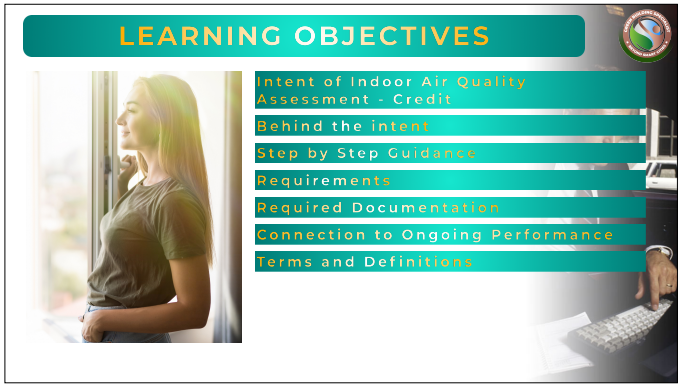

BEYOND
SMART CITIES
INDOOR ENVIRONMENTAL QUALITY - GREEN BUILDING TECHNOLOGY TRAINING PROGRAM
FOR GREEN BUILDING AND SUSTAINABILITY SPECIALISTS
KRISHNAJI PAWAR,LEED AP BD+C,GSAS CGP,ISO 14001:2015,GCP
GREEN BUILDING SPECIALIST CURRICULUM


BEYOND
SMART CITIES
INDOOR AIR QUALITY ASSESSMENT - CREDIT
FOR GREEN BUILDING AND SUSTAINABILITY SPECIALIST
KRISHNAJI PAWAR,LEED AP BD+C,GSAS CGP,ISO 14001:2015,GCP
GREEN BUILDING SPECIALIST CURRICULUM


LEARNING OBJECTIVES
Intent of Indoor Air Quality Assessment - Credit
Behind the intent
Step by Step Guidance
Requirements
Required Documentation
Connection to Ongoing Performance
Terms and Definitions

IEQ- CR(2) - CONSTRUCTION

INTENT

To establish better quality indoor air in the building after construction and during occupancy to protect human health, productivity, and wellbeing.

POTENTIAL TECHNOLOGIES & STRATEGIES

☑ Testing airborne pollutant levels is the best way to demonstrate that source control strategies have been effectively and properly implemented. For VOCs, this credit follows the California Department of Public Health Standard Method v1.1, which is widely recognized by the industry for its science-based best practices and rigorous, well-established testing procedures.

INDOOR AIR QUALITY ASSESSMENT

REQUIREMENTS

Select one of the following two options, to be implemented after construction ends and the building has been completely cleaned. All interior finishes, such as millwork, doors, paint, carpet, acoustic tiles, and movable furnishings (e.g., workstations, partitions), must be installed, and major VOC punch list items must be finished. The options cannot be combined

Option 1. Flush-Out (1 point)
Option 2. Air Testing (1-2 points)

IMPLEMENTATION

REQUIRED DOCUMENTATION

Documentation	Option 1, Path 1	Option 1, Path 2	Option 2
Flush-out report	X	X	
IAQ testing report			X

BEHIND THE INTENT



Many building materials contain substances that are hazardous to human health, and construction activity can introduce contaminants into the indoor environment. Harmful substances include formaldehyde and volatile organic compounds (VOCs) from building materials. Dust, ozone, and fine particulate matter generated by construction activity, diesel engines, or unfiltered outdoor air can also be harmful. Reducing indoor air contaminants has significant human health benefits and typically improves occupants' comfort, lowers absenteeism, and increases productivity.

Testing airborne pollutant levels is the best way to demonstrate that source control strategies have been effectively and properly implemented. For VOCs, this credit follows the California Department of Public Health Standard Method v1.1, which is widely recognized by the industry for its science-based best practices and rigorous, well-established testing procedures.

An alternative to testing that can improve indoor air quality is a building flush-out, an effective method to disperse off-gassed compounds and other contaminants left behind at the end of construction. The threshold for duration of building flush-out is based on a typical mechanical ventilation system. A typical ventilation system supply airflow rate is 0.7 cubic feet per minute per square foot (3.55 liters per second per square meter). Therefore, if a system operates at 100% outdoor air continuously for two weeks, the cubic feet of outdoor air per square foot of floor area is calculated as follows:

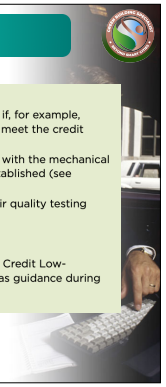
$$\text{14.152 cu ft of outdoor air } \frac{\text{ft}^3}{\text{ft}^2} \text{ of floor area} = \left\{ 0.7 \left(\frac{\text{cfm}}{\text{ft}^2} \right) \times 14 \text{ days} \times \left(\frac{24 \text{ hours}}{\text{day}} \right) \times \left(\frac{60 \text{ mins}}{\text{hr}} \right) \right\}$$

In SI units,

$$\text{4 294 080 l of outdoor air } \frac{\text{l}}{\text{m}^2} \text{ of floor area} = \left\{ 3.55 \left(\frac{\text{l/s}}{\text{m}^2} \right) \times 14 \text{ days} \times \left(\frac{24 \text{ hours}}{\text{day}} \right) \times \left(\frac{60 \text{ mins}}{\text{hr}} \right) \times \left(\frac{60 \text{ sec}}{\text{min}} \right) \right\}$$

This demonstrates that two weeks of flush-out provides adequate time for removing contaminants from the construction process.

STEP-BY-STEP GUIDANCE



STEP 1. ASSESS OPTIONS

Develop a plan for the preferred option. Teams can change to a different option later if, for example, they run out of time to complete a flush-out. Options 1 and 2 cannot be combined to meet the credit requirements.

- Option 1 may be feasible if the project's schedule allows time for a flush-out. Work with the mechanical engineer to estimate the flush-out duration before the construction schedule is established (see *Further Explanation*, *Calculations*, and *Considerations for Flush-Out*).
- Option 2 can typically be completed in less time than a flush-out, but the cost of air quality testing must be factored into the project budget.

STEP 2. SPECIFY LOW-EMITTING PRODUCTS AND MATERIALS

Use the requirements of the source control credits in this credit category, such as EQ Credit Low-Emitting Materials and EQ Credit Construction Indoor Air Quality Management Plan, as guidance during selection and installation of products and materials.

STEP-BY-STEP GUIDANCE +

By incorporating low-emitting products, the project team can reduce the contaminant load before the flush-out and position the project for good test results. However, project teams are not required to achieve EQ Credit Low-Emitting Materials to meet the requirements of this credit.

STEP 3. INSTALL FINISHES, FURNITURE, AND FURNISHINGS

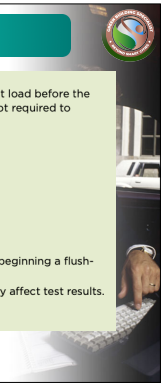
Install all finishes, furniture, and furnishings before testing or beginning a flush-out.

- Ensure that all owner-provided furniture has been installed in residential projects.
- Complete all punch-list items that would generate VOCs or other contaminants.
- Complete testing and balancing of the HVAC system.

STEP 4. CLEAN BUILDING

Consider thoroughly cleaning the building, including the ductwork, before testing or beginning a flush-out.

- Use low-emitting cleaning products to prevent high short-term VOC levels that may affect test results.
- Use vacuum cleaners with HEPA filtration to capture particulates.



STEP-BY-STEP GUIDANCE +

Option 1. Flush-out

STEP 1. SELECT PATH 1 OR PATH 2

Path 1 is preferable if the schedule permits, since it exposes occupants to lower levels of potential toxins; Path 2 is appropriate if the schedule does not allow time for Path 1 (see *Further Explanation, Examples 3–4*).

- For Path 2, begin the flush-out three hours before daily occupancy and continue throughout the occupied portion of the day.
- For Path 2, ensure that outdoor air volume is at least 0.30 cubic feet per minute per square foot (1.5 liters per second per square meter) or the design minimum outdoor air rate, whichever is greater.

STEP 2. CALCULATE REQUIRED VOLUME

Use the gross square footage (or square meters) to calculate the total cubic feet (or liters) of air required. The area used must be consistent with the area used for other credits. Every space in the building must be flushed out (see *Further Explanation, Calculations*).

STEP 3. DETERMINE DURATION OF FLUSH-OUT

Determine the rate of outdoor air the HVAC system can provide and calculate the duration of flush-out with the required volume calculated in Step 1 (see *Further Explanation, Calculations*).

- If a shorter duration is desired, or if the HVAC system is unable to provide at least 0.3 cubic feet per minute per square foot (1.5 liters per second per square meter) for an occupied flush-out, supplemental units may be used. Ventilation fans without supplemental cooling or heating, or temporary, supplemental HVAC units (installed in window or door openings) may be used, provided the outdoor conditions are within the required temperature and humidity constraints at all times during the flush-out. See the credit requirements.
- Commissioning can occur during the flush-out, provided none of the commissioning procedures introduce contaminants into the space and none of the flush-out procedures circumvent the commissioning process. Complete testing and balancing of the HVAC system after the flush-out is complete.
- If even partial construction work occurs during the flush-out (e.g., repainting a room) the flush-out must be started again from the beginning for that space.
- If multiple, discrete HVAC systems operate independently, the team may flush out portions of the building as work is completed in each area served by a given system.

STEP 4. REPLACE OR INSTALL FILTERS

If the permanent HVAC system will be used to perform the flush-out procedure, first replace used filters.

- Replace the used HVAC filtration media with new media. Filter selection has implications for other credits (see *Related Credit Tips*).
- Remove any temporary filters or duct coverings installed as part of the construction indoor air quality management plan.



STEP-BY-STEP GUIDANCE +

STEP 5. COMPLETE FLUSH-OUT

Complete the flush-out, following the requirements for Path 1 or Path 2.

STEP 6. PREPARE FLUSH-OUT REPORT

Provide a flush-out report that includes the following information:

- Duration calculations. Include the capacity of all HVAC units used and indicate which are permanent and which temporary; capacity should take into account the volume of outdoor air and temperature and humidity allowances.
- Description of flush-out procedure. Include a log of dates, hours, and recorded temperature and humidity.
- If the amount of outdoor air is more than has been designed in EQ Prerequisite Minimum Indoor Air Quality Performance or more than shown on the mechanical schedules, include a narrative explaining how the additional air was provided to the building.

Option 2. Air Testing

STEP 1. DETERMINE AIR-TESTING LOCATIONS

Select testing locations with the least ventilation but the greatest concentration of VOCs and other contaminants. Testing must be completed by an appropriately accredited professional. Use current versions of ASTM or ISO methods. The number of testing locations depends on the size of the building and number of ventilation systems but must include all occupied spaces. If sampling is used, all space types must be represented (e.g., office and classroom). Use the following methodology to determine how many air testing locations are required.

- Test at least one location per ventilation system for each occupied space type. There must be a minimum of one test per floor. The locations selected for testing must represent the worst-case zones where the highest concentrations of contaminants of concern are likely to occur.
- For offices, retail, schools, hospitality, and multifamily residential projects, test areas no larger than 5,000 square feet (465 square meters). For warehouses or large open spaces in other building types (e.g., ballrooms in hospitality, gymnasiums in schools), a limit of 50,000 square feet (4 654 square meters) may be used. If there is evidence that the air in the space is well mixed and sources of contaminants of concern are uniform, project teams may test a single location in that space.
- Determine whether the project includes spaces (e.g., offices, school classrooms, or multifamily residential units) that are identical in their construction, finishes, configuration, square footage, and HVAC systems. Project teams may sample identical spaces by testing one in seven. If the sampled space fails the test, all seven must be tested.

STEP 2. PERFORM TEST

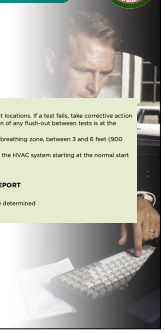
Ensure that the following procedures are followed at all test locations. If a test fails, take corrective action (e.g., clean and flush out the space) and retest. The duration of any flush-out between tests is at the discretion of the project team.

- The measurement equipment must be positioned in the breathing zone, between 3 and 6 feet (900 and 1 800 millimeters) above the floor.
- The test must occur during normal occupied hours, with the HVAC system starting at the normal start time and delivering outdoor air at the minimum rate.
- The gravimetric method must be used for testing.

STEP 3. PREPARE INDOOR AIR QUALITY TESTING REPORT

Develop an IAQ testing report that includes the following:

- Narrative describing procedures and how locations were determined
- Dates and results of each test



REQUIREMENTS

NC, Schools, Retail, Data Centers, Warehouses & Distribution Centers, Hospitality, Healthcare

Select one of the following two options, to be implemented after construction ends and the building has been completely cleaned. All interior finishes, such as millwork, doors, paint, carpet, acoustic tiles, and movable furnishings (e.g., workstations, partitions), must be installed, and major VOC punch list items must be finished. The options cannot be combined.

Option 1. Flush-Out (1 point)
Path 1. Before Occupancy
Install new filtration media and perform a building flush-out by supplying a total air volume of 14,000 cubic feet of outdoor air per square foot (4 267 140 liters of outdoor air per square meter) of gross floor area while maintaining an internal temperature of at least 60°F (15°C) and no higher than 80°F (27°C) and relative humidity no higher than 60%.

OR

Path 2. During Occupancy
If occupancy is desired before the flush-out is completed, the space may be occupied only after delivery of a minimum of 3,500 cubic feet of outdoor air per square foot (1 066 260 liters of outdoor air per square meter) of gross floor area while maintaining an internal temperature of at least 60°F (15°C) and no higher than 80°F (27°C) and relative humidity no higher than 60%.

Once the space is occupied, it must be ventilated at a minimum rate of 0.30 cubic foot per minute (cfm) per square foot of outdoor air (1.5 liters per second per square meter of outside air) or the design minimum outdoor air rate determined in EQ Prerequisite Minimum Indoor Air Quality Performance, whichever is greater. During each day of the flush-out period, ventilation must begin at least three hours before occupancy and continue during occupancy. These conditions must be maintained until a total of 14,000 cubic feet per square foot of outdoor air (4 270 liters of outdoor air per square meter) has been delivered to the space.

OR

Option 2. Air Testing (1-2 points)
After construction ends and before occupancy, but under ventilation conditions typical for occupancy, conduct baseline IAQ testing in occupied spaces for the contaminants listed in Path 1. Particulate matter and inorganic gases (for 1 point) and/or Path 2. Volatile organic compounds (for 1 point). Retail projects may conduct the testing within 14 days of occupancy.

Path 1. Particulate Matter and Inorganic Gases (1 point)



REQUIREMENTS +

Test for the particulate matter (PM) and inorganic gases listed in Table 1, using an allowed test method, and demonstrate the contaminants do not exceed the concentration limits listed in the table.

Table 1. Particulate Matter and Inorganic gases

Contaminant (CAS#)	Concentration Limit (µg/m³)	Allowed Test Methods
Carbon monoxide (CO)	9 ppm; no more than 2 ppm above outdoor levels	ISO 4224 EPA Compendium Method IP-3 GB/T 18883-2002 for projects in China Direct calibrated electrochemical instrument with accuracy of +/- 3% of reading and resolution of 0.1 ppm NDIR CO Sensors with accuracy of 1% of 10 ppm full scale and display resolution of less than 0.5ppm
PM 10	ISO 14644-1:2015, cleanroom class of 8 or lower 50 µg/m³ Healthcare only: 20 µg/m³	Particulate monitoring device with accuracy greater of 5 µg/m³ or 30% of reading and resolution of 1 µg/m³ (1 min average data) +/- 5 µg/m³
PM 2.5	12 µg/m³ or 35 µg/m³ [**]	
Ozone	0.07 ppm	Monitoring device with accuracy greater of 5 ppb or 30% of reading and resolution (1 min average data) +/- 5 ppb ISO 13964 ASTM D5149 – 02 EPA designated methods for Ozone

**Projects in areas with high ambient levels of PM2.5 (known EPA nonattainment areas for PM2.5, or local equivalent) must meet the 35 µg/m³ limit; all other projects should meet the 12 µg/m³ limit.

AND/OR

Path 2. Volatile Organic Compounds (1 point)

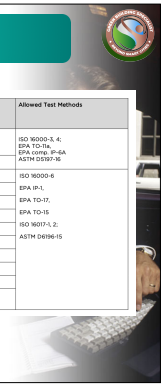
Perform a screening test for Total Volatile Organic Compounds (TVOC). Use ISO 16000-6, EPA TO-17, or ASTM D6196-15 to collect the sample. Calculate the TVOC value per DIN 16979:2017, 12.1, Standard Method v1.2 2017 section 3.8.4, or alternative calculation method as long as full method description is included in test report. If the TVOC levels exceed 500 µg/m³, investigate for potential contaminants of concern and compare the levels found to the associated cognizant authority health-based limits. Correct any identified issues and re-test if necessary.

Additionally, test for the individual volatile organic compounds listed in Table 2 using an allowed test method and demonstrate the contaminants do not exceed the concentration limits listed in the table. Laboratories that conduct the tests must be accredited under ISO/IEC 17025 for the test methods they use.

Exemplary performance is available for projects that test for the additional target volatile organic compounds specified in CDPH Standard Method v1.2-2017, Table 4-1 and do not exceed the full CREL levels for these compounds adopted by CA/EPA OEHHA in effect on June 2018.

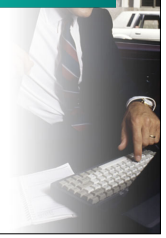
Table 2. Volatile organic compounds

Contaminant (CAS#)	Concentration Limit (µg/m³)	Allowed Test Methods
Formaldehyde 50-00-0	20 µg/m³ (16 ppb)	ISO 16000-3, 4; EPA TO-11a, EPA comp. IP-6A ASTM D5197-16
Acetaldehyde 75-07-0	140 µg/m³	
Benzene 71-43-2	3 µg/m³	ISO 16000-6 EPA IP-1, EPA TO-17, EPA TO-15 ISO 16017-1, 2; ASTM D6196-15
Hexane (n-) 110-54-3	7000 µg/m³	
Naphthalene 91-20-3	9 µg/m³	
Phenol 108-95-2	200 µg/m³	
Styrene 100-42-5	900 µg/m³	
Tetrachloroethylene 127-18-4	35 µg/m³	
Toluene 108-88-3	300 µg/m³	
Vinyl acetate 108-05-4	200 µg/m³	
Dichlorobenzene (1,4-) 106-46-7	800 µg/m³	
Xylenes-total 108-38-3, 95-47-6, and 106-42-3	700 µg/m³	



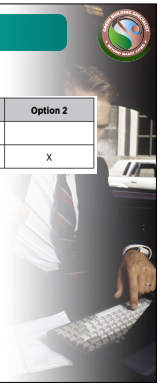
CONNECTION TO ONGOING PERFORMANCE

EED O+M EQ prerequisite Indoor Environmental Quality Performance: Strategies to establish enhanced indoor air quality such as performing air testing for contaminants and meeting contaminant threshold levels can directly contribute to better indoor environmental quality during operations phase.



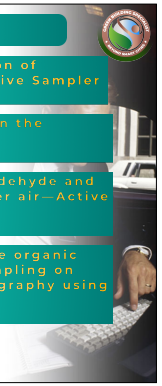
REQUIRED DOCUMENTATION

Documentation	Option 1, Path 1	Option 1, Path 2	Option 2
Flush-out report	X	X	
IAQ testing report			X



REFERENCED STANDARDS

- ASTM D5197-09e1 Standard Test Method for Determination of Formaldehyde and Other Carbonyl Compounds in Air (Active Sampler Methodology): astm.org/Standards/D5197.htm
- ASTM D5149-02(2008) Standard Test Method for Ozone in the Atmosphere: Continuous Measurement by Ethylene Chemiluminescence: astm.org/Standards/D5149
- ISO 16000-3, Indoor air–Part 3: Determination of formaldehyde and other carbonyl compounds in indoor air and test chamber air—Active sampling method: iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=51812
- ISO 16000-6, Indoor air–Part 6: Determination of volatile organic compounds in indoor and test chamber air by active sampling on Tenax TA sorbent, thermal desorption and gas chromatography using MS or MS-FID: iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=52213



TERMS AND DEFINITIONS

None




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