Building Performance Evaluation Report

Hospital X
Pre and Post
Surgery
Genesis Air Off

Building Performance Testing By:

Genesis Air

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Lubbock, TX 79424

AIRCUITY™

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Introduction

Thank you for utilizing the services of Aircuity's Optima™ Building Optimization System. This report and associated analytical services are designed to give facility personnel practical information they can use to make the building more energy efficient, more comfortable and less expensive to maintain. Aircuity's mission is to automate and cost reduce the process of quantifying the comfort, quality and operational efficiency of the indoor environment, thereby allowing facility managers to truly optimize building performance.

The Aircuity Advisor™ has generated this customized report using the information collected using the Optima monitor and combining this data with building information provided during the setup process. The recommendations given are based on this combined information as well as an extensive recorded database from similar buildings.

The results are completely confidential and protected according to the terms in the Limiting Conditions section of this report.

This report is divided into the following sections:

1. Executive Summary - An Executive Summary lists all significant findings. A Building Performance Index is also included in this section.

2. Building Data Summary - Average values during occupied hours and highest measured values during the total test period are summarized in easy to reference tables. Each area tested is listed in these tables.

3. Area Analysis - Provides an in-depth analysis of each area tested including recommendations for each area based on the measurements recorded and building and occupant information provided during the setup process, referred to as profile information. Note: When corrective actions are taken, a follow-up analysis is suggested to demonstrate the effectiveness of the action taken. Indoor air quality data graphs for each area tested are provided.

4. Case Histories - This section contains summaries of similar cases that may help the reader find practical solutions to any issues raised in the report through the experiences of others. While these cases may not directly apply to the case in question, the cause / effect relationships may generate some helpful ideas.

5. Background Information - This section summarizes the building and test area information that was provided. The accuracy and completeness of this information is important since the Aircuity Advisor™ uses this information to develop recommendations.

6. Test Parameters - The test parameters are listed and defined, and explanations given for the typical/comfort and recommended levels shown in the tables.

7. Limiting Conditions - Certain limitations as to accuracy, recommendations, conclusions, and compliance with regulations/guidelines are summarized. Confidentiality is defined.

8. Glossary - Key terms are defined.

Executive Summary

Headquarters - Building Overview

The following table presents the reader with a very high-level view of the building performance in three performance categories. Any review suggested at this level refers to further reading within this report. A complete listing of individual area and sensor ratings can be found in the Results Summary immediately following this section.

			Within guidelines or recommended levels	
	Review required	*Review suggested*	*Improvement possible*	*No action suggested*
Comfort and Ventilation			√	
Air Cleanliness	√			
Building Pollutants				√

Comfort and Ventilation - This category applies to those parameters normally associated with discomfort, but are not necessarily health related. Temperature, relative humidity and carbon dioxide are included. Carbon dioxide in this case is used as an indicator of ventilation in the building since the primary source is occupants, and is not normally considered a pollutant.

Air Cleanliness – This category includes those parameters to which standards do not necessarily apply, but which may still be the source of occupant complaints within the building. These parameters include particles and Total Volatile Organic Compounds (TVOC). In this case, values in the building are scored against values typically associated with occupant discomfort based on documented case studies.

Building Pollutants - This category includes those parameters classified as potential pollutants within buildings, which are scored against regulatory standards. They include carbon monoxide, ozone, and radon, which are all typically found at low levels in most buildings. When moderate to high concentrations of these pollutants are found, simple cost effective solutions are usually available to bring levels within guidelines.

Operations Assessment

This assessment uses the temperature and ventilation measurements during both occupied and unoccupied hours to assess the potential for energy savings. Existing air quality issues are taken into account in this assessment. An onsite building professional is required to determine whether an actual savings opportunity exists or is appropriate.

	Savings likely Review suggested	*Savings possible Review suggested*	*Good Performance*	*Optimum Performance*
Surgery Recovery GA Off	√			

Building Performance Index

The table below rates the overall building performance using data from all the areas tested. The rating "scores" are given in two ways:

1. An absolute score on a scale of 0 – 100 in which a value of 50 or higher means the building is performing at or above the currently accepted guidelines or recommended levels.
2. A percentile score that compares the absolute scores to those of other tested buildings. In this case a score of 60 means that 60% of all buildings scored at or below your building. To ensure stability of percentile scores, all percentile comparisons are based on at least 100 comparison buildings. (Commercial buildings are only compared to other commercial buildings, and residential buildings are only compared to other residential buildings).

When scoring the building many issues are taken into account including the numbers of areas tested, individual sensor scores, and the relative importance of the sensors as determined by building and IAQ experts. The final Building Performance Index (BPI) weighs the three individual index scores equally (rounding of the scores may cause slight apparent variations in the final values).

Type	Absolute Score	Percentile Score
Comfort/Ventilation Index	84	92
Air Cleanliness Index	53	26
Building Pollutants Index	100	99
Building Performance Index	79	43

Comfort and Ventilation Index - A sub-score based on temperature, relative humidity and carbon dioxide.
Air Cleanliness Index - A sub-score based large and small particles, and TVOC.
Building Pollutants Index - A sub-score based on carbon monoxide, radon, and ozone.
Building Performance Index - Overall building score. Mold results are not considered in this score.

Based on its absolute index scores, **Hospital X** is rated

★★★★

★★★★ -- Comfort/Ventilation, Air Cleanliness, and Building Pollutants Absolute Scores all exceed 50

★★★☆ -- Any one Comfort/Ventilation, Air Cleanliness, and Building Pollutants Absolute Scores less than 50

★★☆☆ -- Any two Comfort/Ventilation, Air Cleanliness, and Building Pollutants Absolute Scores less than 50

★☆☆☆ -- Comfort/Ventilation, Air Cleanliness, and Building Pollutants Absolute Scores all less than 50

Building Data Summary

Test Area Highlights

	Comfort and Ventilation			Air Cleanliness			Building Pollutants		
	CO2	Temperature	Relative Humidity	Particles (PM 10)	Particles (PM 2.5)	TVOC	CO	Radon	Ozone
GA Off O									

 *Within guidelines - no action*

 *Outside guidelines - Review suggested*

 *Within guidelines - improvement possible*

 *Outside guidelines - Review required*

Average Values - Occupied Hours

The data gathered by the Optima™ system during the building's occupied hours is summarized below. The average values are shown for each area tested (please note that the carbon dioxide reported value is not the average), and are compared to typical values seen in similar buildings to those recommended by industry guidelines and standards. Values outside these guidelines are highlighted and are further explained in each area analysis section. Data collected during unoccupied hours is also screened by the expert system and is noted where appropriate on the individual area sections of the report.

	Comfort and Ventilation				Air Cleanliness			Building Pollutants		
	CO2 (ppm)	Temperature (°F)	Relative Humidity (%)	**CFM (Outdoor Air PP)	PM 10 (µg/m3)	PM 2.5 (µg/m3)	TVOC (index)	CO (ppm)	Radon (pCi/l)	Ozone (ppm)
GA Off	492	69	52	86	1	0	16	0	0	0
Typical/Comfort	< 1100	71 - 74	20 - 60	> 15	< 40	< 20	< 10	< 3	< 2	< 0.1
Recommended	< 1100	68 - 78	20 - 60	> 15	< 40	< 20	< 35	< 9	< 4	< 0.1

* CO2 (Carbon Dioxide) values expressed as 90th percentile ppm during occupied hours - see Test Methods and Background Information
* CFM (Outdoor Area) refers to Cubic Feet per Minute of Outdoor Air per Person as calculated using ASHRAE guidelines
* CO (Carbon Monoxide)
* TVOC (Total Volatile Organic Compounds)
* PM 2.5 (Particulate Matter 2.5 microns and less in size)
* PM 10 (Particulate Matter 10 microns and less in size)

Extreme Values - Occupied Hours

The table below indicates the extreme values recorded by each sensor. Although the average indicated in the above table may be within normal limits, extreme values over a short period of time may also be important. Further information on any highlighted values can be found in the area summary. The time that the deviations occurred can be easily seen in the data graphs, and may be very useful in linking the event to a mechanical change or activity. Please note that extreme values are not reported for some parameters (Radon, Particles, and CFM/Person calculation) either because they are calculated averages or not relevant to the Aircuity Advisor. Also, the Extreme Values table has been screened by the Aircuity Advisor, which recognizes and rejects spurious sensor signals caused by electronic interference. In these cases you may notice single sensor values in the graphed data that are greater than the extreme value reported in the table (most common with CO data).

	CO2 (ppm)	Temperature (°F)	Relative Humidity (%)	TVOC (index)	CO (ppm)	Ozone (ppm)
GA Off O	540	68-71	48-56	**> 150**	0	0
Typical/Comfort	< 1500	71 - 74	20 - 60	< 10	< 3	< 0.1
Recommended	< 2500	68 -78	20 - 60	< 35	< 30	< 0.3

Area Summary - Surgery Recovery Genesis Air turned off

Historical Summary

Test Dates

Start Dates	Hours Tested
2011-9:49:00 AM	21:31

Comfort and Ventilation - Assessment

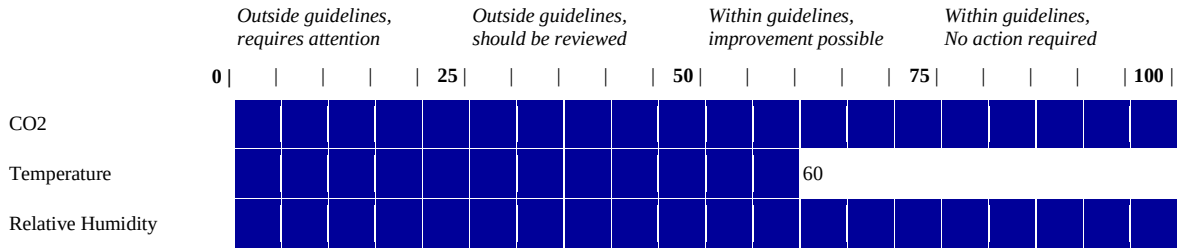
This category applies to those parameters normally associated with comfort, but are not necessarily health related. Temperature, relative humidity and carbon dioxide are included. Carbon dioxide in this case is used as an indicator of ventilation in the building since the primary source is occupants, and is not normally considered a pollutant.

	CO2 (ppm)	Temperature (°F)	Relative Humidity (%)	**CFM (Outdoor Air PP)
Average Values	492	69	52	86
Extreme Values	540	68-71	48-56	N/A
Typical/Comfort	< 1100	71 - 74	20 - 60	> 15
Recommended	< 1100	68 - 78	20 - 60	> 15

Summary

- Under the conditions of this test, and based on carbon dioxide levels, the amount of outdoor air to this area meets or exceeds the currently accepted guideline
- During this testing period, the area temperature was within recommended guidelines though may be improved.
- During this testing period, the area relative humidity was within recommended guidelines and does not require attention.

Comfort and Ventilation Ratings



Recommended Actions

- All Comfort and Ventilation parameters are within recommended limits; therefore, there are no relevant action items at this time.

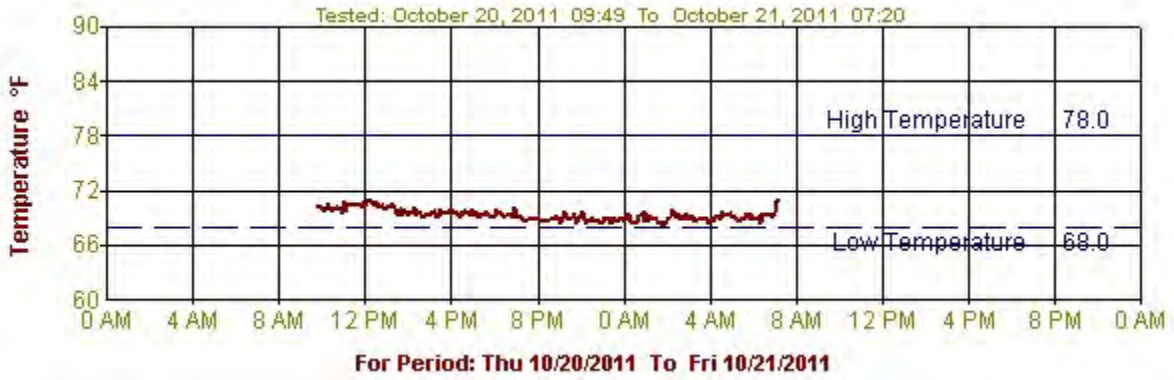
Further Testing

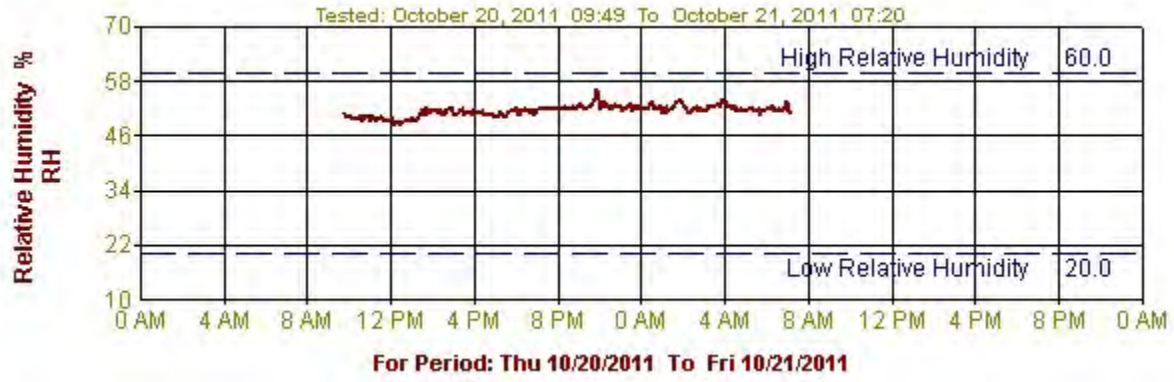
- No further testing is required at this time, based solely on the conditions of this test. However, further testing is recommended when significant changes occur to building conditions (e.g., change of season, occupant density,

use of economizers, maintenance to temperature regulation equipment, etc) that could impact Comfort and Ventilation.

Comfort and Ventilation

Graphs for Test Area : Genesis Air Turned Off





Air Cleanliness Assessment

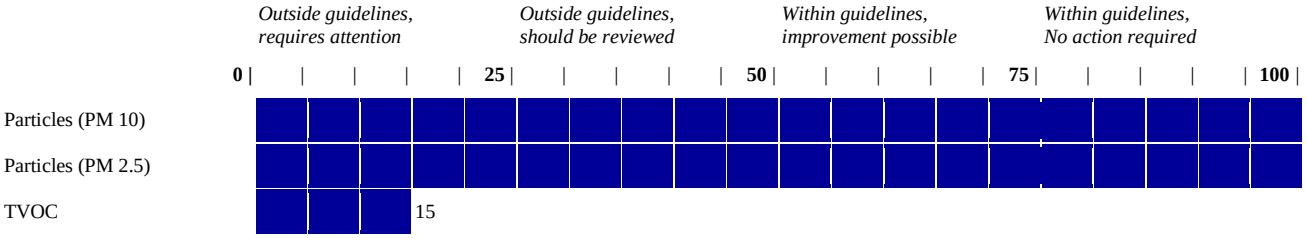
This category includes those parameters to which standards do not necessarily apply, but which may still be the source of occupant irritation within the building. These parameters include particles and Total Volatile Organic Compounds (TVOC). In this case, values in the building are scored against values associated with occupant discomfort based on documented case studies in office buildings.

	PM 10 (µg/m3)	PM 2.5 (µg/m3)	TVOC (index)
Average Values	1	0	16
Extreme Values	N/A	N/A	**> 150**
Typical/Comfort	< 40	< 20	< 10
Recommended	< 40	< 20	< 35

Summary

- During this testing period, the area Particles (PM 10) level was within recommended guidelines and no action is required.
- During this testing period, the area Particles (PM 2.5) level was within recommended guidelines and no action is required.
- **During this testing period, the area TVOC level was significantly outside recommended guidelines and requires attention.**
    - **Area TVOC levels were high for at least 6 consecutive occupied hours.**
        - Entrainment of VOCs from fresh air intakes
        - Outgassing from chemical use (e.g., foods, paint, pesticide, cleaners, solvents)
        - Note: Building has one or more laboratories that may be a source of the VOCS measured in the test space.

Air Cleanliness Assessment Ratings



Recommended Actions

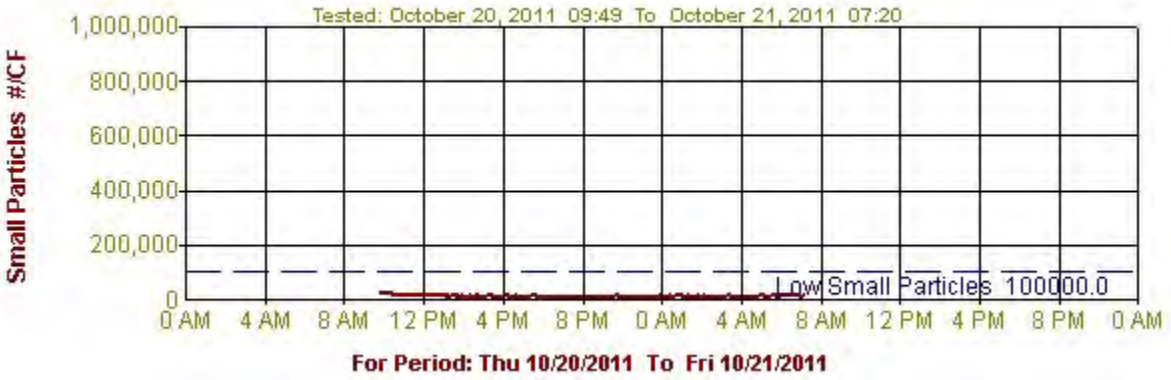
- The following actions are recommended to help reduce the TVOC level within the area:
    - Investigate possible sources of VOCs near outdoor air intakes (e.g., dumpster, fresh roofing tar, pesticides).
    - Investigate whether food odors or cooking may be impacting the air in this area, and minimize if possible.
    - Search for local sources of chemicals in the area.
    - Review the handling and use of cleaning chemicals in the area.
    - Investigate ventilation of adjacent special use spaces such as mechanical rooms, janitors closets, supply closets, etc. Ensure these areas are negatively pressurized with respect to adjacent areas.

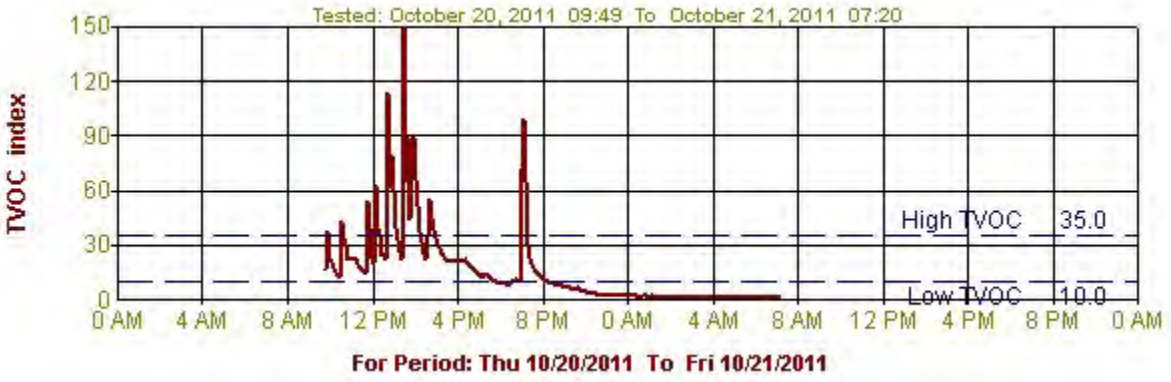
Further Testing

- Follow-up testing after actions are taken will verify previous diagnoses and successful outcomes

Air Cleanliness

Graphs for Test Area : Genesis Air Turned Off





Building Pollutants Assessment

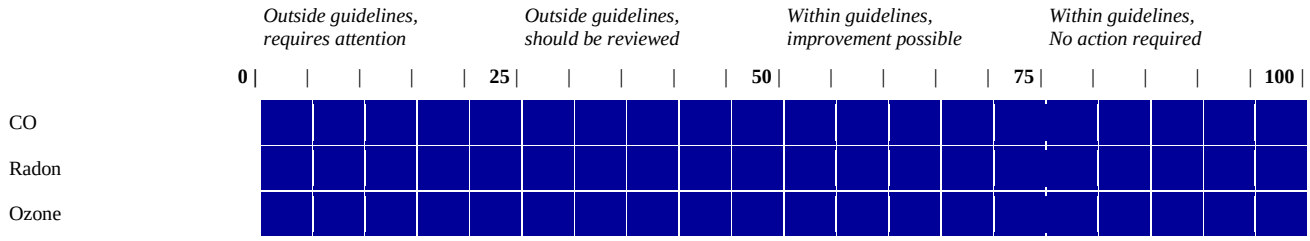
This category includes those parameters classified as potential pollutants within buildings. This report evaluates for the presence of carbon monoxide, radon, and ozone. Parameters of this type can be (or are) found at low levels in most buildings.

	CO (ppm)	Radon (pCi/l)	Ozone (ppm)
Average Values	0	0	0
Extreme Values	0	N/A	0
Typical/Comfort	< 3	< 2	< 0.1
Recommended	< 9	< 4	< 0.1

Summary

- During this testing period, the area carbon monoxide level was within recommended guidelines and does not require attention.
- During this testing period, the area Radon level was within recommended guidelines and no action is required.
- During this testing period, the area Ozone level was within recommended guidelines and no action is required.

Building Pollutants Assessment Ratings



Recommended Actions

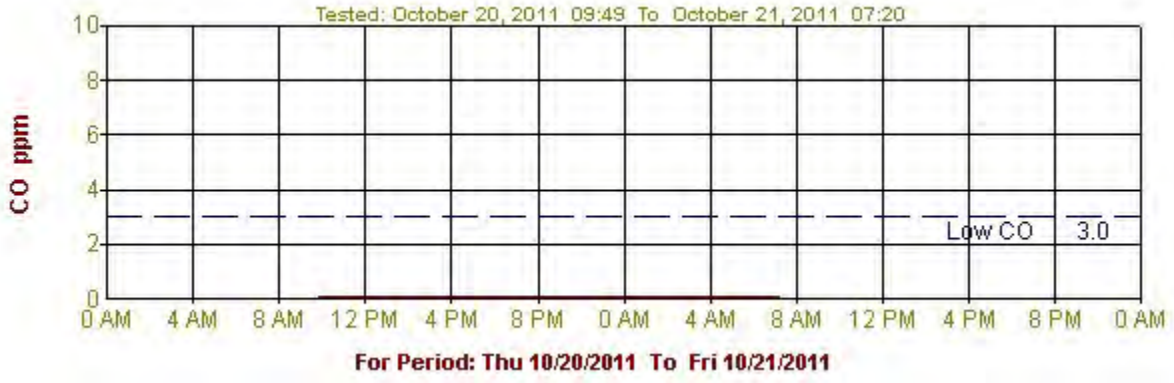
- All Pollutants parameters are within recommended limits; therefore, there are no relevant action items at this time.

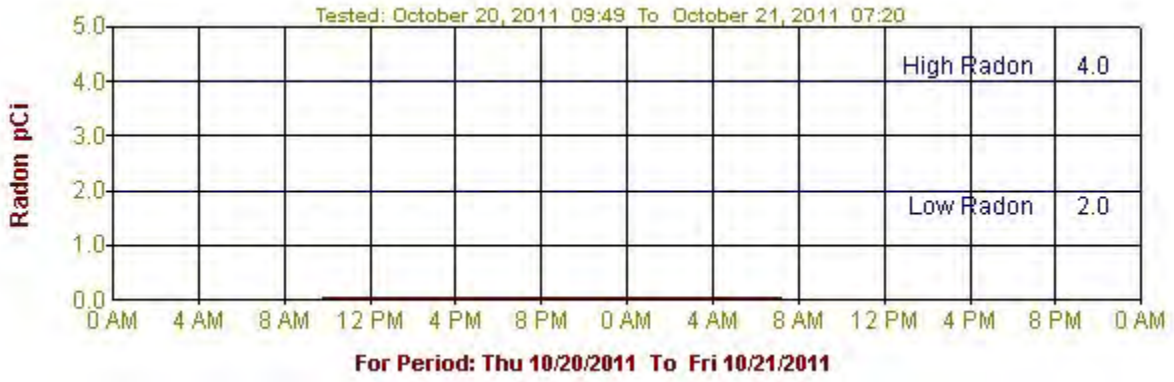
Further Testing

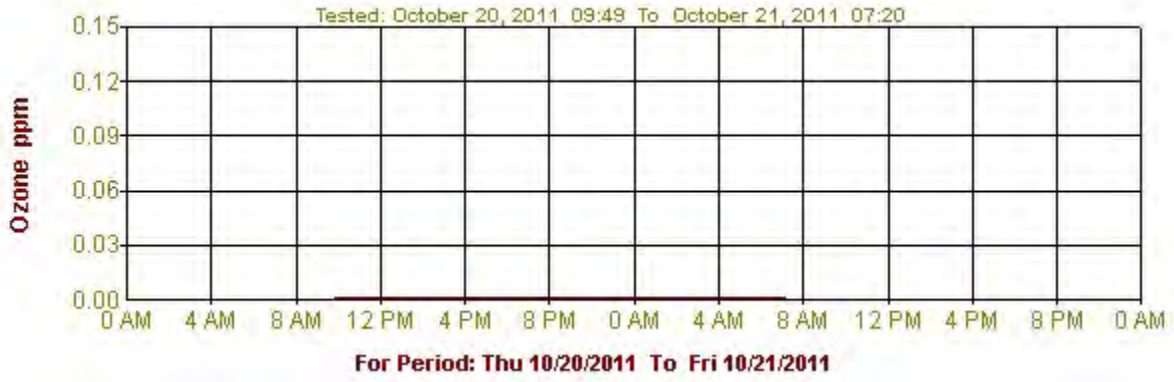
- No further testing is required, based solely on the conditions of the current test. However, further testing is recommended when significant changes to building conditions occur (e.g., maintenance of internal combustion sources, new equipment, etc) that could impact Building Pollutants.

Building Pollutants

Graphs for Test Area : Genesis Air Turned Off







Operations Assessment

This category uses the ventilation measurements to assess the potential for energy savings. Potential IAQ issues are taken into account in this assessment. In this category, a low score indicates the potential for energy savings.

- Assuming the occupancy level of this space was normal during testing,the economizer damper was not in its full open position, and test space windows were closed, this test space appears to be overventilated and may be a candidate for energy savings.
    - This conclusion is based on the 85 CFM value obtained for occupied hours.
    - This conclusion is based on CO2 being below 500 ppm for a predominate percentage of unoccupied hours. (100%)

Recommended Actions

- The following recommendations are suggested to improve area operations:
    - Investigate whether energy efficiency can be improved in the test area by reducing outdoor air levels during occupied and unoccupied hours. Prior to implementing any changes, investigate the minimum outdoor air requirements for the space based on occupancy, pressurization, and source dilution requirements. If the test area did not have normal occupant density or had windows open or the air handling unit was operating in economizer mode, retest the area.

Further Testing

- Follow-up testing after actions are taken will verify previous diagnoses and successful outcomes.

Similar Cases

The following case files may provide insight on problem sources or solutions found in this area. They are in no way intended to represent the actual situation in your building. Please refer to the Case Histories section of the report for the full text of each case file. The number of green balls refers to the strength of fit between study and current case, with three balls indicating a close fit.

- **VOCs**
    - [●] Entrainment of Furan & Toluene from outdoor sources (Case ID 4)
    - [●] Emissions from vents and condensate drain lines (Case ID 77)
    - [●] Laboratory was designed with a return air system, allowing accidental or fugitive chemical emissions to recirculate to other non-laboratory spaces (Case ID 133)

Case Histories

All data samples collected with the Optima monitor are evaluated against other cases and rated a score that reflects the quality and performance of this test area compared to other cases.

Case ID	Case Vignette
4	One related case was concerned with air quality testing at a healthcare facility. Consultants investigated reports of odors that staff said were causing them to experience headaches, nausea, and burning eyes, among other symptoms. Based on observations and testing at the facility, the most likely cause for the reported odors was an outdoor source that produced emissions drawn into the rooftop air-handling units. While on the roof, consultants noted solvent-like odors coming from the roof membrane installation across the street. The wind at the time was coming from the north, which was toward the facility from the direction of the installation. Testing for volatile organic compounds (VOCs) on the fourth floor of the facility revealed the presence of furan, from which polymers are made for corrosion-resistant materials. Furan has an ether-like odor. Furan, along with furan derivatives that were also found in the sample, may have been released from the polymer when seams of the roof membrane were heat-sealed. An elevated toluene level was also noted in the same sample; toluene is a commonly used industrial solvent that may have been a component of the adhesive used to attach the roof membrane. Alternatively, it was noted that emissions from the nearby foundry northeast of the facility may also have been responsible for the odor. Furan polymer is also used in foundry sand cores. However, the proximity of the roofing installation and the presence of industrial solvents in the samples made the first explanation more likely. Considering the strong likelihood that entrainment of an outdoor source was responsible for the odors, the question remained as to why only parts of the third and fourth floors appeared to be affected, not the entire clinic. The affected spaces appeared to be divided into smaller, more discrete areas, such as examination rooms, than were other parts of the clinic. This division of the spaces may have limited the rate at which outdoor supply air mixed with air already in the spaces. Hence, supply air containing odors may have been diluted less rapidly than in other parts of the clinic, resulting in noticeable odors on the third and fourth floors.
77	In one related case, consultants investigated reports of ongoing odors at a hospital. Complaints of a sewer-type odor had been ongoing for about two years but had recently intensified. The source of the odor was believed to be from a damaged sump pump underneath the sink in a conference room. Although this sump pump had been repaired, the odors had persisted. Consultants' understanding of the layout of the plumbing systems was based on discussions with engineering personnel, visual observation, and a review of available plumbing plans. Based on this information, the only plumbing was the sump pump under the sink in the conference room and the condensate drain for the ceiling mounted air-handling unit that provides all of the heating, ventilation, and air-conditioning for the area.

	Both the sump pump discharge and the condensate drain were connected directly to the sanitary sewer at the bathroom suite closest to this area. Consultants identified a vent believed to be for these sewer lines on the roof and began injecting tracer gas using a fan to pressurize the system. Other sewer vents at the roof were sealed with duct tape after determining that they were emitting tracer gas; this finding indicated that they were connected to the same sanitary sewer network. Consultants found only one location and instance where tracer gas was entering the space from the sanitary sewer system. The testing identified a leak at a vent for the condensate drain line from the air handling unit serving the area in question while this unit was off. Consultants believed this condensate line was the source of the odor problems. Consultants offered the following recommendations: 1. If the AHU that serves this area employs shallow V-shaped traps, consider replacing these V-shaped traps at the condensate line with deeper, U-shaped traps. These traps, as well as any other traps, should be kept wet, which may require the periodic addition of water. 2. Another recommendation to consider would be to replace the direct connection between the condensate drain lines and the sanitary sewer. One alternative is an indirect connection to an existing sanitary or storm sewer drain. The drain where the indirect connection is made should be trapped and kept wet. 3. Any open vents in the line should be capped after the direct connection to the sanitary sewer is removed. All changes to the plumbing system should comply with applicable building codes.
133	One investigation centered on elevated TVOCs observed in, and more importantly, near a laboratory. Consultants expressed concern that the laboratory was designed with a return air system. This is generally not recommended for a laboratory. Any accidental or fugitive chemical emissions from the lab would have recirculated to other non-laboratory spaces, increasing the potential exposed population. Typically, lab air is exhausted through a dedicated exhaust system and/or through fume hoods to the outdoors where they cannot be reentrained into the building.

Background Building Information

Attributes

Attribute	Value
Year of Construction	2010
Location	Urban
Number of Floors	3
Square Footage	500000
Primary Use(s)	Healthcare
Closed Space (% building area separated by walls)	Less than 25 percent
Basement	No
Operable Windows (capable of being opened by occupants)	Less than 10 percent
HVAC Equipment	Air Handlers
Air Handler Count	12
Boiler or Furnace	Natural Gas
Cooling Tower	No
Special Features	Laboratory
Elevators (if both, then chose "Hydraulic")	Hydraulic

Events

Event	Date
NO EVENTS RECORDED	

Background Area Information

Background Area Information for- Hospital X GA Off

Attribute	Value
Space Heating Systems	Air System equipped with steam heating coils
Space Cooling Systems	Air System equipped with chilled water coils
Area Type (separated from other areas by walls)	Open
Outdoor Air	Economizer Cycle With Fixed Minimum Outdoor Air Intake
Air Delivery	Variable
Return Air	Ducted
Humidification Method	None
Supplemental Humidification	No
Filtration Type	Particulate
Supplemental Filtration	HEPA
Terminal-Type Supplemental Filtration	No
Floor Covering	Vinyl Tile

Contributing Observations

Occupied hours for this test area are from 12:00 AM to 11:59 PM
Test area is heated with the following systems: steam heating coils (This contributed to the assessment of area temperature.)
Test area is cooled with the following systems: chilled water coils (This contributed to the assessment of area temperature.)
Filtration Method: Particle Filtration(This contributed to the assessment of particles.)
Filtration Is Supplemented by Portable Devices: NO(This contributed to the assessment of particles.)
Filtration Is Supplemented at Terminal Diffusers: NO(This contributed to the assessment of particles.)
Air Delivery Volume: Variable Air (This contributed to the assessment of the area ventilation.)
Test area is mostly Closed (This contributed to the assessment of area ventilation.)
Outdoor Air Control Strategy: economizer cycle_with fixed minimum outdoor air intake(This contributed to the assessment of the area ventilation.)
Air return is: ducted (This contributed to the assessment of particles.)
Floor is covered mostly by: vinyl tile (This contributed to the assessment of particles and TVOCs.)

Reported Symptoms

This report reflects a Proactive survey of this test area.

Test Parameters

All air samples were collected using an Aircuity Optima Monitor. This self-contained device draws in ambient room air at a predetermined rate. The air follows a path past several sensors and is exhausted away from the inlet port

Temperature
Integrated circuit sensor with a range of 34°F-120°F (1°C-49°C), accuracy of +/-1.5 °F, resolution of 0.1°F, and 1 minute response time.

Indoor environmental issues involving thermal discomfort are the most common and the most easily addressed. Many complaints can be minimized by maintaining the conditions recommended by ASHRAE: winter temperature of between 68º and 75º, and summer temperature of between 73º and 79ºF. This evaluation system uses an even more stringent range of 71 to 74 for a typical/comfort setting based upon case studies and practical experience. Relative humidity is closely related to temperature and should also be taken into account when evaluating thermal discomfort. See Relative Humidity.

Carbon Dioxide
A non-dispersive infrared sensor with a range of 0-3000 ppm, accuracy of +/-50 ppm, resolution of 5ppm, and response time of 2 minutes.

People exhale CO2 as a normal byproduct of metabolism. Although the indoor concentrations of CO2 resulting from usual occupant activities are rarely hazardous, this gas can serve as a good indicator of room ventilation rate. This is because CO2 concentrations in indoor air increase in inverse proportion to the amounts of outdoor air that is supplied to a room, that is, the more outdoor air supplied to a room, the lower the CO2 concentration. Supplying adequate ventilation is also important for diluting airborne concentrations of indoor contaminants that may build up due to materials in the space or to occupant activities. By monitoring CO2 levels in an occupied room or area and assuming that equilibrium has been reached, it is possible to estimate the amount of outdoor air that is being supplied to an area.

ASHRAE, a professional organization dedicated to promulgating standards for industry based on a rigorous peer review process, has adopted standards that specify minimum supply quantities of outdoor air for occupied building spaces. While these standards do not have force of law, they are cited widely and are generally regarded as state-of-the-art. These standards, including the IAQ standard, are reviewed every five years so that they incorporate the latest scientific developments and findings.

ASHRAE regards an outdoor air supply rate of 15 cfm (cubic feet per minute) per person as a satisfactory comfort criterion for many indoor environments, such as offices, conference rooms, and shops (ASHRAE 62-2000). A formula contained in this ASHRAE document provides for the conversion of an indoor CO2 measurement to a cfm per person value. Using this calculation, a ventilation rate of 15 cfm per person corresponds to CO2 concentrations less than 1100 parts per million (ppm) during occupied hours, using the ASHRAE assumptions of a specific activity level for office workers, an outdoor air concentration of 400 ppm CO2, and steady-state operating conditions. The value of 400ppm is commonly used for such analysis where indoor CO2 measurements are not accompanied by similar measurements of outdoor air. As an example, see Subchapter 3, Section 121 of the proposed California 2005 Building Energy Efficiency Standards. To ensure good accuracy with this report's ventilation calculations (CFM/person) Aircuity's expert system dynamically adjusts the value of outdoor CO2 used for a specific test event if indoor values of less than 400ppm are detected during a test.

Relative Humidity
A capacitive integrated circuit sensor with a range of 0-100%, accuracy of +/-5%, resolution of +/-0.5%, and 1 minute response time.

Humidity levels of between 20% and 60% are generally considered to be desirable in indoor environments. At levels below 20% people tend to complain of dry-stuffy air, and levels greater than 60% can foster the growth of harmful

microbials and molds. Because the capacity of air to hold water decreases with temperature, relative humidity reflects the percentage of water the air can hold at any given temperature. Condensation appears on cool surfaces when the air in close proximity is in turn cooled to below its dew point.

In northern climates, the relative humidity can fall to levels well below 30% during the heating season. While this may be slightly uncomfortable for occupants, humidification of the air can potentially cause more problems through condensation. This situation is taken into account in the recommendations given by the Aircuity Advisor.

Ozone
An electrochemical sensor with a range of 0-2ppm, accuracy of +/-.02ppmor +/-20% (whichever is greater), resolution of +/-.012ppm, and response time of 2 minutes.

Indoors, common sources of ozone include photocopying machines and laser printers. O3 is emitted in detectable levels by almost all photocopiers and laser printers as a by-product of the electrophotographic process. The gas source is the corona wire producing an electrical discharge that makes the toner powder temporarily adhere to the print drum just before the paper passes over the drum. Therefore, ozone is only produced when the machine is printing, not when the unit is in stand-by mode.

The health effects associated with ozone are mostly acute and are related to irritation of the respiratory system. Symptoms associated with exposure include upper respiratory irritation, cough, dyspnea, and chest pain. Temporary changes in lung function have been associated with exposure to 0.2-0.4 ppm of ozone. Exposures to significantly higher concentrations can cause permanent lung damage, such as pulmonary edema and hemorrhage. (Proctor et. al. 1991) Several federal agencies have established health standards or recommendations to limit human exposure to ozone.

The Occupational Safety and Health Administration (OSHA) requires that workers not be exposed to an average concentration of more than 0.10 ppm for 8 hours. The National Institute of Occupational Safety and Health (NIOSH) recommends an upper limit of 0.10 ppm, not to be exceeded at any time. Additionally, the American Conference of Governmental Industrial Hygienists (ACGIH) has recommended that 15-minute short-term exposures to ozone not exceed 0.3 ppm. Both these recommendations are used to evaluate ozone data in the Aircuity system.

Total Volatile Organic Compounds (TVOC)
A metal oxide sensor with a range of 0-125 ppm (calibrated on isobutylene), with an accuracy of +/-25%, resolution of +/-1ppm at 75°F, and 40% RH, and response time of 2 minutes.

Volatile Organic Compounds (VOCs) include a large number of compounds commonly found in indoor and outdoor environments. These compounds have many sources, such as evaporation of isopropyl alcohol, gasoline, paint solvents, spray product propellants, combustion by-products, emissions from household furnishings, and some natural sources such as many food items. Because we manufacture, use, and dispose of products containing VOCs, many of these compounds are ubiquitous in the air we breathe.

Health effects from exposure to this group of compounds at typical indoor and outdoor concentrations are not generally considered to be problematic. It is known that exposure to certain specific VOCs at concentrations greater than 1,000 times the typical indoor/outdoor levels may cause adverse health effects.

Measurement of total VOCs (TVOCs) is an integrated measurement of the concentrations of all VOCs in an air sample. TVOC measurements in indoor environments are taken primarily for two reasons. The first is to detect any abnormally high levels of VOCs that would indicate the need for more detailed investigations for specific compounds. The second is to obtain readings from different areas and, by comparing the results from these areas, determine potential sites or sources of VOCs, such as methane gas, gasoline vapors, exhaust gases, or vaporized solvents.

Due to differences between readings obtained using different detector designs, as well as the concentration response variations between VOCs on each, the term "index" is used rather than ppm to describe the TVOC concentration. Even though each sensor is calibrated to the same concentration of a particular VOC, a concern is that by expressing the

concentration in parts per million confusion may result when comparing these readings to those obtained by other devices, potentially in the same building.

No recommended guidelines for airborne concentrations of TVOCs currently exist. Measurements of TVOCs are, however, useful for identifying potential sources or locations of VOCs that could present comfort, health, or fire hazards for humans. This data can also be used to determine the cause and effect of various processes that may be associated with the release of these compounds.

Particles
A laser light scatter sensor with a range of 0.3-10 microns.

Particles in indoor air, collectively referred to as dust, form a complex mixture that originates from a variety of sources, including the outdoors, office equipment, building materials, furnishings, and occupants. Particles are an important category of indoor air pollutants because in high enough concentrations, they can act as irritants to the eyes, skin, and respiratory tract.

Particle size affects how far particles can penetrate into the respiratory tract and determines the sites of possible health effects. Inhalable particles are those that can deposit anywhere in the respiratory tract from the nose and upper airways to the lower airways and lung tissue where gas exchange occurs. The diameter of inhaled particles that can reach the nose, mouth, trachea, and airways in the lungs but not in the gas exchange areas is generally between 10 microns (µm) and 100 µm in aerodynamic diameter (1 micron equals approximately 1/25,000 of an inch). Particles less than 5 µm can reach the trachea and all of the airways. Respirable suspended particles (RSP), that is, those that can initially reach the gas exchange region of the lungs, are defined as particles in the air that are less than 3.5 µm in aerodynamic diameter. Because RSP are small enough to reach deeply into the lungs, they may present long-term health concerns. Environmental tobacco smoke is one example of a major source of RSP.

The EPA's 24-hour standard for PM10 is 150 micrograms per cubic meter ($\mu g/m^3$), (0.150 milligrams per cubic meter [mg/m^3]), and cannot be exceeded more than once per year; the standard for the year is an average of 50 $\mu g/m^3$ (0.050 mg/m^3). For PM2.5, these limits are 65 $\mu g/m^3$ and 15 $\mu g/m^3$, respectively. The Occupational Safety and Health Administration (OSHA) has promulgated an occupational permissible exposure limit (PEL) for "particulates not otherwise regulated" of 15 mg/m^3 (15,000 $\mu g/m^3$) for total dust and 5 mg/m^3 (5,000 $\mu g/m^3$) for the respirable fraction of these particulates for eight-hour time-weighted average (TWA) exposures.

Because most of the above guidelines deal with outdoor particle levels, Aircuity has chosen to set limits of 20 and 40 $\mu g/m^3$ respectively for the PM2.5 and PM10 levels in commercial office buildings. These values were arrived at by reviewing particle data collected in approximately 100 commercial office buildings.

The Optima Monitor utilizes a particle counter to measure and record both short and long term trends within the building. However, the only standards developed for IAQ have used a mass measurement system, in which particles of these size ranges are captured on a filter during a specified time period and weighed. In order to give a rough comparison between the particle count information collected by the portable monitor and the current standards, a conversion is used assuming a log normal distribution of particles (see *Air Quality Criteria for Particulate Matter, US EPA, April 1996*) within the two size categories. This conversion is commonly employed in most commercially available particle counting equipment. The portable monitor and database therefore track and record particle count information, and a conversion to mass is performed during the reporting process for comparative purposes

Radon
An integrated circuit sensor with an operating range that goes beyond naturally occurring concentrations, with an accuracy of +/- 1 pCi/L, resolution of +/- 0.2 pCi/L, and response time of 1 hour. (Best results are achieved over 24 hours to account for the natural variations within a typical indoor environment.)

Radon is a colorless, odorless, radioactive gas that occurs naturally and is found throughout the environment at very low levels. The most common source of indoor radon is uranium in the soil or rock on which buildings are built. As uranium naturally breaks down through radioactive decay it forms radium that in turn decays to radon which is a gas. Radon then

enters buildings through dirt floors, cracks in concrete walls and floors, floor drains, and sumps. Radon becomes a health concern when it becomes trapped in buildings and when concentrations build up in indoor air. Inhaled radon (which is radioactive) then breaks down further into decay products (also called radon daughters or progeny). These progeny emit alpha particles that can damage cells lining the airways and possibly lead to cancer.

The only known health effect associated with exposures to elevated levels of radon is lung cancer. EPA estimates that about 5,000 to 20,000 lung cancer deaths a year may be attributed to radon in the United States.

The action level for radon in air in residences established by the EPA is 4.0 picocuries/liter (pCi/L). It is based upon an exposure of 18 hours per day for 40 years. No standards or guidelines currently exist for occupational exposures in commercial office settings, although several residential radon standards and guidelines have been established by various public health and professional organizations.

Carbon Monoxide
An electrochemical sensor with a range of 0-150 ppm, accuracy of +-3 ppm, resolution of 2 ppm, and response time of 1 minute.

CO is a colorless, odorless, and tasteless gas produced by incomplete combustion of carbon fuels. It is a common component of exhaust from motor vehicles and heating units, such as boilers and space heaters, and also is present in tobacco smoke. Although the airborne concentrations of this gas in most indoor environments are usually low, elevated levels can occur under certain situations, such as entrainment of exhaust from trucks idling at a loading dock into a building air intake, migration of air from traffic or parking garages, or leakage of boiler flue gases into a building.

Inhaled CO readily binds to hemoglobin in red blood cells and results in decreased delivery of oxygen to tissues (Coultas and Lambert 1991). The extent of symptoms produced by CO inhalation depends on both personal activity level and airborne concentrations. Exposures to high concentrations may produce headaches, dizziness, fatigue, and nausea. Although average indoor concentrations of CO are usually less than 2 ppm, levels can reach 5 ppm to 10 ppm inside motor vehicles. Symptoms become clinically apparent when the amount of CO bound to red blood cells, termed carboxyhemoglobin, reaches approximately 10%. As an example, a person at rest would have to inhale 80 ppm of CO for eight hours to reach this 10% carboxyhemoglobin level.

The U.S. Environmental Protection Agency's (EPA) National Ambient Air Quality Standard (NAAQS) for CO is 35 ppm for a one-hour exposure and 9 ppm for an eight-hour exposure (EPA 40CFR50.8). Based on this EPA standard, ASHRAE established an IAQ standard of 9 ppm of CO for an eight-hour exposure (ASHRAE 62-1999).

Limiting Conditions

Optima Monitor
The Optima air sampling monitor operates in accordance with generally accepted practices for the determination of indoor air components in both sampling and sensing technology. The operator of the Optima monitor certifies that all manufacturers techniques have been adhered to and that those techniques are in general acceptance by other qualified indoor air quality consultants.

Aircuity Advisor™
The Aircuity Advisor utilizes data from both the Optima monitor and from voluntary input by the operator or their representative. Aircuity cannot guarantee the accuracy of operator input and makes no representation that a physical inspection of the subject building has taken place nor that any communication has taken place directly with Aircuity regarding the subject building, its condition, materials, makeup, occupants, or symptoms of occupants.

Conclusions
The conclusions in this report are based on limited information and are in no way to be construed as absolute analysis of all conditions. These conclusions are intended to guide the user to identify conditions for further investigation or determination by an on-site professional.

Recommendations
Recommendations are expressed as a series of possible solutions to problems identified and are in no way certified as to their effectiveness. Recommendations should be considered by an on-site professional for a determination of effectiveness prior to implementation.

Outside Analysis
When Aircuity has relied on an analysis conducted by an outside laboratory, the results provided by the laboratory are taken at face value; no independent evaluation has been conducted on these results.

Current Law
No attempt has been made to determine the compliance of the subject building to any local, state, federal, or other law or regulation.

Confidentiality
Every effort has been made to safeguard the confidentiality of the contracted users personal, professional, and building specific information. Aircuity will not sell, trade, or rent information to any other related or unrelated party. All efforts have been made, through data encryption and password protection, to make individual building information and test results available only to the contracted user excluding all other parties, including Aircuity, from this information. Aircuity, Inc. may share aggregate data from buildings with other users or researchers in order to provide a more meaningful context with which to compare individual building data, but this information will never include any personal or building-specific identifiers. Aircuity, Inc. will not disclose any confidential client information without the client's specific written authorization.

Glossary

AIR EXCHANGE RATE: The rate at which outside air replaces indoor air in a space. Expressed in one of two ways: the number of changes of outside air per unit of time air changes per hour (ACH); or the rate at which a volume of outside air enters per unit of time - cubic feet per minute (cfm).

ANTIMICROBIAL: Agent that kills microbial growth. See "disinfectant", "sanitizer", and "sterilizer."

BIOLOGICAL CONTAMINANTS: Agents derived from, or that are, living organisms (e.g., viruses, bacteria, fungi, and mammal and bird antigens) that can be inhaled and can cause many types of health effects including allergic reactions, respiratory disorders, hypersensitivity diseases, and infectious diseases. Also referred to as "microbiologicals" or "microbials."

BREATHING ZONE: Area of a room in which occupants breathe as they stand, sit, or lie down.

BUILDING ENVELOPE: Elements of the building, including all external building materials, windows, and walls, that enclose the internal space.

BUILDING-RELATED ILLNESS (BRI): Diagnosable illness whose symptoms can be identified and whose cause can be directly attributed to airborne building pollutants (e.g., Legionnaire's disease, hypersensitivity pneumonitis). Also: A discrete, identifiable disease or illness that can be traced to a specific pollutant or source within a building. (Contrast with "Sick building syndrome").

CFM. Cubic feet per minute. The amount of air, in cubic feet, that flows through a given space in one minute. 1 CFM equals approximately 2 liters per second (l/s).

CO: Carbon monoxide.

CO2:. Carbon dioxide.

COMMISSIONING: Start-up of a building that includes testing and adjusting HVAC, electrical, plumbing, and other systems to assure proper functioning and adherence to design criteria. Commissioning also includes the instruction of building representatives in the use of the building systems.

CONSTANT AIR VOLUME SYSTEMS: Air handling system that provides a constant airflow while varying the temperature to meet heating and cooling needs.

DAMPERS: Controls that vary airflow through an air outlet, inlet, or duct. A damper position may be immovable, manually adjustable or part of an automated control system.

DIFFUSERS AND GRILLES: Components of the ventilation system that distribute and return air to promote air circulation in the occupied space. As used in this document, supply air enters a space through a diffuser or vent and return air leaves a space through a grille.

DRAIN TRAP: A dip in the drain pipe of sinks, toilets, floor drains, etc., which is designed to stay filled with water, thereby preventing sewer gases from escaping into the room.

ENVIRONMENTAL TOBACCO SMOKE (ETS): Mixture of smoke from the burning end of a cigarette, pipe, or cigar and smoke exhaled by the smoker (also secondhand smoke (SHS) or passive smoking).

EXHAUST VENTILATION: Mechanical removal of air from a portion of a building (e.g., piece of equipment, room, or general area).

FUNGI: Any of a group of parasitic lower plants that lack chlorophyll, including molds and mildews.

HEPA: High efficiency particulate arresting (filters).

HVAC: Heating, ventilation, and air-conditioning system.

IAQ: Indoor air quality.

INDICATOR COMPOUNDS: Chemical compounds, such as carbon dioxide, whose presence at certain concentrations may be used to estimate certain building conditions (e.g., airflow, presence of sources).

INDOOR AIR POLLUTANT: Particles and dust, fibers, mists, bioaerosols, and gases or vapors.

MICROBIOLOGICALS: See "Biological Contaminants."

NEGATIVE PRESSURE: Condition that exists when less air is supplied to a space than is exhausted from the space, so the air pressure within that space is less than that in surrounding areas. Under this condition, if an opening exists, air will flow from surrounding areas into the negatively pressurized space.

ORGANIC COMPOUNDS: Chemicals that contain carbon. Volatile organic compounds vaporize at room temperature and pressure. They are found in many indoor sources, including many common household products and building materials.

OUTDOOR AIR SUPPLY: Air brought into a building from the outdoors (often through the ventilation system) that has not been previously circulated through the system. Also known as "Make-Up Air."

PELs: Permissible Exposure Limits (standards set by the Occupational, Safety and Health Administration - OSHA).

PICOCURIE (pCi): A unit for measuring radioactivity, often expressed as picocuries per liter (pCi/L) of air.

PLENUM: Air compartment connected to a duct or ducts.

PM: Preventive Maintenance.

POLLUTANT PATHWAYS: Avenues for distribution of pollutants in a building. HVAC systems are the primary

pathways in most buildings; however all building components interact to affect how air movement distributes pollutants.

POSITIVE PRESSURE: Condition that exists when more air is supplied to a space than is exhausted, so the air pressure within that space is greater than that in surrounding areas. Under this condition, if an opening exists, air will flow from the positively pressurized space into surrounding areas.

PPM: Parts per million.

PRESSURE, STATIC: In flowing air, the total pressure minus velocity pressure. The portion of the pressure that pushes equally in all directions.

PREVENTIVE MAINTENANCE: Regular and systematic inspection, cleaning, and replacement of worn parts, materials, and systems. Preventive maintenance helps to prevent parts, material, and systems failure by ensuring that parts, materials and systems are in good working order.

RADON (Rn) AND RADON DECAY PRODUCTS: Radon is a radioactive gas formed in the decay of uranium. The radon decay products (also called radon daughters or progeny) can be breathed into the lung where they continue to release radiation as they further decay.

RE-ENTRAINMENT: Situation that occurs when the air being exhausted from a building is immediately brought back into the system through the air intake and other openings in the building envelope.

SHORT-CIRCUITING: Situation that occurs when the supply air flows to return or exhaust grilles before entering the breathing zone (area of a room where people are). To avoid short-circuiting, the supply air must be delivered at a temperature and velocity that results in mixing throughout the space.

SOIL GAS: The gas present in soil which may contain radon.

SOURCES: Sources of indoor air pollutants. Indoor air pollutants can originate within the building or be drawn in from outdoors. Common sources include people, room furnishings such as carpeting, photocopiers, art supplies, etc.

STACK EFFECT: The overall upward movement of air inside a building that results from heated air rising and escaping through openings in the building super structure, thus causing an indoor pressure level lower than that in the soil gas beneath or surrounding the building foundation.

STATIC PRESSURE: Condition that exists when an equal amount of air is supplied to and exhausted from a space. At static pressure, equilibrium has been reached.

STERILIZER: One of three groups of antimicrobials registered by EPA for public health uses. EPA considers an antimicrobial to be a sterilizer when it destroys or eliminates all forms of bacteria, fungi, viruses, and their spores. Because spores are considered the most difficult form of a microorganism to destroy, EPA considers the term sporicide to be synonymous with "sterilizer."

TLVs: Threshold Limit Values (guidelines recommended by the American Conference of Governmental Industrial Hygenists).

TVOC: Total volatile organic compounds. See "Volatile Organic Compounds (VOCs)"

UNIT VENTILATOR: A fan-coil unit package device for applications in which the use of outdoor- and return-air mixing is intended to satisfy tempering requirements and ventilation needs.

VARIABLE AIR VOLUME SYSTEM (VAV): Air handling system that conditions the air to constant temperature and varies the supply airflow to ensure thermal comfort.

VENTILATION AIR: Defined as the total air, which is a combination of the air brought inside from outdoors and the air that is being re-circulated within the building. Sometimes, however, used in reference only to the air brought into the system from the outdoors; this document defines this air as "outdoor air ventilation."

VENTILATION RATE: The rate at which indoor air enters and leaves a building. Expressed in one of two ways: the number of changes of outdoor air per unit of time (air changes per hour, or "ach") or the rate at which a volume of outdoor air enters per unit of time (cubic feet per minute, or "cfm").

VOLATILE ORGANIC COMPOUNDS (VOCs): Compounds that vaporize (become a gas) at room temperature. Common sources which may emit VOCs into indoor air include housekeeping and maintenance products, and building and furnishing materials. In sufficient quantities, VOCs can cause eye, nose, and throat irritations, headaches, dizziness, visual disorders, memory impairment; some are known to cause cancer in animals; some are suspected of causing, or are known to cause, cancer in humans. At present, not much is known about what health effects occur at the levels of VOCs typically found in public and commercial buildings.

ZONE: The occupied space or group of spaces within a building which has its heating or cooling controlled by a single thermostat.

Building Performance Evaluation Report

Hospital X
Pre and Post
Surgery
Genesis Air On

Building Performance Testing By:

Genesis Air

5202 CR 7350, Suite D
Lubbock, TX 79424

AIRCUITY™

Table of Contents

Introduction

Thank you for utilizing the services of Aircuity's Optima™ Building Optimization System. This report and associated analytical services are designed to give facility personnel practical information they can use to make the building more energy efficient, more comfortable and less expensive to maintain. Aircuity's mission is to automate and cost reduce the process of quantifying the comfort, quality and operational efficiency of the indoor environment, thereby allowing facility managers to truly optimize building performance.

The Aircuity Advisor™ has generated this customized report using the information collected using the Optima monitor and combining this data with building information provided during the setup process. The recommendations given are based on this combined information as well as an extensive recorded database from similar buildings.

The results are completely confidential and protected according to the terms in the Limiting Conditions section of this report.

This report is divided into the following sections:

1. Executive Summary - An Executive Summary lists all significant findings. A Building Performance Index is also included in this section.

2. Building Data Summary - Average values during occupied hours and highest measured values during the total test period are summarized in easy to reference tables. Each area tested is listed in these tables.

3. Area Analysis - Provides an in-depth analysis of each area tested including recommendations for each area based on the measurements recorded and building and occupant information provided during the setup process, referred to as profile information. Note: When corrective actions are taken, a follow-up analysis is suggested to demonstrate the effectiveness of the action taken. Indoor air quality data graphs for each area tested are provided.

4. Case Histories - This section contains summaries of similar cases that may help the reader find practical solutions to any issues raised in the report through the experiences of others. While these cases may not directly apply to the case in question, the cause / effect relationships may generate some helpful ideas.

5. Background Information - This section summarizes the building and test area information that was provided. The accuracy and completeness of this information is important since the Aircuity Advisor™ uses this information to develop recommendations.

6. Test Parameters - The test parameters are listed and defined, and explanations given for the typical/comfort and recommended levels shown in the tables.

7. Limiting Conditions - Certain limitations as to accuracy, recommendations, conclusions, and compliance with regulations/guidelines are summarized. Confidentiality is defined.

8. Glossary - Key terms are defined.

Executive Summary

Headquarters - Building Overview

The following table presents the reader with a very high-level view of the building performance in three performance categories. Any review suggested at this level refers to further reading within this report. A complete listing of individual area and sensor ratings can be found in the Results Summary immediately following this section.

			Within guidelines or recommended levels	
	Review required	*Review suggested*	*Improvement possible*	*No action suggested*
Comfort and Ventilation			√	
Air Cleanliness				√
Building Pollutants				√

Comfort and Ventilation - This category applies to those parameters normally associated with discomfort, but are not necessarily health related. Temperature, relative humidity and carbon dioxide are included. Carbon dioxide in this case is used as an indicator of ventilation in the building since the primary source is occupants, and is not normally considered a pollutant.

Air Cleanliness – This category includes those parameters to which standards do not necessarily apply, but which may still be the source of occupant complaints within the building. These parameters include particles and Total Volatile Organic Compounds (TVOC). In this case, values in the building are scored against values typically associated with occupant discomfort based on documented case studies.

Building Pollutants - This category includes those parameters classified as potential pollutants within buildings, which are scored against regulatory standards. They include carbon monoxide, ozone, and radon, which are all typically found at low levels in most buildings .When moderate to high concentrations of these pollutants are found, simple cost effective solutions are usually available to bring levels within guidelines.

Operations Assessment

This assessment uses the temperature and ventilation measurements during both occupied and unoccupied hours to assess the potential for energy savings. Existing air quality issues are taken into account in this assessment. An onsite building professional is required to determine whether an actual savings opportunity exists or is appropriate.

	Savings likely Review suggested	*Savings possible Review suggested*	*Good Performance*	*Optimum Performance*
Surgery Recovery GA On	√			

Building Performance Index

The table below rates the overall building performance using data from all the areas tested. The rating "scores" are given in two ways:

1. An absolute score on a scale of 0 – 100 in which a value of 50 or higher means the building is performing at or above the currently accepted guidelines or recommended levels.
2. A percentile score that compares the absolute scores to those of other tested buildings. In this case a score of 60 means that 60% of all buildings scored at or below your building. To ensure stability of percentile scores, all percentile comparisons are based on at least 100 comparison buildings. (Commercial buildings are only compared to other commercial buildings, and residential buildings are only compared to other residential buildings).

When scoring the building many issues are taken into account including the numbers of areas tested, individual sensor scores, and the relative importance of the sensors as determined by building and IAQ experts. The final Building Performance Index (BPI) weighs the three individual index scores equally (rounding of the scores may cause slight apparent variations in the final values).

Type	Absolute Score	Percentile Score
Comfort/Ventilation Index	84	92
Air Cleanliness Index	100	100
Building Pollutants Index	100	99
Building Performance Index	94	94

Comfort and Ventilation Index - A sub-score based on temperature, relative humidity and carbon dioxide.
Air Cleanliness Index - A sub-score based large and small particles, and TVOC.
Building Pollutants Index - A sub-score based on carbon monoxide, radon, and ozone.
Building Performance Index - Overall building score. Mold results are not considered in this score.

Based on its absolute index scores, **Hospital X** is rated

★★★★

★★★★ -- Comfort/Ventilation, Air Cleanliness, and Building Pollutants Absolute Scores all exceed 50

★★★☆ -- Any one Comfort/Ventilation, Air Cleanliness, and Building Pollutants Absolute Scores less than 50

★★☆☆ -- Any two Comfort/Ventilation, Air Cleanliness, and Building Pollutants Absolute Scores less than 50

★☆☆☆ -- Comfort/Ventilation, Air Cleanliness, and Building Pollutants Absolute Scores all less than 50

Building Data Summary

Test Area Highlights

	Comfort and Ventilation			Air Cleanliness			Building Pollutants		
	CO2	Temperature	Relative Humidity	Particles (PM 10)	Particles (PM 2.5)	TVOC	CO	Radon	Ozone
PACU GA On O	●	◓	●	●	●	●	●	●	●

● *Within guidelines - no action*
◓ *Within guidelines - improvement possible*
◒ *Outside guidelines - Review suggested*
● *Outside guidelines - Review required*

Average Values - Occupied Hours

The data gathered by the Optima™ system during the building's occupied hours is summarized below. The average values are shown for each area tested (please note that the carbon dioxide reported value is not the average), and are compared to typical values seen in similar buildings to those recommended by industry guidelines and standards. Values outside these guidelines are highlighted and are further explained in each area analysis section. Data collected during unoccupied hours is also screened by the expert system and is noted where appropriate on the individual area sections of the report.

	Comfort and Ventilation				Air Cleanliness			Building Pollutants		
	CO2 (ppm)	Temperature (°F)	Relative Humidity (%)	**CFM (Outdoor Air PP)	PM 10 (µg/m3)	PM 2.5 (µg/m3)	TVOC (index)	CO (ppm)	Radon (pCi/l)	Ozone (ppm)
GA On	441	69	51	130	0	0	3	0	0	0
Typical/Comfort	< 1100	71 - 74	20 - 60	> 15	< 40	< 20	< 10	< 3	< 2	< 0.1
Recommended	< 1100	68 - 78	20 - 60	> 15	< 40	< 20	< 35	< 9	< 4	< 0.1

* CO2 (Carbon Dioxide) values expressed as 90th percentile ppm during occupied hours - see Test Methods and Background Information
* CFM (Outdoor Area) refers to Cubic Feet per Minute of Outdoor Air per Person as calculated using ASHRAE guidelines
* CO (Carbon Monoxide)
* TVOC (Total Volatile Organic Compounds)
* PM 2.5 (Particulate Matter 2.5 microns and less in size)
* PM 10 (Particulate Matter 10 microns and less in size)

Extreme Values - Occupied Hours

The table below indicates the extreme values recorded by each sensor. Although the average indicated in the above table may be within normal limits, extreme values over a short period of time may also be important. Further information on any highlighted values can be found in the area summary. The time that the deviations occurred can be easily seen in the data graphs, and may be very useful in linking the event to a mechanical change or activity. Please note that extreme values are not reported for some parameters (Radon, Particles, and CFM/Person calculation) either because they are calculated averages or not relevant to the Aircuity Advisor. Also, the Extreme Values table has been screened by the Aircuity Advisor, which recognizes and rejects spurious sensor signals caused by electronic interference. In these cases you may notice single sensor values in the graphed data that are greater than the extreme value reported in the table (most common with CO data).

	CO2 (ppm)	Temperature (°F)	Relative Humidity (%)	TVOC (index)	CO (ppm)	Ozone (ppm)
GA On	472	68-71	48-53	**91**	0	0
Typical/Comfort	< 1500	71 - 74	20 - 60	< 10	< 3	< 0.1
Recommended	< 2500	68 -78	20 - 60	< 35	< 30	< 0.3

Area Summary - Surgery Post and Recovery Genesis Air turned on

Historical Summary

Test Dates

Start Dates	Hours Tested
2011 9:59:00 AM	21:31

Comfort and Ventilation - Assessment

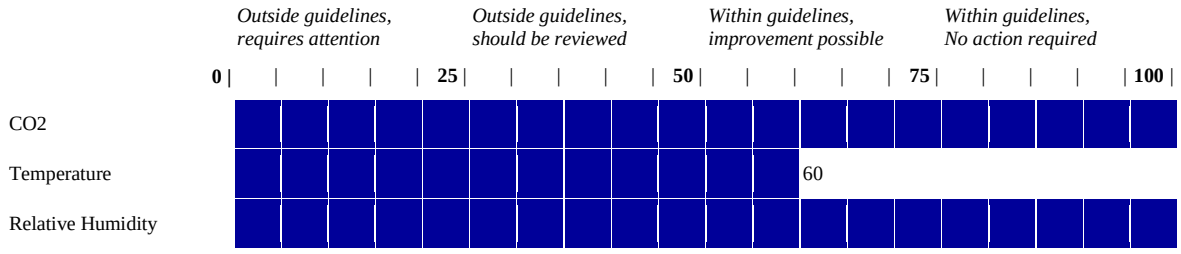
This category applies to those parameters normally associated with comfort, but are not necessarily health related. Temperature, relative humidity and carbon dioxide are included. Carbon dioxide in this case is used as an indicator of ventilation in the building since the primary source is occupants, and is not normally considered a pollutant.

	CO2 (ppm)	Temperature (°F)	Relative Humidity (%)	**CFM (Outdoor Air PP)
Average Values	441	69	51	130
Extreme Values	472	68-71	48-53	N/A
Typical/Comfort	< 1100	71 - 74	20 - 60	> 15
Recommended	< 1100	68 - 78	20 - 60	> 15

Summary

- Under the conditions of this test, and based on carbon dioxide levels, the amount of outdoor air to this area meets or exceeds the currently accepted guideline and no action is required.
- During this testing period, the area temperature was within recommended guidelines though may be improved.
- During this testing period, the area relative humidity was within recommended guidelines and does not require attention.

Comfort and Ventilation Ratings



Recommended Actions

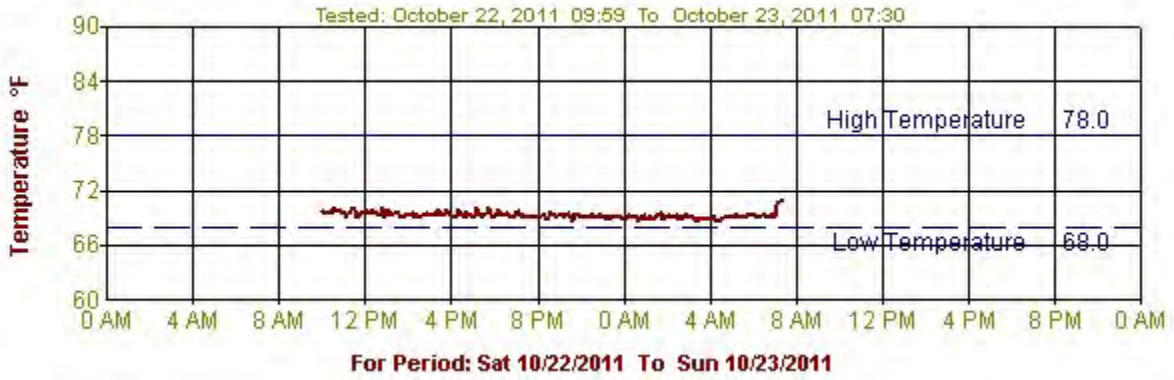
- All Comfort and Ventilation parameters are within recommended limits; therefore, there are no relevant action items at this time.

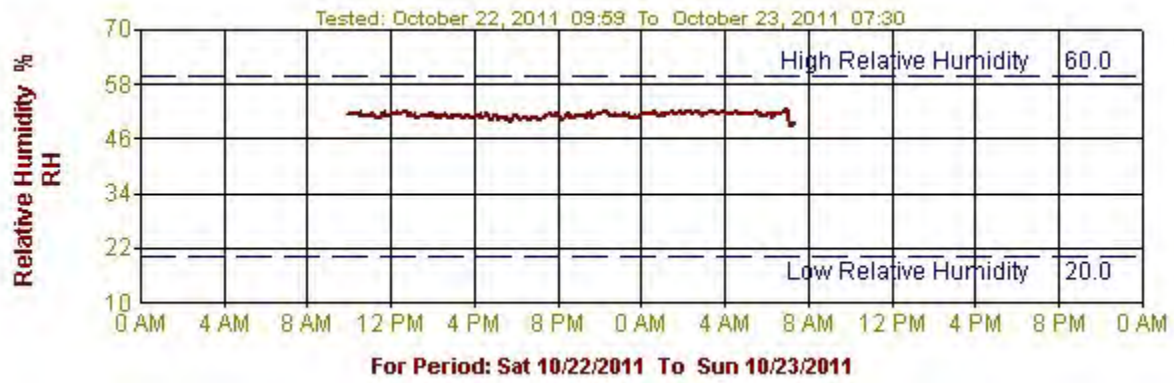
Further Testing

- No further testing is required at this time, based solely on the conditions of this test. However, further testing is recommended when significant changes occur to building conditions (e.g., change of season, occupant density, use of economizers, maintenance to temperature regulation equipment, etc) that could impact Comfort and Ventilation.

Comfort and Ventilation

Graphs for Test Area : GA On





Air Cleanliness Assessment

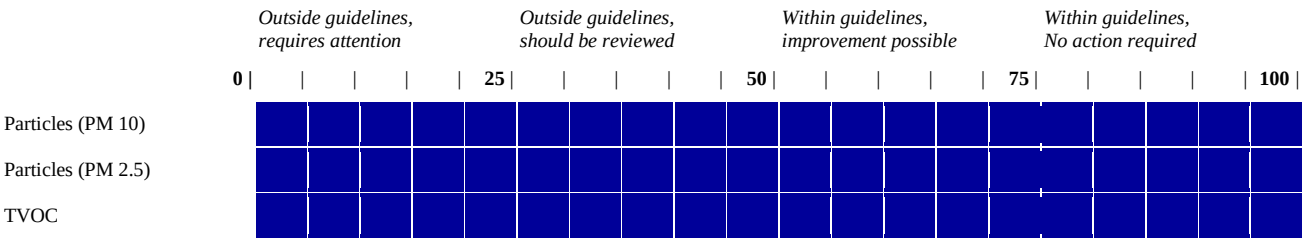
This category includes those parameters to which standards do not necessarily apply, but which may still be the source of occupant irritation within the building. These parameters include particles and Total Volatile Organic Compounds (TVOC). In this case, values in the building are scored against values associated with occupant discomfort based on documented case studies in office buildings.

	PM 10 (µg/m3)	PM 2.5 (µg/m3)	TVOC (index)
Average Values	0	0	3
Extreme Values	N/A	N/A	**91**
Typical/Comfort	< 40	< 20	< 10
Recommended	< 40	< 20	< 35

Summary

- During this testing period, the area Particles (PM 10) level was within recommended guidelines and no action is required.
- During this testing period, the area Particles (PM 2.5) level was within recommended guidelines and no action is required.
- During this testing period, the area TVOC level was within recommended guidelines and no action is required.

Air Cleanliness Assessment Ratings



Recommended Actions

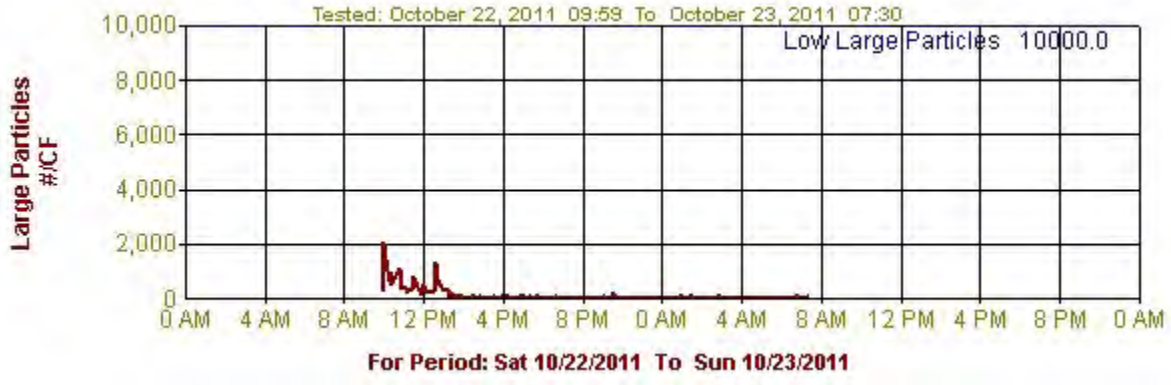
- All Cleanliness parameters are within recommended limits; therefore, there are no relevant action items at this time.

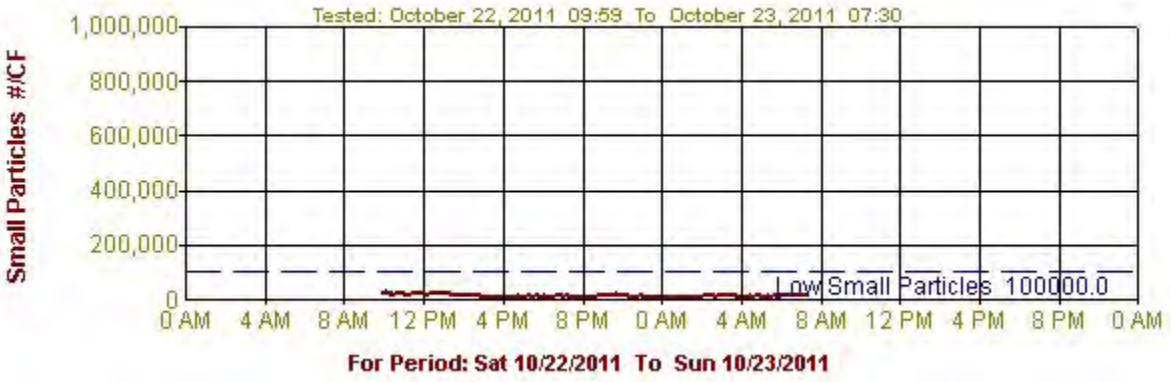
Further Testing

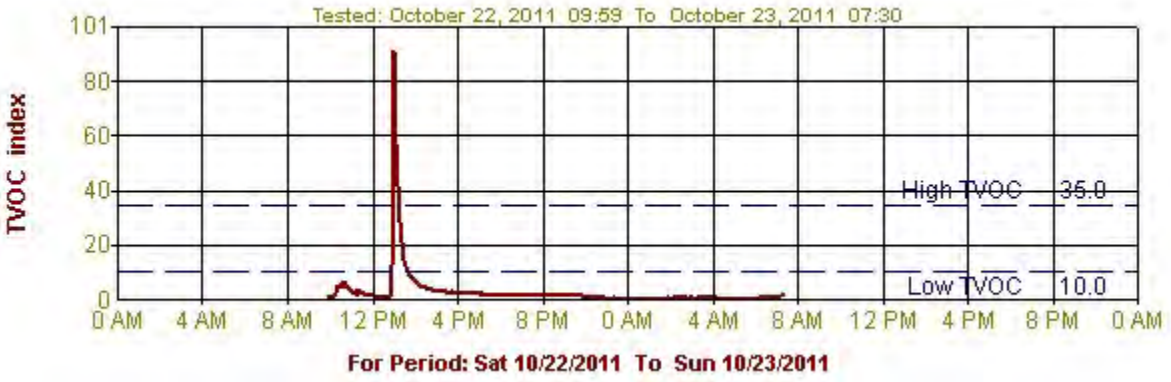
- No further testing is required, based solely on the conditions of the current test. However, further testing is recommended when significant changes to building conditions occur (e.g., change in internal or external activities, chemical usage, etc) that could impact Air Cleanliness.

Air Cleanliness

Graphs for Test Area : GA On O







Building Pollutants Assessment

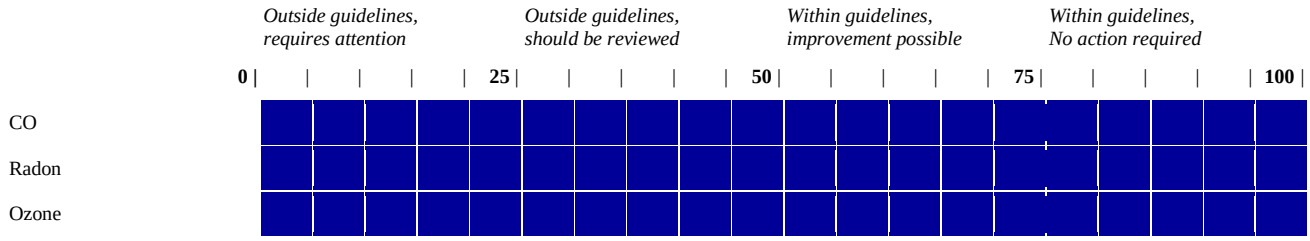
This category includes those parameters classified as potential pollutants within buildings. This report evaluates for the presence of carbon monoxide, radon, and ozone. Parameters of this type can be (or are) found at low levels in most buildings.

	CO (ppm)	Radon (pCi/l)	Ozone (ppm)
Average Values	0	0	0
Extreme Values	0	N/A	0
Typical/Comfort	< 3	< 2	< 0.1
Recommended	< 9	< 4	< 0.1

Summary

- During this testing period, the area carbon monoxide level was within recommended guidelines and does not require attention.
- During this testing period, the area Radon level was within recommended guidelines and no action is required.
- During this testing period, the area Ozone level was within recommended guidelines and no action is required.

Building Pollutants Assessment Ratings



Recommended Actions

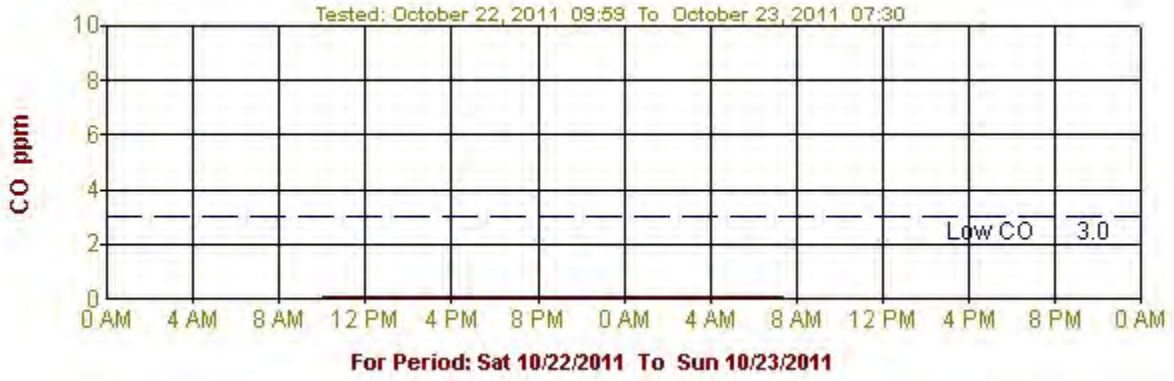
- All Pollutants parameters are within recommended limits; therefore, there are no relevant action items at this time.

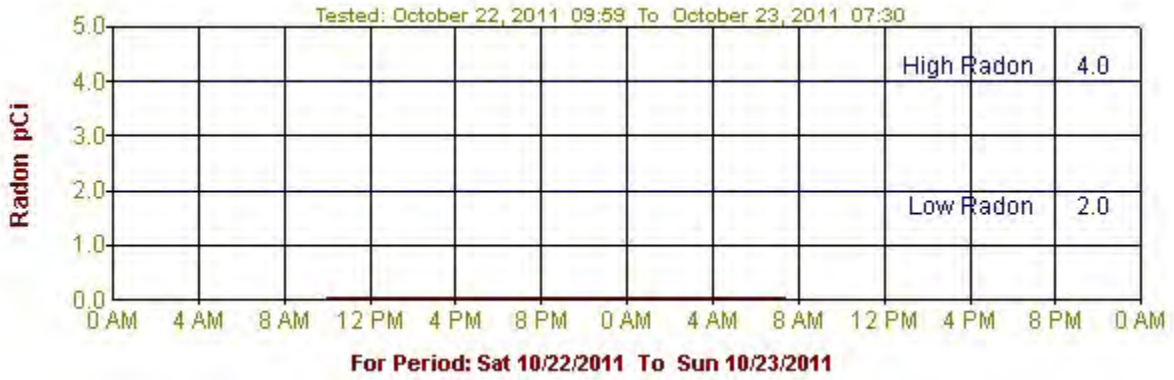
Further Testing

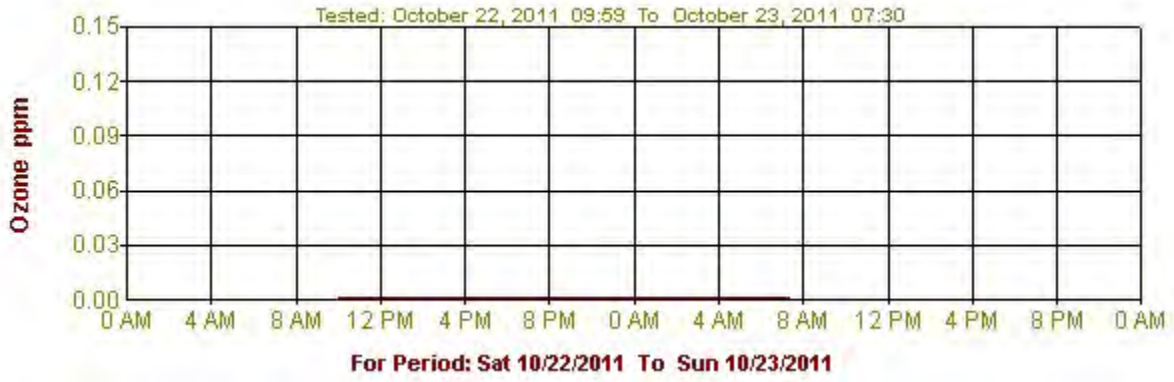
- No further testing is required, based solely on the conditions of the current test. However, further testing is recommended when significant changes to building conditions occur (e.g., maintenance of internal combustion sources, new equipment, etc) that could impact Building Pollutants.

Building Pollutants

Graphs for Test Area : GA On O







Operations Assessment

This category uses the ventilation measurements to assess the potential for energy savings. Potential IAQ issues are taken into account in this assessment. In this category, a low score indicates the potential for energy savings.

- Assuming the occupancy level of this space was normal during testing,the economizer damper was not in its full open position, and test space windows were closed, this test space appears to be overventilated and may be a candidate for energy savings.
    - This conclusion is based on the 129 CFM value obtained for occupied hours.
    - This conclusion is based on CO2 being below 500 ppm for a predominate percentage of unoccupied hours. (100%)

Recommended Actions

- The following recommendations are suggested to improve area operations:
    - Investigate whether energy efficiency can be improved in the test area by reducing outdoor air levels during occupied and unoccupied hours. Prior to implementing any changes, investigate the minimum outdoor air requirements for the space based on occupancy, pressurization, and source dilution requirements. If the test area did not have normal occupant density or had windows open or the air handling unit was operating in economizer mode, retest the area.

Further Testing

- Follow-up testing after actions are taken will verify previous diagnoses and successful outcomes.

Similar Cases

- No case-based recommendations are required at this time.

Case Histories

All data samples collected with the Optima monitor are evaluated against other cases and rated a score that reflects the quality and performance of this test area compared to other cases.

Case ID	Case Vignette

Background Building Information

Attributes

Attribute	Value
Year of Construction	2010
Location	Urban
Number of Floors	3
Square Footage	500000
Primary Use(s)	Healthcare
Closed Space (% building area separated by walls)	Less than 25 percent
Basement	No
Operable Windows (capable of being opened by occupants)	Less than 10 percent
HVAC Equipment	Air Handlers
Air Handler Count	12
Boiler or Furnace	Natural Gas
Cooling Tower	No
Special Features	Laboratory
Elevators (if both, then chose "Hydraulic")	Hydraulic

Events

Event	Date
NO EVENTS RECORDED	

Background Area Information

Background Area Information for- Hospital X GA On

Attribute	Value
Space Heating Systems	Air System equipped with steam heating coils
Space Cooling Systems	Air System equipped with chilled water coils
Area Type (separated from other areas by walls)	Open
Outdoor Air	Economizer Cycle With Fixed Minimum Outdoor Air Intake
Air Delivery	Variable
Return Air	Ducted
Humidification Method	None
Supplemental Humidification	No
Filtration Type	Particle Filtration
Supplemental Filtration	HEPA / Genesis Air's PCO System
Terminal-Type Supplemental Filtration	No
Floor Covering	Vinyl Tile

Contributing Observations

Occupied hours for this test area are from 12:00 AM to 11:59 PM
Test area is heated with the following systems: steam heating coils (This contributed to the assessment of area temperature.)
Test area is cooled with the following systems: chilled water coils (This contributed to the assessment of area temperature.)
Filtration Method: Particle Filtration(This contributed to the assessment of particles.)
Filtration Is Supplemented by Portable Devices: YES(This contributed to the assessment of particles.)
Filtration Is Supplemented at Terminal Diffusers: NO(This contributed to the assessment of particles.)
Air Delivery Volume: Variable Air (This contributed to the assessment of the area ventilation.)
Test area is mostly Closed (This contributed to the assessment of area ventilation.)
Outdoor Air Control Strategy: economizer cycle_with fixed minimum outdoor air intake(This contributed to the assessment of the area ventilation.)
Air return is: ducted (This contributed to the assessment of particles.)

Reported Symptoms

This report reflects a Proactive survey of this test area.

Area Summary Surgery Pre and Post Recovery Genesis Air turned on

Test Parameters

All air samples were collected using an Aircuity Optima Monitor. This self-contained device draws in ambient room air at a predetermined rate. The air follows a path past several sensors and is exhausted away from the inlet port

Temperature
Integrated circuit sensor with a range of 34°F-120°F (1°C-49°C), accuracy of +/-1.5 °F, resolution of 0.1°F, and 1 minute response time.

Indoor environmental issues involving thermal discomfort are the most common and the most easily addressed. Many complaints can be minimized by maintaining the conditions recommended by ASHRAE: winter temperature of between 68º and 75º, and summer temperature of between 73º and 79ºF. This evaluation system uses an even more stringent range of 71 to 74 for a typical/comfort setting based upon case studies and practical experience. Relative humidity is closely related to temperature and should also be taken into account when evaluating thermal discomfort. See Relative Humidity.

Carbon Dioxide
A non-dispersive infrared sensor with a range of 0-3000 ppm, accuracy of +/-50 ppm, resolution of 5ppm, and response time of 2 minutes.

People exhale CO2 as a normal byproduct of metabolism. Although the indoor concentrations of CO2 resulting from usual occupant activities are rarely hazardous, this gas can serve as a good indicator of room ventilation rate. This is because CO2 concentrations in indoor air increase in inverse proportion to the amounts of outdoor air that is supplied to a room, that is, the more outdoor air supplied to a room, the lower the CO2 concentration. Supplying adequate ventilation is also important for diluting airborne concentrations of indoor contaminants that may build up due to materials in the space or to occupant activities. By monitoring CO2 levels in an occupied room or area and assuming that equilibrium has been reached, it is possible to estimate the amount of outdoor air that is being supplied to an area.

ASHRAE, a professional organization dedicated to promulgating standards for industry based on a rigorous peer review process, has adopted standards that specify minimum supply quantities of outdoor air for occupied building spaces. While these standards do not have force of law, they are cited widely and are generally regarded as state-of-the-art. These standards, including the IAQ standard, are reviewed every five years so that they incorporate the latest scientific developments and findings.

ASHRAE regards an outdoor air supply rate of 15 cfm (cubic feet per minute) per person as a satisfactory comfort criterion for many indoor environments, such as offices, conference rooms, and shops (ASHRAE 62-2000). A formula contained in this ASHRAE document provides for the conversion of an indoor CO2 measurement to a cfm per person value. Using this calculation, a ventilation rate of 15 cfm per person corresponds to CO2 concentrations less than 1100 parts per million (ppm) during occupied hours, using the ASHRAE assumptions of a specific activity level for office workers, an outdoor air concentration of 400 ppm CO2, and steady-state operating conditions. The value of 400ppm is commonly used for such analysis where indoor CO2 measurements are not accompanied by similar measurements of outdoor air. As an example, see Subchapter 3, Section 121 of the proposed California 2005 Building Energy Efficiency Standards. To ensure good accuracy with this report's ventilation calculations (CFM/person) Aircuity's expert system dynamically adjusts the value of outdoor CO2 used for a specific test event if indoor values of less than 400ppm are detected during a test.

Relative Humidity
A capacitive integrated circuit sensor with a range of 0-100%, accuracy of +/-5%, resolution of +/-0.5%, and 1 minute response time.

Humidity levels of between 20% and 60% are generally considered to be desirable in indoor environments. At levels below 20% people tend to complain of dry-stuffy air, and levels greater than 60% can foster the growth of harmful

microbials and molds. Because the capacity of air to hold water decreases with temperature, relative humidity reflects the percentage of water the air can hold at any given temperature. Condensation appears on cool surfaces when the air in close proximity is in turn cooled to below its dew point.

In northern climates, the relative humidity can fall to levels well below 30% during the heating season. While this may be slightly uncomfortable for occupants, humidification of the air can potentially cause more problems through condensation. This situation is taken into account in the recommendations given by the Aircuity Advisor.

Ozone
An electrochemical sensor with a range of 0-2ppm, accuracy of +/-.02ppmor +/-20% (whichever is greater), resolution of +/-.012ppm, and response time of 2 minutes.

Indoors, common sources of ozone include photocopying machines and laser printers. O3 is emitted in detectable levels by almost all photocopiers and laser printers as a by-product of the electrophotographic process. The gas source is the corona wire producing an electrical discharge that makes the toner powder temporarily adhere to the print drum just before the paper passes over the drum. Therefore, ozone is only produced when the machine is printing, not when the unit is in stand-by mode.

The health effects associated with ozone are mostly acute and are related to irritation of the respiratory system. Symptoms associated with exposure include upper respiratory irritation, cough, dyspnea, and chest pain. Temporary changes in lung function have been associated with exposure to 0.2-0.4 ppm of ozone. Exposures to significantly higher concentrations can cause permanent lung damage, such as pulmonary edema and hemorrhage. (Proctor et. al. 1991) Several federal agencies have established health standards or recommendations to limit human exposure to ozone.

The Occupational Safety and Health Administration (OSHA) requires that workers not be exposed to an average concentration of more than 0.10 ppm for 8 hours. The National Institute of Occupational Safety and Health (NIOSH) recommends an upper limit of 0.10 ppm, not to be exceeded at any time. Additionally, the American Conference of Governmental Industrial Hygienists (ACGIH) has recommended that 15-minute short-term exposures to ozone not exceed 0.3 ppm. Both these recommendations are used to evaluate ozone data in the Aircuity system.

Total Volatile Organic Compounds (TVOC)
A metal oxide sensor with a range of 0-125 ppm (calibrated on isobutylene), with an accuracy of +/-25%, resolution of +/-1ppm at 75°F, and 40% RH, and response time of 2 minutes.

Volatile Organic Compounds (VOCs) include a large number of compounds commonly found in indoor and outdoor environments. These compounds have many sources, such as evaporation of isopropyl alcohol, gasoline, paint solvents, spray product propellants, combustion by-products, emissions from household furnishings, and some natural sources such as many food items. Because we manufacture, use, and dispose of products containing VOCs, many of these compounds are ubiquitous in the air we breathe.

Health effects from exposure to this group of compounds at typical indoor and outdoor concentrations are not generally considered to be problematic. It is known that exposure to certain specific VOCs at concentrations greater than 1,000 times the typical indoor/outdoor levels may cause adverse health effects.

Measurement of total VOCs (TVOCs) is an integrated measurement of the concentrations of all VOCs in an air sample. TVOC measurements in indoor environments are taken primarily for two reasons. The first is to detect any abnormally high levels of VOCs that would indicate the need for more detailed investigations for specific compounds. The second is to obtain readings from different areas and, by comparing the results from these areas, determine potential sites or sources of VOCs, such as methane gas, gasoline vapors, exhaust gases, or vaporized solvents.

Due to differences between readings obtained using different detector designs, as well as the concentration response variations between VOCs on each, the term "index" is used rather than ppm to describe the TVOC concentration. Even though each sensor is calibrated to the same concentration of a particular VOC, a concern is that by expressing the

concentration in parts per million confusion may result when comparing these readings to those obtained by other devices, potentially in the same building.

No recommended guidelines for airborne concentrations of TVOCs currently exist. Measurements of TVOCs are, however, useful for identifying potential sources or locations of VOCs that could present comfort, health, or fire hazards for humans. This data can also be used to determine the cause and effect of various processes that may be associated with the release of these compounds.

Particles
A laser light scatter sensor with a range of 0.3-10 microns.

Particles in indoor air, collectively referred to as dust, form a complex mixture that originates from a variety of sources, including the outdoors, office equipment, building materials, furnishings, and occupants. Particles are an important category of indoor air pollutants because in high enough concentrations, they can act as irritants to the eyes, skin, and respiratory tract.

Particle size affects how far particles can penetrate into the respiratory tract and determines the sites of possible health effects. Inhalable particles are those that can deposit anywhere in the respiratory tract from the nose and upper airways to the lower airways and lung tissue where gas exchange occurs. The diameter of inhaled particles that can reach the nose, mouth, trachea, and airways in the lungs but not in the gas exchange areas is generally between 10 microns (µm) and 100 µm in aerodynamic diameter (1 micron equals approximately 1/25,000 of an inch). Particles less than 5 µm can reach the trachea and all of the airways. Respirable suspended particles (RSP), that is, those that can initially reach the gas exchange region of the lungs, are defined as particles in the air that are less than 3.5 µm in aerodynamic diameter. Because RSP are small enough to reach deeply into the lungs, they may present long-term health concerns. Environmental tobacco smoke is one example of a major source of RSP.

The EPA's 24-hour standard for PM10 is 150 micrograms per cubic meter ($\mu g/m^3$), (0.150 milligrams per cubic meter [mg/m^3]), and cannot be exceeded more than once per year; the standard for the year is an average of 50 $\mu g/m^3$ (0.050 mg/m^3). For PM2.5, these limits are 65 $\mu g/m^3$ and 15 $\mu g/m^3$, respectively. The Occupational Safety and Health Administration (OSHA) has promulgated an occupational permissible exposure limit (PEL) for "particulates not otherwise regulated" of 15 mg/m^3 (15,000 $\mu g/m^3$) for total dust and 5 mg/m^3 (5,000 $\mu g/m^3$) for the respirable fraction of these particulates for eight-hour time-weighted average (TWA) exposures.

Because most of the above guidelines deal with outdoor particle levels, Aircuity has chosen to set limits of 20 and 40 $\mu g/m^3$ respectively for the PM2.5 and PM10 levels in commercial office buildings. These values were arrived at by reviewing particle data collected in approximately 100 commercial office buildings.

The Optima Monitor utilizes a particle counter to measure and record both short and long term trends within the building. However, the only standards developed for IAQ have used a mass measurement system, in which particles of these size ranges are captured on a filter during a specified time period and weighed. In order to give a rough comparison between the particle count information collected by the portable monitor and the current standards, a conversion is used assuming a log normal distribution of particles (see *Air Quality Criteria for Particulate Matter, US EPA, April 1996*) within the two size categories. This conversion is commonly employed in most commercially available particle counting equipment. The portable monitor and database therefore track and record particle count information, and a conversion to mass is performed during the reporting process for comparative purposes

Radon
An integrated circuit sensor with an operating range that goes beyond naturally occurring concentrations, with an accuracy of +/- 1 pCi/L, resolution of +/- 0.2 pCi/L, and response time of 1 hour. (Best results are achieved over 24 hours to account for the natural variations within a typical indoor environment.)

Radon is a colorless, odorless, radioactive gas that occurs naturally and is found throughout the environment at very low levels. The most common source of indoor radon is uranium in the soil or rock on which buildings are built. As uranium naturally breaks down through radioactive decay it forms radium that in turn decays to radon which is a gas. Radon then

enters buildings through dirt floors, cracks in concrete walls and floors, floor drains, and sumps. Radon becomes a health concern when it becomes trapped in buildings and when concentrations build up in indoor air. Inhaled radon (which is radioactive) then breaks down further into decay products (also called radon daughters or progeny). These progeny emit alpha particles that can damage cells lining the airways and possibly lead to cancer.

The only known health effect associated with exposures to elevated levels of radon is lung cancer. EPA estimates that about 5,000 to 20,000 lung cancer deaths a year may be attributed to radon in the United States.

The action level for radon in air in residences established by the EPA is 4.0 picocuries/liter (pCi/L). It is based upon an exposure of 18 hours per day for 40 years. No standards or guidelines currently exist for occupational exposures in commercial office settings, although several residential radon standards and guidelines have been established by various public health and professional organizations.

Carbon Monoxide
An electrochemical sensor with a range of 0-150 ppm, accuracy of +-3 ppm, resolution of 2 ppm, and response time of 1 minute.

CO is a colorless, odorless, and tasteless gas produced by incomplete combustion of carbon fuels. It is a common component of exhaust from motor vehicles and heating units, such as boilers and space heaters, and also is present in tobacco smoke. Although the airborne concentrations of this gas in most indoor environments are usually low, elevated levels can occur under certain situations, such as entrainment of exhaust from trucks idling at a loading dock into a building air intake, migration of air from traffic or parking garages, or leakage of boiler flue gases into a building.

Inhaled CO readily binds to hemoglobin in red blood cells and results in decreased delivery of oxygen to tissues (Coultas and Lambert 1991). The extent of symptoms produced by CO inhalation depends on both personal activity level and airborne concentrations. Exposures to high concentrations may produce headaches, dizziness, fatigue, and nausea. Although average indoor concentrations of CO are usually less than 2 ppm, levels can reach 5 ppm to 10 ppm inside motor vehicles. Symptoms become clinically apparent when the amount of CO bound to red blood cells, termed carboxyhemoglobin, reaches approximately 10%. As an example, a person at rest would have to inhale 80 ppm of CO for eight hours to reach this 10% carboxyhemoglobin level.

The U.S. Environmental Protection Agency's (EPA) National Ambient Air Quality Standard (NAAQS) for CO is 35 ppm for a one-hour exposure and 9 ppm for an eight-hour exposure (EPA 40CFR50.8). Based on this EPA standard, ASHRAE established an IAQ standard of 9 ppm of CO for an eight-hour exposure (ASHRAE 62-1999).

Limiting Conditions

Optima Monitor
The Optima air sampling monitor operates in accordance with generally accepted practices for the determination of indoor air components in both sampling and sensing technology. The operator of the Optima monitor certifies that all manufacturers techniques have been adhered to and that those techniques are in general acceptance by other qualified indoor air quality consultants.

Aircuity Advisor™
The Aircuity Advisor utilizes data from both the Optima monitor and from voluntary input by the operator or their representative. Aircuity cannot guarantee the accuracy of operator input and makes no representation that a physical inspection of the subject building has taken place nor that any communication has taken place directly with Aircuity regarding the subject building, its condition, materials, makeup, occupants, or symptoms of occupants.

Conclusions
The conclusions in this report are based on limited information and are in no way to be construed as absolute analysis of all conditions. These conclusions are intended to guide the user to identify conditions for further investigation or determination by an on-site professional.

Recommendations
Recommendations are expressed as a series of possible solutions to problems identified and are in no way certified as to their effectiveness. Recommendations should be considered by an on-site professional for a determination of effectiveness prior to implementation.

Outside Analysis
When Aircuity has relied on an analysis conducted by an outside laboratory, the results provided by the laboratory are taken at face value; no independent evaluation has been conducted on these results.

Current Law
No attempt has been made to determine the compliance of the subject building to any local, state, federal, or other law or regulation.

Confidentiality
Every effort has been made to safeguard the confidentiality of the contracted users personal, professional, and building specific information. Aircuity will not sell, trade, or rent information to any other related or unrelated party. All efforts have been made, through data encryption and password protection, to make individual building information and test results available only to the contracted user excluding all other parties, including Aircuity, from this information. Aircuity, Inc. may share aggregate data from buildings with other users or researchers in order to provide a more meaningful context with which to compare individual building data, but this information will never include any personal or building-specific identifiers. Aircuity, Inc. will not disclose any confidential client information without the client's specific written authorization.

Glossary

AIR EXCHANGE RATE: The rate at which outside air replaces indoor air in a space. Expressed in one of two ways: the number of changes of outside air per unit of time air changes per hour (ACH); or the rate at which a volume of outside air enters per unit of time - cubic feet per minute (cfm).

ANTIMICROBIAL: Agent that kills microbial growth. See "disinfectant", "sanitizer", and "sterilizer."

BIOLOGICAL CONTAMINANTS: Agents derived from, or that are, living organisms (e.g., viruses, bacteria, fungi, and mammal and bird antigens) that can be inhaled and can cause many types of health effects including allergic reactions, respiratory disorders, hypersensitivity diseases, and infectious diseases. Also referred to as "microbiologicals" or "microbials."

BREATHING ZONE: Area of a room in which occupants breathe as they stand, sit, or lie down.

BUILDING ENVELOPE: Elements of the building, including all external building materials, windows, and walls, that enclose the internal space.

BUILDING-RELATED ILLNESS (BRI): Diagnosable illness whose symptoms can be identified and whose cause can be directly attributed to airborne building pollutants (e.g., Legionnaire's disease, hypersensitivity pneumonitis). Also: A discrete, identifiable disease or illness that can be traced to a specific pollutant or source within a building. (Contrast with "Sick building syndrome").

CFM. Cubic feet per minute. The amount of air, in cubic feet, that flows through a given space in one minute. 1 CFM equals approximately 2 liters per second (l/s).

CO: Carbon monoxide.

CO2:. Carbon dioxide.

COMMISSIONING: Start-up of a building that includes testing and adjusting HVAC, electrical, plumbing, and other systems to assure proper functioning and adherence to design criteria. Commissioning also includes the instruction of building representatives in the use of the building systems.

CONSTANT AIR VOLUME SYSTEMS: Air handling system that provides a constant airflow while varying the temperature to meet heating and cooling needs.

DAMPERS: Controls that vary airflow through an air outlet, inlet, or duct. A damper position may be immovable, manually adjustable or part of an automated control system.

DIFFUSERS AND GRILLES: Components of the ventilation system that distribute and return air to promote air circulation in the occupied space. As used in this document, supply air enters a space through a diffuser or vent and return air leaves a space through a grille.

DRAIN TRAP: A dip in the drain pipe of sinks, toilets, floor drains, etc., which is designed to stay filled with water, thereby preventing sewer gases from escaping into the room.

ENVIRONMENTAL TOBACCO SMOKE (ETS): Mixture of smoke from the burning end of a cigarette, pipe, or cigar and smoke exhaled by the smoker (also secondhand smoke (SHS) or passive smoking).

EXHAUST VENTILATION: Mechanical removal of air from a portion of a building (e.g., piece of equipment, room, or general area).

FUNGI: Any of a group of parasitic lower plants that lack chlorophyll, including molds and mildews.

HEPA: High efficiency particulate arresting (filters).

HVAC: Heating, ventilation, and air-conditioning system.

IAQ: Indoor air quality.

INDICATOR COMPOUNDS: Chemical compounds, such as carbon dioxide, whose presence at certain concentrations may be used to estimate certain building conditions (e.g., airflow, presence of sources).

INDOOR AIR POLLUTANT: Particles and dust, fibers, mists, bioaerosols, and gases or vapors.

MICROBIOLOGICALS: See "Biological Contaminants."

NEGATIVE PRESSURE: Condition that exists when less air is supplied to a space than is exhausted from the space, so the air pressure within that space is less than that in surrounding areas. Under this condition, if an opening exists, air will flow from surrounding areas into the negatively pressurized space.

ORGANIC COMPOUNDS: Chemicals that contain carbon. Volatile organic compounds vaporize at room temperature and pressure. They are found in many indoor sources, including many common household products and building materials.

OUTDOOR AIR SUPPLY: Air brought into a building from the outdoors (often through the ventilation system) that has not been previously circulated through the system. Also known as "Make-Up Air."

PELs: Permissible Exposure Limits (standards set by the Occupational, Safety and Health Administration - OSHA).

PICOCURIE (pCi): A unit for measuring radioactivity, often expressed as picocuries per liter (pCi/L) of air.

PLENUM: Air compartment connected to a duct or ducts.

PM: Preventive Maintenance.

POLLUTANT PATHWAYS: Avenues for distribution of pollutants in a building. HVAC systems are the primary

pathways in most buildings; however all building components interact to affect how air movement distributes pollutants.

POSITIVE PRESSURE: Condition that exists when more air is supplied to a space than is exhausted, so the air pressure within that space is greater than that in surrounding areas. Under this condition, if an opening exists, air will flow from the positively pressurized space into surrounding areas.

PPM: Parts per million.

PRESSURE, STATIC: In flowing air, the total pressure minus velocity pressure. The portion of the pressure that pushes equally in all directions.

PREVENTIVE MAINTENANCE: Regular and systematic inspection, cleaning, and replacement of worn parts, materials, and systems. Preventive maintenance helps to prevent parts, material, and systems failure by ensuring that parts, materials and systems are in good working order.

RADON (Rn) AND RADON DECAY PRODUCTS: Radon is a radioactive gas formed in the decay of uranium. The radon decay products (also called radon daughters or progeny) can be breathed into the lung where they continue to release radiation as they further decay.

RE-ENTRAINMENT: Situation that occurs when the air being exhausted from a building is immediately brought back into the system through the air intake and other openings in the building envelope.

SHORT-CIRCUITING: Situation that occurs when the supply air flows to return or exhaust grilles before entering the breathing zone (area of a room where people are). To avoid short-circuiting, the supply air must be delivered at a temperature and velocity that results in mixing throughout the space.

SOIL GAS: The gas present in soil which may contain radon.

SOURCES: Sources of indoor air pollutants. Indoor air pollutants can originate within the building or be drawn in from outdoors. Common sources include people, room furnishings such as carpeting, photocopiers, art supplies, etc.

STACK EFFECT: The overall upward movement of air inside a building that results from heated air rising and escaping through openings in the building super structure, thus causing an indoor pressure level lower than that in the soil gas beneath or surrounding the building foundation.

STATIC PRESSURE: Condition that exists when an equal amount of air is supplied to and exhausted from a space. At static pressure, equilibrium has been reached.

STERILIZER: One of three groups of antimicrobials registered by EPA for public health uses. EPA considers an antimicrobial to be a sterilizer when it destroys or eliminates all forms of bacteria, fungi, viruses, and their spores. Because spores are considered the most difficult form of a microorganism to destroy, EPA considers the term sporicide to be synonymous with "sterilizer."

TLVs: Threshold Limit Values (guidelines recommended by the American Conference of Governmental Industrial Hygenists).

TVOC: Total volatile organic compounds. See "Volatile Organic Compounds (VOCs)"

UNIT VENTILATOR: A fan-coil unit package device for applications in which the use of outdoor- and return-air mixing is intended to satisfy tempering requirements and ventilation needs.

VARIABLE AIR VOLUME SYSTEM (VAV): Air handling system that conditions the air to constant temperature and varies the supply airflow to ensure thermal comfort.

VENTILATION AIR: Defined as the total air, which is a combination of the air brought inside from outdoors and the air that is being re-circulated within the building. Sometimes, however, used in reference only to the air brought into the system from the outdoors; this document defines this air as "outdoor air ventilation."

VENTILATION RATE: The rate at which indoor air enters and leaves a building. Expressed in one of two ways: the number of changes of outdoor air per unit of time (air changes per hour, or "ach") or the rate at which a volume of outdoor air enters per unit of time (cubic feet per minute, or "cfm").

VOLATILE ORGANIC COMPOUNDS (VOCs): Compounds that vaporize (become a gas) at room temperature. Common sources which may emit VOCs into indoor air include housekeeping and maintenance products, and building and furnishing materials. In sufficient quantities, VOCs can cause eye, nose, and throat irritations, headaches, dizziness, visual disorders, memory impairment; some are known to cause cancer in animals; some are suspected of causing, or are known to cause, cancer in humans. At present, not much is known about what health effects occur at the levels of VOCs typically found in public and commercial buildings.

ZONE: The occupied space or group of spaces within a building which has its heating or cooling controlled by a single thermostat.