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I. SUMMARY

On January 2, 1992 the National Institute for Occupational Safety and Health (NIOSH) received a request to conduct a health hazard evaluation (HHE) at LORAL Command and Control in Colorado Springs, Colorado. The request was from LORAL management in response to LORAL employees in the specialty engineering section of Building 9975 who reportedly experienced skin rash and irritation, and a burning sensation on their face and in their nose and eyes when working in the building.

On August 24-25, 1992, an investigator from NIOSH conducted an indoor environmental quality (IEQ) investigation at Loral. Air samples were collected to determine the presence of volatile organic compounds (VOCs) which might be associated with XEROX™ copy machines. At one time, several of the machines had been located near the specialty engineering section; the area where IEQ complaints were reported. One chemical, polydimethylsiloxane, was reportedly found in previous air samples taken in this area and thought to responsible for, or associated with, complaints of poor IEQ and building-related illnesses. Styrene was reported by a LORAL employee as being a causative agent of her symptoms of chemical hypersensitivity. A walkthrough evaluation of the work area and an inspection of the heating, ventilation and air conditioning (HVAC) system was conducted. Measurements for carbon dioxide (CO_2), temperature and relative humidity (RH) were made to evaluate thermal comfort in the building. A questionnaire was also distributed to occupants in the area to characterize symptoms possibly associated with poor IEQ.

Air sampling results indicated that decamethycyclopentasiloxane, limonene, 1,1,2-trichloro-1,2,2-trifluroethane and cellosolve acetate were present on the sampling media. Branched alkanes (C_{10}-C_{11}), xylenes, hexanal and toluene were also present in trace amounts. Concentrations of total VOCs were low, reported by the NIOSH laboratory as less than 100 nanograms per sample using laboratory spiked standards for comparisons. Styrene monomer was not detected on any of the sampling media.

The results of air sampling for VOCs, temperature, RH and CO_2 measurements along with the results of a building survey do not indicate that a health hazard existed at the LORAL facility at the time of the investigation. While measurable concentrations of VOCs were found in the building, the pollutants were not in concentrations expected to produce building-related illness.

Keywords: SIC 7371 (Computer Software Systems Analysis and Design), Volatile organic compounds, VOCs, indoor environmental quality, IEQ, building-related illness, sick building syndrome.

II. INTRODUCTION

On August 24-25, 1992, an investigator from the National Institute for Occupational Safety and Health (NIOSH) conducted an indoor environmental quality (IEQ) health hazard evaluation (HHE) at the LORAL Command & Control Facility in Colorado Springs, Colorado. The investigation was performed in response to a request by management for a HHE regarding LORAL employees in the specialty engineering section who have reportedly experienced skin rash and irritation, and a burning sensation on their face and in their nose and eyes. According to the request, several employees have also experienced breathing problems which they said were only relieved when they left the building.

An opening conference was conducted on August 24, 1992. An overview of the HHE program and plans for the initial investigation were discussed at that time. LORAL management representatives and LORAL staff members from the specialty engineering section were present at the meeting to provide information regarding their perception of the building's air quality and to discuss their symptoms. Following the opening conference, a walkthrough familiarization of Building 9975 was conducted with the assistance of the facilities engineer. An interim report was sent to the requestor on January 7, 1993.

III. BACKGROUND

LORAL Command & Control Systems is a computer software development firm located in Colorado Springs, Colorado. According to LORAL management, the area within the facility where the IEQ problem exists is Building 9975, second floor, southwest quadrant. This building is approximately 10 years old and consists of two above-ground floors. It is a steel structure with concrete in place over metal decking. Heating, ventilating and air conditioning (HVAC) is supplied to the building with a variable air volume (VAV) system. The core of the building is heated passively with interior lighting and the heat provided by the building occupant load. Perimeter heat is supplied to the building with hot water (fin tube) coils in place beneath windows on the exterior wall. Make-up air is brought into the building through four roof-top mounted HVAC units. Two-inch pleated filter media are used in each of the rooftop units which serve

half of a floor of the building. Ceiling plenums are used for return air. Steam humidification is provided to the building during periods of low relative humidity which occurs mostly in the winter months when ambient humidity can be quite low.

Prior to the request for a NIOSH HHE, LORAL investigated possible indoor pollutant sources and other building-related problems thought to be affecting the quality of the indoor environment. Occupational Health Technologies, Inc. (OHT), of Pueblo, Colorado was retained to conduct a building investigation. Their reports dated January and March of 1992, indicated airborne formaldehyde concentrations ranged from 0.05 to 0.08 parts per million (ppm) with "no significant variations within the building." According to the contractor's report, indoor formaldehyde concentrations were suspected to increase when the air handlers were not in operation (presumably due to accumulated concentration from offgassing building furnishings). To evaluate this, the contractor performed sampling at night, when air handlers were not in service. However the airborne concentrations of formaldehyde were even lower at 0.02 and 0.03 ppm. Nuisance dust was sampled and reported at 0.2 milligrams per cubic meter (mg/m^3). Volatile hydrocarbons were sampled using charcoal tubes for periods of 120 to 140 minutes. According to the OHT report, a gas chromatography-mass spectroscopy (GC/MS) analysis "suggests that a compound of the siloxane family was present in the air samples." The report indicated that materials utilized in XEROX™ processing on the second floor area of Building 9975 may be responsible for the dimethylsiloxane compounds that were reported on the sampling media. The XEROX™ photocopy products that were used in the machines contained polydimethylsiloxane as the sole component (100%) of the fuser lubricant and fuser oil, according to a material safety data sheet supplied by XEROX™. The contractor's report provided a preliminary recommendation that reproduction equipment be consolidated into a separate room, or rooms, with a dedicated exhaust system and that the room be placed under negative pressure with respect to surrounding office environments. A second report from this firm was dated March 1992. In the second report, the contractor conducted further air sampling for low boiling hydrocarbons and halogenated hydrocarbons (NIOSH methods 1500 and 1003 respectively). The results of this report "suggest the presence of a compound of the siloxane family present in the air samples." The report stated that when the reproduction equipment was not operating, a drastic reduction of siloxane compound was noted in the sampling results. A third report from the same firm dated March 1992 indicated that sampling for silicon dioxide, hydrogen sulfide and dimethylpolysiloxane was conducted. The results reported silicon dioxide at 0.001 mg/m^3, and hydrogen sulfide at 0.03 ppm (± 25%). Sampling for the presence of ozone was conducted. The report stated that ozone was not detected. A limit of detection, however, was not reported. In an effort to isolate the photocopy process because it was suspected as a source of air contamination, the XEROX™ machines were moved into an adjacent, but separate building (Building 9970) in March of 1992.

IV. METHODS

Following the building walkthrough and HVAC evaluation by NIOSH, area air sampling was conducted in outside air and at seven locations in Buildings 9970 and 9975. The sampling was conducted for the presence of volatile organic compounds (VOCs) and was performed using personal sampling pumps, thermal desorption media, and standard SKC® charcoal tubes (100mg/50mg). Thermal desorption media for low-level VOCs were prepared by NIOSH using stainless steel tubes configured for thermal desorption in a Perkin-Elmer ATD 400 thermal desorption system. Carbotrap C™, Carbotrap™ and Carboxen™ were used as the sorbent media. After on-site flow calibration, area air samples were collected at a rates of 50 cubic centimeters per minute (cc/min) and 1 liter per minute (L/min) for thermal desorption media and charcoal tubes, respectively. Five locations were selected for sampling on the second floor of building 9975. Two desktop sampling locations in office cubicles were selected in the "K" and "H" sections of the southwest quadrant (2K211 and 2K311). This is the specialty engineering section, the location of the previous IEQ investigations. Two samples were also taken in office cubicles of the "G" section of the southwest quadrant (2G211 and 2G421), an area with reportedly less IEQ complaints. A sample was also taken in an office cubicle in the northwest quadrant (2B321). To evaluate for the presence of VOCs that might be released by the photocopying machines, two air samples were taken in the reproduction center of Building 9970. According to LORAL management these machines were previously located in Building 9975 and were believed to be a point source of VOCs (specifically siloxane compounds) that were related to complaints of poor IEQ. To compare indoor levels of VOCs to outdoor (ambient) concentrations, an outside air sample was taken at the air handler intake for the unit serving the second floor, southwest quadrant. To visually evaluate building pressurization, smoke was released from smoke tubes and observed near entrances to the building.

A questionnaire was distributed to staff in the southwest and northwest quadrants of the second floor on the afternoon of the second day of the investigation. The questionnaire was used to gather information on staff perceptions of the quality of the indoor environment and to characterize symptoms as a means to define complaint prevalence, evaluate symptom patterns, and determine occupants' perceptions of indoor thermal comfort.

Temperature and relative humidity (RH) measurements were made using a battery-operated, hand-held VelociCalc Plus Model 8360 and Vaisala™ HM 34 temperature and RH meters. A Gastech™ Model RI-411A portable carbon dioxide (CO_2) monitor was used to measure CO_2 concentrations. Real-time measurements were made in office cubicles and hallways, during the morning, at mid-day, and in the afternoon.

A Met One Model 227 hand-held laser particle counter was used to evaluate airborne particulate concentrations in the same occupied areas of the southwest and northwest quadrants of Building 9975 for which VOC sampling was conducted.

V. EVALUATION CRITERIA

A number of published studies have reported high prevalences of symptoms among occupants of office buildings.[1-5] NIOSH investigators have completed over 700 investigations of the indoor environment in a wide variety of settings. The majority of these investigations have been conducted since 1979.

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

Scientists investigating indoor environmental problems believe that there are multiple factors contributing to building-related occupant complaints.[6,7] Among these factors are imprecisely defined characteristics of 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] Reports are not conclusive as to whether increases of outdoor air above currently recommended amounts ($\geq$15 cubic feet per minute per person) are beneficial.[14,15] However, rates lower than these amounts appear to increase the rates of complaints and symptoms in some studies.[16,17] Design, maintenance, and operation of HVAC systems are critical to their proper functioning and provision of healthy and thermally comfortable indoor environments. Indoor environmental pollutants can arise from either outdoor sources or indoor sources.[18]

There are also reports describing results which show that occupant perceptions of the indoor environment are more closely related to the occurrence of symptoms than the measurement of any indoor contaminant or condition.[19-21] Some studies have shown relationships between psychological, social, and organizational factors in the workplace and the occurrence of symptoms and comfort complaints.[21-24]

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, no cause of the reported health effects could be determined.

Chemical or biological 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.[25-27] 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.[28-29] 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 effluents.[30]

Measurement of airborne indoor environmental contaminants often has not proved to be helpful, in the general case, in determining the cause of symptoms and complaints except where there are strong or unusual sources, or a proved relationship between a contaminant and a building-related illness. However, measuring ventilation and comfort indicators, such as CO_2, temperature and RH, are useful in the early stages of an investigation in providing information relative to the proper functioning and control of HVAC systems. The basis for the measurements made in this investigation are presented below.

A. Carbon Dioxide (CO_2)

Measuring airborne concentrations of CO_2, a normal component of exhaled air, is a practice employed in indoor environmental investigations to characterize the degree of dilution ventilation supplied to a building. Dilution ventilation refers to the amount of fresh, outside air, which is being supplied to a building. CO_2 is a normal constituent of exhaled breath and, if monitored, can be used as a screening technique to evaluate whether adequate quantities of fresh air are being introduced into an occupied space. The ASHRAE Standard 62-1989, Ventilation for Acceptable Indoor Air Quality, recommends outdoor air supply rates of 20 cubic feet per minute per person (cfm/person) for office spaces and conference rooms, 15 cfm/person for reception areas, and 60 cfm/person for smoking lounges, and provides estimated maximum occupancy figures for each area.[28]

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

B. Temperature and Relative Humidity

The perception of comfort is related to one's metabolic heat production, the transfer of heat to the environment, physiological adjustments, and body temperatures. Heat transfer from the body to the environment is influenced by factors such as temperature, humidity, air movement, personal activities, and clothing. ANSI/ASHRAE Standard 55-1981 specifies conditions in which 80% or more of the occupants will find the environment thermally comfortable.[29] The thermal comfort range specified by Standard 55-1981 is between 64°F and 74°F in winter months and between 73°F and 79°F in summer months. For RH the comfort range according to ASHRAE is 30% to 60%.

VI. RESULTS

A. Temperature and Relative Humidity

Temperature measurements in the southwest quadrant ranged from 67°F to 72°F. Average temperatures were 67°F, 69°F, and 72°F for morning, mid-day and afternoon periods, respectively. RH was measured at 49%, 47% and 47% during the same periods. As could be expected in an occupied building, a slight increasing trend for daily indoor temperature was seen.

Temperature measurements taken in occupied areas of Building 9975 were found to be less than the summer ASHRAE thermal comfort range of 73°F and 79°F. RH measurements were within the ASHRAE guideline range of 30 to 60 percent relative humidity. Some complaints of temperature being too low in the building could be expected from building occupants if the temperatures measured within the building on the day of the investigation were consistent throughout the summer months.

B. Carbon Dioxide Measurements

Instantaneous measurements of airborne CO_2 measured in Building 9975 ranged in concentration from 450 ppm to 750 ppm. Based on an ASHRAE guideline building occupancy of seven people per 1000 square feet the monitoring results suggest that adequate dilution ventilation is supplied to this building. Generally, in the absence of a known source of indoor CO_2, concentrations in occupied buildings at or above 1000 ppm suggest that dilution ventilation (fresh, outside air) may be insufficient. When this occurs, the atmosphere in the occupied space may be perceived as stale, stuffy or perhaps thermally uncomfortable (often too hot). When the supply of fresh air is lacking, normal airborne contaminants (dusts, for example) or a combination of agents (thermal effects or chemical contaminants) may act in concert to produce health complaints. The percentage of people that may or may not respond in an adverse manner in this situation is highly variable but some factors include current health or emotional status, pre-existing disease or a specific hypersensitivity (allergy).

C. HVAC Inspection, Rooftop Units

All four of the roof-top air handling units (AHUs) were inspected. The outside air dampers on all of the roof-top units were found to be open to the fullest possible position. This appears consistent with the overall low levels of CO_2 measured in the building since an ample supply of outside air will dilute CO_2 produced by building occupants. All filters in each of the rooftop units were found to be correctly installed and were clean, a sign of recent maintenance. There was no evidence of filter bypass in any of the filter supports and an adequate seal was noted between the filter panels and the maintenance access door. Condensate drain pans were found to be free of evidence of microbial contamination and appeared to drain adequately. Three water samples taken from the condensate drain traps were obtained. The traps were full of water at the time of the investigation and several appeared to harbor material which looked like a biological growth. A microscopic examination of the samples was performed by a NIOSH environmental microbiologist. The samples were determined to contain yeasts and the fungi alternaria and cladosporium. These organisms are normal atmospheric flora (ubiquitous organisms) and would not appear to present a problem.

D. Air Sampling

The major chemical compounds that were identified on the sampling media (listed in order of prevalence) included decamethycyclo-pentasiloxane, limonene, 1,1,2-trichloro-1,2,2-trifluroethane and cellosolve acetate. Branched alkanes (C_{10}-C_{11}), xylenes, hexanal and toluene were also present in trace amounts. Copies of reconstructed total ion chromatograms using GC/MS techniques were received from the NIOSH analytical laboratory. GC/MS, a method of chemical analysis that involves separation of a chemical compound into its components (GC) and then identification of the components based on their mass distribution (MS), is a tool often used for characterization of trace quantities of chemical contaminants collected on air sample media.

The types of compounds detected on the five samples taken in Building 9975 were similar for all of the sampling locations. The relative amounts of analyte varied among sample locations, but concentrations of total VOCs were reported by the laboratory to be less than 100 nanograms per sample using laboratory spiked standards for comparisons. Styrene monomer, a chemical of concern due to a reported chemical hypersensitivity by one employee, was not detected on any of the media in any of the sampling locations in either of the buildings.

Air samples taken in the photocopy area of Building 9970 (the current location of the XEROX™ machines) indicated lower overall concentrations of total VOCs in this area, compared to the sampling locations in the southwest or northwest quadrant of Building 9975. The outdoor air sample taken at the fresh air intake of the southwest quadrant of Building 9975 (rooftop AHU) showed an absence of any VOCs as reported on the sampling media.

Indoor airborne particulate concentrations of 0.3 microns measured with the Met One Model 227 laser particle counter were found to be approximately 20% less than levels in outdoor air. Particulates of 5 microns were slightly higher indoors than in outdoor air. Overall concentrations of respirable particulates were judged to be very low based on these monitoring results.

VII. DISCUSSION AND CONCLUSIONS

Results of the HVAC system inspection, employee interviews, building survey, temperature, RH, ventilation, and CO_2 monitoring, suggest that the health problems experienced by employees at LORAL are not likely to be related to temperature control or a lack of sufficient dilution ventilation in the building. The HVAC system was found to be in good operational and mechanical condition. The building was found to be under positive pressure, which is the design specification.

Air sampling results using thermal desorption tubes indicate that very low levels of VOCs were present within the building on the day that sampling was conducted. Air sampling results did not indicate the presence of styrene (reportedly a contaminant of concern) in any of the locations that were sampled.

Decamethycyclopentasiloxane, a siloxane compound, was present on samples collected in both the southwest and northwest quadrants of Building 9975. NIOSH experience using thermal desorption media has shown that siloxanes are quite often found when using thermal desorption techniques. Since siloxane compounds are present in GC capillary columns (the portion of the GC which facilitates separation of chemical compounds) siloxanes may be "artifact" or background on analytical results. In this situation, that does not appear to be the case since the analyte was not detected on either of two field blanks. It is more likely that siloxanes are present as ubiquitous trace quantities in indoor environments since they are quite commonly used in sealants containing silicone fluids and elastomers. This is one explanation for the presence of these compounds in so many IEQ investigations. Dimethylpolysiloxane is used in pharmaceutical preparations as an antifoaming agent and in products used for the treatment of certain digestive disorders.

While the analytical results indicate the presence of a siloxane compound in the air samples taken in Building 9975, abundance of siloxane (and total VOCs) in the two samples taken in the photocopy area of Building 9970 were less than those area samples taken in cubicles and common areas of Building 9975. This is contrary to what would be expected in Building 9975 since the photocopy machines are a known source of siloxane (and possibly VOCs) yet they are no longer located in this building. It is important to note that the VOCs in either Building 9975 or 9970 were found in very low concentrations.

A NIOSH building survey questionnaire was distributed to 125 people. 118 surveys were returned for a response rate of 94.4%. However, not all questionnaires were completed in their entirety, and in some sections missing responses to certain questions were greater than 50%. This was most often the case for questions relating to changes in symptomology after leaving the building.

Age of the respondents was found to be bimodally distributed at ages 35 and 47. Gender was 78% male and 22% female. Of the occupants responding to length of time worked in the building, 74% percent reported a length of one to three years (55/74).

67% percent reported working 40 hours a week (79/118). 87% (85/118) reported a reasonably clean workspace with 13% (15/118) reporting somewhat dusty or very dusty or dirty. Lighting was judged to be acceptable, with 70% (82/118) reporting lighting at the workstation to be just right. 64% (75/118) reported a reasonably comfortable setup of the workstation.

18% of respondents reported a medically diagnosed allergy to dust and to molds (21/116). 24% (28/116) reported a diagnosis of hay fever. 35% (41/118) reported that they believed that they were particularly sensitive to chemicals.

The most common health complaints reported to occur 1-3 days a week to almost every day, included: dry, itching and irritated eyes; 35% (39/113); headache; 27% (30/112); and tiredness/fatigue; 32% (36/113). Strained eyes was a symptom reported by 34% (38/112) of respondents. Nose and sinus problems were reported occurring on the same frequency mentioned previously, in 32% (37/114) of the respondents. Skin rash however, was reported in only 5% (6/110) of respondents. Dizziness and mental fatigue were reported by 9% and 15% (10/112 and 17/111) of employees, respectively. Responses to above questions regarding changes in symptomology when employees were away from work, were missing in more than 50% of the respondents, for each of the questions. Because of this, the responses are not believed to be representative of the survey group as a whole, and were not taken into consideration. However for the reported responses, the general trend was an improvement in perceived symptoms while away from work.

Regarding thermal comfort issues, 35% (39/113) reported too little air movement 1-3 days a week or almost every day. An environment too hot for comfort was reported by 23% (26/112). Temperatures perceived as being too cold were reported by 18% (20/110).

Those individuals completing the questionnaire were comprised of 6% managerial (7/117), 41% professional (48/117), and 45% technical (53/117). Secretaries, clerical and other job categories comprised the remaining employee job titles. Job satisfaction was reported as being very satisfied in 38% (44/116) and somewhat satisfied in 48% (56/100) of employees. Employees reported being not too satisfied, or not at all satisfied, in 14% (14/116) of respondents.

The results of the building survey questionnaire indicate that the symptoms reported by LORAL employees are consistent with symptoms reported by other individuals in buildings investigated for "sick building syndrome." The results of the NIOSH investigation and the environmental sampling results revealing low levels of a number of organic compounds agreed with results obtained in a previous investigation conducted by contractors retained by LORAL. Exposure to the low levels of chemicals found on the sampling media does not adequately explain the illnesses described to the NIOSH investigator by the affected staff at Loral. Cases of non-specific employee illness associated with building occupancy have been found to be associated with changes in the work environment, building renovation, carpet installation and new furnishings. The exact physiologic mechanisms that are associated with possible cases of building-related illnesses are not known at the

present time. The World Health Organization has estimated that up to 30% of workers in modern office buildings may be experiencing symptoms similar to those reported by LORAL employees. As mentioned before, the precise cause of the sick building syndrome is poorly understood, but some investigators have postulated that additive or synergistic effects (exposure to different chemical compounds producing a combination of effects) may be related to symptoms that affect different individuals in a variety of ways.[32]

The environmental sampling data from this investigation do not support an association between the present location of the copy machines and increased levels of indoor air contaminants. In fact, the opposite was found to be the case. No source contaminants were found during this investigation which are believed to be associated building-related illness. While modern building environments are suspected of producing levels of indoor chemical contaminants capable of causing certain hypersensitive individuals to respond in an adverse manner, the results of this investigation do not indicate that a health hazard exists in either of the buildings investigated during this HHE.

VIII. RECOMMENDATIONS

Based on initial interviews with LORAL staff employed in the specialty engineering section and continuing communication with LORAL management and building engineering personnel, it appears that a certain percentage of employees report health symptoms and continue to experience discomfort in the southwest corner of Building 9975. The situation remains unresolved despite significant efforts which were made to identify source contaminants, remediate the problem by isolating suspected sources and, providing increasing amounts of dilution ventilation and adjustments to the HVAC system. It appears that engineering, and logistical efforts to this point, have proven to be ineffective at remedying this problem. It is reasonable then, to propose that a technical solution to this problem, does not appear possible, at least at the present time. A small percentage of employees may continue to register complaints of discomfort regardless of changes made in the building and adjustments made to the HVAC system. With this in mind, the only reasonable recommendation that may be made at this time, is that LORAL staff and management continue to work to identify if any specific changes to the building or work environment can be made which will produce a positive outcome in terms of occupant comfort in those areas of the building which are affected. It is important to mention that the focus of IEQ issues should be directed, in terms of outcome, as health and comfort based, and not disguised as labor-management issues. One option may be to consider if workable alternatives are possible for on-site, and possibly off-site employment accommodations that balance productivity and the mission of the organization, with the need for employee comfort and job satisfaction while working in the building.

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