Case Study – Gold Coast

Lots of air but all bad

We were asked to assess the air in one of the most beautiful residences I have ever visited. This home is a condominium on Chicago's Gold Coast, with a spectacular view of Lake Michigan on one side and downtown Chicago on the other side. The owners had acquired the condo a few years ago, and poured their hearts and souls into refurbishing and renovating it into a domicile that is splendid inside and out.

After construction was completed, one of the owners developed a severe mold related illness that was so incapacitating that she was unable to live in her dream home. When we first visited the condo, several ultraviolet air purifiers and air filtration units were buzzing away throughout the rooms. The air was not odorous, but had a definite lack of freshness. We placed Black Box IAQ™ units in different areas of the condo, and conducted an inspection of the comfort conditioning system and utility chases tucked into the ceiling cavity.

We found no fresh air supply ducts. All air exchange consisted air from the building's internal core flowing into the condo to the kitchen and bathroom exhaust vents. The condo has two recirculating air conditioning systems built into the ceiling. In addition to infiltration through utility space openings into the condo, air leakage in the air conditioning system's supply and return ducts provided another pathway for distributing building core air throughout the condo.

Two reports are attached from our "before" (Test 1) and "after" (Test 2) BB IAQ™ tests. From a first glance, results from the first test indicate extremely low levels of carbon dioxide, VOCs (volatile organic compounds) and radon as one would like. The air exchange rate was very high (72cfm). The second report shows similar low pollutant levels but with a reduced air exchange rate (42cfm) after our fresh air distribution system was installed.

These results show the importance of knowing where your air comes from. "Fresh air" is air that comes directly into your living space from the outdoors. Infiltrated air, such as the air pouring into the condo from the utility chase and elevator shafts, is not fresh air. The core of a building is a filthy place where mold most certainly grows.

Our solution to the problem was simple. On the other side of the condo's glass façades is Lake Michigan's wonderfully freshened air. The trick was to bring the air into the condo in a manner that pressurized the residence such that air from the building's core was prevented from entering. Our design consisted of two fresh air entry points using the transoms above the balcony doorways on each side of the condo. Duct fans were installed that were adjusted to

approximately 50cfm per fan. The duct fans distributed air into the general living areas and bedroom areas such that all areas received fresh air. We adjusted and balanced the bathroom and kitchen exhaust vents in order to reach a level where the fresh air fans would create a positive pressure in the living space. All openings between the utility chase and living area were sealed. The most difficult aspect of the fresh air ventilation system was to install it in a manner that integrated nicely into the décor of the residence. Fortunately, the owners found an excellent contractor who seamlessly installed the new ductwork and did a high quality job sealing the utility space openings.

We placed a BB IAQ™ test unit in the condo for a second air quality test after construction was completed. Upon our return to pick up the sensor boxes two weeks later, we were greeted by the owner had been afflicted by the home's bad air. As we entered her home, we immediately sensed the difference in the condo air quality. Truly fresh air was now washing through the home.

Indoor Air Quality Report

BLACK BOX IAQ ™

Test Number: Test2Unit2
Name: GoldCoast
Email address: test@buildequinox.com
Test Location: Chicago, IL
Report Date: 7/16/2012

Overview: This Black Box IAQ™ report provides an assessment of indoor air quality (IAQ) over the tested time period for the designated space. Black Box IAQ™ measures temperature, humidity, radon, carbon dioxide (CO2), and volatile organic compound (VOC) levels. Based on these measurements, the air exchange rate and pollutant generation rates are determined. The report is divided into two sections as follows:

Section 1: Test Summary Information Reports the measured and calculated values of temperature, humidity, radon, CO2, VOCs , and air flow rate for the measurement space. A determination is made as to whether the levels are acceptable or not. Unacceptable levels suggest corrective action.

Section 2: Recommendations Test results for the measured CO2, VOC, and radon levels are plotted against the calculated air flow rate through the space. Suggested changes to the air exchange rate are given and the impact of changes to the air exchange rate on pollutant levels are provided.

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CERV
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**** Disclaimer:*** *This test is provided for informational purposes only. Results are dependent on a number of testing conditions. It is vital to appreciate that a test result only gives a "snap-shot" estimate for a single time period and a single location under conditions at the time of testing – how well it represents other locations and times is uncertain since the amounts and types of pollutants and air flow rates in the environment is always changing.*

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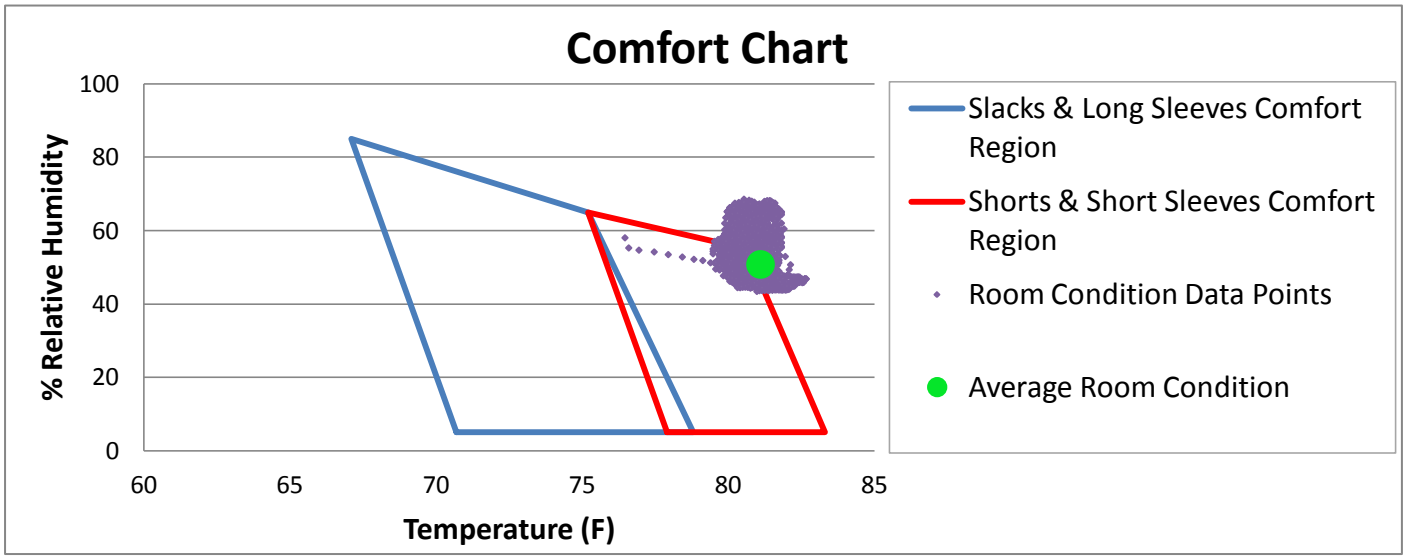
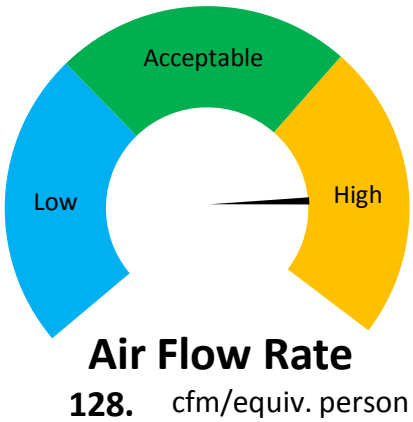
1: Test Summary Information

Measured Temperature and Humidity Levels:



Temperature and relative humidity measured during the test period are shown in the above figure. The two regions represent different comfort levels of clothing for sedentary (eg, office work activity) persons. Room conditions falling mostly within the comfort regions provide confidence that building conditioning systems are operating appropriately. Extended periods of high indoor humidity can be an indirect indicator of mold, a known component of poor indoor air quality.

Infiltration or Controlled Ventilation Air Flow Rates:



Air flow rate into space (cfm/equivalent person)	Rating
Less than 15	**Low**
15 - 25	**Acceptable**
Greater than 25	**High**

Air flow to the measured space results from either controlled ventilation or uncontrolled infiltration through cracks and inadequate sealing around doors and windows. The Black Box IAQ™ analysis calculates the space air flow rate and is reported in two ways: 1) as cubic feet per minute (cfm) and 2) as cfm per equivalent person (cfm/equiv. person) as shown above. It is important to point out that the calculated equivalent person is not the same as the number of occupants. The equivalent person number is based on typical pollution generation rates per person but can be different from the number of occupants due to occupant activity such as cooking using gas cooktops or actual occupancy time in the tested space. Air flow rates less than 15 cfm/equiv. person contribute to “stale air” and higher levels of indoor pollutants. Air flow rates greater than 25 cfm/equiv. person are higher than needed to maintain adequate indoor air quality and thus increase the heating and cooling energy required to condition the space.

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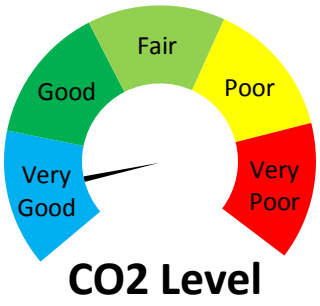
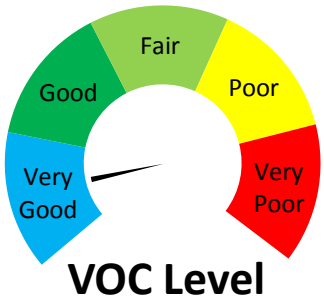
Measured CO2, VOCs, and Radon Levels:



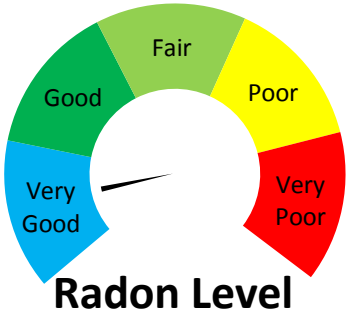
CO2 Level

490.3 ppm average



VOC Level

494.5 ppm average



Radon Level

0.4 pCi/L average

The dial graphs above show the level of measured pollutants during the test period. The table below categorizes the measured levels ranging from "very good" or low pollutant levels to "very poor" or high pollutant levels based on ASHRAE (American Society of Heating, Refrigeration and Air Conditioning Engineers) and EPA (Environmental Protection Agency) recommended ranges.

CO2 or VOC range (ppm)	Radon range (pCi/L)	Rating	
Less than 600	Less than 2.0	Very Good	**Low**
600 – 800	2.0 – 3.0	Good	
800 – 1,000	3.0 – 4.0	Fair	**Acceptable**
1,000 – 1,400	4.0 – 8.0	Poor	**High**
Greater than 1,400	Greater than 8	Very Poor	

CO2 and VOC Levels:

The most common source of indoor CO2 generation is human and correlates with human respiratory activity. Indoor combustion of natural gas, such as from stoves and fireplaces or improper flue venting of gas water heaters and furnaces, is a large contributor of CO2. *Indoor CO2 levels that are unusually high may cause occupants to grow drowsy, get headaches, or function at lower activity levels.* The ASHRAE recommended CO2 upper limit is 1,000 parts per million (ppm).

VOCs are also emitted from human respiration, but additionally as gases from certain solids or liquids. VOCs include a variety of chemicals, *some of which may have short- and long-term adverse health effects*. VOCs can be emitted by a wide array of products including carpet, furnishings, paint, cleaning solutions, cosmetics, and building materials among many others. Natural gas combustion and cooking/food preparation are also sources of VOCs. VOCs should also be kept below 1,000 ppm.

Radon Levels:

Radon is produced by the radioactive decay of radium-226, which is found in uranium ore, phosphate rock, shale, and igneous and metamorphic rock underground. Depending on location and how buildings are constructed and ventilated, radon may accumulate in basements and main living areas of the home. Radon can also seep into an indoor environment through cracks in solid floors, construction joints, cracks in walls, gaps in suspended floors, gaps around service pipes, cavities inside walls, sump/drain pits, and the water supply. In some extreme cases, building materials such as granite can contain radon emitting substances. *High levels of radon exposure cause lung cancer.* The EPA limit for radon level in homes has been set to 4 picoCuries per liter (pCi/L).

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2: Recommendations

The interaction between pollutant level and air flow rate to the space is described in more detail in this section. The first table below summarizes the average measured values of CO2, VOC, and radon during the test period and estimated levels after adjustments are made. The second table summarizes the calculated values of air flow rate and radioactivity flow to the space during the test period; recommended adjusted level of air flow rate to keep CO2/VOC levels below 1,000 ppm and recommended adjusted level of radioactivity flow to keep radon below 4 pCi/L. Controlled ventilation adjustments are based on cfm values.

As air flow rate to the space increases, pollutants are diluted. Conversely, decreases to the air flow rate concentrates pollutants. A suggested reduction in radioactivity flow rate requires some level of radon remediation. Radioactivity flow rates above 20 pCi/sec indicate that sealing foundation cracks, placing sheets of plastic over uncovered dirt, covering and sealing sump pump "pits", and other holes/cracks in your foundation walls and floor should be undertaken. Radioactivity flow rates below 10 pCi/sec are quite low.

Summary Information from Your Test

	Average level during test period	Estimated level after adjustment
CO2	490.3 (ppm)	973.7 (ppm)
VOC	494.5 (ppm)	1000.0 (ppm)
Radon	0.4 (pCi/L)	0.4 (pCi/L)

	Calculated level during test period	Recommended adjusted level	Recommended action to achieve adjusted level
Space Air Flow Rate	42.3 (cfm) 128.9 (cfm/equiv. person)	6.7 (cfm) 20.3 (cfm/equiv. person)	Seal space or reduce controlled ventilation
Radioactivity Flow Rate	0.0 (pCi/sec)	0.0 (pCi/sec)	No recommended action

Additional controlled ventilation air flow always improves radon levels by diluting it. It is important to have an air duct distribution system that "purges" your indoor air in a manner that prevents distribution and circulation of radon throughout the indoor space. For example, supplying controlled ventilation air to the living areas of a home (bedrooms and living areas), and exhausting air from the foundation region (and bathrooms, kitchen and laundry) can combine to keep your indoor air quality controlled (low carbon dioxide and VOCs) while expelling radon from the house.

The following two plots provide additional details showing how air exchange flow rate, pollutant generation, and pollutant levels are related. Current pollutant levels and air exchange flow rates are shown with solid symbols for CO2, VOCs, and radon. Also plotted on the figures are lines showing the relative pollution generation rates (equivalent people generation rates for CO2 and VOCs, and radioactivity flow rate for radon). Hollow symbols show how the suggested air exchange flow rate will impact pollution levels in the space. For radon, a reduction in radioactivity flow may be required, as indicated in the table above and shown in the graph, in order for radon to be reduced below 4 pCi/L.

The suggested change in ventilation is based on CO2 and VOC levels. Whichever is greater is used to determine the suggested ventilation change. If the concentration level is greater than 1000 ppm, an increase in room ventilation is suggested. If the concentration level is less than 1000 ppm, a decrease in room ventilation and/or infiltration is suggested. The associated change required (if needed) in radioactivity flow into the space is determined based on the suggested ventilation level in order to keep radon levels below 4 pCi/L.

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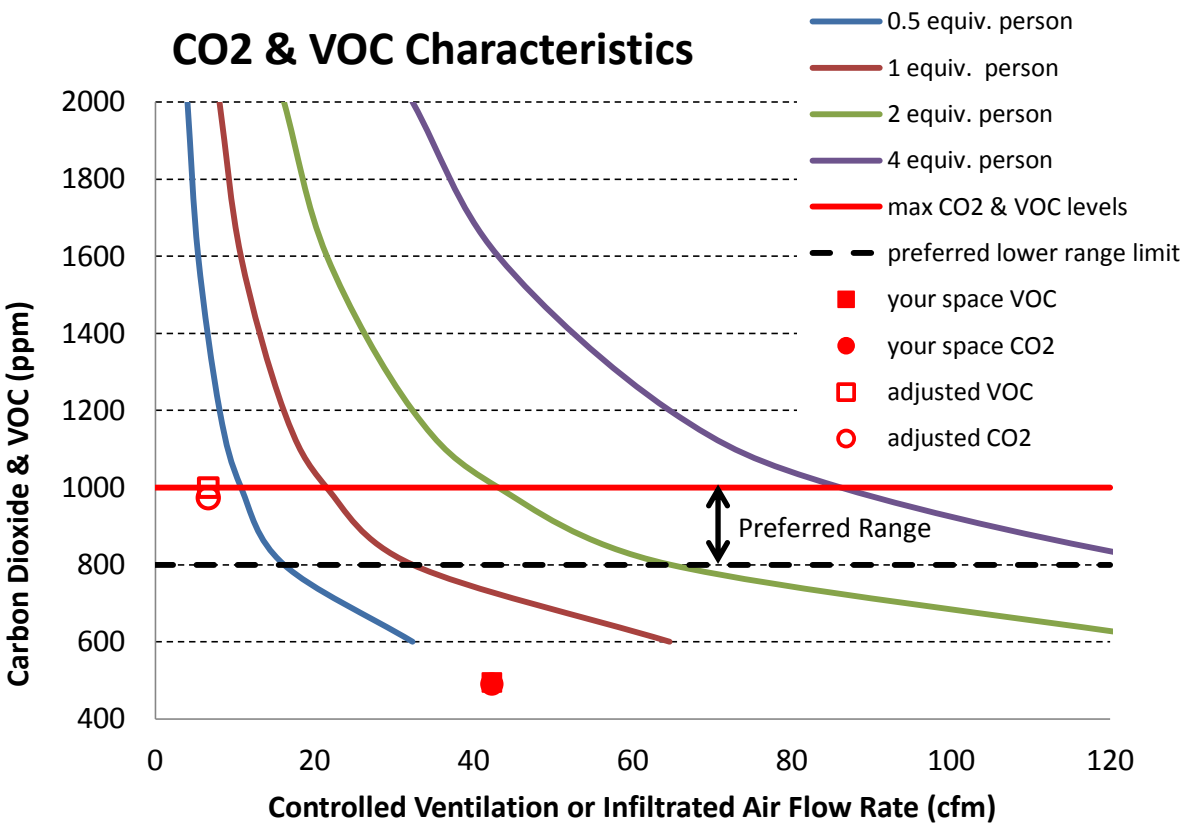
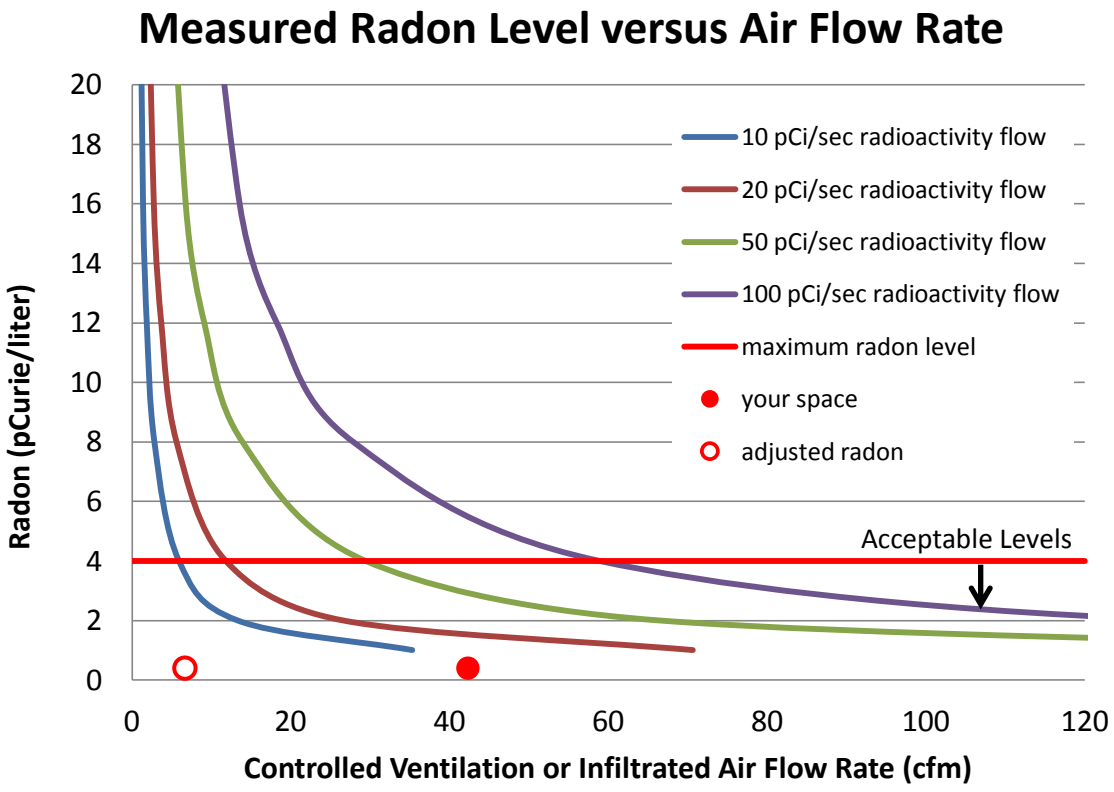
Carbon Dioxide (CO2) and Volatile Organic Compounds (VOCs)



Radon



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Indoor Air Quality Report

BLACK BOX IAQ ™

Test Number: Test1Unit1, Week 2
Name: GoldCoast
Email address: test@buildequinox.com
Test Location: Chicago, IL
Report Date: 4/4/2012

Overview: This Black Box IAQ™ report provides an assessment of indoor air quality (IAQ) over the tested time period for the designated space. Black Box IAQ™ measures temperature, humidity, radon, carbon dioxide (CO2), and volatile organic compound (VOC) levels. Based on these measurements, the air exchange rate and pollutant generation rates are determined. The report is divided into two sections as follows:

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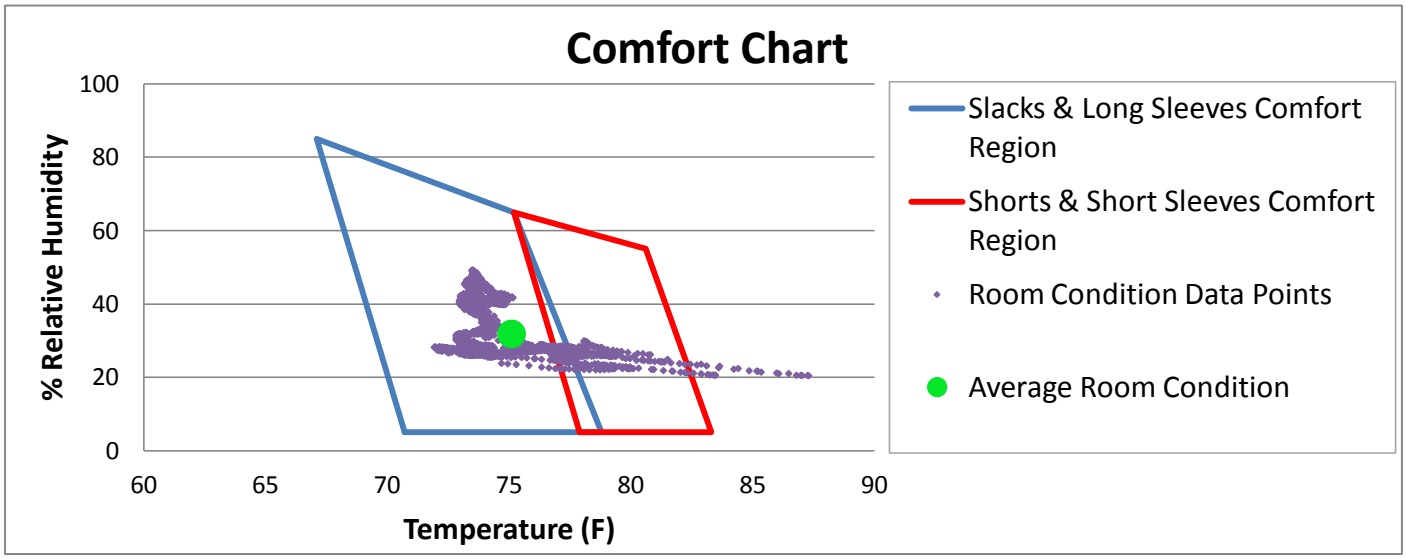

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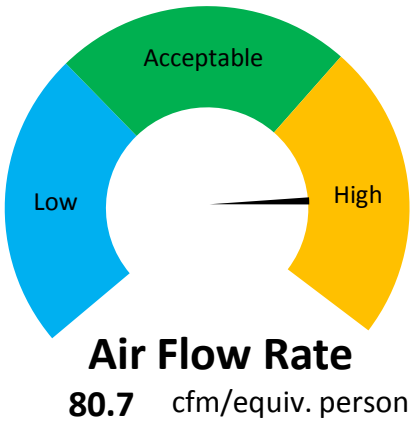

Air flow rate into space (cfm/equivalent person)	Rating
Less than 15	**Low**
15 - 25	**Acceptable**
Greater than 25	**High**

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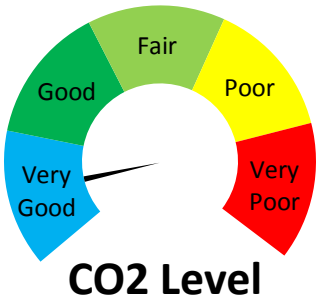
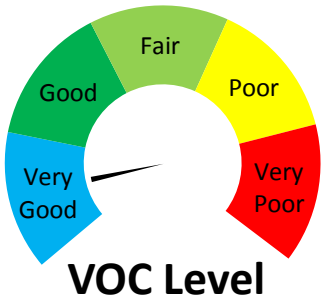


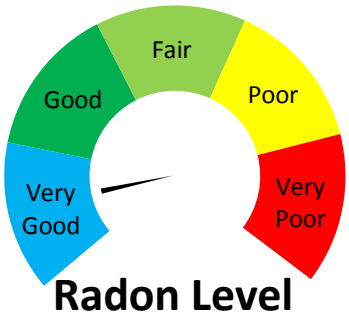
CO2 Level

550.1 ppm average



VOC Level

485.6 ppm average



Radon Level

0.4 pCi/L average

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CO2 or VOC range (ppm)	Radon range (pCi/L)	Rating	
Less than 600	Less than 2.0	Very Good	**Low**
600 – 800	2.0 – 3.0	Good	
800 – 1,000	3.0 – 4.0	Fair	**Acceptable**
1,000 – 1,400	4.0 – 8.0	Poor	**High**
Greater than 1,400	Greater than 8	Very Poor	

CO2 and VOC Levels:

The most common source of indoor CO2 generation is human and correlates with human respiratory activity. Indoor combustion of natural gas, such as from stoves and fireplaces or improper flue venting of gas water heaters and furnaces, is a large contributor of CO2. *Indoor CO2 levels that are unusually high may cause occupants to grow drowsy, get headaches, or function at lower activity levels.* The ASHRAE recommended CO2 upper limit is 1,000 parts per million (ppm).

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2: Recommendations

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As air flow rate to the space increases, pollutants are diluted. Conversely, decreases to the air flow rate concentrates pollutants. A suggested reduction in radioactivity flow rate requires some level of radon remediation. Radioactivity flow rates above 20 pCi/sec indicate that sealing foundation cracks, placing sheets of plastic over uncovered dirt, covering and sealing sump pump "pits", and other holes/cracks in your foundation walls and floor should be undertaken. Radioactivity flow rates below 10 pCi/sec are quite low.

Summary Information from Your Test

	Average level during test period	Estimated level after adjustment
CO2	550.1 (ppm)	1000.0 (ppm)
VOC	485.6 (ppm)	742.0 (ppm)
Radon	0.4 (pCi/L)	0.4 (pCi/L)

	Calculated level during test period	Recommended adjusted level	Recommended action to achieve adjusted level
Space Air Flow Rate	72.0 (cfm) 80.7 (cfm/equiv. person)	18.0 (cfm) 20.2 (cfm/equiv. person)	Seal space or reduce controlled ventilation
Radioactivity Flow Rate	0.0 (pCi/sec)	0.0 (pCi/sec)	No recommended action

Additional controlled ventilation air flow always improves radon levels by diluting it. It is important to have an air duct distribution system that "purges" your indoor air in a manner that prevents distribution and circulation of radon throughout the indoor space. For example, supplying controlled ventilation air to the living areas of a home (bedrooms and living areas), and exhausting air from the foundation region (and bathrooms, kitchen and laundry) can combine to keep your indoor air quality controlled (low carbon dioxide and VOCs) while expelling radon from the house.

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The suggested change in ventilation is based on CO2 and VOC levels. Whichever is greater is used to determine the suggested ventilation change. If the concentration level is greater than 1000 ppm, an increase in room ventilation is suggested. If the concentration level is less than 1000 ppm, a decrease in room ventilation and/or infiltration is suggested. The associated change required (if needed) in radioactivity flow into the space is determined based on the suggested ventilation level in order to keep radon levels below 4 pCi/L.

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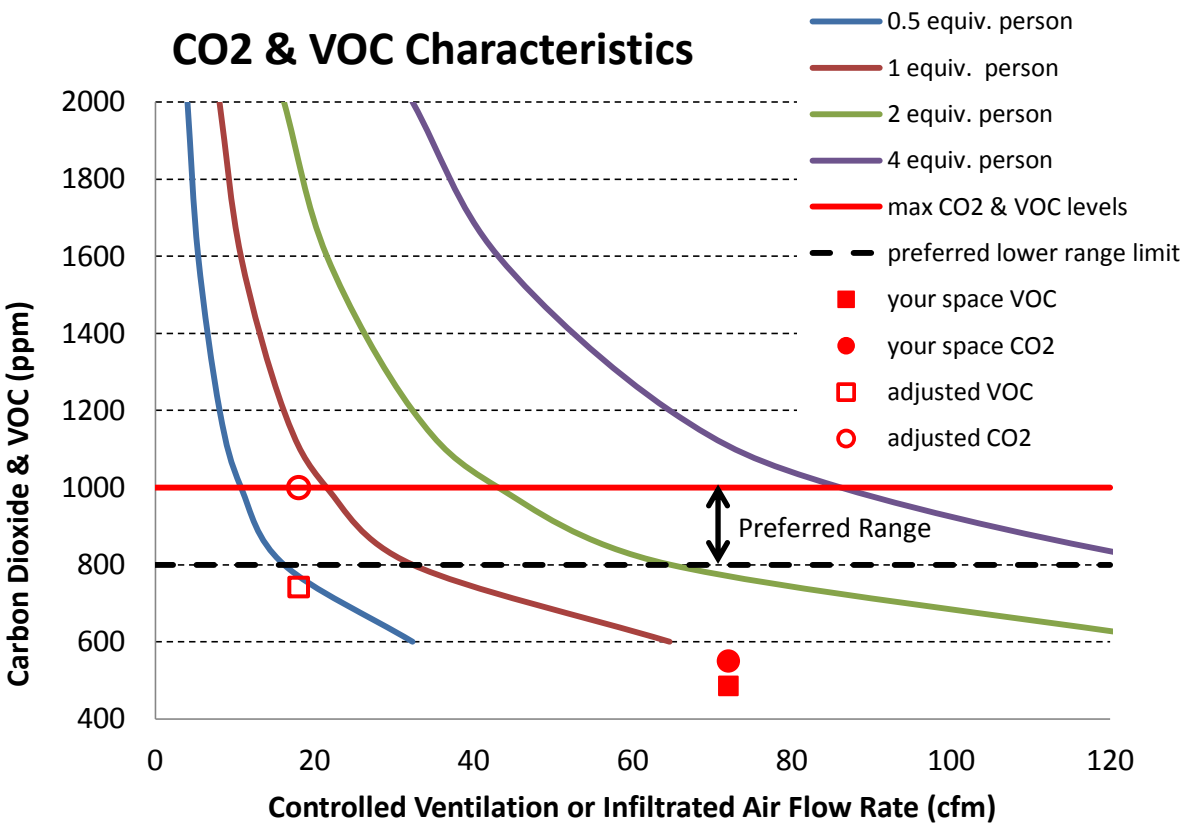
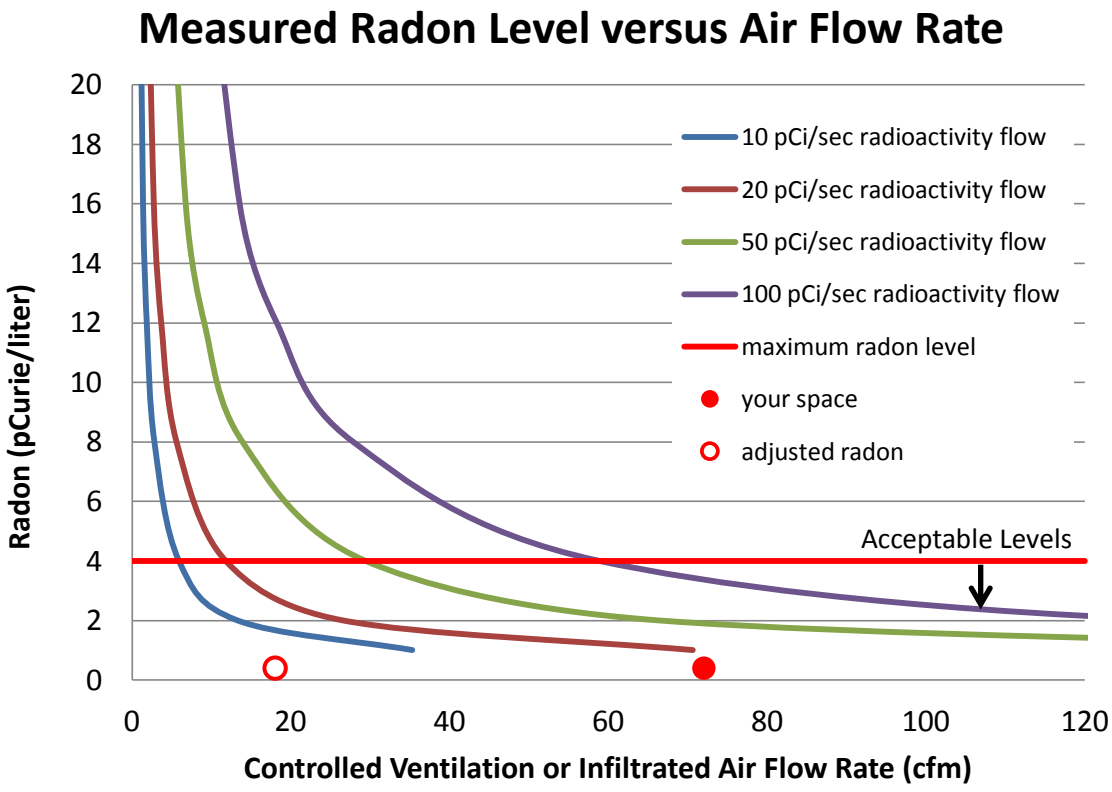
Carbon Dioxide (CO2) and Volatile Organic Compounds (VOCs)



Radon



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