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I. SUMMARY

On August 19, 1991, the National Institute for Occupational Safe Health (NIOSH) received a confidential written request to conduc health hazard evaluation (HHE) at the Social Security Administra (SSA), District Office in Colorado Springs. The requestor was s assistance regarding complaints from SSA employees related to po indoor environmental quality (IEQ). A previous investigation wa conducted in this office in 1985 by the Division of Federal Empl Occupational Health. The investigators sampled for volatile org chemical contaminants such as formaldehyde and perchloroethylene failed to identify the presence of either above the limits of de of 0.03 ppm and 0.2 ppm, respectively. Results of that investig did, however, indicate that poor air circulation and low relativ humidity (RH) were contributing factors that may have precipitat occupant complaints relating to poor IEQ.

On March 26 and 27, 1992, a NIOSH industrial hygienist conducted building investigation at the Citadel Shopette, a single story o complex where the District Office is located. The building is a office rental property containing food service, optical dispensi cleaning, printing and financial management establishments. A b survey questionnaire was distributed to SSA employees and superv an inspection of the heating, ventilating and air conditioning s (HVAC) system was performed and environmental monitoring was con to evaluate temperature and RH and carbon dioxide (CO_2). Air sar for volatile organic contaminants (VOCs) and formaldehyde was al conducted.

Average temperatures in the occupied space ranged from 71°F (mor to 76°F (late afternoon). RH measurements ranged from 19% to 26 Instantaneous CO_2 measurements ranged in concentration from 525 p per million (ppm) to 1000 ppm.

Area air sampling for formaldehyde and volatile organic compound conducted in seven locations, including an outside air sample. one formaldehyde sample (0.04 mg/m^3) was found to be above the m detectable concentration (MDC) of 0.01 mg/m^3 based on a sampling of 40 liters. The outside air sample was non-detectable. VOCs including perchloroethylene, acetone, 1,1,1 trichloroethane, tol and total xylenes were reported on the collection media; Supelco Carbotrap™ 300 thermal desorbtion tubes. Perchloroethylene was in a significantly greater proportion on each sample, at 0.30 mg 0.18 mg/m^3 in indoor and outdoor air samples, respectively.

Temperature measurements were within the American National Stand Institute/American Society of Heating Refrigerating and Air Conditioning Engineers (ANSI/ASHRAE) guidelines for thermal environmental conditions for human occupancy (Standard 55-1981) instances. Relative humidity measurements were on the lower end ANSI/ASHRAE comfort zone. Daily measurements of carbon dioxide approached 1000 parts per million (ppm) suggesting inadequate di ventilation. Results of the questionnaire survey indicated the common health complaints were dry skin and dry or irritated eyes Headache was also mentioned as a health complaint.

No health hazard was identified, however, entrainment of outside contaminated with perchloroethylene from an adjacent dry cleanin operation in combination with low relative humidity may have contributed to employee complaints. Recommendations are given i this report to correct the problem and help alleviate the complaints.

KEYWORDS: SIC 9441, (Government offices) Indoor Environmental Qu (IEQ), Indoor Air Quality (IAQ), Formaldehyde, Perchloroethylene Tetrachloroethylene, Dry Cleaning.

II. INTRODUCTION

On March 26, 1992 an opening conference was conducted with an investigator from the National Institute for Occupational Safety Health (NIOSH), management representatives from the Social Secur Administration (SSA) District Office, and a union representative the American Federation of Government Employees (AFGE). The req which was received on August 19, 1991, related to personnel empl the SSA, Colorado Springs, District Office regarding mucous memb irritation, headache and poor air circulation believed to be rel conditions of the indoor environment. According to the request, at the SSA reported that the air inside the building was stagnan that molds, bacteria, viruses or chemicals in the air were suspe possible factors contributing to poor indoor environmental quali (IEQ) within the office space.

III. BACKGROUND

A. Description of the Facility

The SSA District Office is located within the Citadel Shopett 3628 Citadel Drive North, Colorado Springs, Colorado. The Ci Shopette is a triangular shaped, single story office complex containing a variety of other businesses including, a food concession, optical dispensing store, dry cleaners, a small p shop, a hair styling salon and a chiropractic office. The SS District Office employs 35 people. The nature of the work conducted in the SSA space involves interaction with the publ regarding management of social security benefits, claims mana and associated paperwork processing. The work area consists approximately 11,000 square feet and is arranged primarily as open space layout. Seating arrangements consist of groups of modular desk/work areas accommodating from six to eight perso Two private offices, a multi-purpose room, computer room and training room are located inside the space along the perimete wall. The SSA is provided this space from the General Servic Administration (GSA), which leases from the building owner, t Olive Real Estate Group.

The building is constructed of masonry and structural steel. roof of the building is flat, sealed with hot mastic and grav The space is heated and cooled with seven rooftop package air handling units (AHUs) operating on constant air volume. Each is designed to provide heating and cooling to one of seven zo the office, depending upon the temperature in the space and t respective setpoints on the thermostats. Seven automatic thermostats located throughout the space control the AHUs. Switchover from heating to cooling occurs automatically when temperature in the occupied space reaches a certain heating o

cooling setpoint on the automatic thermostats. Manual switch from heating to cooling is not necessary. According to the mechanical blueprints, the heating, ventilating and air conditioning system (HVAC) is designed to provide 10,245 cubi per minute (cfm) of supply ventilation to the office space. minimum of five cfm per person of outside air is specified in GSA Solicitation for Offers lease agreement for this space. office space is carpeted and the windows are vacuum-sealed, n opening. Office cleaning and vacuuming is provided under a contract with Commercial Cleaning Technicians and occurs betw 7:30 and 9:00 a.m.

The building had a prior IEQ investigation by the regional industrial hygienist of the Division of Federal Employee Occupational Health (FEOH) Region VIII. The results of that investigation, conducted in November 1986 and February and Ap 1987, found that formaldehyde and perchloroethylene were not present (to the limit of detection of 0.03 ppm and 0.2 ppm respectively), temperature was within the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE standard 55-1981 for thermal comfort, and relative humidity (was measured at the lower end of the ASHRAE comfort zone. Ai measurements indicated that, according to design specificatio insufficient air circulation or a ventilation system imbalanc low RH, were contributing factors related to complaints of po IEQ.

IV. MATERIALS AND METHODS

Wind direction and speed were evaluated on the morning of the fi of the investigation because entrainment of outside air contamin was suspected by the investigator. An east wind of approximatel miles per hour (mph) was present and outside air temperature and were 58°F and 24% respectively. Indoor measurements at 9:00 a.m 70°F and 21% RH. The investigation began with an inspection of seven roof top AHUs. A technician from the Olive Company was av to facilitate inspection of the HVAC units. The units are numbe the mechanical blueprint as roof top units (RTUs) RT-12,13,14,1 and "new 3 ton unit." Units 12-17 are Trane 3.5 ton units while ton unit is a Carrier model. The service panel of each unit was removed and the unit was inspected for the presence, condition a correct installation of filter media, position of outside air da signs of microbiological growth, condition of duct linings, coil drain pans.

To characterize aspects of ventilation and thermal comfort, carb dioxide, temperature and RH were measured at fifteen locations throughout the space at three intervals during the day: 9:00 a.m 11:30 a.m., and 4:30 p.m. A total of forty-five temperature and

measurements were made using a battery-operated, hand-held Vaisa 34 temperature and RH meter. Real-time CO_2 was measured using a Gastech Model RI-411A portable CO_2 analyzer. This instrument is capable of measuring CO_2 concentrations from 50 to 5000 ppm. Aft zeroing and span gas calibration were performed, measurements we taken three times during the day, at fifteen separate locations. Supply air (ceiling diffuser) flow was characterized with the us smoke tubes.

On the second day of the investigation, area air sampling was co inside the building to evaluate the presence of formaldehyde, an volatile organic compounds (VOCs). Perchlorethylene and formald were suspect chemicals in this investigation because of the prox of rooftop exhaust stacks and the presence of new furnishings in office area. Sampling for formaldehyde was conducted according NIOSH method 3500 using all-glass midget impingers and a 20 mill of 1% sodium bisulfite solution.[1] After on-site calibration wit primary standard, personal sampling pumps were used to collect a samples at a flow rate of 200 cubic centimeters per minute (cc/m Supelco™ Carbotrap™ 300 tubes and personal sampling pumps were u sample at a rate of 20 cc/min for VOCs. Six desk top locations, in a separate ventilation zone, were sampled. Background sample formaldehyde and VOCs in outdoor air were also taken at a locati the rear of the building.

A self-administered questionnaire was distributed to all full-ti staff present in the office at the time of the investigation. T one responses were received, for an 89% response rate. The purp the questionnaire was to determine occupant perceptions of build thermal comfort and health effects related to IEQ.

V. EVALUATION CRITERIA

NIOSH investigators have completed over 1100 investigations of t indoor environment in a wide variety of settings. The majority these investigations have been conducted since 1979.

The symptoms and health complaints reported by building occupant been diverse and usually not suggestive of any particular medica diagnosis or readily associated with a causative agent. A typic spectrum of symptoms has included headaches, unusual fatigue, va degrees of itching or burning eyes, irritations of the skin, nas congestion, dry or irritated throats, and other respiratory irritations. Typically, the workplace environment has been impl because workers report that their symptoms lessen or resolve whe leave the building.

A number of published studies have reported high prevalences of symptoms among occupants of office buildings.[2-6] Scientists

investigating indoor environmental problems believe that there a multiple factors contributing to building-related occupant complaints.[7-8] Among these factors are imprecisely defined characteristics of heating, ventilating, and air-conditioning (H systems, cumulative effects of exposure to low concentrations of multiple chemical pollutants, odors, elevated concentrations of particulate matter, microbiological contamination, and physical such as thermal comfort, lighting, and noise.[9-14] Reports are not conclusive as to whether increases of outdoor air above currentl recommended amounts (≥15 cubic feet per minute per person) are beneficial.[15-16] However, rates lower than these amounts appear t increase the rates of complaints and symptoms in some studies.[17-1 Design, maintenance, and operation of HVAC systems are critical their proper functioning and provision of healthy and thermally comfortable indoor environments. Indoor environmental pollutant arise from either outdoor sources or indoor sources.[19]

There are also reports describing results which show that occupa perceptions of the indoor environment are more closely related t occurrence of symptoms than the measurement of any indoor contam or condition.[20] Some studies have shown relationships between psychological, social, and organizational factors in the workpla the occurrence of symptoms and comfort complaints.[21]

Less often, an illness may be found to be specifically related t something in the building environment. Some examples of potenti building-related illnesses are allergic rhinitis, allergic asthm hypersensitivity pneumonitis, Legionnaires' disease, Pontiac fev carbon monoxide poisoning, and reaction to boiler corrosion inhi The first three conditions can be caused by various microorganis other organic material. Legionnaires' disease and Pontiac fever caused by Legionella bacteria. Sources of carbon monoxide inclu vehicle exhaust and inadequately ventilated kerosene heaters or fuel-burning appliances. Exposure to boiler additives can occur boiler steam is used for humidification or is released by accide

Problems NIOSH investigators have found in the non-industrial in environment have included poor air quality due to ventilation sy deficiencies, overcrowding, volatile organic chemicals from offi furnishings, machines, structural components of the building and contents, tobacco smoke, microbiological contamination, and outs pollutants; comfort problems due to improper temperature and rel humidity conditions, poor lighting, and unacceptable noise level adverse ergonomic conditions; and job-related psychosocial stres In most cases, however, no cause of the reported health effects be determined.

Standards specifically for the non-industrial indoor environment exist. NIOSH, the Occupational Safety and Health Administration

and the American Conference of Governmental Industrial Hygienist (ACGIH) have published regulatory standards or recommended limit occupational exposures.[22-24] With few exceptions, pollutant concentrations observed in the office work environment fall well these published occupational standards or recommended exposure l The American Society of Heating, Refrigerating, and Air-Conditio Engineers (ASHRAE) has published recommended building ventilatio design criteria and thermal comfort guidelines.[25-26] The ACGIH ha developed a manual of guidelines for approaching investigations building-related complaints that might be caused by airborne liv organisms or their effluents.[27]

Measurement of indoor environmental contaminants has rarely prov be helpful, in the general case, in determining the cause of sym and complaints except where there are strong or unusual sources, proved relationship between a contaminant and a building-related illness. However, measuring ventilation and comfort indicators CO_2, and temperature and relative humidity, is useful in the ear stages of an investigation in providing information relative to proper functioning and control of HVAC systems. The basis for t measurements made in this investigation are presented below.

A. CARBON DIOXIDE

Carbon Dioxide (CO_2) is a normal constituent of exhaled breat if monitored, can be used as a screening technique to evaluat whether adequate quantities of fresh air are being introduced an occupied space. The ASHRAE Standard 62-1989, Ventilation Acceptable Indoor Air Quality, recommends outdoor air supply of 20 cubic feet per minute per person (cfm/person) for offic spaces and conference rooms, 15 cfm/person for reception area 60 cfm/person for smoking lounges, and provides estimated max occupancy figures for each area.[25]

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

B. TEMPERATURE AND RELATIVE HUMIDITY

The perception of comfort is related to one's metabolic heat production, the transfer of heat to the environment, physiolo adjustments, and body temperatures. Heat transfer from the b the environment is influenced by factors such as temperature, humidity, air movement, personal activities, and clothing. A

Standard 55-1981 specifies conditions in which 80% or more of occupants would be expected to find the environment thermally comfortable.[26]

C. FORMALDEHYDE

Symptoms of exposure to low concentrations of formaldehyde in irritation of the eyes, throat, and nose, headaches, nausea, congestion, asthma, and skin rashes. It is difficult to ascr particular health effects to specific concentrations of formaldehyde to which people are exposed, because of variabil subjective responses and complaints. Irritation symptoms may in people exposed to formaldehyde at concentrations as low as 0.1 ppm, but more frequently in exposures of 1.0 ppm and grea Some sensitive children or elderly, those with preexisting allergies or respiratory diseases, and persons who have becom sensitized from prior exposure may have symptoms from exposur concentrations of formaldehyde between 0.05 and 0.10 ppm. Formaldehyde-induced asthma and bronchial hyperactivity devel specifically to formaldehyde are uncommon. [28]

Formaldehyde vapor has been found to cause a rare form of can Fischer 344 rats exposed to a 15 ppm concentration for 6 hour day, 5 days per week, for 24 months. Whether these results c extrapolated to human exposure is the subject of considerable speculation in the scientific literature. Conclusions cannot drawn with sufficient confidence from published mortality stu of occupationally exposed adults as to whether or not formald is a carcinogen. Studies of long-term human occupational exp to formaldehyde have not detected an increase in nasal cancer Nevertheless, the animal results have prompted NIOSH to recom that formaldehyde be considered a potential occupational carc and that workplace exposures be reduced to the lowest feasibl limit.[29]

Effective June 27, 1992, OSHA has reduced the time-weighted a (TWA) Permissible Exposure Level (PEL) for formaldehyde to 0. for an 8-hour shift, with a 0.5 ppm action limit. There are changes for the 15-min short-term exposure limit (STEL) of 2. or the action level of 0.5 ppm.[30] The ACGIH has given formalc an A2 designation, indicating that ACGIH considers formaldehy suspected human carcinogen. The ACGIH TLV/TWA for formaldehy 1.0 ppm and the TLV/STEL is 2.0 ppm.[31] The ACGIH has issued a Notice of Intended Change for formaldehyde to 0.3 ppm ceiling (TLV/C).[32] If, after two years, no evidence comes to light th questions the appropriateness of the proposed change, the val will be considered for adoption into the TLV listing.

D. PERCHLOROETHYLENE

Perchloroethylene (also called tetrachloroethylene) is a clea colorless, non-flammable liquid with an ether-like odor. Rep contact may cause a dry, scaly, and fissured dermatitis. Hig exposure to airborne concentrations may produce eye and nose irritation. Acute exposures have caused effects on the centr nervous system, mucous membranes, eyes, kidneys, liver, heart skin. Symptoms of overexposure include headache, dizziness, v and unconsciousness. [33] While perchloroethylene can be metabo from the body, the process is relatively slow. The substance deposited in body fat with a biological half-life estimated a days.

The National Cancer Institute (NCI), in a long-term animal st has demonstrated that perchloroethylene, administered by gava causes hepatocellular carcinoma (liver cancer) in laboratory of both sexes. [34] A two-year inhalation study done by the Nati Institutes of Health (NIH), National Toxicology Program (NTP) rats and mice has shown evidence of carcinogenicity from perchloroethylene exposure, in males and females of both spec In a NIOSH retrospective cohort mortality study of 1,690 dry cleaning workers having potential exposure to perchloroethyle deaths to liver cancer were observed.[36] However, NIOSH consic substances that cause cancer in experimental animals to also potential risk in humans. While safe levels of exposure to carcinogens have not been demonstrated, the probability of developing cancer is lowered by decreasing exposures to carcinogens. In this light, NIOSH recommends occupational ex to perchloroethylene be minimized while its carcinogenic pot in the workplace is further evaluated.

VI. RESULTS AND DISCUSSION

A. HVAC SYSTEM

Filter media in the HVAC systems were found to be clean, inta installed correctly in each of the seven units that were insp Outdoor air dampers, which are manually operated, were found to the greatest possible position. The Carrier three-ton uni a recent modification to the HVAC system, and was not install with an outdoor air intake. The unit served the SSA training and was configured with optional installation of an economize Economizers are used to provide outside air (dilution ventila as a means of providing "free cooling" to interior spaces. unit, in its condition without an economizer or a source of m air, did not provide any outside air to the indoor space. Th simply provided heating and cooling of recirculated building All condensate pans and drains appeared to be free of visible

of microbial growth. There were signs of water staining and damaged fiberglass duct liner in each of the mixing boxes on downstream side of the filter media on RTUs 12-17. The prese debris such as bugs and dirt on the downstream side of the fi suggests that filter bypass has occurred or that debris may b entraining into the system when the maintenance covers are re for servicing.

B. TEMPERATURE AND RELATIVE HUMIDITY

Average daily temperatures were 71°F (9:00 a.m.), 74°F (2:00 and 76°F (4:30 p.m.) in the occupied space. Increasing dail temperature was an obvious trend. A peak temperature of 81°F recorded late in the afternoon of the second day of the investigation in the multi-purpose room. The reason for the temperature in the multi-purpose was later determined to be a faulty fan motor on the HVAC unit serving the room. Accordin office manager, the problem was corrected and temperatures normalized. The RH measurements ranged from 19% to 26% with decreasing daily trend. The 9:00 a.m. average RH was 26%, 2:0 measured 21% and the 4:30 p.m. average was 21%.

The ASHRAE Standard 55-1981 specifies conditions in which 80% more of the occupants would be expected to find the environme thermally comfortable.[26] The thermal comfort range as specifie this standard is between 64°F and 74°F in winter months and b 73°F and 79°F in summer months. The comfort range for RH according to ASHRAE is 30% to 60%.

Considering the ASHRAE winter season temperature criteria (be 64°F and 74°F), average temperatures measured in the SSA spac outside the ASHRAE thermal comfort parameters. Average RH measurements were well below the ASHRAE parameters of 30% to 60% RH. Figure 1 presents temperature and RH measurements.

Smoke tubes were used to characterize air flow around supply diffusers. At several randomly selected locations, considera variations in air flow were observed using the smoke to compa diffusers having identical blueprint specifications for suppl Small desk fans were observed being used by a number of staff need for desk top fans in a properly operating, mechanically ventilated building suggests inadequate air distribution with space. This problem can be related to a number of causes, including HVAC system imbalance, "short-circuiting," or disru of room air flow within the room by office dividers or partit

C. CARBON DIOXIDE

Average indoor carbon dioxide measurements ranged in concentr from 525 ppm to 1000 ppm. Average airborne concentrations at 9 a.m. were 700 ppm, at 2 p.m. and 4:30 p.m. concentrations w 800 and 650 ppm, respectively. Peak concentrations of 900-10 were measured at 2 p.m. Figure 2 shows carbon dioxide trends a day of the investigation.

In the interest of clarification, it is important to stress t airborne concentrations of CO_2 as a chemical, are not thought responsible for health complaints in the range typically foun office settings. Outdoor concentrations of CO_2 average approximately 350 parts per million (ppm). When indoor concentrations approach 1000 ppm, insufficient dilution venti may exist within the occupied space which may indicate a pote IAQ problem. An increase in CO_2 level is seen when dilution ventilation (fresh, outside air) is lacking and the atmospher the occupied space may be perceived as stale, stuffy or perha thermally uncomfortable (often too hot). At the same time, n airborne contaminants (dusts, for example) or a combination o agents (thermal effects or chemical contaminants) may act in concert to produce health complaints. The percentage of peop that may or may not respond in an adverse manner in this situ is highly variable but some factors include current health or emotional status, pre-existing disease or a specific hypersensitivity (allergy). The ASHRAE Standard 62-1989, Ventilation for Acceptable Indoor Air Quality, recommends out air supply rates of 20 cubic feet per minute per person (cfm/person) for office to keep levels of CO_2 below 1000 ppm.[3]

D. FORMALDEHYDE

Six air samples were taken at various locations in the office evaluate for the presence of formaldehyde. As a background s one measurement was taken outdoors at the rear of the buildin six indoor air samples, only one measuring 1.7 micrograms per sample or 0.04 milligrams per cubic meter (mg/m^3) measured ab the minimum detectable concentration of 0.01 mg/m^3 based on a sample volume of 40 liters. For this set of samples the anal limit of detection (LOD) was reported as 0.5 micrograms per s (average sample volumes were 36 liters). The remainder of th indoor samples measured 1 or <1 micrograms per sample (an ave of .02 ppm). Values of 1 or <1 micrograms per sample were be the limit of detection (LOD) and the limit of quantitation (L for the method. These values cannot be considered "firm" num amounts and should be considered semi-quantitative. The concentration for the quantifiable sample was well below the

general industry standard PEL for formaldehyde of 0.75 ppm (0
mg/m^3). The outdoor sample was reported as non-detectable. I
recommends that exposure to formaldehyde be limited to the lo
feasible level since it is a potential human carcinogen.[29]

E. VOLATILE ORGANIC COMPOUNDS

Samples were collected at a flow rate of 20 cc/min over a sam
period of approximately five hours, for an average total samp
volume of 5.6 liters. Six samples were taken indoors and one
sample was taken outdoors as a comparison criteria to ambient

Samples were found to have detectable levels of five volatile
organic compounds: perchloroethylene, acetone, 1,1,1
trichloroethane, toluene and total xylenes. Perchloroethylen
present in a significantly greater proportion on each sample,
found above the MDC of 0.001 mg/m^3 based upon average sample
volumes of 5.6 liters. The laboratory reported limit of dete
was 50 nanograms per sample. Perchloroethylene, also called
tetrachloroethylene, is a common commercial dry cleaning solv
All of the VOCs detected were found at concentrations below
existing OSHA PELs. VOCs, like formaldehyde, have no specifi
regulatory criteria as air contaminants in the non-industrial
workplace. Tentative guidelines for acceptable exposures to
solvent-like VOCs have been proposed by Mølhave.[37] Total VOC
concentrations of <0.16 milligrams per cubic meter (mg/m^3) is
suggested as an amount for which irritation is not expected;
3.0 mg/m^3 is proposed as a range in which irritation and disc
are possible if other chemical exposures with additive effect
present. The range of discomfort (irritation and headache)
proposed by Mølhave is 3-25 mg/m^3 with irritation and discomf
probable outcomes; headache is possible if other additive eff
exposures interact. >25 mg/m3 is listed as a toxic concentra
Average levels of total VOCs found in the SSA District Office
0.45mg/m^3. Outside (ambient) air levels of total VOCs were 0
mg/m^3. The U.S. Ambient Air Quality Standards (AAQS) for
hydrocarbons is 0.16 mg/m3 averaged over 1 hour.[38]
Perchloroethylene was present at 0.30 mg/m^3 and 0.18 mg/m^3 in
indoor and outdoor air samples, respectively (Figure 3).

Concentrations of perchloroethylene in indoor air were found
consistently related to sampling location. Airborne concentr
of perchloroethylene in HVAC zones served by the new three to
unit, RT-12 and RT-13 were roughly double those areas within
space served by RT-14, RT-15 and RT-17. This is likely due t
physical location; RTs-12 and 13 are located closer to the dr

cleaners roof top exhaust. Figure 4 shows rooftop HVAC layou concentrations of perchloroethylene in relation to HVAC zone. recognizes perchloroethylene as a potential occupational carc and recommends that occupational workplace exposures be kept LFL.[33]

F. QUESTIONNAIRE RESULTS

Thirty-one questionnaires were received in response to the distribution to thirty-five full-time staff. Twenty, (71%) o respondents, had spent three or more years in the building. Eighteen (58%) reported spending an average of forty hours a in the building. Overall satisfaction with workplace cleanli and lighting was reported; twenty-two respondents (71%) repor their impression of the workspace to be very clean or reasona clean, and twenty-four respondents (77%) indicated that light was acceptable for working tasks. Workstation comfort was considered acceptable, with twenty-five (81%) and twenty-thre (74%) reporting a reasonably or very comfortable desk, and ch respectively.

Of the thirty-one respondents, the most common health complai were dry skin and dry, itching or irritated eyes. Both categ of symptoms were reported by fourteen individuals (42%). Hea was reported by ten employee (32%), 72% indicated that this s improved when they were away from work. Sneezing was reported eight individuals (26%). Eleven employee (37%) indicated tha experienced a dry throat several days a week or almost everyd however, an equal number reported not experiencing this sympt the last four weeks. Fifty percent of those experiencing dry throat reported disappearance of this symptom upon leaving wo Ten individuals (33%) reported being medically diagnosed as h an allergy to dust, 8 (28%) reported a medical diagnosed alle mold.

Thermal comfort complaints (temperature too hot) were reporte occurring several days a week to almost every day in twenty-o (75%) of the respondents. Twenty respondents (69%) reported the building was too dry every, or almost every day.

VII. CONCLUSIONS

Results of environmental monitoring and air sampling at the SSA District Office located in the Citadel Shopette in Colorado Spri Colorado indicate a likely cause of health complaints is the entrainment of outdoor air contaminants, specifically exhausted from an adjacent dry cleaning operation. Perchloroethylene, a c dry cleaning solvent, was the most predominant air contaminant m in both indoor, and outdoor air samples. Formaldehyde, an air contaminant often found in office areas, was measured above the only one of six indoor air samples at 0.04 mg/m3. Formaldehyde measured in outdoor air at levels above the MDC for the method u Relative humidity, measured at levels lower than a thermal comfo index recognized by ASHRAE, combined with poor air circulation a were factors likely to be related to occupant thermal comfort complaints.

VIII. RECOMMENDATIONS

The following recommendations were offered to provide acceptable air quality in the space.

1. Roof-mounted HVAC exhausts serving the dry cleaning establish should be evaluated and reconfigured to minimize reentrainmen exhaust effluent into outdoor air serving the SSA office spac The addition of a stack may be necessary to accomplish this. Properly designed stacks disperse exhausted air away from bui air intakes and into the ambient environment, allowing diluti take place. Stacks which are insufficient in height or locat close proximity to air handling units increase the possibilit reentrainment of stack gasses. An engineering firm familiar stack design and HVAC systems should be consulted to evaluate dry cleaning facility rooftop exhaust units at the Citadel Shopette. A practice generally accepted among designers of industrial stacks is to engineer stack height in relation to building height.[39] For buildings 1-3 stories, a simple rule f stacks is to use 0.5 x the building height. A building 10 fe high would require a 5 foot stack. This recommendation perta more specifically toward the building owner (The Olive Compan Correcting the situation is in the best interests of all buil occupants at the Citadel Shopette.

2. Air balance should be checked on the SSA HVAC system. A qual HVAC test and balance firm should be contacted to evaluate, t and balance the entire system. A properly balanced system sh result in an even distribution of supply air in the occupied and may alleviate thermal comfort problems. An evaluation sh be made to determine the amount of outside air delivered to t

space. The system should be adjusted to deliver a minimum of 15 cfm per person of outside air during periods of normal occ as specified in the 1989 ASHRAE standard.

3. The SSA space should be under positive atmospheric pressure relative to the outdoor environment and the adjacent business Each SSA roof top package unit should provide an outside infl volume which is at least 10% greater than the exhaust air vol from the area served.

4. Doors opening to the service hallway at the back of the dry cleaning establishment should be kept shut to prevent solvent vapors from migrating into the hallway and entering the SSA s This is particularly important because the SSA space was foun be under negative pressure, and the hallway could be acting a transport path for air contaminants migrating this known sour perchloroethylene.

5. The Carrier three-ton unit should be modified to bring in out air in accordance with the current ASHRAE recommendation. On method to accomplish this would be the addition of an economi A ventilation engineer should be consulted in regard to this particularly considering that unless the problem with the sta corrected, entrainment of outside air contaminants are a cont possibility.

6. Office cleaning (dusting and vacuuming) should be conducted **a** normal working hours when office staff have vacated the build The results of the questionnaire indicate that 33% of office personnel report a medically diagnosed allergy to dust. Vacu with traditional (low efficiency) vacuum cleaners can actuall increase levels of airborne dust, provoking upper respiratory symptoms or allergic asthma in sensitized individuals.

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