. Information on the presence of these compounds in the soil of areas surrounding the T.O. Vinson Center, and surface sampling data from nearby buildings of a similar age, would help better understand this finding.

Other potential explanations noted for the odor at the T.O. Vinson Center include both internal and external sources. The deteriorated carpet in the former WIC area and the padded wall partitions may have been a factor. Water-damaged or soiled carpet is a potential source of microbial growth. The affect of having large surface areas of porous material (e.g., the wall partitions, copier room) is problematic. Studies have shown that porous surfaces will adsorb and later emit volatile materials; however this phenomena is poorly understood.[42] The impact of an improperly functioning HVAC system (prior to implementing the consultant's recommendations) on IEQ is not known. Building dynamics may have been different, allowing infiltration of outdoor contaminants, including compounds responsible for the odor, into occupied areas.

RECOMMENDATIONS

1. The contamination detected on the maintenance dock must be mitigated. The extent of the contamination must be fully characterized and a complete remediation conducted. Qualified hazardous materials firms capable of conducting this type of work should be utilized, and the Georgia EPD should be consulted.

2. Improve housekeeping in the mechanical room housing HVAC System #2, the X-Ray developer room, and the cage area. Carpeting on the first floor and other areas was identified as a significant concern by employees due to its appearance. Additionally, the carpet sample from the first floor showed trace amounts of pesticides and other organic contaminants. The carpet should be removed to eliminate this as a potential problem. After completion of the renovation and mitigation of the pesticide contamination on the back dock, a thorough cleaning of the interior of the T.O. Vinson Center should be conducted.

3. After the planned renovation, conduct a complete test and balance of the HVAC System to ensure it meets appropriate design criteria.

4. Verify that the mixing boxes perform as designed and have a minimum stop feature to ensure there is always air flow from these units.

5. Ensure the HVAC systems are configured to meet current ASHRAE guidelines for providing sufficient outside air ventilation to all occupied areas.

6. Improve access to the HVAC coils and condenser system to allow frequent inspection and maintenance.

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

    -- Proper operation and maintenance of HVAC equipment.

    -- Overseeing the activities of occupants and contractors that affect IEQ (e.g., housekeeping, pest control, maintenance, food preparation).

    -- Maintaining and ensuring effective and timely communication with occupants regarding

IEQ.

-- Educating building occupants and contractors about their responsibilities in relation to IEQ.

-- Pro-active identification and management of projects that may affect IEQ (e.g., redecoration, renovation, relocation of personnel, etc.).

The NIOSH/EPA Building Air Quality Guidance Document should be consulted for details on developing and implementing IEQ management plans.[43]

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