University of Massachusetts
Quinn Administration and
McCormack & Wheatley Halls

Interim Indoor Air Quality
Report
Date:
September 10\textsuperscript{th}, 2019

Prepared For:
Consigli Construction Co.
72 Sumner Street
Milford, MA
Certification of Field Activities

**IAQ Assessment**

Site Location: UMass Boston  
McCormack & Whealy Halls  
Quinn Administration Building  
100 Morrissey Boulevard  
Boston, MA

Conducted By: Stephen Powell

IAQ Issues Identified: [ ] Yes [ ] No

Date: September 10th, 2019

**Report Preparation**

Prepared By: Mr. Stephen Powell  
Title: Project Manager

Date: September 13th, 2019

**QC / Review**

Reviewed By: Mr. Allen Grinnell  
Title: General Manager

Date: September 13th, 2019

Signature: [Signature]
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1 Executive Summary

ALG Environmental Consulting, LLC (ALG) has been retained by Consigli Construction Co. to provide oversight and independent quality control of indoor air quality (IAQ) testing as part of the IAQ Construction Management Program during the planned renovations to the Quinn Administration Building and McCormack & Wheatley Halls on the campus of UMass Boston at 100 Morrissey Boulevard in Boston, Massachusetts.

The information contained herein summarizes the results of an Interim indoor air quality survey, referred herein as “the Interim IAQ”, conducted on September 13th, 2019 by ALG. The Interim IAQ was conducted for the purpose of documenting ambient air quality conditions within the facility at select locations adjacent to or abutting areas of planned renovations.

The data contained in this report documents ambient air conditions as observed on September 13th, 2019. The Interim IAQ of September 13th, 2019 included collection of temperature, relative humidity, carbon monoxide, carbon dioxide, total volatile organic compounds, PM-2.5 and PM-10 particulate measurement.

The Interim IAQ of September 13th, 2019 identified ambient air quality conditions as observed at the locations tested were within acceptable ranges as recommended by the Massachusetts Department of Public Health.

Sampling was conducted throughout various spaces including: in the McCormack building on the 2nd & 3rd floor levels in the Main Corridor, in the Wheatly building on the 4th floor in the Main Hallways and on the 3rd floor in the South Hallway, in the Quinn Administration building on the Upper Level, 1st floor and 2nd floor in the elevator lobbies and Outdoor Control sample.

The following is a narrative summary of the various parameters as tested:

- Temperature was consistent between the areas tested ranging from 71 degrees to 76.6 degrees Fahrenheit.
- Relative Humidity was consistent between all areas tested ranging from 42.1 % to 58.5 % with the outside humidity level at 63 %
- Carbon Monoxide readings throughout the areas tested were less than 0.9 ppm, substantially less than OSHA’s PEL of 50 ppm.
- Carbon Dioxide was within normal ranges averaged 1023 ppm – 1797 ppm.
• Total Voc’s for all locations tested averaged 837 – 1184 ppb consistent with normal building activities.

• Pm 2.5 particle counts ranged from 0.44 ug/m3 to 1.36 ug/m3.

• Pm 10 particle counts ranged from 3.53 ug/m3 to 32.21 ug/m3.

The overall readings are substantially lower than US EPA National Ambient Air Quality Standards (NAAQS) as of July 2011- PM2.5 (<2.5 micron particles) 15.0 µg/m3 24 hr TWA and PM10 (<10 micron particles) 150 µg/m3 24 hr TWA.
2 Site Description

The facility areas assessed are identified as the Quinn Administration Building and McCormack & Wheatley Halls on the campus of UMass Boston at 100 Morrissey Boulevard in Boston; Massachusetts. The buildings surveyed are steel frame and cement structure with brick façades. The interior walls in the area of renovation are sheetrock, cement and CMU block. The floors are cement slabs with some areas covered with vinyl tile and carpet. Where present the ceilings are suspended 1x1, 2x2 and 2x4 ceiling tiles.
3 IAQ Detailed Testing Data by Parameter

IAQ testing was performed based on the following parameters including; VOCs, Carbon Monoxide, Carbon Dioxide, Particulates (pm 2.5 & 10 respirable dust), Temperature and Relative Humidity utilizing Gray Wolf Sensing Solutions Direct Sense IAQ monitoring equipment.

Sampling was conducted throughout various spaces including; in the McCormack building on the 2nd & 3rd floor levels in the Main Corridor, in the Wheatly building on the 4th floor in the Main Hallways and on the 3rd floor in the South Hallway, in the Quinn Administration building on the Upper Level, 1st floor and 2nd floor in the elevator lobbies and Outdoor Control sample.

This section of the report contains outdoor air data and detailed testing data by parameter along with an explanation why each parameter is measured.
### Outdoor Air Data

<table>
<thead>
<tr>
<th>Date Time</th>
<th>TVOC ppb</th>
<th>Carbon Dioxide mg/m3</th>
<th>Carbon Monoxide ppm</th>
<th>Temperature °F</th>
<th>Relative Humidity %RH</th>
<th>PM 2.5 µg/m3</th>
<th>PM 10.0 µg/m3</th>
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<td>73.3</td>
<td>62.0</td>
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</table>
Temperature

Why Measure Temperature

Temperature is among the most common of indoor air environmental factors implicated in occupant discomfort. It is often recognized as an aggravating factor, when other indoor comfort issues exist. In fact, numerous studies have found an association of increased air temperatures with Sick Building Syndrome symptoms and with perceptions of worsened IAQ. While direct temperature related health problems are unusual for IAQ surveys, extreme cold or extreme heat carry obvious health hazards. Elevated temperatures may also increase the off-gassing from building materials of irritating and, sometimes, hazardous compounds, including volatile organic compounds.


ASHRAE (American Society of Heating Refrigeration and Air-Conditioning Engineers) Standard 55-2004 states that occupant comfort may best be obtained by maintaining operative temperatures (approximated by air temperatures under specific conditions) between ~67F (19C) and ~80F (27C) at the maximum acceptable 62.2F (16.8C) dew point temperature or between ~71F (21.5C) and ~83F (28C) at very low humidity ~0F (-18C) dew point temperature. Clothing, radiant heat and many other factors influence the recommendations of this standard. Reference ASHRAE Standard 55-2004 for details.

Calibration and Care Information for Temperature

The temperature sensor is calibrated, at minimum, once every 2 years. However, annual recalibration is preferable.
## Temperature detail for University of Massachusetts Boston Interim IAQ 9-10-19

<table>
<thead>
<tr>
<th>Location</th>
<th>Date/Time</th>
<th>Temperature °F</th>
<th>Comments</th>
</tr>
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<tr>
<td>Outdoor Air UMass Interim IAQ 9-10-19 (10-Sep-19)*</td>
<td>10-Sep-19 03:34:50 PM to 10-Sep-19 03:43:50 PM</td>
<td>72.6</td>
<td>*average reading</td>
</tr>
<tr>
<td>McCormack 2nd Floor Hall (10-Sep-19)*</td>
<td>10-Sep-19 03:56:25 PM to 10-Sep-19 04:02:25 PM</td>
<td>76.2</td>
<td>*average reading</td>
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<td>McCormack 3rd Floor Hall (10-Sep-19)*</td>
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<td>*average reading</td>
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<td>76.5</td>
<td>*average reading</td>
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<tr>
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<td>*average reading</td>
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<tr>
<td>Quinn Upper Level Elev Lobby (10-Sep-19)*</td>
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<td>76.0</td>
<td>*average reading</td>
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<tr>
<td>Wheatley 3rd Floor South Hall (10-Sep-19)*</td>
<td>10-Sep-19 03:23:40 PM to 10-Sep-19 03:30:10 PM</td>
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<td>*average reading</td>
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<tr>
<td>Wheatley 4th Floor Hall (10-Sep-19)*</td>
<td>10-Sep-19 03:15:29 PM to 10-Sep-19 03:22:29 PM</td>
<td>74.2</td>
<td>*average reading</td>
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</table>
Relative Humidity

Why Measure Relative Humidity

Relative humidity indicates how moist the air is.

Relative humidity may be defined as the ratio of the water vapor density (mass per unit volume) to the saturation water vapor density, usually expressed in percent. Relative humidity is also approximately the ratio of the actual to the saturation vapor pressure.

Actual vapor pressure is a measurement of the amount of water vapor in a volume of air and increases as the amount of water vapor increases. Air that attains its saturation vapor pressure has established equilibrium with a flat surface of water. That means, an equal number of water molecules are evaporating from the surface of the water into the air as are condensing from the air back into the water.

Relative Humidity is among the most common of indoor air environmental factors implicated in occupant discomfort. Elevated humidity has been shown to be associated with a worsened perception of IAQ. High %RH is also an indicator of conditions favorable to mold and microbial growth.

Government and Industry Guidelines for Relative Humidity

US OSHA Standard Interpretations: 02/2003 - Reiteration of Existing OSHA Policy on Indoor Air Quality: Office Temperature/Humidity and Environmental Tobacco Smoke: As a general rule, office temperature and humidity are matters of human comfort. OSHA has no regulations specifically addressing temperature and humidity in an office setting. However, Section III, Chapter 2, Subsection V of the OSHA Technical Manual, "Recommendations for the Employer," provides engineering and administrative guidance to prevent or alleviate indoor air quality problems. OSHA recommends humidity control in the range of 20%RH-60%RH.

ASHRAE (American Society of Heating Refrigeration and Air-Conditioning Engineers) Standard 55-2004 states that occupant comfort may best be obtained by maintaining humidity ratio below 0.012. This can be calculated, at standard atmospheric pressure, as a maximum of approximately 56%RH at 80F (27C) up to approximately 86%RH at 67F (19C). Clothing, radiant heat and many other factors influence the recommendations of this standard. Reference ASHRAE Standard 55-2004 for details.

Per ASHRAE Standard 55-2004: There are not any established lower humidity limits for thermal comfort. However, non-thermal comfort factors such as skin drying, irritation of mucus membranes, dryness of the eyes, and static electricity
generation, may place limits on the acceptability of very low humidity environments.

**Calibration and Care Information for Relative Humidity**

The %RH sensor is calibrated a minimum of once every 12 months. Some indoor environmental protocols require more frequent calibration. Dirty environments, such as smoking areas, may require more frequent calibration.

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**Relative Humidity detail University of Massachusetts Boston Interim IAQ 9-10-19**

<table>
<thead>
<tr>
<th>Location</th>
<th>Date/Time</th>
<th>Relative Humidity %RH</th>
<th>Comments</th>
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<tr>
<td>Outdoor Air UMass Interim IAQ 9-10-19 (10-Sep-19)*</td>
<td>10-Sep-19 03:34:50 PM to 10-Sep-19 03:43:50 PM</td>
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<td>McCormack 2nd Floor Hall (10-Sep-19)*</td>
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<tr>
<td>McCormack 3rd Floor Hall (10-Sep-19)*</td>
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<tr>
<td>Quinn 1st Floor Elev Lobby (10-Sep-19)*</td>
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<tr>
<td>Quinn 2nd Floor Elev Lobby (10-Sep-19)*</td>
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<td>50.9</td>
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<tr>
<td>Quinn Upper Level Elev Lobby (10-Sep-19)*</td>
<td>10-Sep-19 04:12:03 PM to 10-Sep-19 04:18:03 PM</td>
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<td>*average reading</td>
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<tr>
<td>Wheatley 3rd Floor South Hall (10-Sep-19)*</td>
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<td>42.6</td>
<td>*average reading</td>
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</table>
**Carbon Monoxide**

**Why Measure Carbon Monoxide**

Elevated CO may be present in any type of space for a number of reasons: most commonly due to inappropriately exhausted combustion processes.

This insidious toxic gas is odorless, and often goes undetected prior to detrimental levels of exposure which may lead to short-term productivity issues and to long-term health effects. At highly elevated levels Carbon Monoxide MAY BE FATAL!

**Health Effects Associated with Carbon Monoxide**

At low Carbon Monoxide (CO) concentrations CO can cause fatigue in healthy people and chest pain in people with heart disease. CO at moderate concentrations can cause impaired vision and coordination; headaches; dizziness; confusion and nausea. CO can cause flu-like symptoms that clear up after leaving the space that contains the elevated concentrations. CO may be fatal at very high concentrations.

Acute effects are due to the formation of carboxyhemoglobin in the blood, which inhibits oxygen intake leading to reduced brain function.

**Typical Background Levels for Carbon Monoxide**

Global CO background concentrations, outdoors, fall in the range of 60 to 140 g/m3 (0.05 to 0.12ppm).

Average levels in homes without gas stoves vary from 0.5 to 5 parts per million (ppm). Levels near properly adjusted gas stoves are often 5 to 15 ppm and those near poorly adjusted stoves may be 30 ppm or higher.

Per AIHA "The IAQ Investigator's Guide", 2006

Levels commonly found indoors*: ND to 4ppm

*Outside level may affect inside levels

**Typical Sources of Carbon Monoxide**

Elevated CO may be present in any type of space for a number of reasons: most commonly due to inappropriately exhausted combustion processes.

Idling motor vehicles such as gas or propane powered fork lifts; unvented kerosene and gas space heaters; leaking chimneys, boilers and furnaces; back-drafting from
furnaces, gas water heaters, wood stoves, and fireplaces; gas stoves; generators and other gasoline powered equipment and tobacco smoke are all common CO sources. Incomplete oxidation during combustion in gas ranges and unvented gas or kerosene heaters may cause high concentrations of CO in indoor air. Worn or poorly adjusted and maintained combustion devices (e.g., boilers, furnaces) can be significant sources, or if the flue is improperly sized, blocked, disconnected, or is leaking. Auto, truck, or bus exhaust from attached garages, nearby roads, parking areas or air intakes improperly located near loading docks or rooftop heliports, for example, can also be a source.

**Government and Industry Guidelines for Carbon Monoxide**

The Occupational Safety and Health Administration (OSHA) Permissible Exposure Limit (PEL) for carbon monoxide is 50 parts per million (ppm) parts of air (55 milligrams per cubic meter (mg/m(3))) as an 8-hour time-weighted average (TWA) concentration [29 CFR 1910.1000 Table Z-1 as of Feb 2006].

The National Institute for Occupational Safety and Health (NIOSH) has established a recommended exposure limit (REL) for carbon monoxide of 35 ppm (40 mg/m(3)) as an 8-hour TWA and 200 ppm (229 mg/m(3)) as a ceiling [NIOSH 1992].

ACGIH 2006 TLVs and BEIs; 25ppm (8 hour TWA).

ASHRAE Standard 62.1-2004 references US OSHA, NIOSH and ACGIH values. However, ASHRAE suggests that consideration must be taken that those values have been established for healthy workers. For indoor environments, where occupants may not be of excellent health, may be exposed to more than 8 hours per day, and may not be expecting any type of toxic exposure; exposures should always be lower than the worker exposure levels.

The U.S. EPA National Ambient Air Quality Standards, 1990, for outdoor air are 9 ppm (10 mg/m3) for 8 hours, and 35 ppm (40 mg/m3) for 1 hour.


- 100 mg/m3 (90 ppm) for 15 min
- 60 mg/m3 (54 ppm) for 30 min
- 30 mg/m3 (27 ppm) for 1 h
- 10 mg/m3 (9 ppm) for 8 h

**Calibration and Care Information for Carbon Monoxide**

The CO sensor is calibrated a minimum of once every 12 months. Some indoor environmental protocols require more frequent calibration.
The electrochemical CO sensor has a lifetime of approximately 24 to 36 months. If response becomes sluggish or if it doesn't hold calibration, the sensor should be replaced.

The CHECK CAL icon appears when WolfSense detects that the zero value for CO has drifted low, below specifications, and is in need of user re-zeroing.

### Carbon Monoxide detail University of Massachusetts Boston Interim IAQ 9-10-19

<table>
<thead>
<tr>
<th>Location</th>
<th>Date/Time</th>
<th>Carbon Monoxide ppm</th>
<th>Comments</th>
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</table>
**Carbon Dioxide**

**Why Measure Carbon Dioxide**

CO₂ is measured as a tracer gas, to determine the outdoor air ventilation (dilution air) rate in an occupied space. It is rarely of toxic concern for indoor air quality applications.

People exhale CO₂ (at a concentration of almost 40,000 ppm), and therefore are used as the source of the tracer gas (although CO₂ may be injected into an unoccupied space as an alternative method).

Low CO₂ concentration, when measured during periods of average and higher occupancy, implies that human generated pollutants are being properly diluted. And in absence of a specific pollutant source, it is a rough estimator that the thousands of potential building generated pollutants are being dispersed. This makes it a key indoor air quality indicator.

**Health Effects Associated with Carbon Dioxide**

Carbon Dioxide is very rarely a pollutant of direct health concern, itself! Rather, because building occupants exhale CO₂ (at close to 40,000 ppm), the CO₂ that they breathe out is used as a tracer gas that is an excellent indicator of adequate (or inadequate) ventilation. Insufficient ventilation can lead to occupant complaints of discomfort and reduced productivity as human and building generated pollutants build up. Some combinations of these elevated pollutants may have short or long-term detrimental health effects.

CO₂ will generally only be of concern as a toxic gas itself in industrial processes where bottled CO₂ gas is utilized, such as breweries, or when there is an inadequately ventilated combustion process (where the other combustion gases will usually be of much greater concern).

**Typical Background Levels for Carbon Dioxide**

Typical outdoor CO₂ levels are 350 to 360ppm (although they can be 100 to 300ppm higher in urban areas). It is of note that the average outdoor CO₂ levels worldwide have increased >25ppm over the last 50 years.

**Typical Sources of Carbon Dioxide**

The concentration of CO₂ in the exhaled breath of building occupants approaches 40,000 ppm. For light office work, the estimated CO₂ generation rate of 0.6 cfm/min (0.3 l/s) per occupant is typically assumed. This will usually increase the CO₂ concentrations in the occupied space above the outdoor, ambient levels. The greater the outdoor (dilution) air ventilation rate, generally the less increase in CO₂ that will
In general, CO₂ will only be of concern as a toxic gas itself in industrial processes where bottled CO₂ gas is utilized, such as breweries and fire extinguisher mfg, or when there is an inadequately ventilated combustion process (where the other combustion gases will normally be of much greater concern).

Generally, house plants will have an insignificant impact in reducing the CO₂ concentrations that result from human occupation.

**Government and Industry Guidelines for Carbon Dioxide**

US OSHA Technical Manual (section iii, chapter 2), 1999, states that 1,000 ppm CO₂ should be used as an upper limit for indoor levels, as a guideline for occupant comfort.

US OSHA Regulation (Standards - 29 CFR), 1997 TABLE Z-1 Limits for Air Contaminants. - 1910.1000 TABLE Z-1 PEL (Permitted Exposure Level), updated as of Feb 2006: 5000ppm; 9000 mg/m³ for an 8 hour Time Weighted Average (TWA). It is of note that OSHA has published intentions to raise the 8 hour CO₂ TWA to 10,000ppm, but this change is yet to be approved.

OSHA 1994 proposed Indoor Air Quality Rules: If the indoor sample results show levels that are greater than 800 ppm or that the indoor levels are significantly more than the outdoor levels, initiate actions to investigate the functioning of the HVAC system and determine if the employees are affected. Note that the proposed 1994 IAQ rules have not been adopted by OSHA.

NIOSH 1992 REL (Recommended Exposure Limit): TWA 5000 ppm (9000 mg/m³) STEL (Short Term Exposure Limit) 30,000 ppm (54,000 mg/m³)

ACGIH 2006 TLVs & BEIs: 5000ppm 8 hour TWA, 30,000ppm STEL

ASHRAE Standard 62.1-2004 suggests maintaining a steady-state CO₂ concentration in a space no greater than about 700 ppm above outdoor air levels to remove human generated pollutants. Additional ventilation may be needed to dilute building generated pollutants.

ASHRAE Standard 62.1-2004 defines adequate ventilation for specific use designed spaces. For example, 17 cfm/person of dilution air is suggested for office spaces (because such spaces have additional pollutants introduced from copiers, laser printers, etc), which translates to a CO₂ concentration of roughly 600 ppm above outdoor air levels.
There are no USEPA outdoor standards for CO₂. Typical outdoor CO₂ levels are usually 350ppm to 360ppm (although they can be 100-300ppm higher in urban areas).

**Calibration and Care Information for Carbon Dioxide**

For accurate CO₂ readings your sensor must be calibrated at minimum every 6 (six) months. However, most IAQ protocols call for more frequent calibration. It is advisable to check calibration as often as is practical (the IQ-410 is easy to calibrate)!

Typical outdoor CO₂ levels are usually just above 350ppm (although they can be 100-300ppm higher in urban areas). If your readings (inside or out) are less than 300ppm your sensor is clearly out of calibration, or in need of service.

The CHECK CAL icon appears when CO₂ has drifted below 300ppm.

A reading of -1 ppm CO₂ (after the sensor has stabilized) indicates the sensor may be faulty, or has become dislodged.

**Carbon Dioxide detail University of Massachusetts Boston Interim IAQ 9-10-19**

<table>
<thead>
<tr>
<th>Location</th>
<th>Date/Time</th>
<th>Carbon Dioxide mg/m³</th>
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<tr>
<td>Outdoor Air UMass Interim IAQ 9-10-19 (10-Sep-19)*</td>
<td>10-Sep-19 03:34:50 PM to 10-Sep-19 03:43:50 PM</td>
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</tr>
</tbody>
</table>
**Why Measure TVOC-ppb range**

A Volatile Organic Compound (VOC) is defined as any compound containing carbon, except methane, that can be readily vaporized. Total VOCs are known as TVOCs, Microbial generated VOCs are known as MVOCs.

VOCs are released into indoor environments from cleaning and disinfecting products, paints, wood preservatives, carpeting, building materials, copier machines, aerosol sprays, moth repellants, air fresheners, perfumes, dry cleaned clothing, microbial growth and a host of other sources.

The USEPA has consistently measured higher levels of VOCs in indoor environments when compared to outdoors (ref "Report to Congress on Indoor Air Quality: Exec Summary and Recommendation", Vol 1-3, EPA-400/1-89-001 A-D)

While some specific VOCs have adverse health effects at low concentrations, many others do not. When measuring the whole 'soup' of VOCs, an elevated TVOC reading, in that absence of a known benign VOC source, is an indication that a closer examination and possible air sampling for lab analysis may be justified.

A Photo Ionization Detector (PID) sensor based VOC monitor can also be useful, in some circumstances, to bloodhound the source of elevated VOCs.

The PID is one of the most widely used gas detection techniques. The main field of PID application is for detection of a wide variety of organic compounds and some inorganic gases in ambient air.

Note that a PID will not distinguish between different specific compounds; it is not a specific gas analyzer.

**Health Effects Associated with TVOC-ppb range**

In sufficient quantities, some VOCs can cause eye, nose, and throat irritation; headaches, loss of coordination, nausea; damage to liver, kidney, and central nervous system. Some organics can cause cancer in animals; some (such as Benzene) are suspected or known to cause cancer in humans. Key signs or symptoms associated with exposure to VOCs include conjunctival irritation, nose and throat discomfort, headache, allergic skin reaction, dyspnea, declines in serum cholinesterase levels, nausea, emesis, epistaxis, fatigue, dizziness.

The ability of organic chemicals to cause health effects varies greatly from those that are highly toxic, to those (such as Acetic Acid, an approximately 5%
component of vinegar) with no known health effect. As with other pollutants, the extent and nature of the health effect will depend on many factors including level of exposure and length of time exposed. Eye and respiratory tract irritation, headaches, dizziness, visual disorders, and memory impairment are among the immediate symptoms that some people have experienced soon after exposure to some organics. At present, not much is known about what health effects occur from the levels of organics usually found in buildings or homes.

**Typical Background Levels for TVOC-ppb range**

The US EPA's Total Exposure Assessment Methodology (TEAM) studies have found levels of about a dozen common organic pollutants to be 2 to 5 times higher inside homes than outside, regardless of whether the homes were located in rural or highly industrial areas. Additional TEAM studies indicate that while people are using products containing organic chemicals, they can expose themselves and others to very high pollutant levels, and elevated concentrations can persist in the air long after the activity is completed.

For buildings, toluene (one of the most prevalent VOCs in indoor air) has itself been reported in a majority of indoor air samples, at an overall average ~0.15mg/m3 (40ppb).

The USEPA initiated study "INDIVIDUAL VOLATILE ORGANIC COMPOUND PREVALENCE AND CONCENTRATIONS IN 56 BUILDINGS OF THE BUILDING ASSESSMENT SURVEY AND EVALUATION (BASE) STUDY"; Girman, Hadwen, Burton, Womble & McCarthy, published in the Proceedings of Indoor Air 1999 found (for "randomly selected buildings"):

"Forty-eight VOCS were found indoors at quantifiable concentrations. Eight VOCS were found in all samples and an additional 26 VOCS were found in 81-99% of the samples...the twelve VOCS with the highest median indoor concentrations: acetone; toluene; d-limonene; m- & p-xylene; 2-butoxyethanol; n-undecane; benzene; 1,1,1-trichloroethane; n-dodecane; hexanal;nonanal; and n-hexane. Indoor VOC concentrations ranged from below the limit of detection to 0.45 mg/m3".

In a review of 12 studies of indoor VOC concentrations by Johansson*, the range was found to be 0.5 to 19 mg per cubic meter in new buildings, which is 10 times the range of older buildings (0.01-1.7 mg per cubic meter). The most common VOC's reported included alkanes (decane, undecane, nonane), and aromatic hydrocarbons (toluene most prominently).

Typical Sources of TVOC-ppb range

A wide array of volatile organics are emitted by products used in home, office, school, and arts/crafts and hobby activities. These products, which number in the thousands, include:

- personal items such as perfumes, after-shave, nail polish (and removers) and hair sprays;
- household products such as finishes, rug and oven cleaners, paints and lacquers (and their thinners), paint strippers, pesticides, mothballs, deodorizers;
- vinegar;
- dry-cleaning fluids;
- building materials and home furnishings;
- office equipment such as some copiers and printers;
- office products such as correction fluids and carbonless copy paper;
- graphics and craft materials including glues and adhesives, permanent markers, and photographic solutions.

Many materials, such as carpets, carpet adhesives, pressed wood products, paint, furniture and foam cushions will off-gas VOCs at a significantly higher rate when new.

The metabolic actions of bacteria and fungi, when in large concentrations, may also contribute detectible levels of Microbial VOCs ("MVOCs").

Government and Industry Guidelines for TVOC-ppb range

In North America and Europe, TVOCs are not generally regulated as a combination of compounds; rather some specific volatile organic compounds are regulated.

A few examples of the US OSHA worker Permitted Exposure Levels (8 hour TWA) for specific VOCs are listed below:

- Acetone 1000ppm
- Benzene 1ppm
- Ethanol 1000ppm
- Formaldehyde 0.75ppm (note that the GrayWolf 10.6 eV PID does not ionize this VOC. HUD has established a level of 0.4 ppm for mobile homes)
- Styrene 100ppm
- Toluene 200ppm
- Turpentine 100ppm
- Xylene 100ppm
Calibration and Care Information for TVOC-ppb range

The PID sensor is a very sensitive device.

As a rule, calibration of the sensor on a daily basis is recommended. However, if the sensor is used in a clean environment, calibration frequency can be reduced to just once a week or even once per month.

Storage in high humidity conditions >60 %RH may cause sensor drift, which takes time to re-stabilize after power-up. A 20-minute warm-up, prior to recalibration and use, should minimize high %RH storage bias. Utilize desiccant to maintain lower %RH during storage. Use the ACC-ADY AC power adapter to power the probe overnight ahead of use to reduce the warm-up period.

If the sensor is being exposed to dirty samples (containing heavy compounds and/or particles), the lamp window will get contaminated. The rate of the window contamination is a function of the sample gas condition, i.e. how badly it is contaminated with chemicals and particles. Contamination of the lamp window can cause partial UV light blocking, which in turn will rapidly reduce the detector's sensitivity. In this case, more frequent calibration is needed.

If the sensor has been stored for a significant amount of time, it may become contaminated. This in turn may cause excessive drift of the background signal. Therefore, it is highly recommended to run the sensor for some period of time before operating it after prolonged storage, especially if it going to be used for low-level applications. An overnight burn-in period should be sufficient in most cases. During this time, the detector will clean itself and the baseline signal will drop and stabilize. If the sensor is used on a frequent basis, the user should let it stabilize for 10-20 minutes before use. If high accuracy is not important (for example, in leak detection application) or in the case of measuring relatively high concentrations (> 100 ppm), this stabilization procedure can be skipped.

The linearity of the sensor may vary somewhat, depending on the target compound. As a rule, the greater the sensor's response to some compounds, the narrower the linear range, and vice versa. Therefore, if an application requires high accuracy, linearity characteristic of the sensor should be experimentally measured for this particular application's target compound. Another way to improve the accuracy of measurement of a specific compound is to calibrate the sensor at a concentration of the target gas, within the expected application range.
## TVOC detail for University of Massachusetts Boston Interim IAQ 9-10-19

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<tr>
<th>Location</th>
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<td>934</td>
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**Particle Counts**

**Why Measure Particle Counts**

Comparing indoor particle counts to outdoor counts provides information regarding the effectiveness of filtration, as well as for the potential that there are indoor sources contributing to airborne particulate. Many investigators have developed experience with elevated particle counts in specific particle size ranges to provide additional clues towards determining potential sources of these particles. For example, tobacco smoke is known to be in the .01 to 1.0 micron size range, and pollens are typically >10 microns. However, published scientific data is scant on this subject.

<table>
<thead>
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<th>&lt;0.1</th>
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<th>1.0-2.5</th>
<th>2.5-5.0</th>
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<td>Pet Dander</td>
<td>Mold</td>
<td>Mold Spores</td>
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<td>Tobacco Smoke</td>
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<td>Oil Smoke</td>
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<td>Auto Emissions</td>
<td>Suspended Atmospheric Dust</td>
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<td></td>
<td></td>
<td>Lung Damaging Dust</td>
<td>Asbestos</td>
<td>Unl</td>
</tr>
</tbody>
</table>

Establishing a baseline of particle count data to compare to when complaints arise, or when construction is in progress or after changes have been made to an occupied space can provide valuable information to an IAQ investigator.

In some cases, tracking increasing particle counts may be used to "bloodhound" a source of airborne particulate. Elevated particle counts, in the absence of aknow source, may also indicate justification for air sampling, to be sent out for detailed laboratory analysis of the chemical composition of the particles.

**Typical Sources of Particle Counts**

Particulate matter is typically brought in from outdoor dust, pollen, smoke, smog and other outdoor sources. Indoor sources may include copier machines, printers, paper dust, environmental tobacco smoke, carpet fibers, upholstery, skin cells, pet
dander and poorly ventilated combustion processes (fireplaces, kitchen cooking areas, boilers, furnaces, gas heaters, wood stoves, etc).

From outdoor sources; respirable particles that are 2.5-10 µm, and course, inhalable, suspended particles that are 10 -25 µm+, are found near roadways and dusty industries. Fine particles, those that are 2.5 µm and smaller, are usually the result of smoke and haze (forest fires, gases from power plants, industries, and motor vehicles).

Mold and mold spores are microscopic (2-25 µm) and are naturally present in both indoor and outdoor air. Molds reproduce by means of spores. Some molds have spores that are easily disturbed and waft into the air and settle repeatedly with each disturbance. Other molds have sticky spores that will cling to surfaces and are dislodged by brushing against them or by other direct contact. Whether or not the spores are alive, the allergens and toxins in them may remain for years.

**Government and Industry Guidelines for Particle Counts**

**US Indoor Air Quality (IAQ) Exposure Guidelines for PM:**

American Society of Heating Refrigeration and Air Conditioning Engineers (ASHRAE)

ASHRAE Standard 62.1-2013 references US OSHA, NIOSH, ACGIH and German MAK values. However, ASHRAE suggests that consideration must be taken that those values have been established for healthy workers. For indoor environments, where occupants may not be of excellent health, may be exposed to more than 8 hours per day, and may not be expecting any type of toxic exposure; exposures should always be lower than the worker exposure levels.

**Illinois**

IL Department of Heath Public Health IAQ Guidelines (Updated May, 2011)

PM2.5 (<2.5 micron particles)
65 µ/m3

PM10 (<10 micron particles)
150 µ/m3

http://www.idph.state.il.us/envhealth/factsheets/indoorairqualityguide_fs.htm

**Texas**

TX Voluntary Indoor Air Quality Guidelines for Government Buildings, 2002

PM2.5
15.0 µg/m3 24 hr TWA
65 µg/m3 annual mean
PM10
150 µg/m³ 24 hr TWA
http://www.dshs.state.tx.us/iaq/SchoolsGuide.shtm

US Green Building Council (USGBC)

USGBC LEED IEQ Credit 3.2, Option 2 (2009, updated 2013) requires PM10 to be measured <50 µg/m³ for a minimum of 4 hours ahead of allowing occupancy in a new facility or reconstructed existing building.

US Ambient Air Guidelines for PM:

US EPA National Ambient Air Quality Standards (NAAQS) as of July 2011
PM2.5 (<2.5 micron particles)
15.0 µg/m³ 24 hr TWA
35 µg/m³ annual mean
PM10 (<10 micron particles)
150 µg/m³ 24 hr TWA

TWA=Time Weighted Average

US Occupational Exposure Limits for PM:

US OSHA GENERAL INDUSTRY PEL, 1997 (table Z-1 updated as of Feb 2006):

PM10
5.0 mg/m³ 8 hour TWA respirable fraction,
15.0 mg/m³ 8 hour TWA total dust
TSP (Total Suspended Particles)

ACGIH TLVs, 2013:
For biologically inert, insoluble or poorly soluble particles, ACGIH TLVs (Threshold Limit Values) Guideline, 2013 recommends:

PM10
3 mg/m³ 8 hour TLV for respirable particles and
TSP
10 mg/m³ for inhalable particles.
### PM 2.5 detail for University of Massachusetts Boston Interim IAQ 9-10-19

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<tr>
<td>Quinn Upper Level Elev Lobby</td>
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### PM 10.0 detail for University of Massachusetts Boston Interim IAQ 9-10-19

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4 Conclusions and Recommendations

The survey that has been performed has not identified any specific indoor air quality (IAQ) problems. All air parameters tested are within expected levels and are at acceptable concentrations in consideration of the government and industry guidelines for indoor air. In fact, the indoor levels were equivalent or favorable for most parameters in comparison to the outdoor air values measured.

A visual inspection did not identify any apparent problems that would negatively impact IAQ. It is ALG Consulting’s opinion that a HEPA exhaust system be in use during all future work and that the work zones are isolated from the general public. It is recommended that dust control measures and cleaning be maintained in those areas that will be impacted until the renovations are completed.

Thermal comfort parameters were measured to be within ASHRAE guidelines. Thermal discomfort will often aggravate occupants’ perception of the quality of the indoor air.

Information contained in this report is intended to be used as baseline for comparative purposes for future IAQ sampling during construction.
5 Appendices

5.1 Calibration Data
5.2 Testing Equipment Listing and Specifications
5.1 Calibration Data

**IQ610 (05-368) latest adjustment on 10-Sep-19**

Calibration used in McCormack 3rd Floor Hall (10-Sep-19), McCormack 4th Floor Hall (10-Sep-19), Outdoor Air UMass Inreim IAQ 9-10-19 (10-Sep-19), Quinn 1st Floor Elev Lobby (10-Sep-19), Quinn 2nd Floor Elev Lobby (10-Sep-19), Quinn Upper Level Elev Lobby (10-Sep-19), Wheatley 3rd Floor South Hall (10-Sep-19), Wheatley 4th Floor Hall (10-Sep-19)

Temperature (Factory cal on 3/13/2017)
Factory set points = (Low) 20.0°C, (High) 39.2°C

Carbon Monoxide (Factory cal on 3/13/2017)
Factory set points = (Low) 0.1ppm, (High) 100.0ppm

Carbon Dioxide (Factory cal on 3/13/2017)
Factory set points = (Low) 375ppm, (High) 1,250ppm
::User cal (High) @500ppm offset= -2,234ppm from Factory Cal on 12/18/2018 9:25 AM
::User cal (Low) @0ppm offset= -1,771ppm from Factory Cal on 7/11/2019 11:16 AM

Relative Humidity (Factory cal on 3/13/2017)
Factory set points = (Low) 1.3%, (High) 75.0%

TVOC (Factory cal on 3/13/2017)
Factory set points = (Low) 10ppb, (High) 7,500ppb
::User cal (Low) @100ppb offset= 32ppb from Factory Cal on 9/10/2019 2:49 PM
::User cal (High) @7,500ppb offset= 1,009ppb from Factory Cal on 9/10/2019 3:02 PM
5.2 Testing Equipment Listing and Specifications
The following equipment will be used to collect the data:

**IQ-610**

The IQ-610 probe utilizes highly accurate, rapid response sensors for ppb TVOC, CO2, CO, %RH, Temperature and Toxic Gas (plus derived Dewpoint, Wetbulb Temperature, Specific Humidity, Absolute Humidity and Humidity Ratio). The IQ-610 contains 1 upgradeable electrochemical gas sensor slot.

**PC-GW3016**

GrayWolf 6-Channel Particle Counter

**WS-ARG**

Advanced Report Generator software module.

**CA-GS25L VOC gas calibration kit**

GrayWolf probes with SEN-TVOC-PPB

low-range PID sensor installed. Includes: 0.0 ppm and 7.5 ppm isobutylene ref gases, CA-HD2, CA-REG1, and PCC-GC2 2 Cylinder Case.
The above equipment has been chosen for the collection of air quality data as it represents state of the art technology designed to perform in an integrated manner. This specific equipment is completely data loggable allowing for the download of data directly into the Advanced Report Generator.

The equipment provided by Grey Wolf Sensing solutions maintains the integrity of the data with a simple integrated solution for reporting the data.

Sensor Specifications
Carbon Dioxide

<table>
<thead>
<tr>
<th>Range</th>
<th>0 to 10,000 ppm</th>
<th>0 to 18,000 mg/m3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accuracy</td>
<td>+/- 3%rdg +/- 50ppm</td>
<td></td>
</tr>
<tr>
<td>T90 response</td>
<td>&lt;75 seconds (in 50fpm, 0.25 m/s airflow)</td>
<td></td>
</tr>
<tr>
<td>Expected lifetime</td>
<td>&gt;10years</td>
<td></td>
</tr>
</tbody>
</table>

This sensor may be used up to 20,000ppm, but with reduced accuracy. High range calibration is recommended for any applications where optimum accuracy >2000 ppm is important.

The standard CO2 sensor employed by GrayWolf utilizes dual band, folded path NDIR (Non-Dispersive Infra-Red) technology with a reference channel for self-compensation. The sensor has excellent accuracy and exhibits very fast response (important for walk-thru surveys and for checking outdoor conditions), yet low power consumption. A gold-plated optical/gas cavity provides stable signal levels, operating in varying ambient temperature, pressure and humidity. The rugged
stainless steel construction is resistant to corrosion and the over-all design provides immunity from ‘poisoning’

Carbon Monoxide

Carbon Monoxide (solo) sensor (based on AlphaSense model CO-AF):

Range 0.0 to 750.0ppm
Instrument resolution 0.1ppm
Limit of detection <0.3ppm
Sensor Drift 3%/year
T90 response time <25 seconds
Expected sensor life: mfg specifies >24 months, GrayWolf’s experience is 36 to 60 months
Sensor Accuracy: +/- 2ppm <50ppm, +/- 3%rdg >50ppm

ENVIRONMENTAL
• Sensitivity @ -20°C % (output @ -20°C/output @ 20°C) @ 400ppm CO 63 to 88
• Sensitivity @ 50°C % (output @ 50°C/output @ 20°C) @ 400ppm CO 102 to 115
• Zero @ -20°C ppm equivalent change from 20°C < +/-3
• Zero @ 50°C ppm equivalent change from 20°C < +/-8

CROSS SENSITIVITY
• SO2 sensitivity measured gas @ 20ppm SO2< 0.02ppm
• NO sensitivity measured gas @ 50ppm NO < 2.5ppm
• NO2 sensitivity measured gas @ 10ppm NO2< 0.01ppm
• Cl2 sensitivity measured gas @ 10ppm Cl2< 0.01ppm
• H2 sensitivity measured gas @ 400ppm H2 at 20C < 240ppm
• C2H4 sensitivity measured gas @ 400ppm C2H4< 100ppm
• H2S sensitivity % measured gas @ 20ppm H2S < 0.02ppm
• NH3 sensitivity % measured gas @ 20ppm NH3< 0.02ppm

KEY SPECIFICATIONS
• Temperature range -30 to 50 °C (-22 to 122 °F)
• Pressure range kPa 80 to 120
• Humidity range % RH continuous 15 to 90

CO/H2S combo sensor (based on City Tech model 4COSH):

Range: 0.0 to 500.0ppm CO
Limit of detection 1ppm CO
CO Sensor Drift 5%/year
T90 response time <35 seconds
Expected sensor life: mfg specifies 36 months, GrayWolf’s experience is 36 to 60 months
Sensor accuracy: -2ppm to +3ppm +/- 3% reading

CROSS SENSITIVITY
• H2S sensitivity measured gas @ 15ppm H2S 0 to 6ppm CO
• H2 sensitivity measured gas @ 100ppm H2 ~20ppm CO
• NO sensitivity measured gas @ 35ppm NO <0.1ppm CO
• NO2 sensitivity measured gas @ 5ppm NO2 <0.1ppm CO
• Cl2 sensitivity measured gas @ 1ppm Cl2 0ppm CO
• SO2 sensitivity measured gas @ 5ppm SO2 0ppm CO

KEY SPECIFICATIONS
• Temperature range -20 to 50 °C(-22 to 122 °F)
• Pressure range kPa 90 to 110
• Humidity range % RH 15 to 90 non-condensing