INDOOR AIR QUALITY ASSESSMENT

Massachusetts Department of Developmental Services
Charles River West Area Office
255 Elm Street, Suite 205
Somerville, MA 02144

Prepared by:
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Bureau of Environmental Health
Indoor Air Quality Program

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Background/Introduction

At the request of Kevin Buckley, Business Manager for the Massachusetts Department of Developmental Services' (MDDS) Metro Region Office, the Massachusetts Department of Public Health (MDPH), Bureau Environmental Health (BEH) provided assistance and consultation regarding indoor environmental and health concerns at the MDDS' Charles River West Area Office at the Gorin Building, 255 Elm Street, Somerville, Massachusetts. The request was made in response to reports of respiratory irritation suspected of being related to indoor air quality concerns. On May 19, 2009, a visit to conduct an indoor air quality (IAQ) assessment was made by Michael Feeney, Director, of the Bureau of Environmental Health's (BEH) IAQ Program, and Sharon Lee, an Environmental Analyst within the BEH's IAQ Program

The MDDS occupies an office suite on the second floor of the Gorin Building, which was constructed in 1986. The three-story Gorin Building also houses a theatre on the first floor, a lawyer's office and massage therapy facility on the second floor, and a real estate office on the third floor. The MDDS has occupied the Gorin Building since the early 1990s. The suite was renovated based on specifications made by the MDDS prior to occupancy.

Methods

Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 7565. Air tests for airborne particulate matter with a diameter less than 2.5 micrometers were taken with the TSI, DUSTTRAK™ Aerosol Monitor Model 8520. BEH staff also performed a visual inspection of building materials for water damage and/or microbial growth. Tests were taken during normal operations, and results appear in Table 1.

Results

The MDDS has an employee population of approximately 30 and can be visited by up to 10 people daily. Testing was conducted during normal operations and results appear in Table 1. Locations of tests are indicated in Figure 1.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were elevated above 800 parts per million (ppm) in all areas sampled, indicating less than adequate air exchange. Fresh air is introduced into the ceiling plenum (the space above the suspended ceiling tile system) by three air-handling units (AHUs) located on the building's rooftop (Pictures 1 to 3). Heat pumps located above the suspended ceiling tile system (Picture 4) draw air from the ceiling plenum and distribute filtered air to occupied areas via ceiling-mounted air diffusers (Picture 5). Filters are reportedly changed four times a year, or more frequently as needed. Filters were reportedly changed approximately 2 weeks prior to the BEH assessment. During the summer months, additional cooling is reportedly provided by a cooling unit located in the server room (Picture 6). Air supplied to offices is pressurized into the hallway, where exhaust vents return air to the AHUs (Picture 7).

Each of the AHU units is controlled by a thermostat. At the time of assessment, BEH staff observed that all thermostats in the fan "auto" setting (Picture 8). In the auto setting, the thermostat activates the HVAC system at a preset temperature. Once the preset temperature is reached, the HVAC system is deactivated. Therefore, no mechanical ventilation is provided until the thermostat re-activates the system. For example, at the time of assessment, one of the thermostats was set to 75 ^{o}F (Picture 8). Since the thermostat is set to 75^{o}F, the HVAC would not be activated until that temperature is reached indoors. Since the temperature in the majority of areas assessed was below 75^{o}F, the thermostat did not activate the AHU to provide conditioned fresh air (Table 1). Limiting the provision of fresh air can contribute to an increase in carbon dioxide levels and a decrease in the comfort of building individuals. Consideration should be given to operating the thermostat at a lower setpoint and with the fan in the on mode when the building is occupied.

To maximize air exchange, the MDPH recommends that both supply and exhaust ventilation operate continuously during periods of occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. It is recommended that HVAC systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994). The date of the last balancing of these systems was reportedly at the time of installation.

The Massachusetts Building Code requires that each room have a minimum ventilation rate of 20 cubic feet per minute (cfm) per occupant of fresh outside air or openable windows (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded.

When this happens, a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The MDPH uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, please see Appendix A.

Temperature measurements ranged from 69^{o} F to 76^{o} F, which were within the MDPH recommended comfort guidelines in most areas surveyed during the assessment. The MDPH recommends that indoor air temperatures be maintained in a range of 70^{o} F to 78^{o} F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

Although temperatures measured were within MDPH guidelines during the assessment, complaints of thermal discomfort and stuffiness were expressed by several MDDS staff members. In an attempt to increase thermal comfort, occupants reportedly adjust the thermostat settings. Repeated adjustments of the thermostat have reportedly damaged the AHUs in the past. During the winter of 2004-2005, repeated changes to the thermostat reportedly resulted in frequent freezing/thawing of snow and ultimately ice buildup on the roof, near the equipment. This reportedly resulted in pipe and AHU damage, leaks to the building, and failure of the

HVAC equipment. The failed unit was subsequently replaced. As discussed, the thermostats for the AHU are set to fan auto. Setting the fans to the on position while the building is occupied will allow for continuous air circulation that would increase comfort for building occupants and decrease carbon dioxide levels. Additionally, building management should work with MDDS staff establish a thermostat setpoint for both the heating and cooling season to improve thermal comfort. Building occupants should refrain from repeated manual adjustments to the thermostats as this can change the setpoint, which can result in reduced air supplied to the areas and increase comfort complaints.

The relative humidity in the building ranged from 30 to 37 percent, which was below the MDPH recommended comfort range in all areas surveyed on the day of the assessment. The MDPH recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is common during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

At the time of the assessment, BEH staff observed water leaking from the air-conditioning unit located in the computer server room. Carpeting was saturated from the leak (Picture 9). BEH staff immediately notified Mr. Wallach of the leak. Mr. Wallach contacted the building management; the building managers promptly assessed the server room, contacted the HVAC service technician regarding the unit, and brought industrial fans to dry carpeting. The

HVAC technician reportedly indicated that he would provide on-site response and asked that the system be turned off in the interim.

Water-damaged ceiling tiles were noted in several areas (Picture 10), likely from pipe leaks or condensation formed on pipes and subsequently dripping on tiles below. Ceiling tiles should be replaced after a water leak is discovered and repaired. Missing ceiling tiles observed in some areas can result in uneven heating and/or cooling conditions as well as movement of particles into occupied areas.

Open seams between sink countertops and walls were observed in several rooms (Picture 11). If not watertight, water can penetrate through the seam, causing water damage. Improper drainage or sink overflow can lead to water penetration into the countertop, cabinet interior and areas behind cabinets. Water penetration and chronic exposure of porous and wood-based materials can cause these materials to swell and show signs of water damage. Repeated moistening of porous materials can result in mold growth.

The US Environmental Protection Agency (US EPA) and the American Conference of Governmental Industrial Hygienists (ACGIH) recommend that porous materials be dried with fans and heating within 24 to 48 hours of becoming wet (US EPA, 2001; ACGIH, 1989). If not dried within this time frame, mold growth may occur. Once mold has colonized porous materials, they are difficult to clean and should be removed/discarded.

Plants were observed in several areas. Some plants did not have drip pans. Plant soil and drip pans can serve as a source for mold growth. Plants should be properly maintained and be equipped with drip pans. Over-watering should also be avoided. Plants should also be located away from the air stream of mechanical ventilation to prevent aerosolization of dirt, pollen or mold.

Other IAQ Evaluations

Indoor air quality can be negatively influenced by the presence of respiratory irritants, such as products of combustion. The process of combustion produces a number of pollutants. Common combustion emissions include carbon monoxide, carbon dioxide, water vapor and smoke (fine airborne particle material). Of these materials, exposure to carbon monoxide and particulate matter with a diameter of 2.5 micrometers (μm) or less (PM2.5) can produce immediate, acute health effects upon exposure. To determine whether combustion products were present, BEH staff obtained measurements for carbon monoxide and PM2.5.

Carbon Monoxide

Carbon monoxide is a by-product of incomplete combustion of organic matter (e.g., gasoline, wood and tobacco). Exposure to carbon monoxide can produce immediate and acute health affects. Several air quality standards have been established to address carbon monoxide and prevent symptoms from exposure to these substances. The MDPH established a corrective action level concerning carbon monoxide in ice skating rinks that use fossil-fueled ice resurfacing equipment. If an operator of an indoor ice rink measures a carbon monoxide level over 30 ppm, taken 20 minutes after resurfacing within a rink, that operator must take actions to reduce carbon monoxide levels (MDPH, 1997).

The American Society of Heating Refrigeration and Air-Conditioning Engineers (ASHRAE) has adopted the National Ambient Air Quality Standards (NAAQS) as one set of criteria for assessing indoor air quality and monitoring of fresh air introduced by HVAC systems (ASHRAE, 1989). The NAAQS are standards established by the US EPA to protect the public health from six criteria pollutants, including carbon monoxide and particulate matter (US EPA, 2006). As recommended by ASHRAE, pollutant levels of fresh air introduced to a building should not exceed the NAAQS levels (ASHRAE, 1989). The NAAQS were adopted by reference in the Building Officials & Code Administrators (BOCA) National Mechanical Code of 1993 (BOCA, 1993), which is now an HVAC standard included in the Massachusetts State Building Code (SBBRS, 1997). According to the NAAQS, carbon monoxide levels in outdoor air should not exceed 9 ppm in an eight-hour average (US EPA, 2006).

Carbon monoxide should not be present in a typical, indoor environment. If it *is* present, indoor carbon monoxide levels should be less than or equal to outdoor levels. Indoor measurements were non-detect (Table 1).

Particulate Matter (PM2.5)

The US EPA has established NAAQS limits for exposure to particulate matter. Particulate matter is airborne solids that can be irritating to the eyes, nose and throat. The NAAQS originally established exposure limits to particulate matter with a diameter of 10 μm or less (PM10). According to the NAAQS, PM10 levels should not exceed 150 microgram per cubic meter ($\mu g/m^3$) in a 24-hour average (US EPA, 2006). These standards were adopted by both ASHRAE and BOCA. Since the issuance of the ASHRAE standard and BOCA Code, US EPA established a more protective standard for fine airborne particles. This more stringent PM2.5 standard requires outdoor air particle levels be maintained below 35 $\mu g/m^3$ over a 24-hour average (US EPA, 2006). Although both the ASHRAE standard and BOCA Code adopted the PM10 standard for evaluating air quality, MDPH uses the more protective PM2.5 standard for evaluating airborne particulate matter concentrations in the indoor environment.

PM2.5 levels measured inside ranged from 4 to 8 μg/m^3 (Table 1), which were below the NAAQS PM2.5 level of 35 μg/m^3 and levels measured outdoors. Frequently, indoor air levels of particulates (including PM2.5) can be at higher levels than those measured outdoors. A number of mechanical devices and/or activities that occur in offices can generate particulate during normal operations. Sources of indoor airborne particulates may include but are not limited to particles generated during the operation of fan belts in the HVAC system, cooking in the cafeteria stoves and microwave ovens; use of photocopiers, fax machines and computer printing devices; operation of an ordinary vacuum cleaner and heavy foot traffic indoors.

At the time of assessment, MDDS staff were concerned with dust accumulation on exhaust vents. Dust was reportedly cleaned from these vents recently. At the time of assessment, BEH staff did not observe dust on any exhaust vents. However, BEH staff did observe dust on supply vents, personal fans, and sprinklers. Dust/dirt was observed on the metal casings of supply vents (Picture 12), likely the result of air passing over the metal casing which creates a static charge that attracts dust particles. Occasion wet wiping/cleaning of supply and exhaust vents should be conducted to prevent dust accumulation and re-aerosolization. Similarly, personal fans should also be cleaned regularly to prevent aerosolization of dust accumulated on fan blades/housing when the unit is activated. Dust accumulated on sprinkler heads should be removed to prevent clogging of the head.

Additional sources that can contribute to odors/irritants in building include the configuration of food warming appliances and cleaning products/air deodorizers. BEH staff observed a toaster oven and microwave stacked under a cabinet in the kitchen (Picture 13). Of particular concern is the proximity of the toaster oven to the cabinet. The lack of open space around these appliances prevents heat and odors from dissipating. Overtime, heat generated by the toaster oven can cause the cabinet to delaminate and off-gas volatile organic compounds (VOCs), which are irritating to the eyes, throat, and respiratory system. This configuration can also be a fire hazard.

Air fresheners and cleaners were also observed in the MDDS suite. Air fresheners and cleaners contain a number of chemicals, including volatile organic compounds (VOCs). VOCs are materials that can cause eye, nose and respiratory irritation. Some hypersensitive individuals may experience irritant symptoms when exposed. Air deodorizers contain chemicals that can be irritating to the eyes, nose and throat of sensitive individuals. Many air fresheners contain 1,4-dichlorobenzene, a VOC which may cause reductions in lung function (NIH, 2006). Furthermore, deodorizing agents do not remove materials causing odors, but rather mask odors that may be present in the area.

Conclusions/Recommendations

The conditions observed in MDDS suite appear to be related to lack of continuous supply and exhaust ventilation coupled with adjustments of the thermostat on a daily basis by multiple individuals. Low relative humidity typical of fall/winter months in New England and use of VOC containing materials (i.e. cleaners) also plays a role in contributing irritants to the indoor environment.

In view of findings at the time of assessment, the following recommendations are made:

1. Consider operating the thermostat fan setting in the ‘on’ mode while the building is occupied to provide adequate fresh air to the building.
2. Refrain from manual adjustments to the thermostat to prevent increases in comfort complaints and to allow for adequate air provision within the suite. Building

management should work with MDDS staff to determine an optimal thermostat setpoint to improve occupant comfort and prevent damage to AHUs.

3. Balance the HVAC system to ensure appropriate delivery of fresh air, *after* the return vents are repositioned.

4. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, regular scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a HEPA filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

5. Replace water-damaged ceiling tiles once leaks are repaired.

6. Seal breach between sink countertop and backsplash to prevent water infiltration.

7. Clean supply and exhaust vents and sprinklers to prevent accumulation of dust and debris.

8. Clean personal fans to prevent aerosolization of dusts.

9. Relocate the toaster oven and microwave away from cabinet and place in area that allows for odors and heat to dissipate the top, sides, and back of the appliances.

10. Eliminate the use of air deodorizers.

11. Reduce the use of VOC-containing cleaners in work areas.

References

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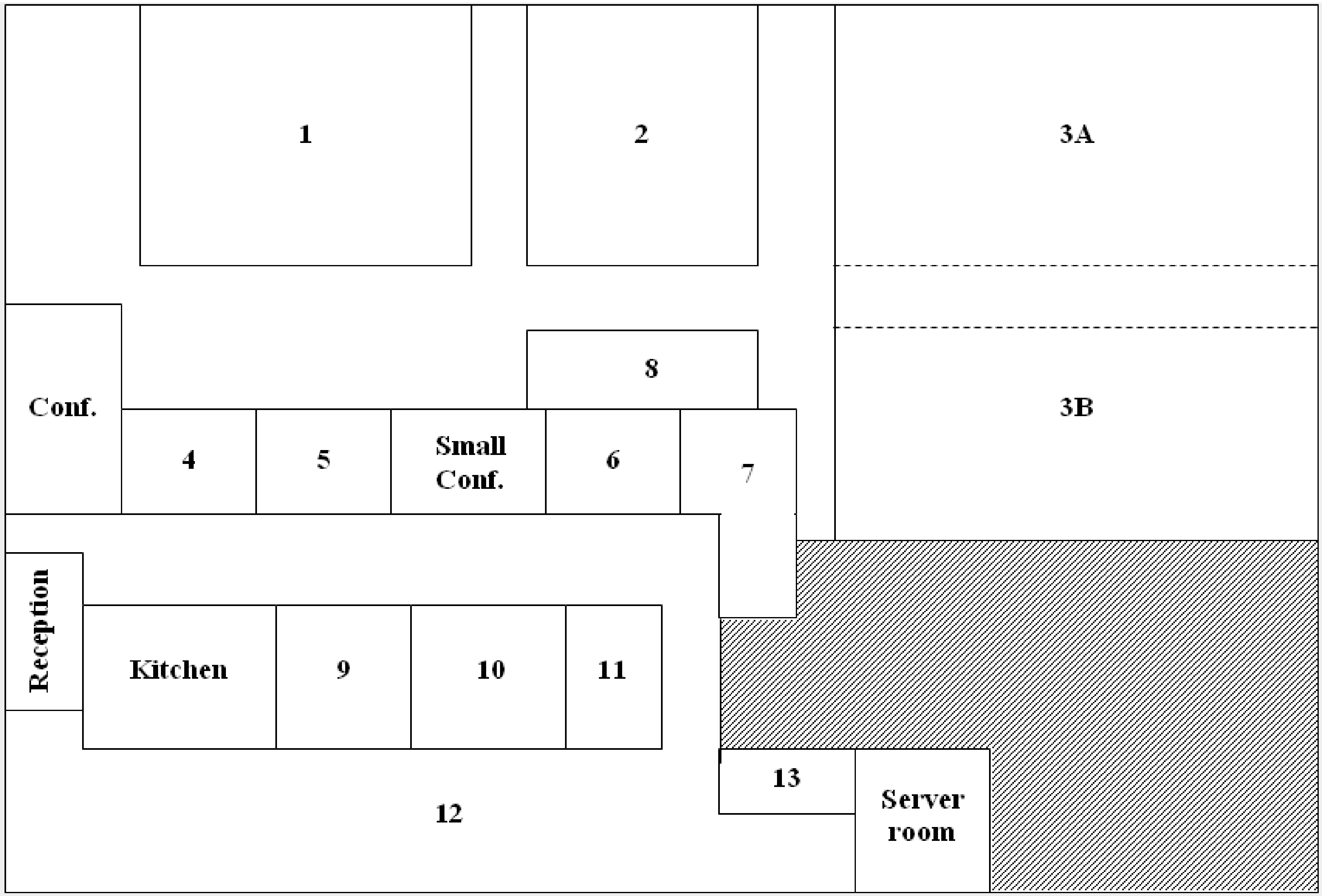
Figure 1



Approximate Layout of MDDS Suite

Picture 1

Rooftop AHU #1

Picture 2

Rooftop AHU #2

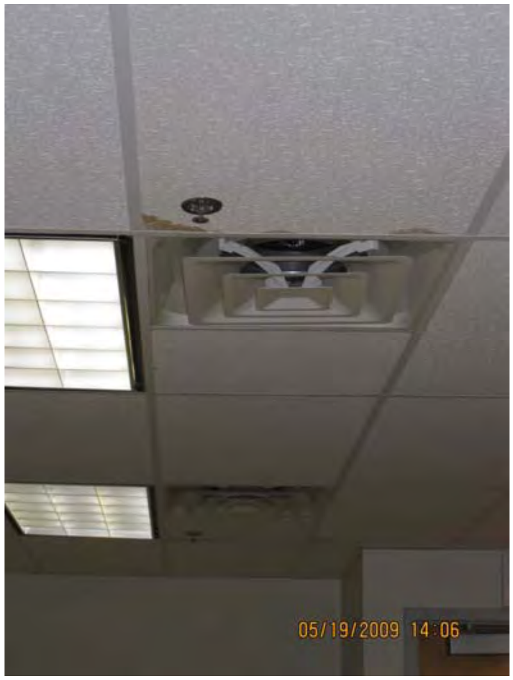
Picture 3

Rooftop AHU #3

Picture 4

Heat pump in ceiling plenum

Picture 5



Ceiling-mounted supply vents

Picture 6

Cooling unit in server room

Picture 7

Ceiling-mounted exhaust vent

Picture 8

Thermostat Fan set to auto, temperature pre-set to 75 ^{o} F

Picture 9

Wet carpet from leaking cooling unit

Picture 10

Water-damaged ceiling tile

Picture 11

Breach between sink countertop and backsplash

Picture 12

Dust on supply vent metal casing

Picture 13

Toaster oven and microwave placed below cabinet

Location: MDDS Charles River West Area Office **Indoor Air Results**

Address: 255 Elm Street, Somerville, MA **Date: 5.19.2009**

Table 1

Location	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	PM2.5 (ug/m3)	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
Outside (Background)		76	26	433	ND	13				Sunny, street traffic
Conference room	0	74	32	1032	ND	6	N	Y	N	DO, 1 WD-CT
Kitchen	1	70	32	1078	ND	4	N	Y	N	DO, toaster oven stacked on microwave with little air space
Reception	1	71	32	1104	ND	4	N	Y	N	DO
Server room	0	74	31	1129	ND	5	N	Y	N	Air-conditioner actively leaking; carpet visibility saturated
Small conference	3	75	37	1494	ND	8	N	Y Cycled off	N	DO
1	3	76	33	1208	ND	6	N	Y Cycled off	Y	DO, plants, 1 WD-CT
2	1	76	32	1188	ND	6	N	Y Cycled off	Y	DO
3A	0	75	33	1099	ND	8	N	Y Cycled	Y	DO, PF, cleaners/deodorizers, exhaust vent recently cleaned;

ppm = parts per million
ug/m3 = micrograms per cubic meters

AT = ajar ceiling tile
design = proximity to door
DO = door open

DEM = dry erase materials
GW = gypsum wallboard
MT = missing ceiling tile

ND = non detect
PC = photocopier
PF = personal fan

TB = tennis balls
VL = vent location
WD = water-damaged

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

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Table 1 (continued)

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								Supply	Exhaust	
								off		complaints about dust
3B	2	73	33	1113	ND	5	N	Y	Y	DO
4	0	71	31	1030	ND	4	N	Y	N	DO
5	1	72	31	1190	ND	5	N	Y	N	DO, PF
6	1	72	32	1138	ND	4	N	Y	N	DO, items
7	2	72	32	1207	ND	5	N	Y	N	DO, PF, plants
8	1	75	32	1127	ND	5	N	Y	Y	DO
11	0	72	31	1190	ND	5	N	Y	N	DO
12	2	69	32	1080	ND	4	N	Y	N	Dusty sprinklers, 4 WD-CT, 1 MT
13	1	75	30	1228	ND	6	N	Y	Y	DO, 2 WD-CT, PF; former dedicated smoking room

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