LARGE BUILDING AIR TIGHTNESS TESTING

Challenges and Opportunities

INTRODUCTION

Building Knowledge Canada

Since 1986 we have been providing energy efficiency consulting, and services to the homebuilding industry

- *Energy efficient design consulting*
- *Energy program support and certifications*
- *Energy code compliance*
- *Building science training, consulting, diagnostics*

OUTLINE OF THIS PRESENTATION

- *The what, why, and how of why air tightness*
- *The building science connection*
- *Where the industry is at this time*
- *Where the industry is going, standards, codes, and programs*

WHAT IS LARGE BUILDING AIR TIGHTNESS TESTING

- *Method of calculating and / or measuring of air leakage in and out of a building under controlled conditions.*
- *Similar to the testing we have done for years for various OBC Part 9 residential building efficiency programs*

RESIDENTIAL HIGH RISE

In addition to whole building leakage multi family buildings can also be individual suite tested. Several programs require this for smoke and fume compliance.

SCHOOLS / GOVERNMENT

New or Retrofit publicly funded buildings can require air tightness testing for quality control and HVAC sizing.

COMMERCIAL AND INDUSTRIAL

Air tight owner occupied buildings can reduce the HVAC size, improve comfort, and save annual energy costs.

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WHY AIR TEST ?

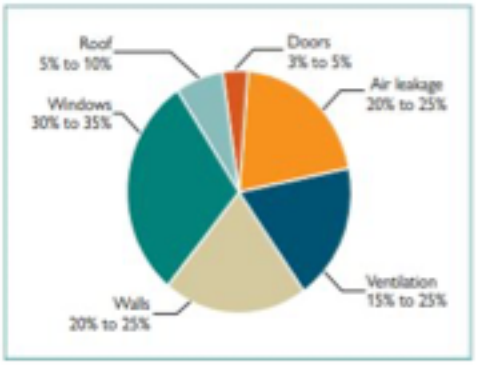
"Air leakage into and out of buildings affects building durability, occupant thermal and acoustical comfort, indoor air quality, and energy consumption.

In response to increasing societal concern regarding these building performance characteristics, and in particular energy consumption, improving building enclosure airtightness to reduce air leakage is receiving increased attention.

In various North American jurisdictions and worldwide, this has led to a shift in the way the industry designs, specifies, builds, and measures airtightness"

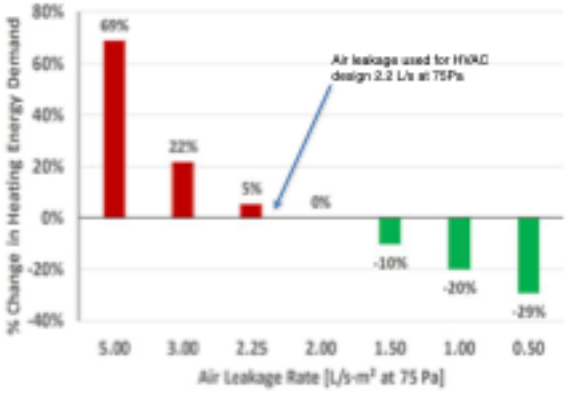
Lorne Ricketts, MASc, PEng

Study on Part 3 Building Airtightness



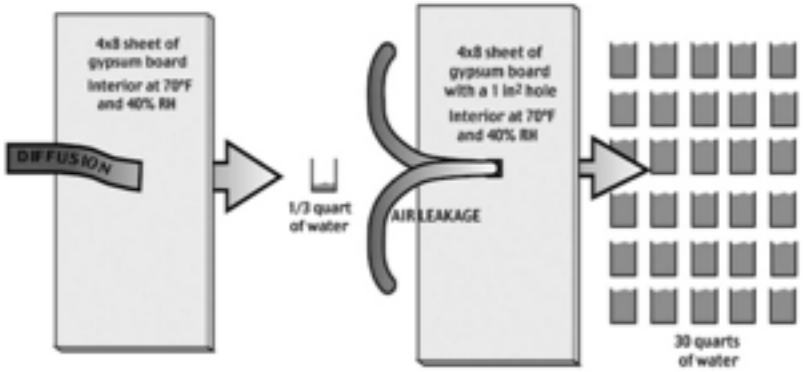
16% OF OFFICE BUILDINGS AND 24% OF MULTI – UNIT RESIDENTIAL BUILDINGS ENERGY USAGE IS ATTRIBUTED TO AIR LEAKAGE

ENERGY CONSUMPTION



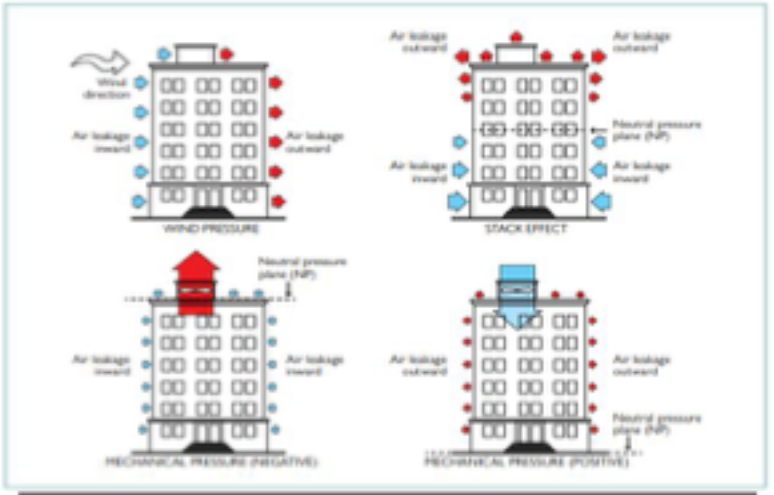
ENERGY CONSUMPTION / RDH CASE STUDY

https://buildingsciencelabs.com/research-testing/case-studies/energy-consumption-of-multi-unit-residential-buildings/

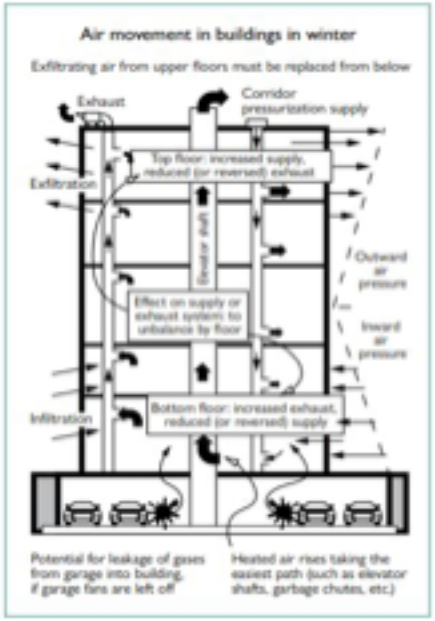


AIR LEAKAGE CAUSES 90X MORE MOISTURE IN WALL STRUCTURES THAN DIFFUSION. THIS CAN LEAD TO STRUCTURAL DAMAGE

DURABILITY



OCCUPANT THERMAL AND ACOUSTICAL COMFORT



- Controlling pollutants and pollutant pathways
- Empowering pressure barriers
- Optimizing ventilation effectiveness

INDOOR AIR QUALITY

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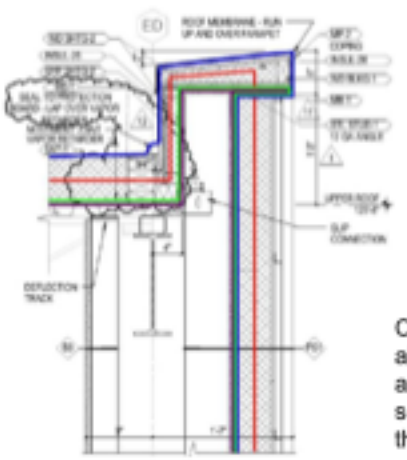
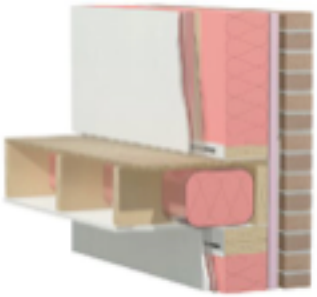
STOPPING AIR LEAKAGE: AIR BARRIERS





Combinations of air barrier materials and air barrier accessories that are designated and designed within the environmental separator to act as a continuous barrier to the movement of air

DEFINITION OF AN AIR BARRIER ASSEMBLY

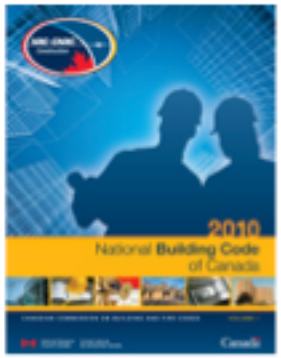
Part 9 – 9.25.3 Air Barrier Systems

9.25.3.1(1) Thermally insulated wall, ceiling and floor assemblies **shall** be constructed so as to include an air barrier system that will provide a continuous barrier to air leakage.

Part 3 – 5.4.1 Air Barrier Systems

Summary - an air barrier system **shall** be installed to provide the principal resistance to air leakage, **except** where it can be shown that uncontrolled air leakage will not adversely effect the health and safety of the building users, the intended use of the building, or the operation of building services.

AIR BARRIERS IN THE ONTARIO BUILDING CODE



Division B Part 5 – 5.4.1 Air Barrier Systems

5.4.1.1(1) Where a building component or assembly separates interior conditioned space from exterior space, interior space from the ground, or environmentally dissimilar interior spaces, the properties and position of the materials and components in those components or assemblies **shall** be such that they control air leakage or permit venting to the exterior as to

A) Provide acceptable conditions for the building occupants,

B) Maintain appropriate conditions for the intended use of the building,

C) Minimize the accumulation of condensation in and the penetration of precipitation into the building component or assembly....

5.4.1.1(3) an air barrier system **shall** be installed to provide the principal resistance to air leakage.

AIR BARRIERS IN THE NATIONAL BUILDING CODE

OBC Part 5 - 2017

5.4.1.2. Air Barrier System Properties

(1) Except as provided in Sentence (2), materials intended to provide the principal resistance to air leakage shall,

(a) have an air leakage characteristic not greater than 0.02 L/(s·m²) measured at an air pressure difference of 75 Pa, or

(b) conform to CAN/ULC-S741, "Air Barrier Materials – Specification".

(2) The air leakage limit specified in Sentence (1) is permitted to be increased where it can be shown that the higher rate of leakage will not adversely affect any of,

(a) the health or safety of *building* users,

(b) the intended use of the *building*, or

(c) the operation of *building* services.

(3) The *air barrier system* shall be continuous,

(a) across construction, control and expansion joints,

(b) across junctions between different *building* assemblies, and

(c) around penetrations through the *building* assembly.

90.1 - 2007

ANSI/ASHRAE/IESNA Standard 90.1-2007
(Supersedes ANSI/ASHRAE/IESNA Standard 90.1-2004)
Includes ANSI/ASHRAE/IESNA Addenda listed in Appendix F

ASHRAE STANDARD

Energy Standard for Buildings Except Low-Rise Residential Buildings

I-P Edition

5.4.3 Air Leakage

5.4.3.1 Building Envelope Sealing. The following areas of the *building envelope* shall be sealed, caulked, gasketed, or weather-stripped to minimize air leakage:

a. joints around *fenestration* and *door* frames
b. junctions between *walls* and foundations, between *walls* at building corners, between *walls* and structural *floors* or *roofs*, and between *walls* and *roof* or *wall* panels
c. openings at penetrations of utility services through *roofs*, *walls*, and *floors*
d. site-built *fenestration* and *doors*
e. building assemblies used as ducts or plenums
f. joints, seams, and penetrations of vapor retarders
g. all other openings in the *building envelope*

90.1 - 2010

STANDARD

ANSI/ASHRAE/IES Standard 90.1-2010
(Supersedes ANSI/ASHRAE/IESNA Standard 90.1-2007)
Includes ANSI/ASHRAE/IES Addenda listed in Appendix F

Energy Standard for Buildings Except Low-Rise Residential Buildings

I-P Edition

5.4.3 Air Leakage

5.4.3.1 *Continuous Air Barrier.* The entire *building envelope* shall be designed and constructed with a *continuous air barrier*.

5.4.3.1.1 Air Barrier Design. The air barrier shall be designed and noted in the following manner:

a. All air barrier components of each *building envelope* assembly shall be clearly identified or otherwise noted on *construction documents*.
b. The joints, interconnections, and penetrations of the air barrier components including lighting *fixtures* shall be detailed or otherwise noted.
c. The *continuous air barrier* shall extend over all surfaces of the *building envelope* (at the lowest floor, exterior *walls*, and ceiling or *roof*).
d. The *continuous air barrier* shall be designed to resist positive and negative pressures from wind, stack effect, and mechanical ventilation.

2010

5.4.3.1.3 Acceptable Materials and Assemblies.

Continuous air barrier materials and assemblies for the *opaque building envelope* shall comply with one of the following requirements:

Materials that have an air permeance not exceeding 0.004 cfm/ft^2 @ 0.3 in. w.g. (75 Pa) when tested in accordance with ASTM E 2178.

Materials such as:

- Plywood & OSB —minimum 3/8 in.
- Extruded polystyrene insulation board or foil faced Insulation board—minimum 1/2 in.
- Exterior gypsum sheathing or interior gypsum board—minimum 1/2 in.
- Cement board—minimum 1/2 in.
- Roofing membranes
- Portland cement/sand parge, stucco - min. 1/2"
- Cast-in-place and precast concrete.
- Sheetmetal
- Closed cell 2lb/ft^3 nominal density spray polyurethane foam—minimum 1 in.

Air Tightness Testing Standards

Materials:
< 0.004 cfm/ft2 @75 Pa (ASTM E 2178)
< 0.02 L/s• m² @ 75 Pa

Assemblies:
< 0.04 cfm/ft2 @75 Pa (ASTM E 2357 or E 1677)
< 0.2 L/s• m² @ 75 Pa

Whole Buildings:
< 0.25 cfm/ft2 @75 Pa (ASTM E779)
< 1.25 L/s• m² @ 75 Pa TGS Target is 0.4 cfm/ft2 @75 Pa (ASTM E779)

- Canadian Building Digest 23: Air Leakage in Buildings – Wilson, A.G. 1963.12.xx
- Canadian Building Digest 72: Control of Air Leakage is Important – Garden, G.K., 1965
- CMHC: Controlling Stack Pressure in High-Rise Buildings by Compartmenting the Building – 1996.03.xx
- Building Science Digest 014: Air Flow Control in Buildings – John Straube 2007.10.15
- Building Science Digest 040: Airtightness Testing in Large Buildings – John Straube 2014.03.18
- Energy Conservatory: Blower Door Applications Guide: Beyond Single Family Residential – v.1.0 2014.04.01
- 14th Canadian Conference on Building Science and Technology – 2014.10.28-30
  - Papers for presentations below are available on OBEC website members area
- Building America Report: Field Testing of Compartmentalization Methods for Multifamily Construction – 2015.03

STATE OF TESTING AND RESEARCH – LARGE BUILDING AIR TIGHTNESS TESTING

air barrier abaa association of america

NABA National Air Barrier Association

AIR BARRIERS - INDUSTRY ASSOCIATIONS

BUILDING KNOWLEDGE
WWW.BUILDINGKNOWLEDGE.CA

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AIR TIGHTNESS TESTING

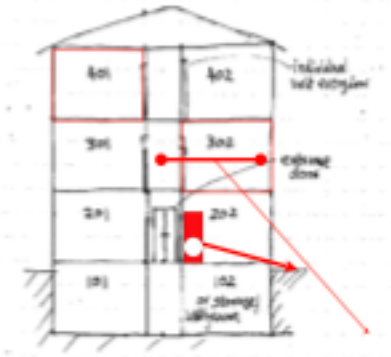
Tests can be done as one zone, multiple guarded zones, or individual suite testing.

Guarded Testing - Helpful to the process

A Guarded test is used to eliminate the pressure difference between zones.

- *This type of testing can be used to focus the results to identify air leakage of a specific interior space(s) to the exterior.*
- *set up a test fan system in each zone adjacent to the tested zone. Use the test fan systems to ensure the pressure difference between the adjacent zones and the tested zone is as close to zero as possible,*

Compartmentalization



- "Compartmentalize" suites
- Seal all exterior wall, ceiling, floor penetrations
- Seal all common wall, ceiling, floor penetrations
- Seal penetrations to common spaces
- TEST = 1.25in²/100ft²
- Verify exhaust fan flows and hallway to suite pressures
- Average of 5 Pa, no less than 1 Pa

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AIR TIGHTNESS TESTING

Building Knowledge has the equipment to test up to 70,000 cfm. Or 100,000 sq ft @ 4 lps / m² @ 75pa a one zone.

STANDARDS FOR AIR TIGHTNESS TESTING

PROGRAMS / STANDARDS SPECIFYING AIR TIGHTNESS TESTING AND TARGETS

Air Tightness vs. Air Leakage

- No *air tightness* threshold specified in current the Code,
- There is an *air leakage* metric for modeling buildings for energy savings, 0.25 l/s/m2 @ 5Pa
- This coincides with the air tightness target being suggesting for the 2020 step-code update - 1.5 l/s/m2 @ 75Pa.
- The suggested target for 2020 is lower than study's completed using testing data
  - RDH –Study of Part 3 Building Airtightness, Dec 22 2015, 2.15 l/s/m2 @ 75Pa. Approximate average air tightness for large buildings in Canada

LOCAL PROGRAMS REQUIRING AIR TIGHTNESS TESTING

Toronto Green Standards

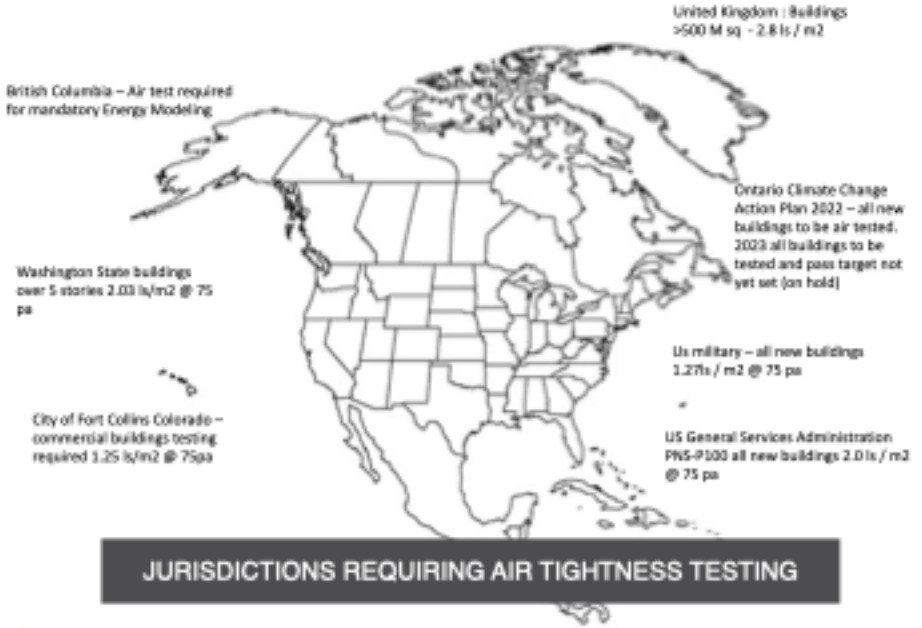
Mid to High-Rise Residential & Non-Residential Version 3

- Tier 1- no air tightness testing requirements / current minimum requirement
- Tier 2 - Conduct a whole-building Air Tightness Test / minimum requirement starting 2022
- Tier 3 – Net Zero ready
- Tier 4 – Net Zero home or passive House

ENERGY STAR® MULTIFAMILY PILOT

- Whole-Building airtightness testing encouraged but not required
- Suite compartment airtightness testing

LOCAL PROGRAMS REQUIRING AIR TIGHTNESS TESTING



JURISDICTIONS REQUIRING AIR TIGHTNESS TESTING

BUILDING KNOWLEDGE CANADA INC. WWW.BUILDINGKNOWLEDGE.CA

AIR BARRIERS / TESTING WHERE WE ARE GOING

- *Ontario's Climate Change Action Plan is a five-year plan that will help Ontario fight climate change over the long term*
- *Possible future code changes*
- *Possible development requirements*

BENEFITS OF BUILDING AIR TIGHT

- *Lower operating costs of the building*
- *Lower HVAC equipment costs*
- *Alignment with a green or energy program for marketing, rebates, incentives*
- *Using air tightness as a quality control measure*
- *Increased awareness of air barrier details during design and construction, resulting in a better building*

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BUILDING KNOWLEDGE TESTING

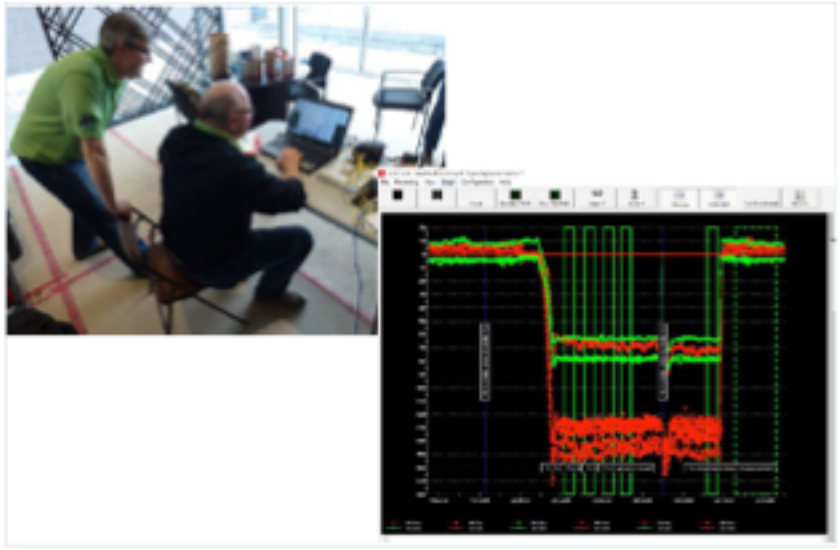
Examples of buildings tested by our office

On Site; Equipment Set Up

Site Preparation

Site Preparation

Performing the Test



Sifton

Experience. The Difference.™

SIFTON CENTER AIR TEST

Sifton Center

Air Test Results:

Specific Leakage Rate (Envelope) @ -75 Pa: 0.39 l/s/m2

Specific Leakage Rate (Envelope) @ +75 Pa: 0.49 l/s/m2

Average Specific Leakage Rate @ +75 Pa: 0.44 l/s/m2

Sifton

Experience. The Difference.™

SIFTON CENTER AIR TEST

Ron Joyce Center

Air test to the ISO 9972 standard:

Specific Leakage Rate (Envelope) @ -75 Pa: q_{E75} = 0.54 l/s/m²

Specific Leakage Rate (Envelope) @ +75 Pa: q_{E75} = 0.55 l/s/m²

Average Specific Leakage Rate q_{E75} = 0.545 l/s/m²

mohawk COLLEGE

RON JOYCE CENTER AIR TEST

mohawk COLLEGE

RON JOYCE CENTER AIR TEST

St. Mark's Lutheran Church
growing in faith, caring, and community

ST MARKS CHURCH AIR TEST

St Marks Church

Air test to the PHIUS+ standard:

Air Changes Per Hour	@ -50 Pa:	2.84 ACH50
Air Changes Per Hour	@ +50 Pa:	3.73 ACH50

St. Mark's Lutheran Church
growing in faith, caring, and community

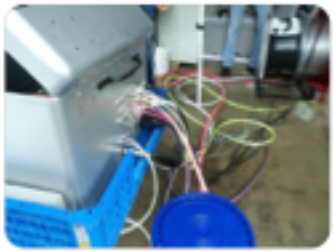
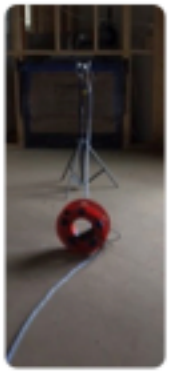
ST MARKS CHURCH AIR TEST

New Technologies are Available

AEROBARRIER
Breakthrough Envelope Sealing Technology

AeroBarrier is a convenient, cost effective approach that seals homes in less than 3 hours and provides verification that the air-tightness requirement has been achieved.

The AeroBarrier Process

North York Women's Shelter

- Owner & Architect set strong energy goals
- General contractor unable to meet goal through conventional means (1.5 ACH@50)
- Through the **Aerobarrier Technology** project was able to hit target of 1.0ACH@50
- Allowing everyone to celebrate the win!




The AeroBarrier Patent Pending Process

Verified Results!

Every seal provides a certificate of completion outlining the sealing work. Pre and post-leakage are captured and the seal duration and leakage reduction are all displayed on the graph

Less than 1 ACH_{50} in only a few hours!

Air Tightness vs. Air Leakage

NLR - Normalized leakage rate
- A metric at pressure
- CFM / ft^2 or L/s / m^2
- At 50 Pa or 75 Pa

< 2.00 L/s• m^2 @ 75 Pa TGS Target

NLR - Normalized leakage rate
- A metric at operating conditions
- CFM / ft^2 or L/s / m^2
- At 5 Pa or ???

NECB = 0.25 L/s•m^2 @ 5 Pa

CANADIAN STUDY'S AND REPORT'S AVAILABLE

SUMMARY

- Air tightness has many advantages

  CONTROL:
  - Moisture
  - Noise
  - Odours
  - Energy
  - Ventilation
- Compartmentalization is powerful
- Testing will be common
- Standards will improve
- Consistent protocols will be crucial for compliance
- There are game changing technologies to help
- Be conscious of Tightness Testing vs. Modelling Leakage

BUILDING KNOWLEDGE CANADA INC.

THANK YOU

Questions?

Rob Johnston
Gord Cooke

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