ASHRAE 90.1 2019- Impacts on the Design, Construction, and Testing of Air Barriers

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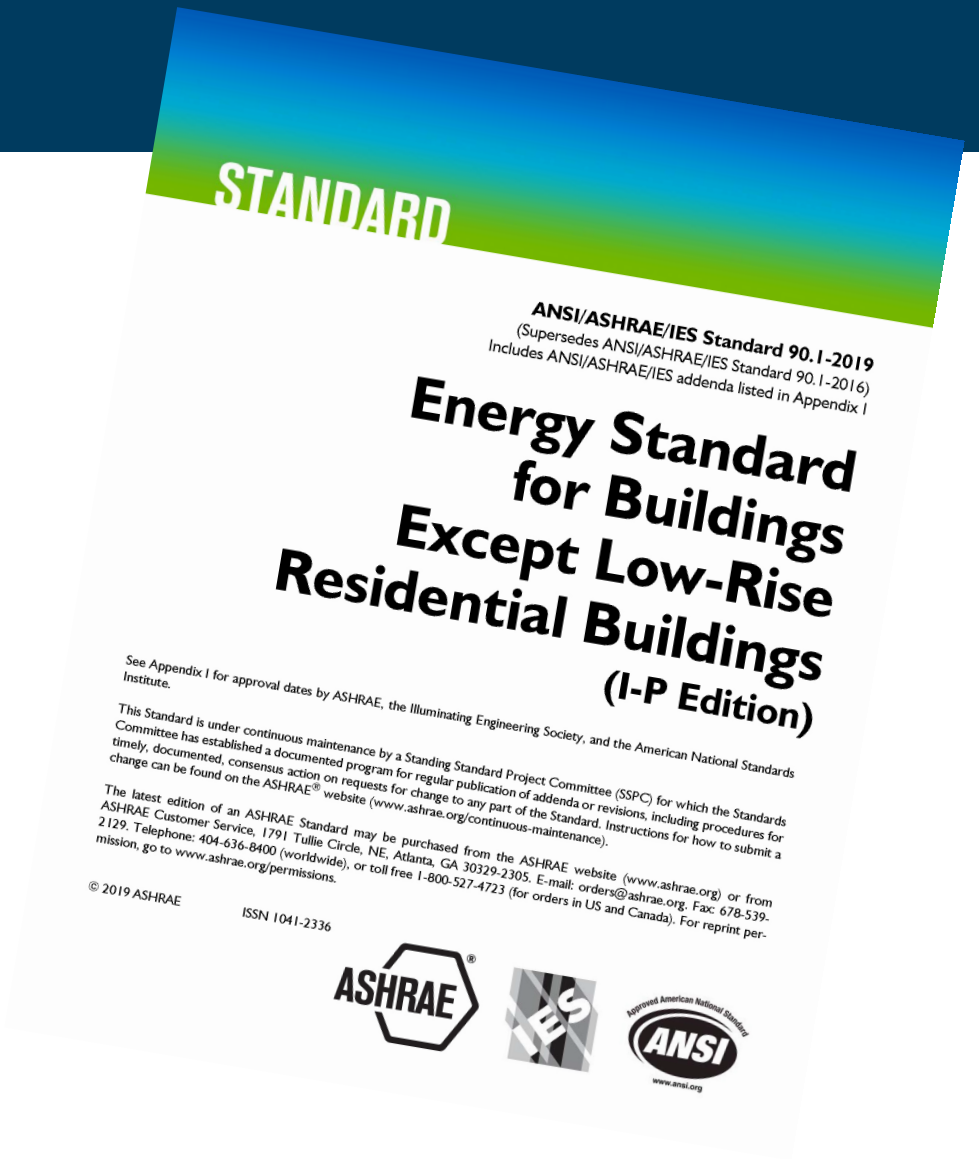
Description

Over the past decade, energy codes have brought several changes with respect to improving the performance of the building enclosure both in design and construction. Most notable is the increasing importance placed on air-leakage through the enclosure and how this often-unknown value affects many of the energy efficiency metrics that define the performance of the building. In North America, there are currently multiple jurisdictions requiring Whole Building Air Leakage Testing (WBALT) as a code requirement. The most recent energy code to be adopted in many jurisdictions is ASHRAE 90.1-2019. This code will either require WBALT or an increased presence of an air barrier consultant to review and document the air barrier from design through construction. While the requirements of the new energy code are predicted to achieve energy savings, there are many questions to be answered. Through a review historical advancements in air barrier requirements this presentation will provide lessons learned approach of what is to come as various jurisdictions adopt the ASHRAE 90.1 -2019 Energy Code



Learning Objectives

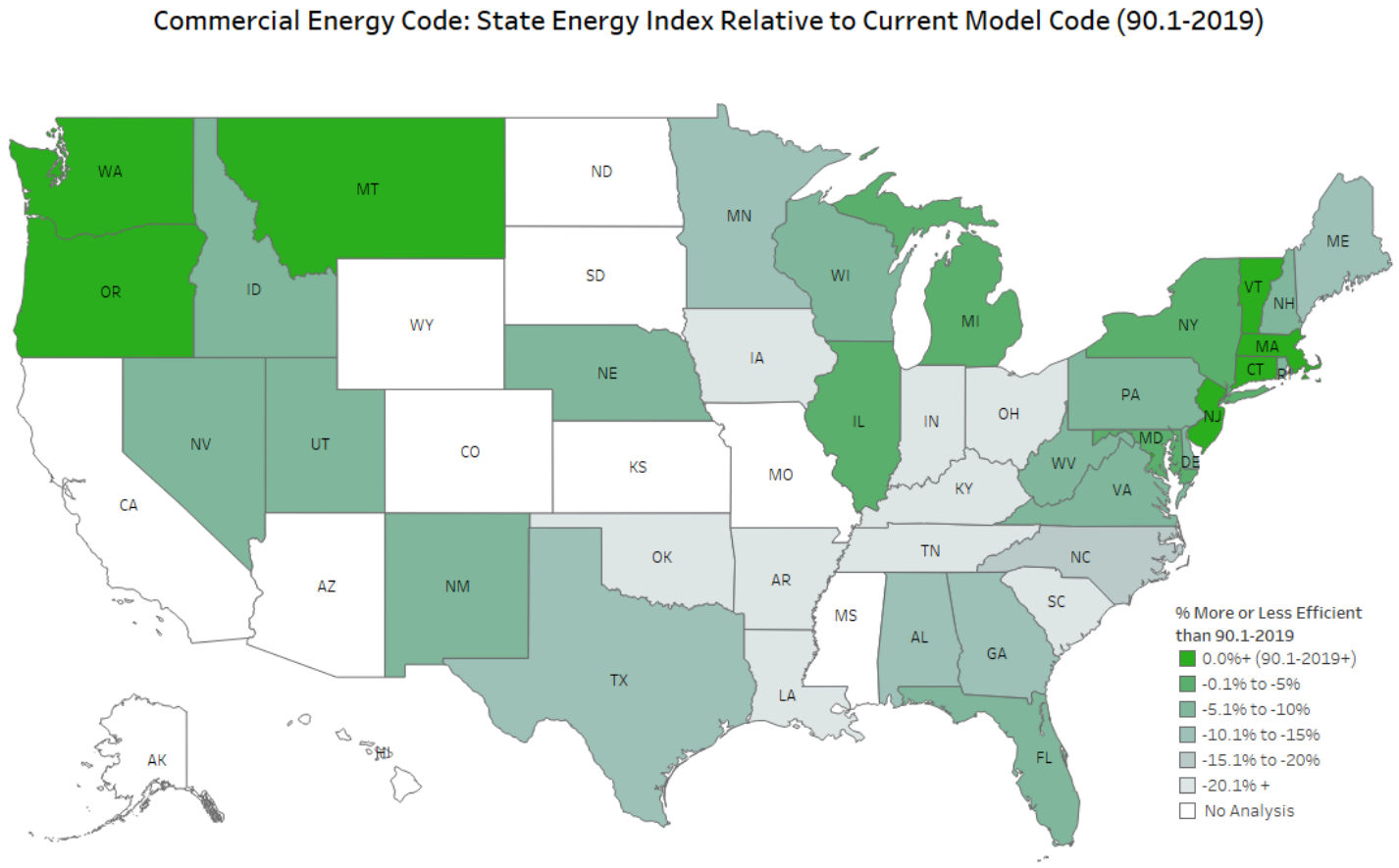
1. Review the theory and historical progression of air tightness requirements and understand the metrics that provide the baseline for levels of air tightness.

2. Understand what ASHRAE 90.1- 2019 Air Leakage requirements are.

3. Understand validity, impact, and relevance of similar of air tightness codes and standards- with an emphasis on ASHRAE 90.1 2019.

4. Understand whole building air leakage testing (WBALT) as compared to holistic enclosure consulting.

Code Adoption by State

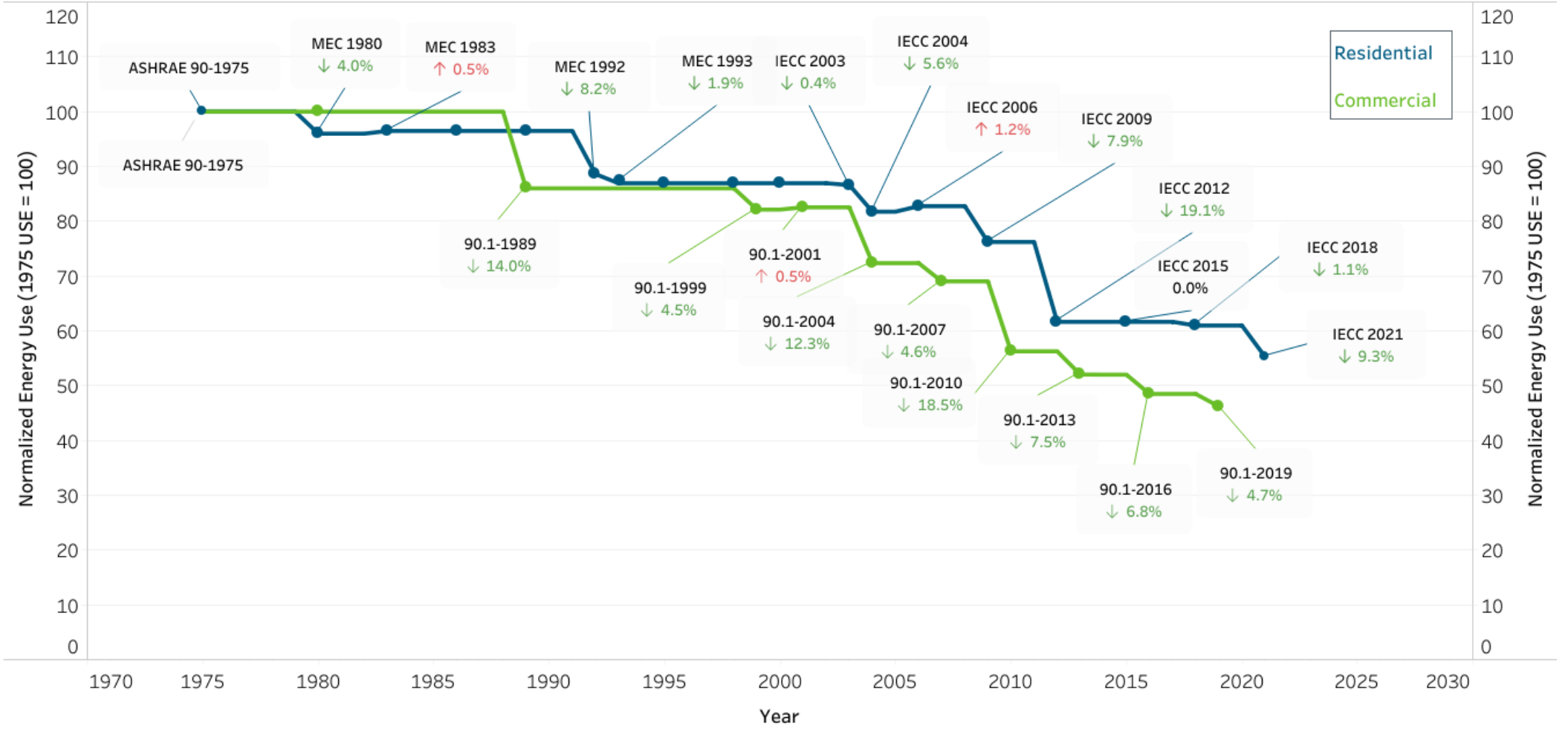


US DOE BECP: Status of State Energy Code Adoption - https://www.energycodes.gov/status/commercial
State Energy Index Data: https://www.energycodes.gov/sites/default/files/2022-09/StateLevelResidentialCodesEnergyUseIndex_FY2022Q4.xlsx
Updated as of 06/30/23

U.S. DEPARTMENT OF ENERGY

Estimated Improvement in Residential & Commercial Energy Codes
(1975 - 2021)

Pacific Northwest NATIONAL LABORATORY



Is it About Energy or Money?

On July 28, 2021, the DOE issued a determination that ANSI/ASHRAE/IES 90.1-2019 achieves greater energy efficiency in buildings covered by the standard than the 2016 version. The DOE estimated national savings in commercial buildings of approximately 4.7% site energy, 4.3% source energy, 4.3% energy cost, and 4.2% carbon emissions.

As a result, states were given two years to adopt a commercial building energy code at least as stringent as 90.1-2016 or justify why they cannot comply. A handful of states are already in compliance.

By July 28, 2023, all states must adopt a commercial building energy code at least as stringent as the standard 90.1-2019, or justify why they cannot comply.

Why do we need a carrot?

Enrollment will open soon for state and local governments to apply for more than $1.2 billion in federal grants to support adoption of energy-efficient building codes. The American Institute of Architects encourages state and local components to partner with their states leaders to access the significant support. The resources, a combination of funding made available by the Infrastructure Investment and Jobs Act (IIJA) and the Inflation Reduction Act (IRA), are aimed to enable sustained, cost-effective implementation of updated building energy codes, adopt the latest energy codes that meet or exceed the 2021 International Energy Conservation Code (IECC) and/or ASHRAE 90.1-2019. Grants are also expected for adopting and implementing zero-energy stretch codes.

The IIJA funding is expected to be released by the end of 2022, while IRA funds are likely to roll out in mid to late 2023.

Air Leakage

- Air Leakage
  - Whole Building testing to 0.40 cfm/ft^2 is the criteria with exceptions:
    - Portions of buildings
    - Allowance for up to 0.60 cfm/ft^2
    - Compliance by inspection and verification
      - Material and Assembly compliance
- 5.7-submittals
- 5.8-products
- 5.9-verification testing and compliance

- Air Leakage
  - Materials – 0.004 cfm/ft^2
  - Assemblies – 0.04 cfm/ft^2
  - Buildings – 0.40 cfm/ft^2
    - With exception up to 0.60 cfm/ft^2

How Leaky Are Buildings…?

Example #1

Standard Commercial Construction
Air Leakage Rate:

0.40 to 1.60 cfm/sf @ 0.3” wg

100,000sf of envelope =
40,000cfm to 160,000cfm

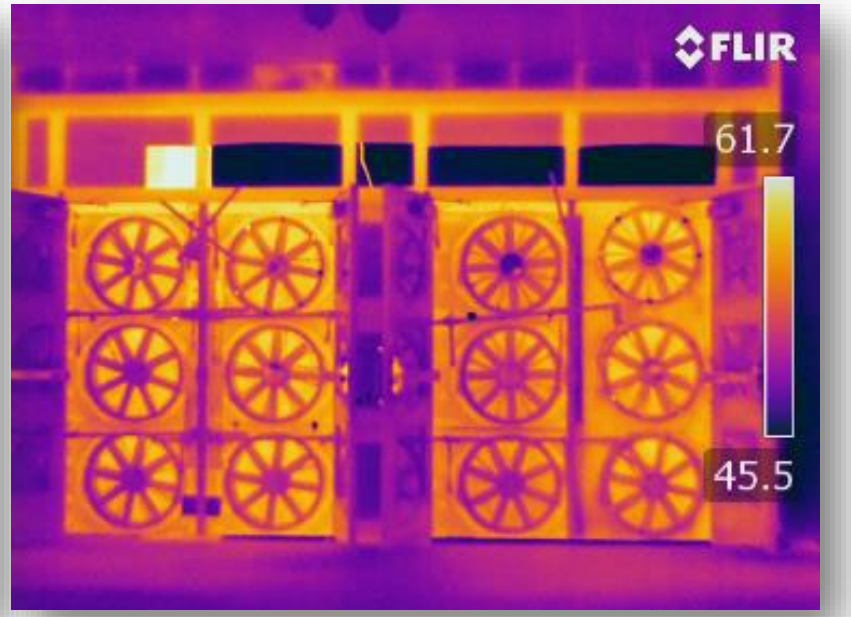
How Leaky Are Buildings…?

Example #2

Materials, Assemblies, WBALT

ASTM 2178

ASTM 2357



ASTM e779….

5.4.3 Air Leakage

5.4.3 Air Leakage

Air leakage control for the *building envelope* shall comply with this section. Materials and assemblies that are part of the *continuous air barrier* and *fenestration* and *doors* shall comply with Section 5.8.3.

5.4.3.1 Continuous Air Barrier

The *exterior building envelope* and the *semiexterior building envelope* shall have a *continuous air barrier* complying with Sections 5.4.3.1.1 and 5.4.3.1.2.

Exceptions to 5.4.3.1

1. *Semiheated spaces* in Climate Zones 0 through 6, except as required to complete the *continuous air barrier* of an adjacent *conditioned space*.
2. Single wythe concrete masonry *buildings* in Climate Zone 2B.

5.4.3.1.1 Whole-Building Air Leakage

5.4.3.1.1 Whole-Building Air Leakage

Whole-building pressurization testing shall be conducted in accordance with ASTM E779 or ASTM E1827 by an independent third party. The measured air leakage rate of the *building envelope* shall not exceed 0.40 cfm/ft^2 under a pressure differential of 0.3 in. of water, with this air leakage rate normalized by the sum of the above-grade and below-grade *building envelope* areas of the *conditioned space* and *semiheated space*.

Where a *building* contains both *conditioned space* and *semiheated space*, compliance shall be shown

a. separately for the *conditioned space* and for the *semiheated space*, with the air leakage rate for the *conditioned space* normalized by the *exterior building envelope* area of the *conditioned space* and the air leakage rate for the *semiheated space* normalized by the *semiexterior building envelope* area of the *semiheated space*; or

b. for the *conditioned space* and for the *semiheated space* together, with the air leakage rate for the overall *space* normalized by the sum of the *exterior building envelope* area and the *semiexterior building envelope* area minus the *semiexterior building envelope* area that separates the *conditioned space* from the *semiheated space*.

A Look At Requirements Globally

			cfm/ ft²[L/s*m²]at 75Pa
US	ASHRAE / IECC	0.40 cfm/ft² at 75Pa	**0.40/2.02**
US	LEED	1.25 in² EfLA @ 4 Pa / 100 ft²	**0.30/1.52**
US	ASHRAE Average handbook of fundamentals	0.30 cfm/ft² at 75Pa	**0.30/1.52**
→	**U.S. UFC**	**0.25 cfm/ ft² at 75Pa**	**0.25/1.27**
UK	TS-1Commercial Tight	2 m³/h/m² at 50 Pa	**0.14/0.71**
CAN	R-2000	1 in² EqLA @10 Pa /100 ft²	**0.13/0.66**
US	ASHRAE 90.1 Tight handbook of fundamentals	0.10 cfm/ft² at 75Pa	**0.10/0.51**

For a 4 story building, 120 x 110 ft, n=0.65

Looser

Tighter

→ Passive House 0.06 cfm/ft² at 75Pa

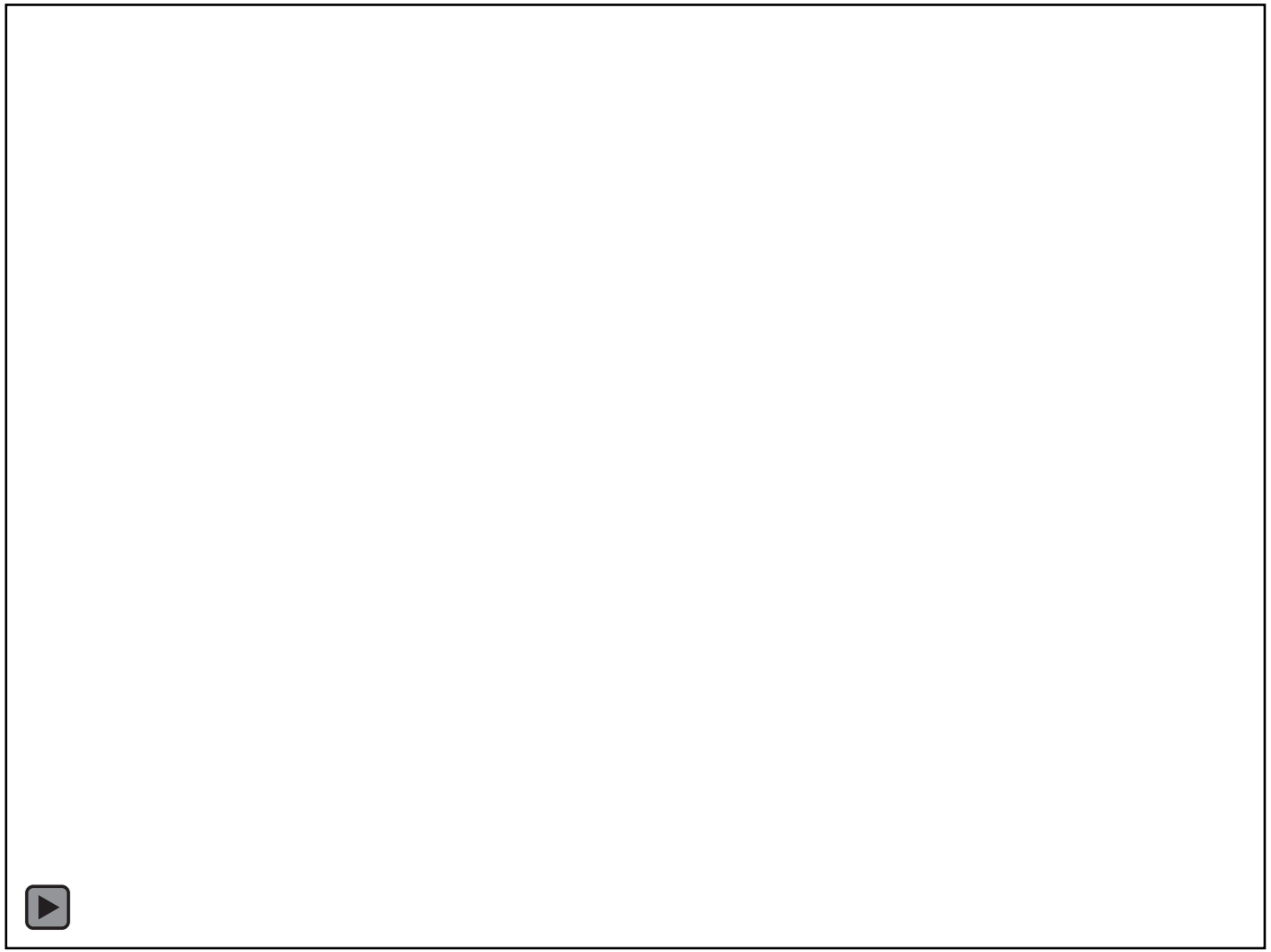
What Does an ASTM E779 Look Like?

Detroit Arsenal Bldg. 270

Detroit Arsenal Bldg. 270

WBALT

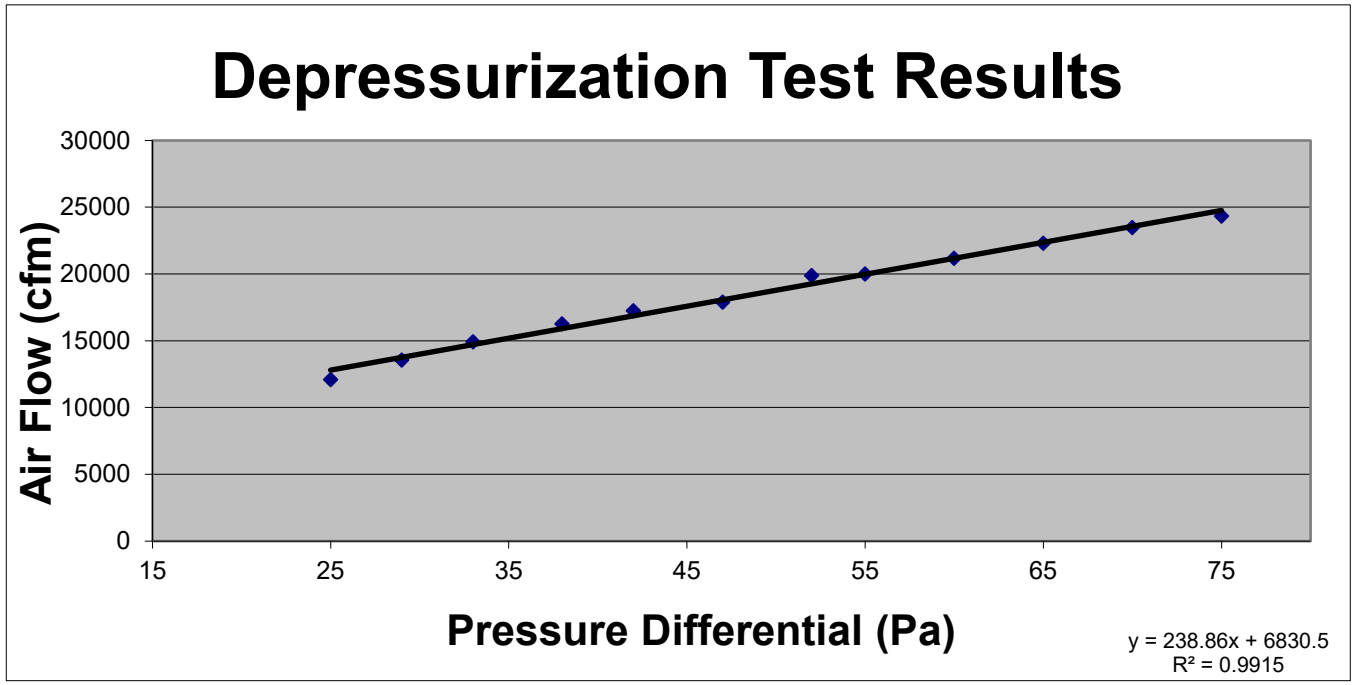
Test Set-up



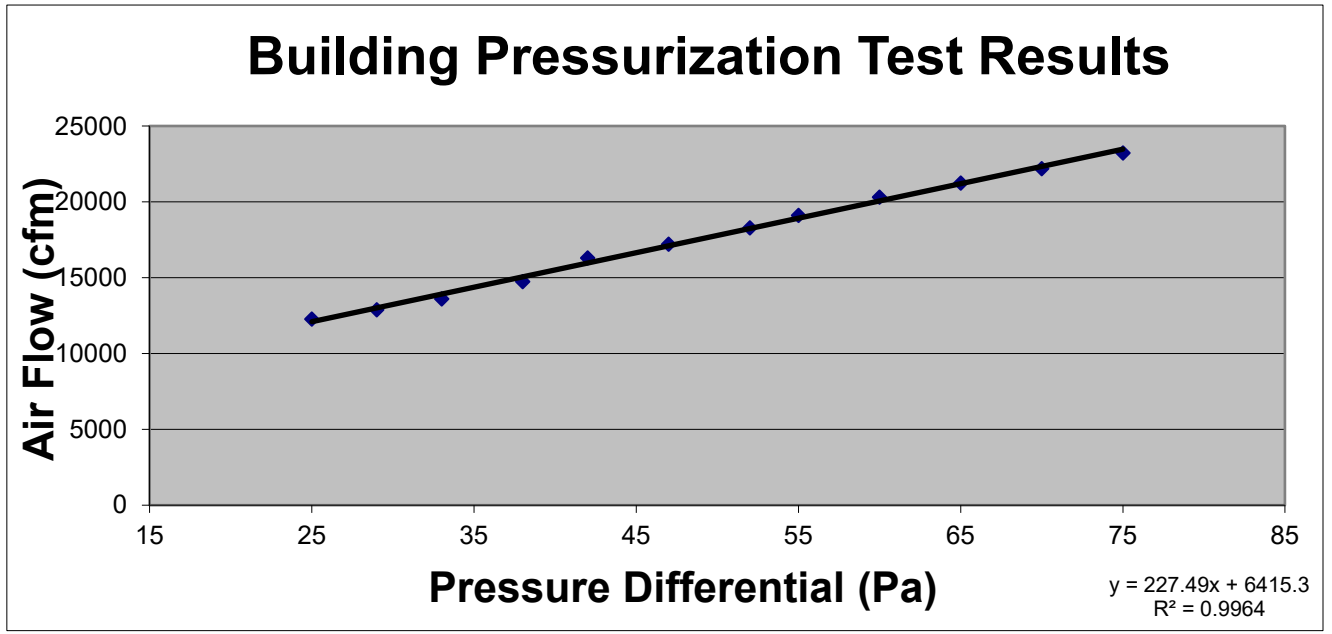
Target Air Leakage

USACE	cfm/sf@75Pa
RFP Requirement	*.25cfm/sf @75PA*
Detroit Arsenal Bldg. 270	*Envelope SF: 144,622*
Allowable leakage rate	*36155.5 cfm*

Data


Depressurization Test Results
Air Flow (cfm)
30000
25000
20000
15000
10000
5000
0
15
25
35
45
55
65
75
Pressure Differential (Pa)
y = 238.86x + 6830.5
R² = 0.9915

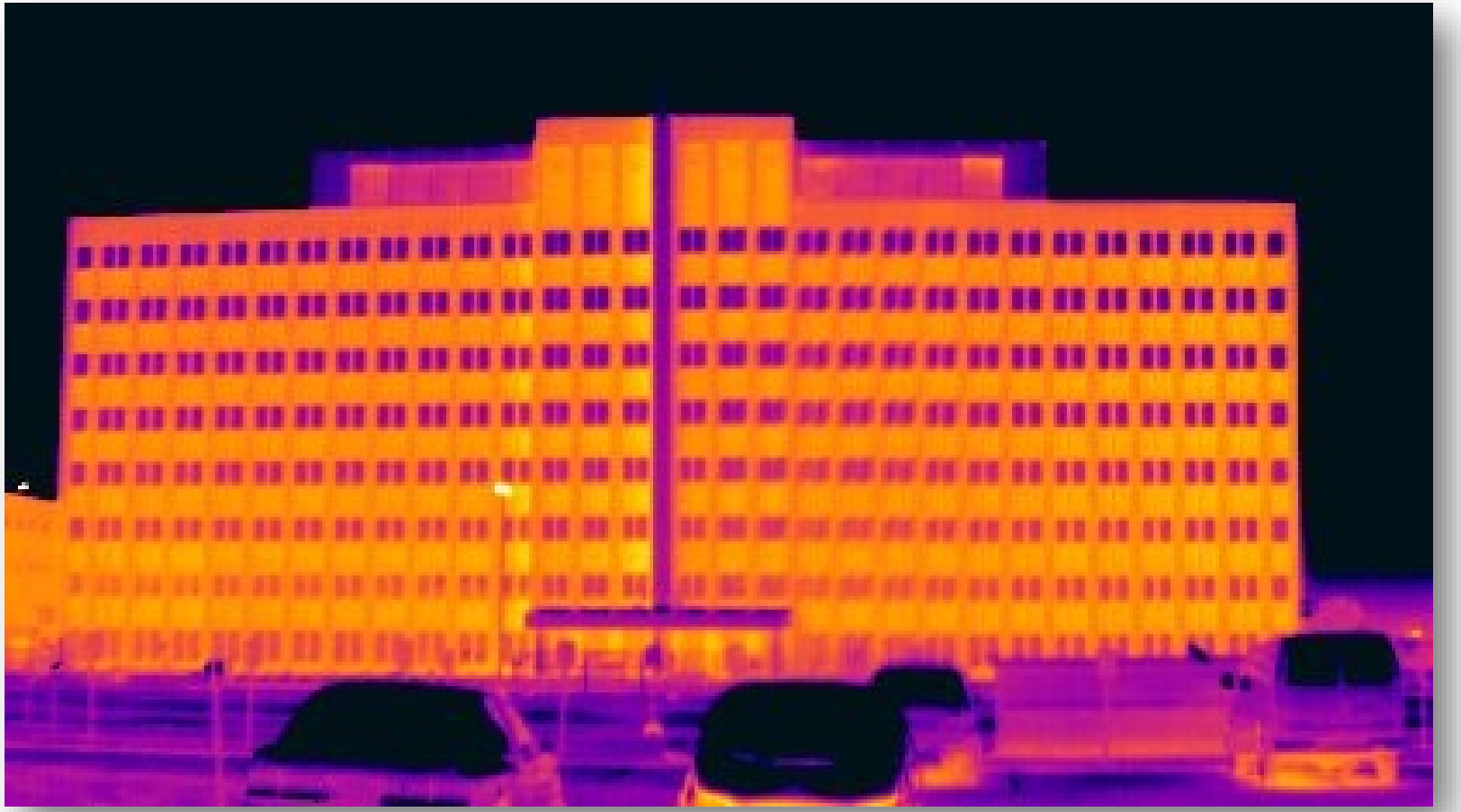
Data


Building Pressurization Test Results
Air Flow (cfm)
25000
20000
15000
10000
5000
0
15
25
35
45
55
65
75
85
Pressure Differential (Pa)
y = 227.49x + 6415.3
R² = 0.9964

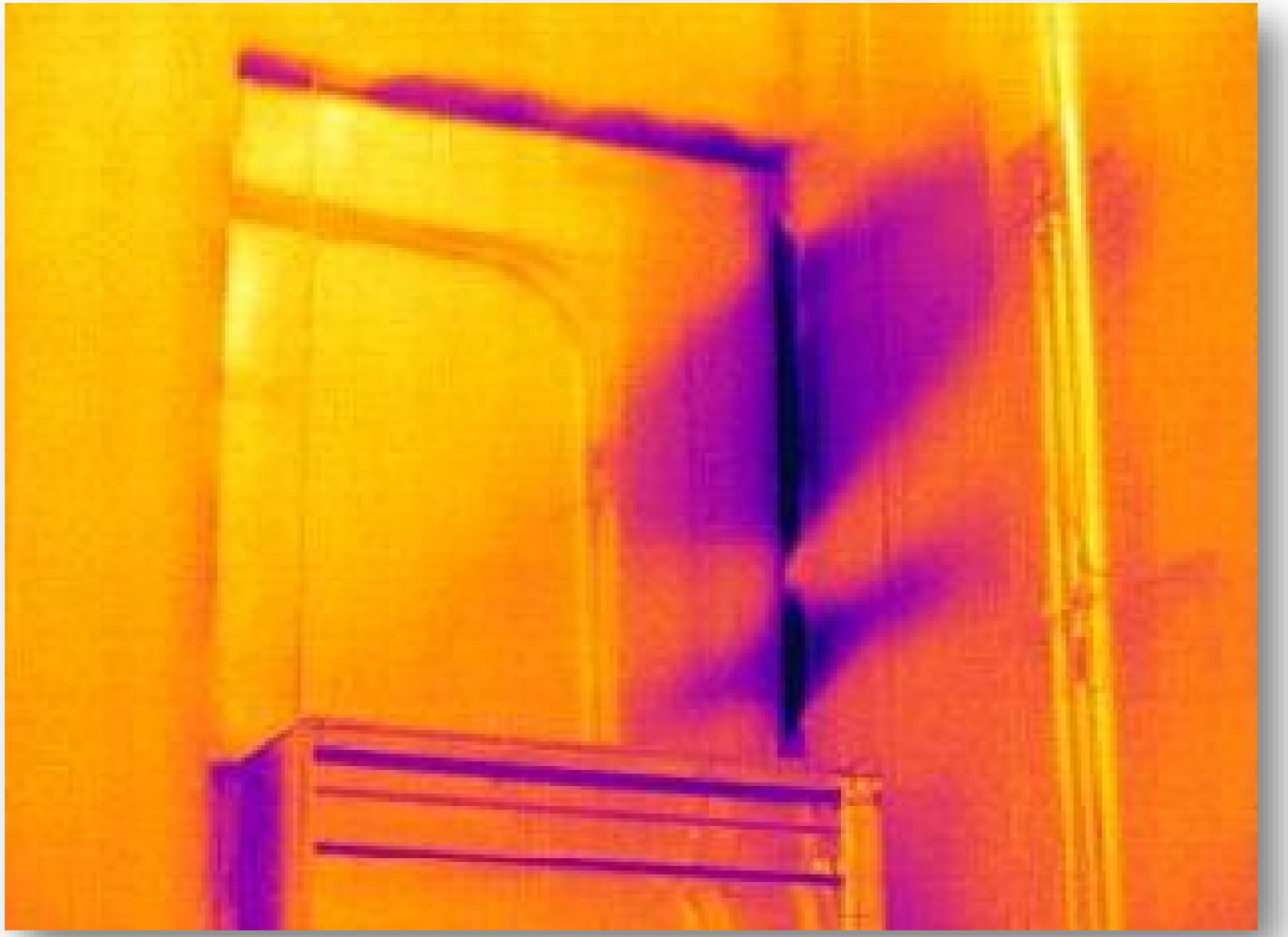
Results

Depressurize	Pressurize
0.168	0.161
24,330 cfm/75	23,235 cfm/75
Average = 0.16 - Data correlation > 99%	

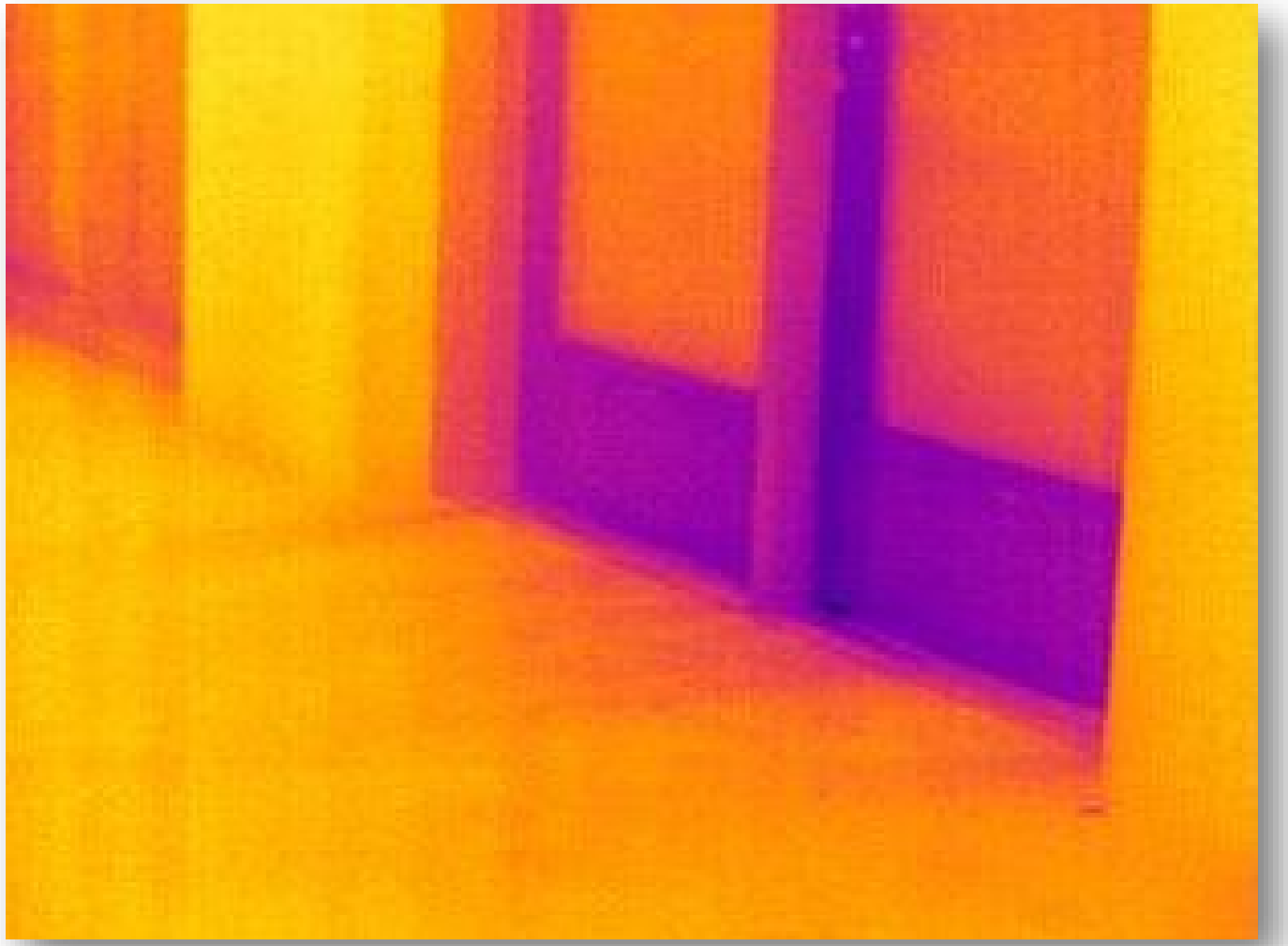
Infrared Survey



Infrared Survey

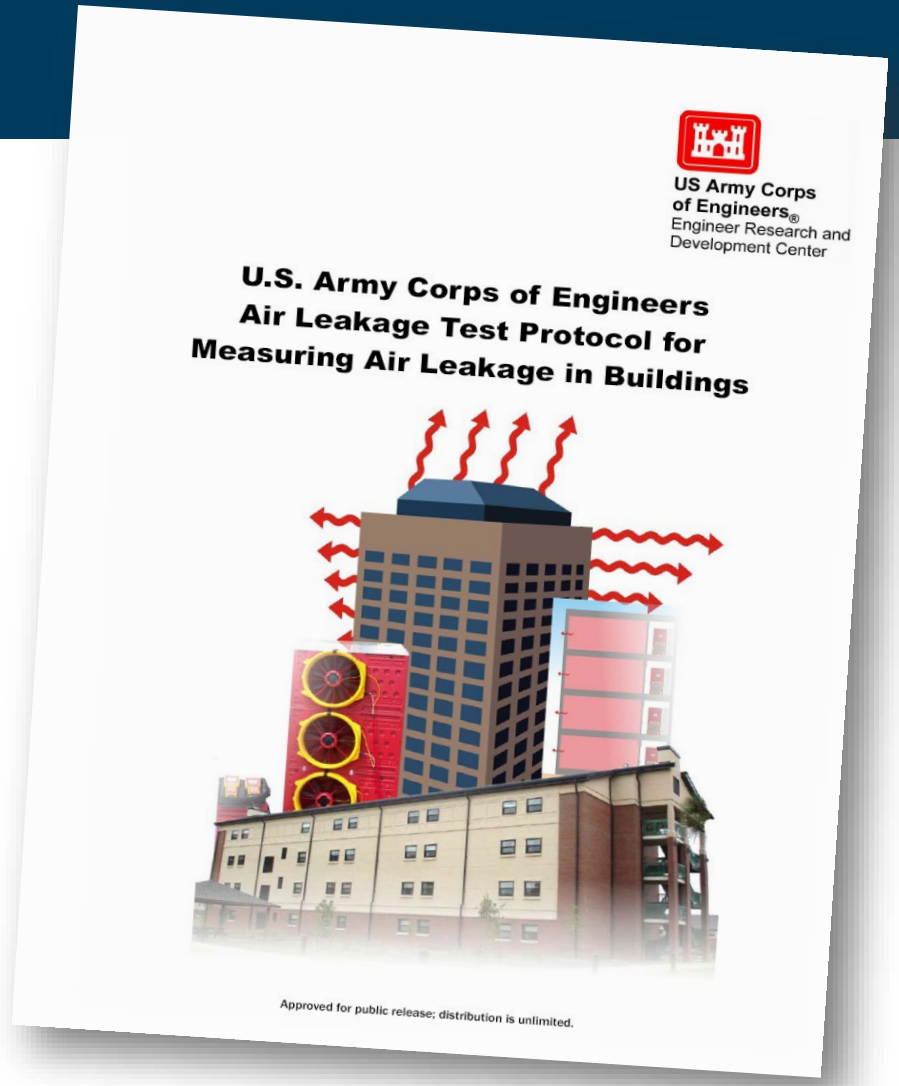


Infrared Survey



A lot of Questions….

- 0.25 cfm/sf is not achievable
- There are too many building types for one standard
- An air tightness standard will limit construction type
- An air tightness standard will limit material type
- This is space-age technology that requires new materials
- Needed is an education and training process that will take years to usher in



Test Study

- 285 DoD buildings
- Time range of 29 months
- 34+ DoD installations
- All climate zones in the United States *with some additional off shore*
- One to nine stories
- Building envelope areas ranging from 1,000 ft^2 to 370,000 ft^2
- All building types/uses

Air Tightness in New and Retrofitted US Army Buildings

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Abstract

The Engineer Research and Development Center, Construction Engineering Research Laboratory (ERDC-CERL) recently developed design/construction strategies that improve the energy efficiency, prevent mold, and improve indoor air quality in newly constructed buildings and buildings undergoing major renovations. ERDC-CERL performed building envelope leakage tests on Army facilities to test their general integrity and the effect of increased air tightness on building energy consumption. Results were used to develop air tightness criteria and performance requirements for new construction and major renovation projects, which have been included in Army design/construction strategies.

Since 2009, the US Army Corps of Engineers (USACE) has implemented an air tightness requirement in all new construction and building enclosure renovation projects. Engineering and Construction Bulletin (ECB) 2012-16 set levels of air tightness for building enclosures at the material, assembly, and system level. ECB 2012-16 requires whole building air leakage test to be conducted at completion of construction to verify the constructed air barrier system's performance. The current Air Leakage Test Protocol for Building Envelopes developed by ERDC-CERL, the Air Barrier Association of America (ABAA), and other industrial partners was published in May 2012.

This paper presents the results of air tightness tests before and after the new requirements were established, updated results for air leakage tests of more than 285 newly constructed and renovated large buildings, and a performance analysis of the design and construction process, air barrier materials, building use, and construction types. These data may support future decisions regarding air tightness levels to be adopted for commercial buildings.

Keywords

Air tightness, air barrier testing protocol, energy conservation

1. INTRODUCTION

All Army facilities have been required to increasingly reduce site energy consumption in response to Energy Policy Act of 2005 (EPAct), ECB 2010-14, and the Army Sustainable Design and Development Policy Update (Environmental and Energy

Success of the USACE Air Tightness Requirement

- Achievable
- Applicable
- Does not limit construction type
- Does not limit construction materials
- Building envelope discipline

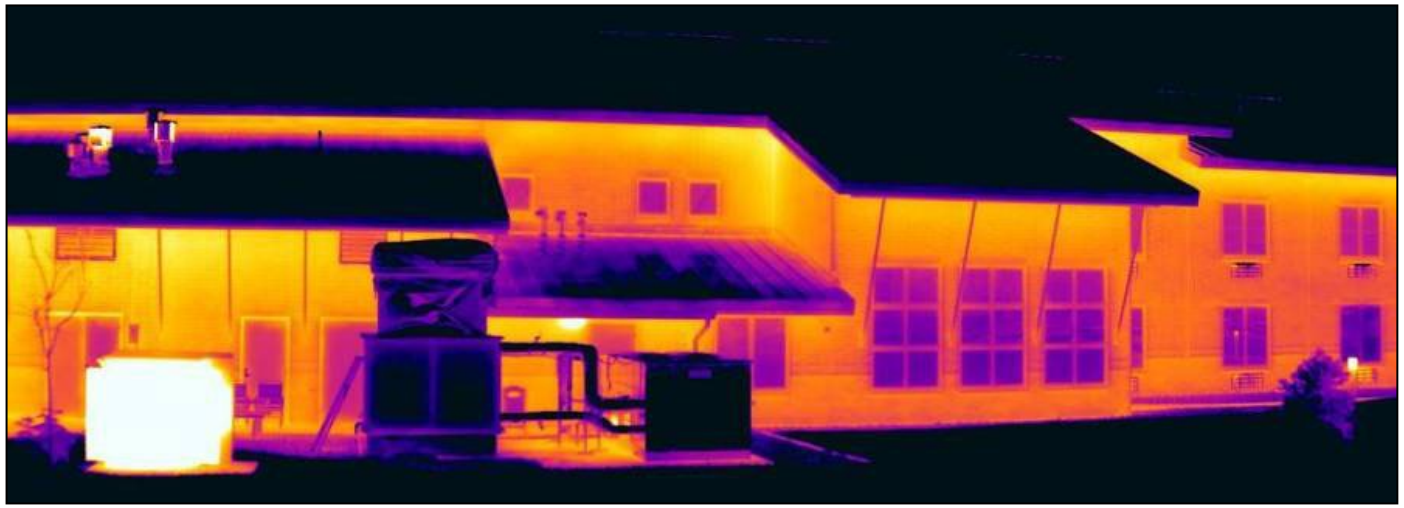
504.3.1.1 - Exceptions

1. For *buildings* having over 50,000 ft^2 of *gross conditioned floor area*, air leakage testing shall be permitted to be conducted on less than the whole *building*, provided the following portions of the *building* are tested and their measured air leakage is area-weighted by the surface areas of the *building envelope*:

    a. The entire *floor* area of all *stories* that have any *spaces* directly under a *roof*.
    b. The entire *floor* area of all *stories* that have a *building entrance* or loading dock.
    c. Representative *above-grade wall* sections of the *building* totaling at least 25% of the *wall* area enclosing the remaining *conditioned space*. Floor area tested per (a) and (b) shall not be included in the 25%.

504.3.1.1 - Exceptions

2. Where the measured air leakage rate exceeds 0.40 cfm/ft^2 but does not exceed 0.60 cfm/ft^2, a diagnostic evaluation, such as a smoke tracer or infrared imaging shall be conducted while the *building* is pressurized, and any leaks noted shall be sealed if such sealing can be made without destruction of *existing building* components. In addition, a visual inspection of the air barrier shall be conducted, and any leaks noted shall be sealed if such sealing can be made without destruction of *existing building* components. An additional report identifying the corrective actions taken to seal leaks shall be submitted to the *code official* and the *building* owner and shall be deemed to satisfy the requirements of this section.



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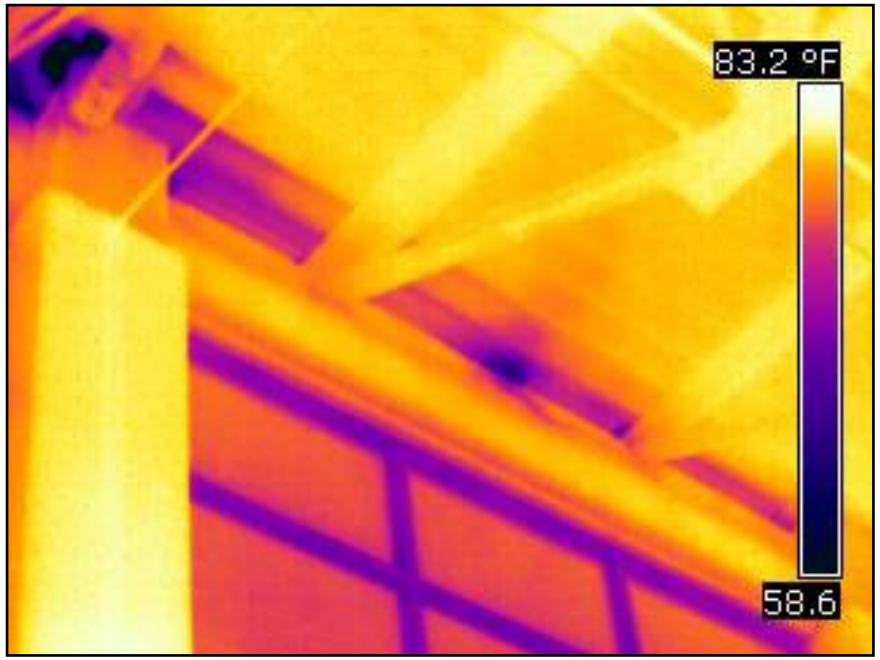

504.3.1.1 - Exceptions

3. *Continuous air barrier* design and installation verification program in accordance with Section 5.9.1.2.

5.9.1.2 Verification of the Design and Installation of the Continuous Air Barrier

Verification of the design and installation of the *continuous air barrier* shall be determined in accordance with the following by an independent third party when using Exception 3 of Section 5.4.3.1.1:

a. A design review shall be conducted to verify and document compliance with the requirements in Sections 5.4.3 and 5.8.3.2.

b. Periodic field inspection of the *continuous air barrier* materials and assemblies shall be conducted during *construction* while the *continuous air barrier* is still accessible for inspection and *repair* to verify and document compliance with the requirements of Sections 5.4.3.1.2 and 5.8.3.

c. Reporting shall comply with Section 4.2.5.1.2.

5.4.3.1.2 Continuous Air Barrier Design and Installation

5.4.3.1.2 Continuous Air Barrier Design and Installation

The *continuous air barrier* shall be designed and installed in the following manner:

a. Components designed to provide the *continuous air barrier*, and the component's position within each of the *building envelope* assemblies, shall be clearly identified on *construction documents*.

b. The joints, interconnections, and penetrations of the *continuous air barrier* components shall be detailed in the *construction documents*.

c. The *continuous air barrier* shall extend over all surfaces of the *building envelope* and be identified in the *construction documents* to be continuous.

d. The *continuous air barrier* shall be designed to resist positive and negative pressures from wind, stack effect, and mechanical *ventilation* and allow for anticipated movements.

e. The following areas of the *continuous air barrier* in the *building envelope* shall be wrapped, sealed, caulked, gasketed, or taped in an approved manner to minimize air leakage:

   1. Joints around *fenestration* and *door* frames
   2. Junctions between *walls* and *floors*, between *walls* at *building* corners, and between *walls* and *roofs*
   3. Penetrations through the *continuous air barrier* in *building envelope roofs*, *walls*, and *floors*
   4. *Building* assemblies used as ducts or plenums
   5. Joints, seams, connections between planes, and other changes in *continuous air barrier* materials

Hurdles, Unknowns, or Grey Areas

- Who is to contract the third party testing agency or the consultant for the Design/Inspection Verification Plan.
- Who is qualified to perform the testing?
- Who is qualified to perform Design/Inspection Verification of the Air Barrier?
- How many reviews are required and what reporting/documentation will each AHJ require to show compliance with design/construction review?
- Is ASTM E779 the right Test Standard?
- Lack of Protocol has the potential to usher in “Junk Science”

Questions/Discussion

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