Residential HVAC Safety:

Addressing IAQ and Depressurization Risks

Transforming Oversight from Compliance to Performance

IAQ, Depressurization & Kitchen Hoods

Why design intent, validation, and commissioning must be standard expectations

Building officials directly impact occupant health and safety. Code minimums don't equal proven performance. Today we'll align oversight with measurable outcomes to ensure safer, healthier homes backed by measured performance.

Air Quality

Monitor and control indoor contaminants

Pressure Safety

Prevent dangerous depressurization

Kitchen Hoods

Proper exhaust and makeup air design

Why Your Attention Matters

Health & Safety Foundation

Indoor air quality is not just a matter of comfort, it is a very serious matter of health and safety. Building officials provide critical oversight and opportunity to intervene and improve the state of the built environment.

Radon Risk

Leading lung cancer risk for non-smokers. ~3,000 deaths annually in Canada.

CO Poisoning

Carbon Monoxide (CO) is a silent killer from combustion appliances. Every year approx 170k poisonings are reported in Canada. Officials prevent exposure through proper ventilation and combustion safety.

Particulate Matter (PM) Impact

Harms heart and lungs through deep penetration. Wildfire seasons increase exposure.

Your Role

Current inspection workflow must catch IAQ risks before occupancy.

Good practices can be code-enforcable.

9.32.3.2. Design and Installation

(1) Aspects of mechanical ventilation systems not specifically described in this Subsection shall be designed, constructed and installed in accordance with good practice such as that described in the ASHRAE Handbooks and Standards, the HRAI Digest, the HRAI Residential Mechanical Ventilation Manual, the Hydronics Institute Manuals and the SMACNA Manuals.

What the Contaminants Are

Understanding contaminant sources enables effective control strategies. Each requires different mitigation approaches based on origin.

Contaminant	External Sources	Internal Sources
Radon	Soil gas through foundation	—
VOCs	—	Finishes, adhesives, furnishings, cleaning products
PM2.5	Wildfire, traffic	Cooking, candles, smoking
CO_2	—	Occupants (proxy for ventilation adequacy)
Moisture	Humid outdoor air, leaks	Showers, cooking, plants
CO	—	Combustion appliances (furnaces, water heaters, gas stoves), attached garages, fireplaces

Key Takeaway: If you can name the source, you can design the control.

Radon (NBC 9.13.4 Soil Gas Control)

1

Hazard & Health Impact

Radon is a colourless, odourless, and tasteless radioactive gas that seeps into homes from the ground. As it decays, it emits radioactive particles that, when inhaled, damage lung tissue. In Canada, long-term radon exposure is the leading cause of lung cancer among non-smokers and contributes to approximately 16 percent of all lung cancer deaths, which translates to over 3,000 deaths annually.

2

Sources

Radon comes from the natural breakdown of uranium in soil, rock, and water. It enters homes through cracks in foundations, floor drains, sump pumps, and other openings in the building's structure.

3

Building Official's Role in Radon Mitigation

Building officials play a crucial role in ensuring effective radon soil gas control. Key responsibilities include:

- **Design Review:** Require radon mitigation efforts to be designed and clearly identified on permit drawings, ensuring compliance with NBC 9.13.4 soil gas control requirements.
- **Inspection & Verification:** Inspect to verify conformance with code requirements, including proper sealing of cracks and penetrations in slabs prior to occupancy.
- **Rough-in Requirements:** Ensure proper installation of sub-slab depressurization rough-ins where required by code.
- **Post-Occupancy Guidance:** While officials cannot force owners to conduct testing or connect active systems, provide recommendations and guidance as part of post-occupancy documentation, including information on radon testing and when to activate mitigation systems.
- **Code Enforcement:** Verify that all soil gas control measures specified in NBC 9.13.4 are properly implemented during construction.

ⓘ Source: Information on radon, including health impacts and mitigation strategies, is derived from Health Canada.

Volatile Organic Compounds (VOCs) (NO CODE REFERENCE)

1

Hazard & Health Impact

VOCs are chemical gases emitted from a wide array of products and materials used in and around our homes. These invisible compounds can impact indoor air quality. At high concentrations, they can cause short-term effects such as eye, nose, and throat irritation, headaches, nausea, and dizziness. Long-term exposure to some VOCs has been linked to more serious health issues, including liver, kidney, and central nervous system damage, and some are suspected carcinogens.

2

Sources

VOCs enter homes from the off-gassing of various products and materials. Common sources include:

- Paints, varnishes, and sealants
- Cleaning supplies and disinfectants
- New furnishings and carpeting
- Adhesives and composite wood products
- Air fresheners and personal care products

Emissions from these sources can persist long after products are applied or installed, contributing to what's often referred to as "new house smell."

3

Building Official's Role in VOC Mitigation

While there are no specific code citations in the OBC requiring low-VOC construction materials, building officials play a crucial role in VOC mitigation through proper oversight of ventilation systems. Key responsibilities include:

- **Comprehensive Compliance:** Ensure ventilation systems comply not just with individual clauses of the code, but with the entirety of the standards cited in the OBC, such as CSA F326 and ASHRAE 62.1/62.2.
- **Ventilation System Design Review:** Thoroughly review ventilation plans to verify adequate fresh air supply and exhaust capacity, essential for diluting and removing VOCs from indoor environments.
- **Adherence to Standards:** Verify that mechanical ventilation systems meet the full requirements of referenced standards, extending beyond mere minimum code compliance to ensure optimal indoor air quality management.
- **Commissioning Verification:** Confirm that commissioning processes are in place and verified to ensure ventilation systems operate as designed, effectively managing and mitigating VOCs from construction materials and other sources.
- **Operational Assurance:** Emphasize the importance of proper design, installation, commissioning, and ongoing operation of ventilation systems as critical tools for long-term VOC control.

Particulate Matter (PM) (NBC Part 6 → ASHRAE 62.1 / Range Hood - CSA F326)

1

Hazard & Health Impact

Particulate matter (PM) refers to microscopic solid or liquid particles suspended in the air. PM10 are inhalable particles 10 micrometers or smaller, while PM2.5 are even finer, at 2.5 micrometers or less.

Due to their minute size, PM2.5 particles can penetrate deep into the lungs and enter the bloodstream. Exposure can lead to severe respiratory problems, aggravate asthma, and contribute to cardiovascular diseases, posing a significant risk to occupant health.

2

Sources

Particulate matter originates from various combustion sources, both indoors and outdoors. Common sources include:

- Vehicles (especially diesel engines)
- Wildfires and wood-burning stoves
- Cooking (frying, broiling, baking)
- Candles and incense
- Tobacco smoke
- Industrial processes and power plants

3

Building Official's Role in PM Mitigation

While the NBC currently has no specific requirements regarding indoor air filtration quality for particulate matter, building officials play a critical role in PM mitigation through rigorous oversight of ventilation systems. The NBC, specifically section 9.32.3.1, references CSA F326, which provides detailed sizing and performance requirements for residential range hoods—a key tool for effective PM control.

Key responsibilities for building officials include:

- **Ventilation System Design Review:** Thoroughly review ventilation plans to verify adequate exhaust capacity for PM removal, particularly focusing on kitchens where cooking generates significant particulates.
- **Compliance with Standards:** Verify that mechanical ventilation systems meet the full requirements of referenced standards, including CSA F326 for range hoods and ASHRAE 62.1, ensuring optimal indoor air quality management.
- **Proper Range Hood Design:** Ensure kitchen ventilation systems are properly designed according to CSA F326 standards to effectively capture and remove cooking-generated particulates at the source.
- **Commissioning Verification:** Confirm that commissioning processes are in place and verified to ensure exhaust systems operate as designed, effectively removing particulates and mitigating their impact.
- **Focus on Source Control:** Emphasize the importance of effective source control through proper kitchen exhaust design, rather than solely relying on filtration, for long-term PM control.

Carbon Dioxide (CO2) (NBC Part 6 → ASHRAE 62.1)

1

Hazard & Health Impact

Indoor carbon dioxide (CO2) primarily originates from human respiration. While not directly toxic at typical indoor levels, elevated CO2 concentrations serve as an indicator of inadequate ventilation and insufficient fresh air exchange.

High CO2 can lead to symptoms such as drowsiness, headaches, and reduced cognitive performance, impacting occupant comfort and productivity. Monitoring CO2 levels is crucial for assessing indoor air quality and ensuring sufficient dilution of other potential indoor pollutants.

2

Sources

The main indoor source of carbon dioxide is human exhalation. Additionally, CO2 can be generated by combustion processes indoors, including:

- Human respiration
- Combustion appliances (e.g., gas stoves, unvented heaters, fireplaces)
- Candles and incense

3

Building Official's Role in CO2 Mitigation

While the NBC currently has no specific requirements regarding indoor CO2 concentration limits, building officials play a critical role in CO2 mitigation through rigorous oversight of ventilation systems. The NBC, specifically Part 6, references ASHRAE 62.1, which provides detailed ventilation requirements for CO2 management.

Key responsibilities for building officials include:

- **Ventilation System Design Review:** Verify building plans incorporate appropriate ventilation systems, verify static pressures, duct sizes and lengths.
- **Compliance with Standards:** Verify that mechanical ventilation systems meet the full requirements of referenced standards, including F326, ensuring optimal indoor air quality management.
- **Airflow Calculations:** Review and approve airflow calculations to ensure installed systems provide sufficient outdoor air supply to dilute indoor contaminants, including CO2.
- **Commissioning Verification:** Mandate and review commissioning reports to confirm ventilation systems are installed correctly and operate as designed to maintain acceptable IAQ.

Moisture (NBC Part 6 → ASHRAE 62.1)

1

Hazard & Health Impact

Excess indoor moisture, whether from internal activities or external sources, creates an ideal environment for problems. It compromises building materials and fosters unhealthy conditions.

Uncontrolled moisture leads to significant issues such as mold growth, wood rot, and structural decay. It also attracts pests and can trigger adverse health effects in occupants, including allergic reactions and respiratory issues. Early detection and proper management are crucial for preserving both building integrity and occupant health.

2

Sources

Moisture inside a building can originate from a variety of sources, broadly categorized into internal and external:

- **Internal Activities:** Common daily activities such as cooking, bathing, showering, and doing laundry release water vapor into the indoor air.
- **External Sources:** This includes rain intrusion through leaky roofs or walls, groundwater seepage into basements, and high outdoor humidity levels that infiltrate the building envelope.

3

Building Official's Role in Moisture Mitigation

For building officials, ensuring proper moisture management involves critical oversight of building design and construction to prevent water intrusion and manage internal humidity. The NBC, specifically Part 6, references ASHRAE 62.1, which provides detailed ventilation requirements for moisture control.

Key responsibilities for building officials include:

- **Ventilation System Design Review:** Verify that building plans include appropriate exhaust systems for high-moisture areas (e.g., bathrooms, kitchens) and ensure proper design, installation, commissioning, and operation of ventilation systems.
- **Building Envelope Protection:** Ensure all susceptible surfaces are above dewpoint through proper minimum R-values, warm wall and window specifications, required insulation of ducts and pipes, and required dampers.
- **Vapor Barrier Installation:** Ensure proper specification and installation of vapor barriers and air barriers in walls, roofs, and foundations to prevent moisture migration through the building envelope.
- **Drainage Systems:** Review site drainage plans, including grading, gutters, and foundation waterproofing, to ensure effective diversion of external water away from the building structure.
- **Range Hood Design:** Ensure properly designed, installed, commissioned and operated range hood systems to control cooking-generated moisture at the source.
- **Commissioning Verification:** Mandate and review commissioning reports to confirm that moisture control systems operate as designed to maintain healthy indoor moisture levels.

Carbon Monoxide (CO)

1

Hazard & Health Impact

Carbon monoxide (CO) is a colorless, odorless, and tasteless gas produced by the incomplete combustion of fuels. It is extremely dangerous as it binds to hemoglobin, preventing oxygen transport and significantly reducing the oxygen supply to vital organs. This leads to poisoning symptoms like headache, dizziness, nausea, and confusion. Severe exposure can cause irreversible brain damage, heart failure, and death.

Approximately 170,000 cases of carbon monoxide poisoning are reported annually in Canada, underscoring the pervasive risk this silent killer poses to occupant health.

2

Sources

Carbon monoxide is generated by fuel-burning appliances and engines when combustion is incomplete or improperly vented. Common indoor sources include:

- **Fuel-burning appliances:** Furnaces, water heaters, gas stoves, and fireplaces.
- **Improperly vented sources:** Blocked chimneys, running vehicles in attached garages, and portable generators used indoors.

3

Building Official's Role in CO Mitigation

Building officials play a critical role in carbon monoxide prevention through oversight of building design and construction systems. Various sections of the OBC provide requirements for CO safety.

- **Solid Fuel-Fired Appliances:** Ensure proper design, installation, commissioning, and operation according to NBC 9.22 requirements.
- **Ventilation Systems:** Verify proper design, installation, commissioning, and operation of balanced ventilation system to prevent depressurization of dwelling.
- **Range Hood Exhaust:** Ensure proper design, installation, commissioning, and operation of range hood exhaust systems.
- **Protection Against Depressurization:** Verify compliance with CAN/CGSB-51.71 and OBC requirements to prevent backdrafting that can cause CO entry.
- **CO Detectors:** Mandate the installation of UL/CSA approved carbon monoxide detectors on every level of residential buildings and near sleeping areas.
- **Venting System Inspection:** Inspect chimneys, flues, and vents for proper connections and blockages to ensure safe combustion gas removal.

Beyond Our Senses: The Unseen Threat

Unlike immediate hazards, indoor air quality issues often go unnoticed because many contaminants are invisible, odorless, and imperceptible to our natural senses. This makes them easy to overlook, yet their long-term health and safety impacts are profound.

Invisible Pollutants

Many harmful substances like radon, carbon monoxide, and volatile organic compounds (VOCs) lack sensory cues. You can't smell or see them, even at dangerous concentrations.

Delayed Symptoms

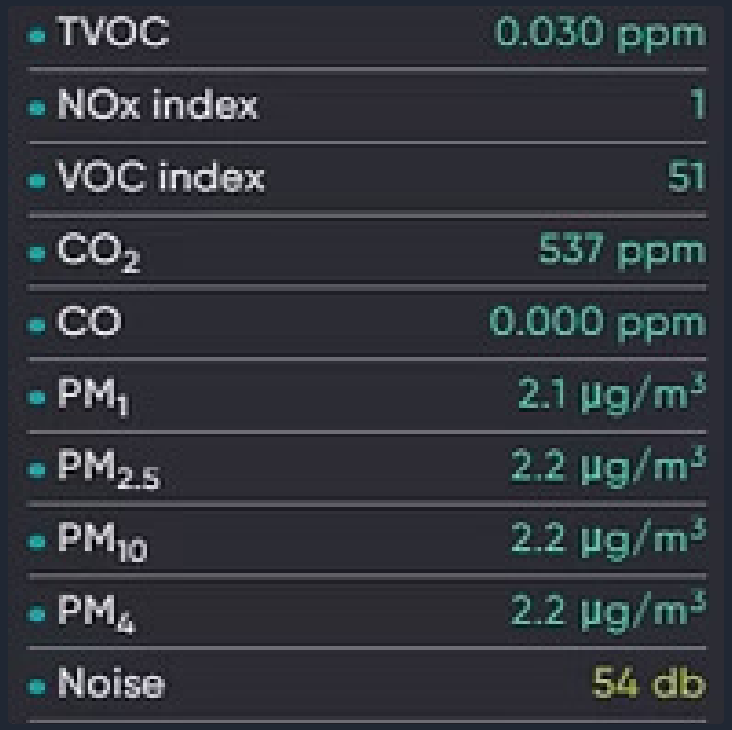
The health effects of poor IAQ often manifest only after prolonged exposure, making it difficult to connect symptoms directly to the indoor environment.

The Need for Data

Accurate assessment and verification of indoor air quality require specialized instrumentation and consistent monitoring, beyond what our senses can provide.

Commercially Available IAQ Sensors

Commercially available Indoor Air Quality (IAQ) sensors are critical tools for detecting and measuring invisible pollutants. These devices can display real-time data and log historical trends, providing actionable insights into your indoor environment. By increasing awareness of contaminant levels, these sensors empower individuals and businesses to make informed decisions and enable integration with control systems for automated ventilation and filtration.



N-3C Imbalance @ CEC (Critical Exhaust Condition) for systems with spillage succeptable devices

301	2000	ft² Total conditioned floor area (crawlspace counts as 1/2 actual area).		
302	2.5	Air Changes @ 50 Pa	Older Homes - 2.5 ACH	
320	-5 to -10pa	Pa Depressurization limit at CEC		
321	0.022	Flow Factor		
322	110	CFM Allowable Net Exhaust (Line 301 x Line 302 x Line 321)		
323		CFM TVCC Exhaust		
324		CFM TVCC Supply		
325		CFM Dryer Exhaust Rate		
325a	200	CFM Additional Exhaust	Appliance:	Range Hood
325b		CFM Additional Exhaust	Appliance:	
325c		CFM Additional Exhaust	Appliance:	
326	200	CFM Net Exhaust @ CEC		
327	90	CFM Required Make-Up Air at CEC at Depressurization limit.		

Notes

Depressurization in Tight Homes: Even Modest Exhausts Pose Risks

Why Pressure Safety Matters

Modern, tightly-sealed homes are susceptible to significant depressurization even from modest exhaust fans, not just oversized units. For instance, calculations based on **CSA F326 standards show that a common 200 CFM range hood can easily exceed safe depressurization limits** in a typical modern residential setting. Residential kitchens rarely receive commercial-level design for proper capture and containment, leading to widespread pressure imbalances.

Even Modest Exhaust

Any significant CFM without makeup air creates negative pressure

Consequences

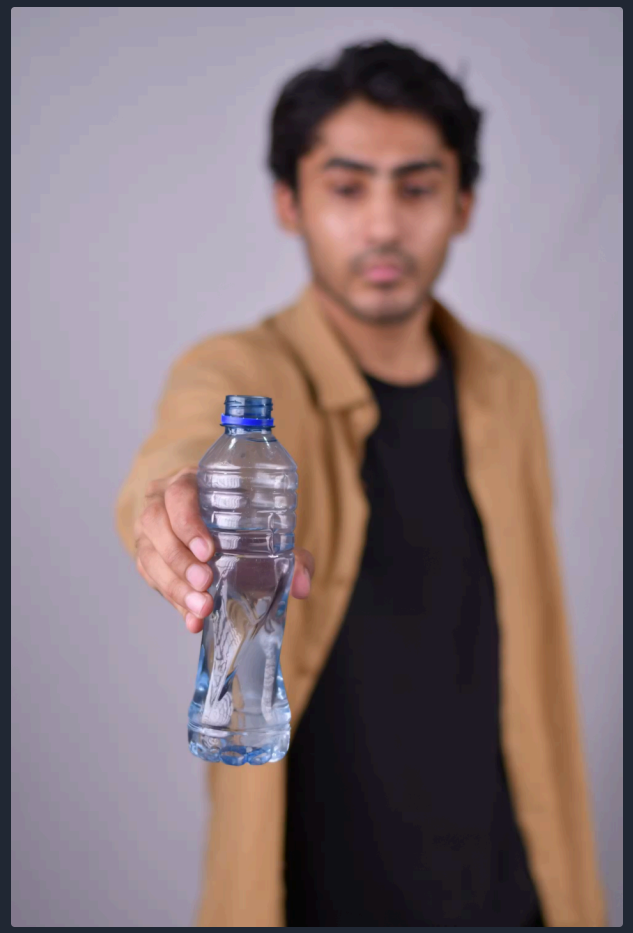
Backdrafting combustion appliances, CO entry, soil gas infiltration

Solution

Dedicated makeup air to balance pressure

⚠ **Key Takeaway:** With houses so tight even moderate amounts of exhaust can excessively depressurize the building.

Understanding Depressurization: The Bottle Analogy



Think of trying to suck air out of a sealed plastic bottle. Initially, it's easy, but as you remove more air, the bottle's walls collapse inward, and it becomes increasingly difficult to extract any more. This illustrates how depressurization works.

Designing Effective Residential Range Hood Systems

In residential construction, it's common practice to select range exhaust systems based on aesthetics or perceived functionality rather than rigorous design. However, we have the opportunity, and indeed the responsibility, to design these systems properly to ensure safety and performance. Established methods, particularly the CSA F326 ventilation standard, provide clear direction on how to achieve this.

CSA F326 Requirements for Range Hoods and Range-Top Fans (Section 8.13.5)

- Range hood shall be at least as wide as the range, and at least 425 mm from front to back.
- Bottom of hood rim shall be no more than 750 mm above the range top.
- Ductwork shall be noncombustible, corrosion-resistant material.
- Ductwork shall be exhausted directly outside and not connected to other exhaust fans or ducts.
- Range hood fans shall have minimum capacity of 65 L/s/m of hood width for wall-mounted hoods, and 75 L/s/m for island/peninsula hoods, but never less than 50 L/s total.
- Kitchen range hood ducts shall be equipped with grease filter at intake.

By adhering to these guidelines, we can move beyond simply "picking what's available" and ensure that residential kitchens benefit from well-designed, safe, and efficient range hood systems that truly meet their ventilation needs.

Kitchen Exhaust System with Makeup Air

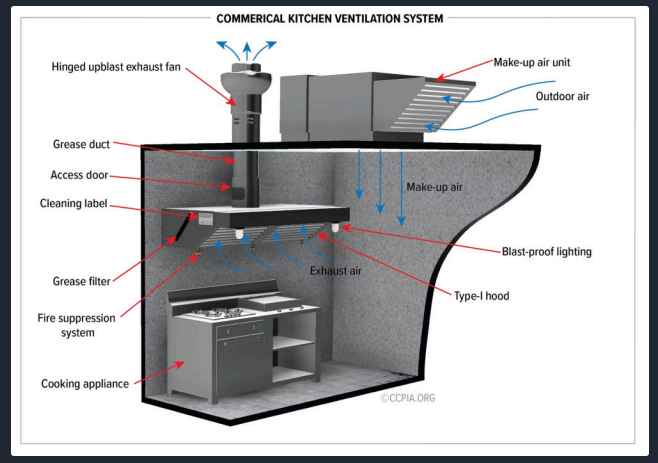


Image credit: Commercial kitchen exhaust via Unsplash.

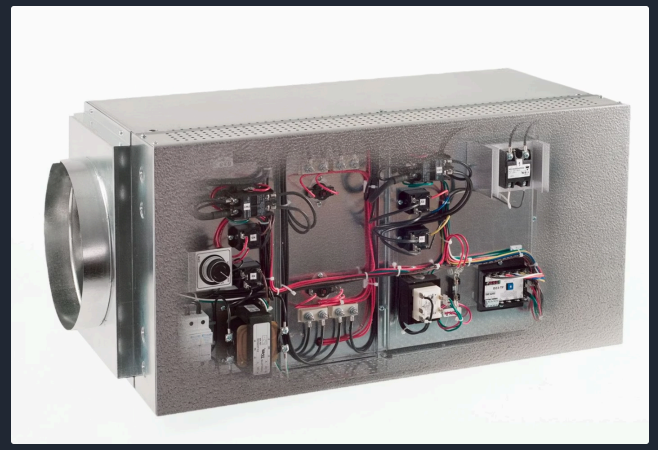


Image credit: Mini Make Up Air by Thermolec.

- **Capture & Remove Contaminants** – Control grease, smoke, moisture, and combustion by-products directly at the cooking source.
- **Protect Occupant Health** – Reduce exposure to pollutants (PM2.5, VOCs, NO_2, CO) that can harm lungs, heart, and overall wellbeing.
- **Maintain Comfort** – Limit odours, smoke, and heat spread to other rooms or units.
- **Protect Safety & Durability** – Prevent grease buildup and excess moisture that create fire hazards or damage building materials.
- **Maintain Pressure Balance & Compliance** – Provide makeup air, prevent backdrafting, and interference with exhaust air streams.

Code References: National Building Code (NBC) 2020

The National Building Code (NBC) provides specific requirements to address depressurization risks, especially in homes with fuel-fired appliances. Understanding and enforcing these codes is crucial for ensuring occupant safety and healthy indoor environments.

NBC 9.32.3.8. Protection Against Depressurization

This article mandates that most mechanical exhaust devices (beyond basic ventilation) in dwelling units with certain non-direct-vented or mechanically vented fuel-fired appliances *must* be paired with a makeup air fan.

Key Requirements & Exceptions

- Makeup air flow must match the exhaust device's capacity (up to +10%).
- The makeup air fan must activate simultaneously with the exhaust device.
- Makeup air must be introduced to unoccupied areas or tempered to at least 12°C.
- Exceptions include homes where all other fuel-fired appliances are direct/mechanically vented, or if depressurization testing proves limits will not be exceeded.

What Officials Can Do: Require & Review Designs

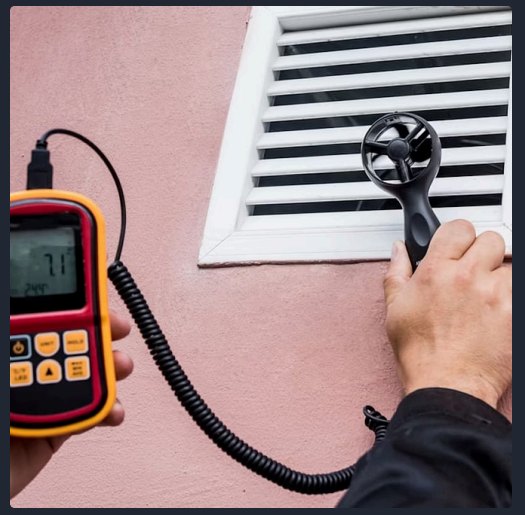
A CFM note alone is insufficient. Duct length, flex connections, and termination losses significantly change delivered airflow from design intent.

Evidence of Design

Require detailed ventilation sizing, duct sizing, and pressure drop calculations. Ensure compliance with standards like CSA F326, CSA-F300 or NBC 9.32.

Protect against Depressurization

Mandate clear requirements to demonstrate protections against depressurization, including explicit makeup air strategies and calculations to ensure proper pressure balance.



Verify Performance & Testing

Require comprehensive performance testing and demonstration as required by the relevant standards.

What Officials Can Do: Validate in the Field

Confirm Design is Actually Delivered

Field validation ensures that design intent translates to real-world performance. Simple tests can dramatically raise the bar for system quality.

Measure Airflows

Bath fans, HRV/ERV, range hood flows verified against design using flow hoods and calibrated instruments

Inspect Installation

Duct routing, terminations, and balancing reports match approved plans and specifications

Pressure Safety

Worst-case depressurization checks when large exhausts operate simultaneously

Kitchen Systems

Verify exhaust and makeup air volumes actually reach the cooking zone effectively

Key Takeaway: Design intent must be proven in the field.

Continuing Learning & References

Concrete Next Steps

Professional development and authoritative sources to improve inspection practices and enforcement capabilities.

HRAI Training Courses

www.hrai.ca

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Looking to sharpen your skills? Want to offer your customers next-level service? Boost your expertise with HRAI's post HVAC trades training...

ASHRAE Resources

store.accuristech.com

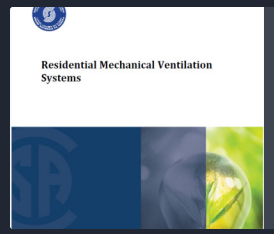
Residential Indoor Air Quality Guide: ...

www.ashrae.org

Free Read-Only Versions of ASHRAE Standards

Access free Read-Only versions of the ASHRAE Standards

Key Standards & References



CSA Group

CSA Store – CSA F326:23

Residential mechanical ventilation systems

CSA Group

CSA Store – CSA F300:22

Residential depressurization

www.canada.ca

Radon

About radon: How radon gets into your home, radon levels in Canada and additional materials to understand radon.

www.canada.ca

Fine particulate matter

Find out about fine particulate matter, its sources and health risks.

Key Takeaway: Keep learning; as our sensor technology as well as our scientific understanding of IAQ changes, we will solve some problems and identify more.

Seminar & Speaker Evaluation

Please use this QR code to provide feedback on this presentation!

Contact Me

I welcome the opportunity to connect and discuss how we can further improve building safety and indoor air quality.

Blinq

Niss Feiner, C.E.T, CHD's Blinq Card

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