CITY OF VANCOUVER

DEVELOPMENT, BUILDINGS AND LICENSING
Chief Building Official (CBO) and Building Code and Policy
Building Policy Branch

BULLETIN 2023-004-AD/BU **September 12, 2023**

Airtightness Testing – Process and Requirements for New Buildings

This Bulletin introduces the new "Guideline – Airtightness Testing – Process and Requirements for New Buildings". The *Guideline* advises designers, builders, and airtightness testing agents with respect to acceptable whole building and individual suite airtightness testing methods per the requirements of the Vancouver Building By-law.

An effective date (January 1, 2024) for the submittal of airtightness documentation at the Building Permit stage is included below.

Background

Article 10.2.2.21. of the Vancouver Building By-law (the *VBBL*) requires airtightness testing of the whole building or individual suites. Depending on the building type, size or configuration, different airtightness metrics or testing and reporting requirements are applicable. For example, smaller buildings (e.g. 1-3 storey residential) eligible for an EnerGuide rating have a different set of applicable airtightness metrics compared to larger buildings (e.g. >3 storey residential, commercial or office occupancies), as do projects pursuing Passive House certification. Clarification for each building type is provided in the new 'Guideline – Airtightness Testing – Process and Requirements for New Buildings' (the *Guideline*).

Clarification

The purpose of the *Guideline* is to provide designers, builders, and airtightness testing agents with guidance on what the Chief Building Official considers acceptable practice when demonstrating whole building and individual suite airtightness testing. Air leakage control in buildings is a key component of building performance as air control impacts durability, indoor air quality, occupant comfort, and energy efficiency. As such, whole building and dwelling unit airtightness testing is required by the *VBBL*.

The Guideline (provided in Appendix A) clarifies:

- the airtightness metrics, testing and reporting requirements as applied to specific building types;
- the acceptable approaches in the event a building is unable to meet the maximum tested air leakage rates outlined in Article 10.2.2.21. of the *VBBL*; and,
- provides guidance on alternate testing methods when a single-zone test is not feasible.

For buildings other than EnerGuide or Passive House projects, a test plan and/or confirmation letter for reduced infiltration in accordance with the Guideline (Section 8.1) are required for projects whose Building Permit application package (or in the case of staged projects, Stage 1 Building Permit application package) is accepted by the City for review after January 1, 2024.

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This *Guideline* is not intended to be an exhaustive set of technical requirements or best practices and therefore should be used in addition to the referenced test standards as per the *VBBL*.

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Appendix A:

Guideline – Airtightness Testing – Process and Requirements for New Buildings – version 1.0

City of Vancouver *Chief Building Official (CBO) and Building Code Policy*

Development, Building and Licensing – Building Policy Branch

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Guideline

Airtightness Testing - Process and Requirements for New Buildings

Effective September 12, 2023

Authority: Chief Building Official

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1. Background and context

The purpose of this Guideline is to advise designers, builders, and airtightness testing agents with respect to acceptable whole building and individual suite airtightness testing methods per the requirements of Article 10.2.2.21. of the *Vancouver Building By-Law* (VBBL) or per the *Green Buildings Policy for Rezonings* (amended February 7, 2017 and May 2, 2018) for new buildings.

Air leakage control in buildings is a key component of building performance as air control impacts durability, indoor air quality, occupant comfort, and energy efficiency. As such, whole building and dwelling unit airtightness testing is required by *Section 10.2.2.21 of the* VBBL. This guidance document clarifies:

- the airtightness metrics, testing and reporting requirements as applied to specific building types;
- the acceptable approaches in the event a building is unable to meet the maximum tested air leakage rates outlined in Section 10.2.2.21 of the VBBL; and,
- provides guidance on alternate testing methods when a single-zone test is not feasible.

This Guideline is not intended to be an exhaustive set of technical requirements or best practices and therefore should be used in addition to the referenced test standards. For further information on airtightness testing procedures, please refer to the *Illustrated Guide – Achieving Airtight Buildings* published by BC Housing and *Standard Method for Building Enclosure Airtightness Compliance Testing* published by the Air Barrier Association of America.

1.1. Qualifications

Airtightness testing is to be planned and performed by qualified individual(s) who can demonstrate experience conducting testing in buildings of similar size and complexity or has completed airtightness testing training acceptable to the City. Airtightness testing plans and reports must be signed (and sealed, if a seal is available to the professional) by 1) a licensed professional (e.g., Professional Engineer, Applied Science Technologists, Architect, or Architectural Technologist) in good standing with the appropriate regulatory body, or 2) an Energy Advisor in good standing with Natural Resources Canada (NRCan) and their affiliated Service Organization.

2. Testing and reporting protocols for EnerGuide projects

Unless explicitly stated otherwise in this document, projects that are eligible for an EnerGuide rating shall follow the airtightness testing protocols in *EnerGuide Rating System Standard Version 15.10* or higher, and the *EnerGuide Rating System HOT2000 User Guide* for details on airtightness modelling procedures. Airtightness reporting requirements for code compliance will follow the guidance in this section.

Airtightness testing is to be performed by a registered Energy Advisor, and EnerGuide-certified projects are quality assured by NRCan and their network of service organizations.

2.1. Airtightness testing metrics for EnerGuide projects

Table 1 below provides clarification of applicable VBBL maximum air leakage metrics for EnerGuide projects based on building typology.

Building Typology[1]	Applicable Airtightness Metric in Table 10.2.2.21[2]
Houses (1&2 Family)	ACH_{50}
Houses with Secondary Suites	ACH_{50}

Building Typology[1]	Applicable Airtightness Metric in Table 10.2.2.21[2]
Side-by-side Townhomes, Rowhomes	ACH_{50}
Dwelling units under <110m^2 floor area	ACH_{50} or NLA_{10}
Laneway and Coach Houses	ACH_{50} or NLA_{10}
Stacked Townhomes	ACH_{50} or $L/s/m^2$ $_{75Pa}$ (whole building only)
Multi-family Building	ACH_{50} or $L/s/m^2$ $_{75Pa}$ (whole building only)

1. Testing methodology (i.e. unit-by-unit or whole building) follows EnerGuide testing protocols
2. The numeric targets depend on the applicable VBBL version based on a project's building permit application date, and are therefore not included in the table. Refer to VBBL Table 10.2.2.21. for current targets.

Table 1: Applicable maximum air leakage requirements based on building type for EnerGuide projects

2.2. Submission requirements for EnerGuide projects

Table 2 provides details and submission requirements for airtightness modelling and testing at each project stage:

Project Stage	Details	Submission Requirements
Building Permit	The project must indicate they will meet the applicable airtightness requirement in Table 10.2.2.21., or as otherwise required by Net Zero, Passive House or other applicable standards. The applicable airtightness value is inputted in the energy model.	At Building Permit (BP) application stage, the applicant must provide the applicable code minimum airtightness requirement on the Pre-Permit Checklist. This is also required for projects seeking other building standards (e.g. Passive House).
Mid Construction	The project must demonstrate via blower door test that it achieves or exceeds the airtightness requirement as indicated at BP stage. The intent is to test at this critical time when repairs are more accessible, and to set the project up for success at Final Occupancy stage.	The Energy Advisor (or equivalent) completes the Mid-Construction Checklist with all relevant airtightness procedures and results, and provides a copy to the Building Official.
Final Occupancy / As-Built	The project must demonstrate via blower door test that it achieves or exceeds the airtightness requirement as indicated at BP stage. The actual blower door test result must be inputted into the energy model to reflect actual performance.	The Energy Advisor (or equivalent) completes the Final As-Built Checklist with all relevant airtightness procedures and results, and provides a copy, along with the Homeowner Information Sheet (HOIS) to the Building Official.

Table 2: Details and submission requirements at each permitting stage for EnerGuide projects

2.3. Inability to meet airtightness requirements for EnerGuide projects

For EnerGuide projects, when a building fails to hit the required targets at either of the mid-construction or final occupancy stage, remediation steps must be taken; refer to Section 7 in this document for recommended actions. If after significant remediation is completed and the project still fails to achieve the required targets, the Building Official at their discretion may allow the project to submit a Lessons Learned report, with details outlined in Section 6 of this Guideline.

3. Testing and reporting protocols for Passive House projects

Projects pursuing Passive House certification may have different airtightness targets (measured as ACH50) and testing procedures based on certification requirements. Additional testing to demonstrate compliance to *VBBL* maximum air leakage rates is not required. Projects should test according to Passive House referenced standards and the test results should then be converted to match the units and testing pressures as listed in Table 10.2.2.21 of the VBBL. An online conversion tool[1] developed by the Air Barrier Association of America may be useful for this purpose.

Passive House projects should provide reporting as per the guidance in Section 6, which may be in addition to the Passive House certification reporting requirements.

Multi-family Passive House projects should note the *VBBL* requirement for suite-testing applies as per Table 10.2.2.21 of the *VBBL* (Refer to Section 5 of this Guideline).

4. Testing protocols for all other buildings

Sections 4 to 8 outline the airtightness testing and reporting requirements for all new buildings, except for those following EnerGuide or Passive House protocols (refer to Sections 2 and 3 for EnerGuide or Passive House projects). Typically these buildings may be categorized under VBBL Section 10.2.1.3. The general procedure for a typical single-zone test is presented in this section and are broadly separated into the planning and testing phases.

The testing standards referenced in the VBBL are:

- ASTM E779, Standard Test Method for Determining Air Leakage Rate by Fan Pressurization.
- USACE Version 3, Air Leakage Test Protocol for Building Envelopes.
- Airtightness protocol recognized by Natural Resources Canada (for use in homes and buildings labeled under the EnerGuide for New Homes program)

The intent of these standards is to quantify the airtightness of the building enclosure for single-zone buildings, and they all use a similar approach. The key differences between these standards include acceptable environmental testing conditions, range of test pressure differentials, and number of test points and/or data collection duration. In addition, some standards stipulate a preferred testing direction (i.e. pressurization or depressurization). For compliance with the VBBL, both directions must be tested.

The following modifications to the above referenced standards are required to demonstrate compliance with the VBBL:

1. Tests shall be accomplished using both pressurization and depressurization.

[1] https://www.airbarrier.org/wp-content/uploads/2018/01/F-115-052-Rev-1-ABAA-Whole-Building-AirTightness-Testing-Air-Leakage-Unit-Conversions.xlsx

2. The test pressure range shall be from 25 Pa to 80 Pa, but the upper limit shall not be less than the reporting pressure of the applicable air leakage rate metric (e.g. 50 or 75 Pa), and the difference between the upper limit and the lower limit shall not be less than 25 Pa.
3. If the pressure exponent n is less than 0.45 or greater than 0.85, the test shall be re-run with additional reading over a longer time interval.

4.1. Planning for whole building airtightness testing

The following tasks should be performed before the test:

1. Define the test boundary;
2. Verify the testing equipment airflow capacity;
3. Establish the fan layout;
4. Prepare the building; and
5. Review environmental conditions.

4.1.1. Define the test boundary

The test boundary and the associated surface area calculations should be clearly identified and coordinated with the energy modelling inputs per the *City of Vancouver Energy Modelling Guidelines* (*Energy Modelling Guidelines)*. Design and construction drawings should include details of the continuous air barrier. Note that the test boundary may not always consist exclusively of exterior walls, and the surface area for testing differs from the modelled floor area from the energy model. For example, HVAC rooms, electrical rooms, parking garages, and loading docks may be designed to be outside of the air barrier such that interior wall, floor, and roof assemblies form portions of the airtight building enclosure and act as the test boundary. The total surface area of the building envelope used in the conversion between the modelled infiltration rate and the target air leakage rate should be coordinated between the relevant design professionals (e.g. architect, building envelope consultant, energy modeller, etc.). Whenever possible, the whole building should be tested as a single-zone. If this is not feasible, refer to Section 4.3 Alternative Test Methods.

4.1.2. Verify the testing equipment capacity

Once the test boundary is established, review the capacity of the equipment to be used to test the air barrier system. The capacity of the testing equipment is primarily driven by the target air leakage rate. The maximum air leakage rate is stipulated by the *VBBL*; however, the design team may choose to target a lower air leakage rate. When planning to target a lower air leakage rate, refer to the section on Reduced Infiltration Rates in the *Energy Modelling Guidelines* for minimum allowable modelled infiltration rates. See also Section 4.4.

While the airtightness target is expressed at 75 Pa, collecting test points at pressures higher than the reporting pressure improves the accuracy of the results. This may not be achievable due to the capacity of the air-moving equipment, the lack of airtightness in the building, and/or the weather conditions. In such cases, the minimum pressure difference achieved is to be 75 Pa.

A comfortable safety margin should be allocated to account for baseline pressures, and to reduce on-site power supply and other effects that may prevent the target pressure from being attained.

4.1.3. Establish the fan layout

The next step is to establish the fan layout in such a way that ensures a uniform pressure can be attained within the test boundary. Review the building plan to ensure that the building can be configured as a single-zone. This will require identifying bottlenecks such as stairways and elevator shafts. This may require fans to be installed at different locations to improve airflow and elevator doors may also need to be held open during testing to allow airflow between different floors of the building – a small opening of 75-100mm is generally sufficient. This may also require openings to be installed at specific locations to allow enough air to move freely within test zones to achieve a uniform pressure across the test boundary. For example, multi-unit residential buildings that are not internally connected via a common corridor, such as townhouses, may require temporary openings to be installed at the suite partition walls. Ensure appropriate safety measures are implemented where required to maintain worker safety.

4.1.4. Prepare the building

The prescribed airtightness test is intended to measure the building enclosure air barrier only (see *VBBL* Notes to Part 10 A-10.2.2.21). Consequently, during the planning phase, intentional openings should be noted as they may be sealed during the test. Intentional openings include air intake or exhaust penetrations, make-up air intakes, dryer, kitchen and bathroom exhaust vents, and other intentional holes that are not included in the air barrier system design. Windows and doors that are part of the test boundary should be closed and in the locked position, and no temporary supplementary sealing is permitted. All plumbing traps and floor drains should be filled with water to prevent airflow to or from the sewer system. Ventilation systems should be shut down or disabled for the test as these systems may activate during the test, potentially causing inaccuracies in the results.

4.1.5. Review environmental conditions

Airtightness testing is a weather-sensitive procedure. Each testing standard has specific environmental requirements. These requirements are intended to reduce the impact of external forces such as stack effect and wind on the measured results. Therefore, leading up to the scheduled testing date, the tester should review the weather forecast to determine whether the testing conditions as prescribed by the testing standard are likely to be met. On the day of the test, document the relevant environmental conditions, and confirm compliance with testing limits.

4.2. Testing for whole building airtightness

On the day of the test, the following activities should be performed:

1. Pre-test building walkthrough;
2. Depressurization test; and
3. Pressurization test.

4.2.1. Pre-test building walkthrough

Prior to setting up the testing equipment, the tester should walk through the building with the general contractor to ensure the building has been prepared as planned. During this walkthrough, take all necessary photo documentation to demonstrate how penetrations are prepared. The photo documentation should also demonstrate how the building was prepared to ensure it is interconnected throughout the zone. For example, all interior doors may be wedged open and 1% of the ceiling tiles may be removed on each floor to ensure interconnection.

4.2.2. Depressurization test

An initial depressurization test should be carried out to verify the building preparation is sufficient for the duration of the test. The initial depressurization test should be held at the maximum testing pressure while an internal walkthrough is conducted. This second

walkthrough is to review that the building has been prepared properly and that the preparation has not been undone by the induced pressure. For example, verify that sewer gases are not being pulled through the plumbing system and that any interior sealed penetrations have not become undone. Once these have been reviewed and corrected as needed, the test data for reporting can be collected.

In addition, during this walkthrough, the tester must verify that the single zone condition has been achieved. This can be done by measuring the pressure difference on the extremities of the test zone relative to the test fan location(s). Typically, airtightness testing standards define a uniform pressure as being within 10% of the targeted pressure difference across the entire test boundary.

4.2.3. Pressurization test

Similar to the depressurization test procedure, an initial pressurization test must be conducted at the maximum testing pressure during a walkthrough. Review any penetrations sealed from the outside to ensure the temporary sealing measures have not been blown off by the induced pressure. Once these have been reviewed, the test data for reporting can be collected.

4.3. Alternative test methods

For some buildings, completing an airtightness test of the whole building as a single zone is impossible or impractical due to the building geometry and/or large pressure differences due to wind and stack effect. In particular, whole building testing is likely to be challenging for tall buildings, building with isolated zones, very large buildings, or buildings pursuing phased occupancy. For these types of buildings, alternate testing methods which meet the intent of the airtightness testing requirements in the *Green Buildings Policy for Rezonings* and/or the VBBL is an option.

If a project is intending to pursue alternative airtightness testing methods, submit an airtightness testing plan as part of the full-construction Building Permit application. This plan should include the following:

- Rationale for not pursuing a whole building single zone airtightness test per the requirements;
- Identification of the proposed test zones and alterative test methods;
- Indication of sampling rates and rationale if applicable;
- Indication of how the airtightness testing rates will be processed to provide confirmation of the whole building air infiltration rates used in the energy modelling;
- Signature of the qualified individual (and Seal if a seal is available); and
- Qualifications of the airtightness tester (list experience conducting testing in buildings of similar size and complexity, or relevant airtightness testing training).

Several appropriate alternative testing approaches are outlined below for reference.

- Tall Buildings: Pressure equalized airtightness testing of a sampling of floors is a reasonable alternative approach to conducting a whole building airtightness test for tall buildings. Teams pursuing this approach should plan to test each unique floor (i.e. top floor, bottom floor, and other unique floors such as at transition from podium to tower) and a sampling of repetitive floors. A sampling rate of testing approximately 1 floor for every 7 similar floors is typically appropriate, however, the qualified individual should provide a rationale for the sampling rate selected.

- Large Buildings: Pressure equalized (or unequalized) testing of portions of large buildings may be a reasonable alternative approach to conducting a whole building airtightness test for large buildings. Teams pursuing this approach should plan to test the entire building through a series of pressure equalized tests of portions of the building.

- Isolated Residential Zones: For residential buildings where suites are not connected via an interior corridor such as buildings with exterior corridors or interior courtyards, openings between suites may be required to test the building as one interconnected zone. Such buildings may be tested at an earlier stage when the air barrier is finished but pre-drywall and before the completion of interior finishes. If the tested airtightness meets the airtightness requirement, this may be used to demonstrate compliance.

- Isolated Auxiliary Zones: In some cases, zones of a building can be isolated from the main volume of the building. Common examples can include commercial retail units (CRU) within mixed-use buildings, and conditioned spaces within parking garages. If these spaces cannot readily be made part of the main interior volume of the building, project teams should anticipate testing at least a sampling of these spaces. In some circumstances where the impact of these zones is likely to be negligible in the context of the whole building, the Chief Building Official may exempt these zones from the airtightness testing requirements.

- Phased Occupancy & Existing Buildings: When buildings are to be completed and occupied in phases, or consist of work on existing buildings, it may be impractical to coordinate whole building airtightness testing. In these cases, separate tests of zones of the building such that all parts of the building are tested may be a reasonable method. Where an existing building remains partially occupied throughout construction, testing of portions of the building may be sufficient to satisfy the requirements.

4.4. Energy modelling of reduced infiltration rates

Building airtightness has significant impacts on the building's modelled energy and emissions performance limits (e.g. TEDI, TEUI, GHGI) of the *VBBL* or the applicable policies.

For buildings demonstrating compliance to energy and emissions performance requirements using the *Energy Modelling Guidelines,* a modelled infiltration rate (0.20 L/(s·m^2)) is used in the energy model. For a project pursuing TEDI targets of 30 kWh/m^2a or lower, the modelled infiltration rate may be reduced; refer to the minimum modelled infiltration rates in the *Energy Modelling Guidelines*.

If the project opts to pursue a reduced infiltration rate, submit a detailed confirmation letter from a building envelope professional as part of the full-construction Building Permit application. The confirmation letter should include the following:

- Confirmation that the building envelope professional has been retained to provide design review and field review of the air barrier system;
- Modelled infiltration rate and the associate airtightness testing performance target;
- Outline of a design and construction plan intended to assist the team in achieving the target;
- Include descriptions of the following strategies (if applicable to the project):
    - Production of labelled air barrier system drawings;
    - Field review frequency and the parties involved in these activities;
    - Construction team responsibilities and key contacts (i.e. the "air boss");
    - Mid-construction testing plans (if any);
    - Qualitative testing strategies; and
- Signature (and Seal, if available) of the building envelope professional.

5. Individual suite compartmentalization airtightness testing

As per Section 10.2.2.21 of the *VBBL*, suites in multi-family buildings must be tested to maximum air leakage rates. Individual suite compartmentalization airtightness testing must be carried out in accordance with ASTM E779. The suites must be tested both under depressurization and pressurization. The average between these two tests must meet the requirement as stipulated by VBBL. Mechanical penetrations can be sealed for this test. Similar to the whole building airtightness test, a multi-point approach must be used.

When required by either the *Green Buildings Policy for Rezonings* or Section 10.2.2.21 of the *VBBL*, 10% of the first 100 units, and 5% of all units above that shall be tested, with a minimum of 1 (one) per building. Round to the nearest whole number of units tested. Select suites that are representative of different building exposures and conditions.

Any tested suite that does not meet the maximum air leakage rate shall be remediated and re-tested, and one (1) additional suite shall be tested to ensure project failures are either isolated occurrences or have been appropriately addressed. If after two (2) additional suite tests and remediation of failed suites, the project is still unable to meet the suite maximum air leakage rates in the tested suites, a "lessons learned" report is required to be added to the airtightness testing report – refer to Section 7.2.

6. Reporting protocols and compliance for all other buildings

Reporting is the final step of the airtightness testing process.

For projects following EnerGuide protocols, refer to Section 2 for reporting requirements. For all other buildings, a testing report (including a suite testing report and a "Lessons Learned" section, if applicable) must be submitted as part of the occupancy documentation prior to the issuance of the Occupancy Permit. Complete the 'Airtightness Compliance Results' section of the appropriate Energy Checklist[2]. Additionally, Passive House projects may need to complete additional reporting per the Certified Passive House Standard requirements.

Test reports may be between 10-30 pages including photos of the test setup, plus appendices and detailed test results. Testing reports including "Lessons Learned" sections may be longer to provide additional detail.

6.1. Whole building airtightness test report requirements

For buildings where whole building airtightness testing is required, a whole building airtightness testing report must be submitted prior to issuance of the Occupancy Permit and include the following information:

- Building and site details;
- Building address;
- Testing agency contact information;
- Signature of the qualified individual (and Seal if a seal is available);
- Qualifications of the airtightness tester (list experience conducting testing in buildings of similar size and complexity, or relevant airtightness testing training);
- Test boundary description;
- Building height and test boundary enclosed surface area;
- Test arrangement and equipment used;
- Description of the building air barrier system;

[2] https://vancouver.ca/home-property-development/large-building-energy-requirements-forms-checklists.aspx#redirect

- Condition of all intentional openings and fenestration with photo documentation;
- Location of testing equipment with photo documentation;
- Verification of the single zone condition;
- Detailed test results under pressurization and depressurization, including recorded airflow, pressure differences, duration of readings, indoor and outdoor air temperature before and after the measurements, calculated air leakage coefficient, flow exponent, correlation coefficient;
- Normalized air leakage rate at 75 Pa for pressurization and depressurization scenarios, as well as the average of the two methods demonstrating achievement of the performance target;
- Indicate whether the airtightness test target as stipulated in the energy model and *VBBL* has been met. In the event the project is unable to meet airtightness requirements, include a section on Lessons Learned (see Section 6.1);
- For multi-family buildings with residential suites, provide the results of the suite airtightness testing – see Section 6.2.

6.2. Suite airtightness test report requirements

For buildings where suite airtightness testing is required, a suite airtightness testing report must be submitted as part of the final building inspection prior to issuance of the Occupancy Permit and include the following information:

- Building and site details;
- Building address;
- Testing agency contact information;
- Signature of the qualified individual (and Seal if a seal is available);
- Qualifications of the airtightness tester (list experience conducting testing in buildings of similar size and complexity, or relevant airtightness testing training);
- Test boundary description;
- Test suite locations;
- Test arrangement and equipment used
- Condition of all intentional openings and fenestration with photo documentation
- Location of testing equipment with photo documentation
- Detailed test results under pressurization and depressurization tests, including recorded airflow, pressure differences, duration of readings, indoor and outdoor air temperature before and after the measurements; and
- Indicate whether the suite airtightness test target has been met for each tested suite. In the event the project is unable to meet airtightness requirements, include a section on Lessons Learned (see Section 7.2).

7. Inability to meet airtightness requirements for all other buildings

If the results of airtightness testing indicate that the targeted performance level (either from the whole building air leakage rate as per VBBL, or the modelled reduced infiltration rate) is not achieved, the project team must identify and remediate air leakage locations and provide a “Lessons Learned” report as part of the airtightness testing report. In order to minimize costs and disruption to the project, it is advisable to locate and remediate air leakage locations immediately.

7.1. Locating air leakage locations

First, locate and seal sources of air leakage using qualitative investigation techniques. There are a variety of different qualitative assessment techniques, but the two most common are the infrared thermography and smoke tracer testing.

7.1.1. Infrared thermography

Using either fan equipment or the building's ventilation equipment, the building is pressurized and then depressurized relative to the exterior when there is a temperature difference between the interior and exterior. Typically, a temperature difference of at least 10°C is recommended, which may limit the applicability of this approach. Once the building is pressurized or depressurized, an infrared camera can be used to visualize the surface temperature of building components. Locations where the surface temperatures are different between pressurization and depressurization are likely air leakage locations. This two-stage approach to infrared thermography allows for air leakage to be distinguished from thermal bridging.

7.1.2. Smoke tracer testing

The use of smoke tracers can be done by either pressurizing or depressurizing the building using fan equipment or the building's ventilation equipment. A smoke generator is used to produce non-toxic smoke on the high-pressure side of the building enclosure, typically the interior. The pressure differential provides a driving force that pushes the smoke through the building enclosure to the low-pressure side, allowing air leakage to be visibly detected.

7.2. Lessons learned report

A "Lessons Learned" report must added to the whole building airtightness report documenting the team's efforts to identify or remediate the air leakage locations. This report is to include the following:

- Results of the quantitative airtightness testing;
- Documentation of the qualitative investigative measures undertaken to identify air leakage locations, including photos;
- Description of air leakage locations that were identified, including photos if available;
- Description of the remedial actions undertaken;
- Description of why further remedial action to improve the performance is not feasible; and
- Recommendations for avoiding similar leakage locations for future building projects, including suggestions for improvements in design, construction, field review and/or other quality assurance processes, etc.

7.3. Compliance to energy & emissions performance limits

For projects required to test for airtightness, the tested result must be updated in the energy model using the approach outlined in the *Energy Modelling Guidelines* and submitted with final occupancy documentation as part of the project's *Energy & Emissions Design Report*[3].

Some projects may no longer demonstrate compliance to the energy & emissions performance limits from VBBL or applicable policies as a result of airtightness testing; however, this is accepted if the project follows the steps to locate and remediate the leakage locations and document the lessons learned as outlined in this Section.

Since designing and constructing to airtightness requirements is relatively new to the Vancouver industry, there are currently no additional steps for failing to meet airtightness requirements or failing to meet energy and emissions performance limits due to tested airtightness results. As the local industry gains more experience with this by-law requirement, further remediation requirements or penalties may be introduced in the future.

[3] https://vancouver.ca/files/cov/energy-and-emissions-design-report.xlsx

8. Submission requirements for all other buildings

8.1. Building Permit

At the Building Permit full construction stage, projects must complete airtightness information and sections in the appropriate Energy Checklist[4].

Additional submittals related to airtightness testing are required under the following situations:

- If a project is intending to pursue alternative airtightness testing methods other than single zone, submit an airtightness testing plan (See Section 4.3). If the project is planning on testing using single zone methodology, an airtightness plan should be prepared but does not need to be submitted.
- If a project is modelling reduced infiltration rates to demonstrate compliance to energy and emissions limits during the design stage, submit a detailed confirmation letter from a building envelope professional (See Section 4.4). If a project is not modelling reduced infiltration, no submittals related to airtightness testing are required.
- The above submittals will be required for projects whose Building Permit application package (or, in the case of staged projects, Stage 1 Building Permit application package) is accepted by the City for review after **January 1, 2024.**

8.2. Occupancy Permit

As part of the Occupancy Permit process, submit the whole building airtightness testing report as part of the final occupancy documents. Complete the airtightness compliance sections in the appropriate Energy Checklist[5]. Include the suite airtightness testing report and any lessons learned reports, as necessary.

[4] https://vancouver.ca/home-property-development/large-building-energy-requirements-forms-checklists.aspx#redirect
[5] https://vancouver.ca/home-property-development/large-building-energy-requirements-forms-checklists.aspx#redirect

9. Additional resources

1. Air Leakage Control in Multi-Unit Residential Buildings (2017) published by CMHC
2. ASTM E779-10 Standard Method for Determining Air Leakage Rate by Fan Pressurization
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