abaa2025 building enclosure conference

Current and Future Energy Codes-Impacts on the Design, Construction, and Testing of Air Barriers

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BPL Enclosure

AIA Continuing Education Provider



Current and Future Energy Codes- Impacts on the Design, Construction, and Testing of Air Barriers

This presentation provides a comprehensive exploration of air tightness by tracing its theoretical evolution and historical progression, examining the key metrics that define baseline performance levels.

Attendees will gain insights into the holistic phases of enclosure consulting with a focus on air barrier strategies, while also critically evaluating the wide range of air tightness codes and standards to understand their validity, impact, and relevance.



Lee Durston

Lee has been in the building enclosure industry since 2001. During this time, he has overseen and completed hundreds of projects in forensic, design, construction administration, construction observation, and quality control for new construction and rehabilitation projects related to several types of façade assemblies.





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 and IECC 2021 Air Leakage requirements are.
- Understand the validity, impact, and relevance of the wide range of air-tightness codes and standards.
- 4. Understand whole building air leakage testing (WBALT) as compared to holistic enclosure consulting.

WHY AIR BARRIERS AND WHY NOW?

- Energy Conservation Measure
 - First Costs/Construction
 - Operational Costs

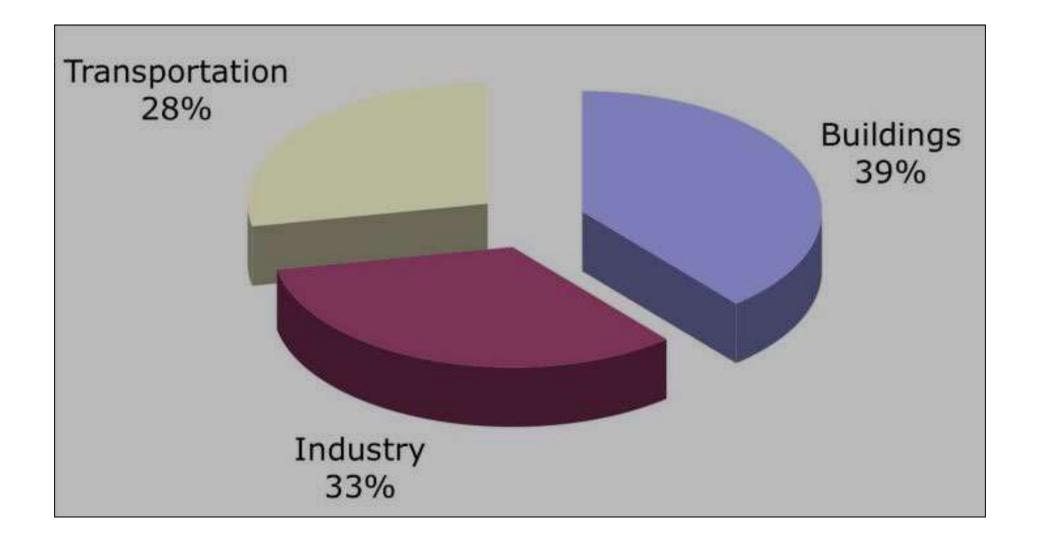
- Building Envelope Durability
 - H- Heat Barrier
 - A- Air Barrier
 - M_I Moisture Liquid
 - M_V- Moisture Vapor







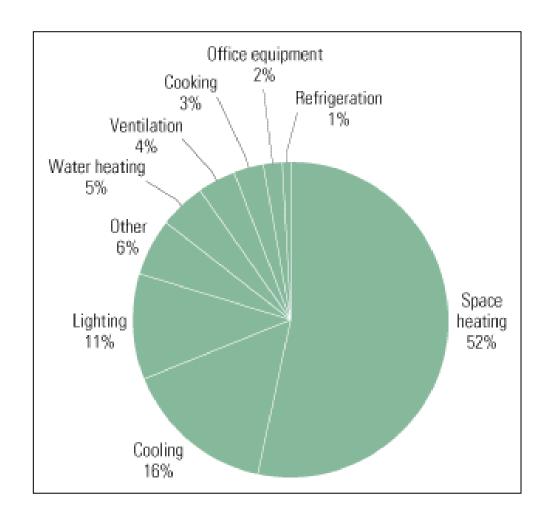
ENERGY



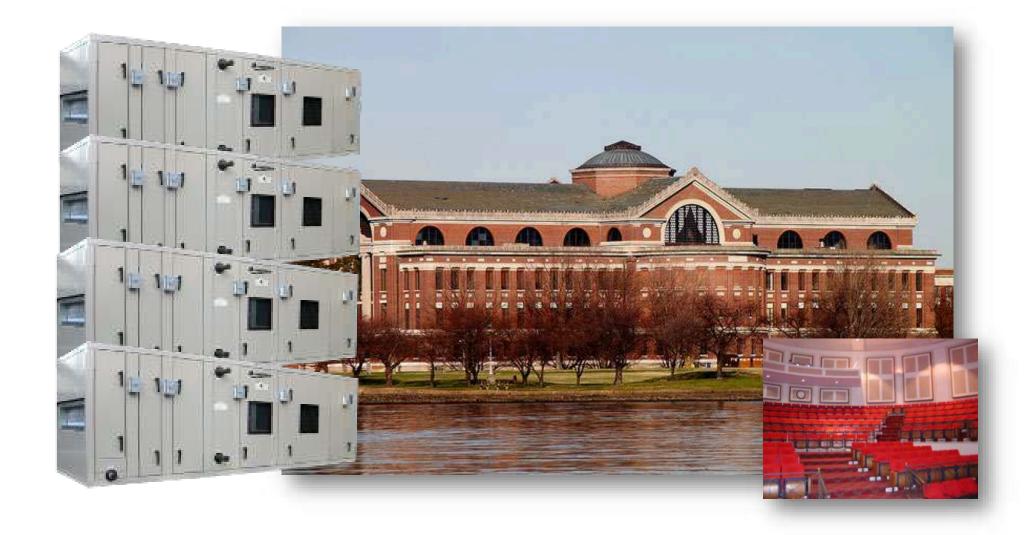


ENERGY

- Building Envelope (walls, roof, windows, and floors)
- Lighting
- Heating, Ventilating, and Air Conditioning (HVAC)
- Internal and Process Loads (cooking, hot water, manufacturing, etc.)

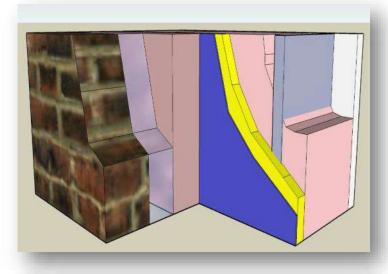


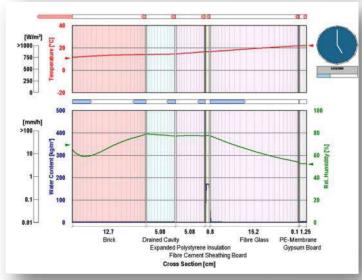
ENERGY

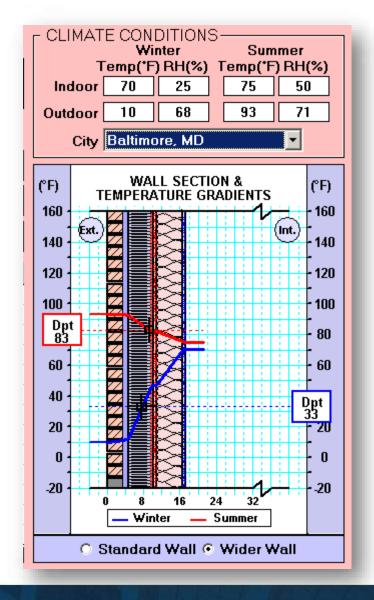




BUILDING ENCLOSURE DESIGN









DURABILITY





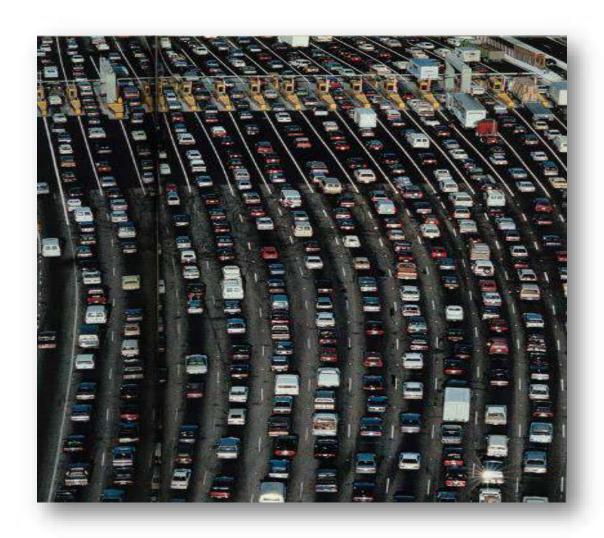


MOISTURE TRANSPORT- VAPOR DIFFUSION



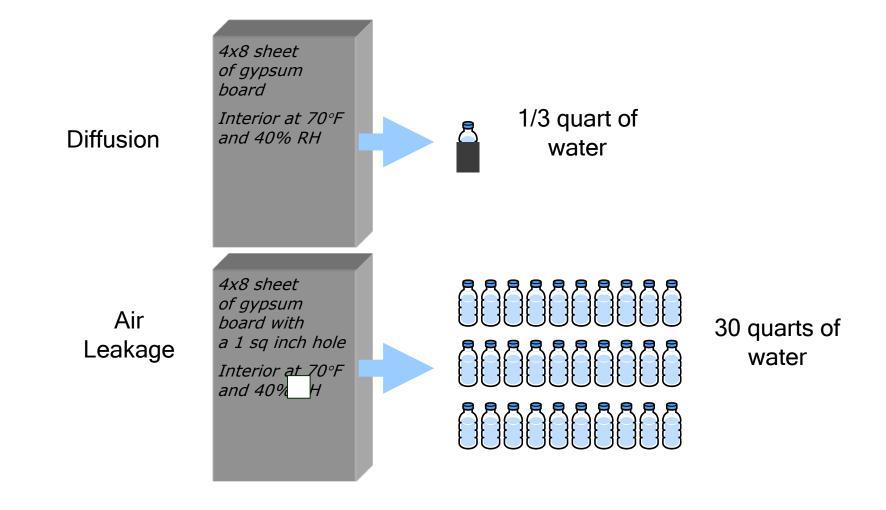


MOISTURE TRANSPORT- AIR LEAKAGE





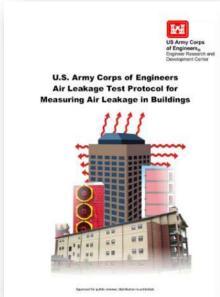
MOISTURE TRANSPORT

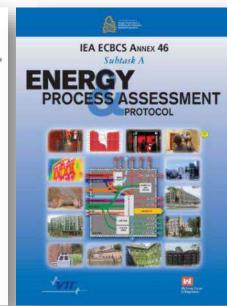




THE SILENT ISSUE







Air Tightness in New and Retrofitted US Army Buildings

Alexander Zhivov," Dale Herron, J. Lee Durston,2 Matthew Heron,2 and George Lea

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o, Annada, CO Bourg, USA. 6 Sheet Mill Westington,

Abstract

The Engineer Research and Development Center. Construction Engineering Research Laboratory (REDC-EER) recently developed design/constructions strategies that improve the energy efficiency, prevent mold, and improve indoor air quality in newly constructed backlings and backlings undergoing major recovariests. REDC-CERL performed backling envelope feedings in the second contraction of the properties of the

Since 2009, the US Army Carpo of Engineers (USACE) has implemented as air tightness requirement in all new constructions and building enclosure creatorisms projects. Engineering and Construction Bulletin (UCB) 2012-16-set levels of air tightness for building enclosures at the national, anomably, and power level. EUB 2012-16 requires whele building as in ladage to to the conducted at completion of the construction of the construction of the conducted at completion of the construction of the constructio

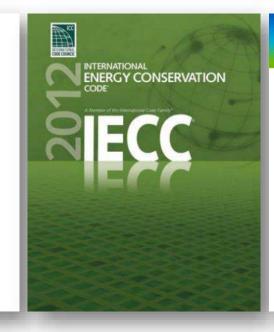
This paper presents the results of air lightness trees before and after the ever requirement were established, applied results for air leading a treat of more than 285 newly commercial and resourced large buildings, and a performance analysis of the design and construction process, as therefore materials, buildings sea, 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



STANDARD

ANSI/ASHRAE/IES Standard 90.1-2019 (Superseses ANSI/ASHRAE/IES Standard 90.1-2016) Includes ANSI/ASHRAE/IES addendo iszed in Appondix i

Energy Standard for Buildings Except Low-Rise Residential Buildings (I-P Edition)

Set Appendix I for approval cates by ASHRAB, the Humbridge Englishing Section, and Engineer can Markets Humbridge

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





- ASHRAE 90.1- 2019
- 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

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



ASHRAE 90.1

Verification Requirements

- Whole Building Air Leakage Testing (WBALT)
 - <= 0.40 cfm/sf75 = PASS</p>
 - >0.60 cfm/sf75 = FAIL
 - Fix Leaks and re-test (destructive)
 - $0.40 0.60 \text{ cfm/sf75} = MARGINAL}$
 - use diagnostic methods to find and fix all leaks (non-destructive)

- Air Barrier Design & Installation Verification Program
 - Independent Third-Party
 - Design Review
 - Periodic Site Visits
 - Repair issues during construction
 - (This option is removed in future versions of ASHRAE 90.1)

OR



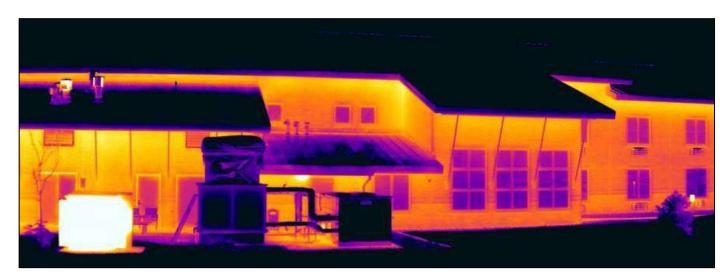
5.4.3.1.1 - EXCEPTIONS

- 1. For *buildings* having over 50,000 ft² 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%.



5.4.3.1.1 - EXCEPTIONS

2. Where the measured air leakage rate exceeds 0.40 cfm/ft² but does not exceed 0.60 cfm/ft², 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.







LOCATE / FIX / DOCUMENT







5.4.3.1.1 - 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
 - Junctions between walls and floors, between walls at building corners, and between walls and roofs
 - Penetrations through the continuous air barrier in building envelope roofs, walls, and floors
 - 4. Building assemblies used as ducts or plenums
 - Joints, seams, connections between planes, and other changes in continuous air barrier materials



- Denver 2019
- IECC 2018
- Section C402.5 Air Leakage

Section C402.5 Air leakage—thermal envelope (Mandatory) is replaced as follows:

C402.5 Air leakage—thermal envelope (Mandatory). The building thermal envelope shall comply with Sections C402.5.1 through C402.5.8

Section C402.5.1 Air barriers and the exception is replaced as follows:

C402.5.1 Air barriers. A continuous air barrier shall be provided throughout the building thermal envelope. The continuous air barrier shall be located on the inside or outside of the building thermal envelope, located within the assemblies comprising the building thermal envelope, or any combination thereof. The air barrier shall comply with Sections C402.5.1.1, C402.5.1.2 and C402.5.1.3

2019 DENVER AMENDMENTS TO THE 2018 INTERNATIONAL ENERGY CONSERVATION CODE

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Exception: Heated spaces between slabs and dropped ceilings utilizing greater than 3.4 Btu/sq ft. but less than 12Btu/sq ft for space conditioning purposes may eliminate the *air barrier* at the plenum floor, and instead maintain air barrier continuity across the slab following C402.5.1.1. The slab must have minimum R-5 insulation and the plenum floor must have minimum R-19 insulation. Flexible batt insulation shall be supported in a permanent manner by supports no greater than 24 in. on center.



- Denver 2019
- IECC 2018
- Section C402.5 Air Leakage

Section C402.5.1.2 Air barrier compliance options is replaced as follows:

C402,5.1.2 Air barrier compliance options. A continuous air barrier for the opaque building envelope shall comply with the following:

All buildings or portions of buildings shall meet the provisions of Section C402.5.1.2.1 or C402.5.1.2.2, and C402.5.1.2.3. Buildings or portions of buildings of other than Group I occupancy shall also meet the provisions of Section C402.5.1.2.3. Section C402.5.1.2.3 Building thermal envelope performance verification is added as follows:

Section C402.5.1.2.3 Building thermal envelope performance verification. The installation of the continuous air barrier shall be verified by a registered design professional or approved agency in accordance with the following:

- A review of the construction documents and other supporting data shall be conducted to assess compliance with the requirements in Sections C402.5.1. A verification report shall be completed by the registered design professional or approved agency and included in the Energy Compliance Package submitted with the permit application.
- Inspection of continuous air barrier components and assemblies shall be conducted during
 construction while the air barrier is still accessible for inspection and repair to verify compliance
 with the requirements of Sections C402.5.1.1 and C402.5.1.2. A preliminary commissioning report
 shall be completed by the registered design professional or approved agency and provided to the
 building owner or owner's authorized agent and the code official.
- A final commissioning report shall be completed by the registered design professional or approved
 agency and provided to the building owner or owner's authorized agent and the code official. The
 report shall identify deficiencies found during the review of the construction documents and
 inspection and details of corrective measures used.

Exception: 10% of the air barrier may be unverified as long as the required 0.40 CFM/ft² air leakage metric has been met in accordance with C402.5.1.3. For buildings not required to test for air leakage, full air barrier verification is required.



- Denver 2019
- IECC 2018
- Section C402.5 Air Leakage

Section C402.5.1.3 Building thermal envelope testing and subsection is added as follows:

C402.5.1.3 Building thermal envelope testing. The building thermal envelope shall be tested in accordance with ASTM E 779 or an equivalent method approved by the code official.

Exception: Testing shall not be required to include all portions of the building thermal envelope where the following portions of the building are tested and the measured air leakage is area-weighted by the surface area of the building thermal envelope in each portion:

- The entire envelope area of all stories that have any spaces directly under a roof,
- The entire envelope area of all stories that have a building entrance, exposed floor, loading dock, or are below grade, and
- Representative above-grade sections of the building totaling at least 25 percent of the wall area enclosing the remaining conditioned space.

2019 DENVER AMENDMENTS TO THE 2018 INTERNATIONAL ENERGY CONSERVATION CODE

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C402.5.1.3.1 Building thermal envelope corrective measures. Where the measured air leakage rate exceeds 0.40 cfm/ft² (2.0 L/s·m²) a diagnostic evaluation using smoke tracer or infrared imaging shall be conducted while the building is pressurized along with a visual inspection of the air barrier. Any leaks noted shall be sealed where 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.

Section C402.5.3 Rooms with fuel-burning appliances is replaced in its entirety as follows (remainder of section unchanged):

C402.5.3 Rooms with fuel-burning appliances. In Climate Zones 3 through 8, where combustion air is supplied through openings in an exterior wall to a room or space containing space conditioning or service water heating fuel-burning appliances, one of the following shall apply:



- Denver 2019
- IECC 2018
- Section C402.5 Air Leakage
- Requires testing to a 0.30cfm/sf @0.3"w.c.

Section C402.5 Air leakage—thermal envelope is replaced as follows (other subsections remain unchanged, unless noted otherwise):

C402.5 Air leakage—thermal envelope. The building thermal envelope shall comply with Sections C402.5.1 through C402.5.11.1 and shall be tested in accordance with Section C402.5.2 for occupancy types R or I, or Section C402.5.3 for all other occupancy types.

Section C402.5.1.5 Building envelope performance verification is modified as follows (Item 3 remains without modification):

C402.5.1.5 Building envelope performance verification. The installation of the continuous air barrier shall be verified by a registered design professional or approved agency in accordance with the following:

- A review of the construction documents and other supporting data shall be conducted to assess compliance with requirements in Section C402.5.1. A verification report shall be completed by the registered design professional or approved agency and included in the submittal with the permit application.
- Inspection of continuous air barrier components and assemblies shall be conducted during construction while the air barrier is still accessible for inspection and repair to verify compliance with the requirements of Sections C402.5.2 and C402.5.3.



DEBUNKING THE MYTH AND SETTING GOALS

- In 1998 a NIST study and paper showed commercial buildings were not the air tightness champions they were thought to be.... (Persily 1998)
- In 2005 a NIST study and paper was released that concluded that a potential of 40% reduction in energy use could be achieved with a focus on air-tightness in buildings.... (Emmerich, Anis 2005)

ANALYSIS OF THE NIST COMMERCIAL AN INSTITUTIONAL BUILDING ENVELOPE LEAK DATABASE

Steven J Emmerich*1, Andrew K Persily1

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ABSTRACT

In 1998, NIST published a review of commercial and institutional building that found significant levels of air leakage and debunked the "myth" of the commercial building (Persily 1998). Since then, NIST has expanded and r database of whole building envelope leakage measurements of U.S. com institutional buildings. In addition to building leakage values collected fr publications, low-energy building programs and private pressurization to database includes basic building characteristics such as year built, build number of stories, location, and wall construction type for many of the of the database is to establish default values for building simulation, to savings potential of artightness requirements in standards and codes, opportunities for additional improvements in building airtightness per presents an update of the currently available airtightness data from if

The U.S. commercial building envelope leakage database now co buildings including more than 50 constructed in the past decade determine the impact on airtightness of factors such as building ty recent additions to the database include numerous building specifications of sustainable or high performance building prof Building Council's LEED rating system as well as buildings (air barriers, both of which tend to correlate with lower building

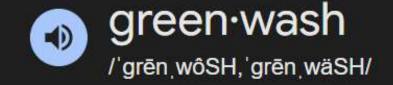
Airtightness, air barrier, fan pressurization test, infiluration, sustainable buildings

Investigation of the Impact of NISTIR 7238 Commercial Building Envelope Airtightness on HVAC Energy Use

> Steven J. Emmerich Tim McDowell



IS IT LEGITIMATE?



noun

misleading or <u>deceptive</u> publicity <u>disseminated</u> by an organization so as to present an <u>environmentally</u> responsible public image.

"the recycling bins in the cafeteria are just feeble examples of their corporate greenwash"



MailOnline

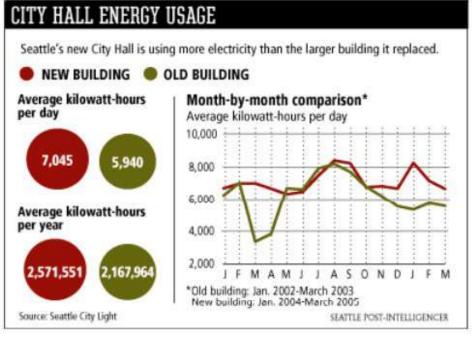
Airline asks passengers to use the toilet before boarding... so they will weigh less and help cut carbon emissions

- A Japanese airline has started asking passengers to go to the toilet before boarding in a bid to reduce carbon emissions.
- Nippon Airways (ANA) claims that empty bladders mean lighter passengers, a lighter aircraft and thus lower fuel use.
- ANA hopes the weight saved will lead to a five-tonne reduction in carbon emissions over the course of 30 days.





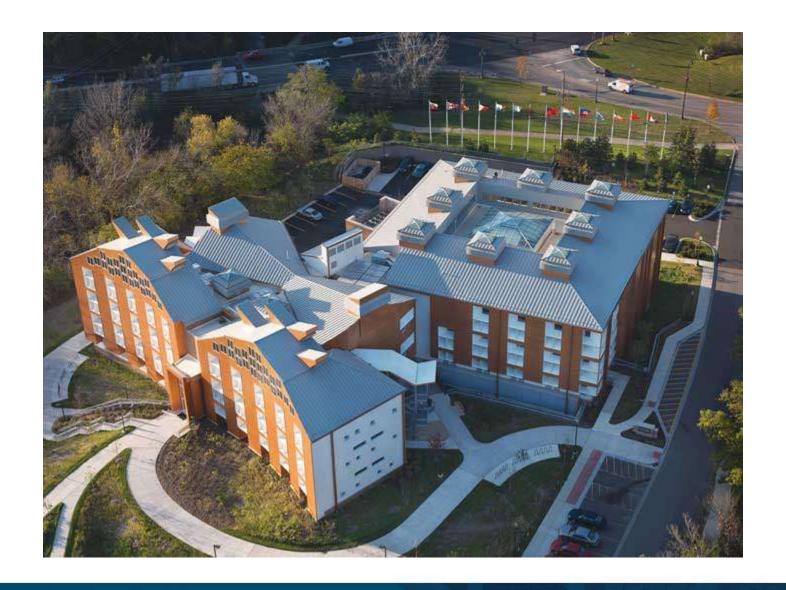


















A LOOK AT REQUIREMENTS GLOBALLY

			cfm/ ft²[L/s*m²]at 75Pa	
US	ASHRAE 189.1/90.1	0.40 cfm/ft² at 75Pa	0.40/2.02	
US	LEED	1.25 in ² EfLA @ 4 Pa / 100 ft ²	0.30/1.52	
US	ASHRAE HOF average handbook of fundamentals	0.30 cfm/ft² at 75Pa	0.30/1.52 Leakie	
	U.S. DoD Standard	0.25 cfm/ ft ² at 75Pa	0.25/1.27	
UK	TS-1Commercial Tight	2 m ³ /h/m ² at 50 Pa	0.14/0.71	
CAN	R-2000	1 in ² EqLA @10 Pa /100 ft ²	0.13/0.66	
US	ASHRAE HOF 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				



Passive House 0.06 cfm/ft² at 75Pa



AIR LEAKAGE BY THE NUMBERS

	ASHRAE 90.1 Append. Z	US Army Corps Engineers	Canada NBC (L/(s*m² @75Pa)
	(cfm/ft ^{2 @} .3" w.c.)		
Material	0.004	0.004	0.02
Assembly	0.04	0.04	0.2
Building	0.4	0.25	2.0





MATERIALS OR ASSEMBLIES OR WBALT



Shouldn't it be and, and



HOW LEAKY ARE BUILDINGS...?

Example #1



Standard Commercial
Construction
Air Leakage Rate:

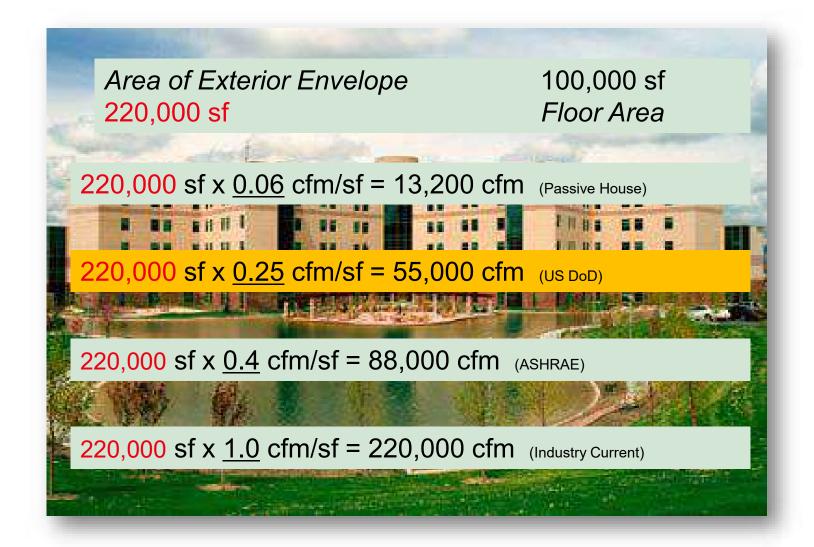
0.40 to 1.60 cfm/sf @ 0.3" wg

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



HOW LEAKY ARE BUILDINGS...?

Example #2





A LOOK AT REQUIREMENTS GLOBALLY

			cfm/ ft²[L/s*m²]at 75Pa	
US	ASHRAE 189.1/90.1	0.40 cfm/ft² at 75Pa	0.40/2.02	
US	LEED	1.25 in ² EfLA @ 4 Pa / 100 ft ²	0.30/1.52	
US	ASHRAE HOF average handbook of fundamentals	0.30 cfm/ft² at 75Pa	0.30/1.52 Leakie	
	U.S. DoD Standard	0.25 cfm/ ft ² at 75Pa	0.25/1.27	
UK	TS-1Commercial Tight	2 m ³ /h/m ² at 50 Pa	0.14/0.71	
CAN	R-2000	1 in ² EqLA @10 Pa /100 ft ²	0.13/0.66	
US	ASHRAE HOF 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				



Passive House 0.06 cfm/ft² at 75Pa



6 STEPS TO QUALITY AIR BARRIER SYSTEMS

- 1. System Design/Selection
- 2. Independent Technical Review
- 3. Subcontractor Qualifications
- 4. Mock-Up
- 5. Managing Work Sequence
- 6. Independent Audits





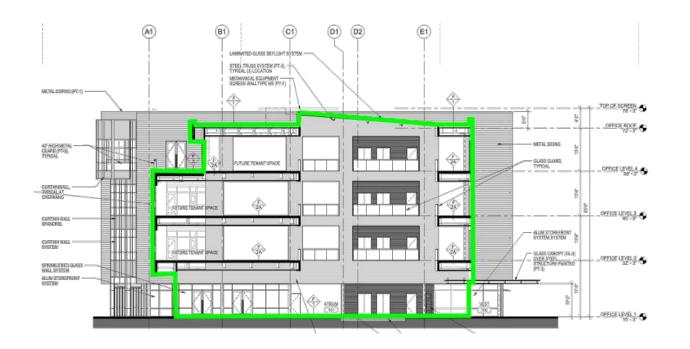
SYSTEM DESIGN AND SELECTION





INDEPENDENT TECHNICAL REVIEWS

- Is The System Design Complete...?
- Will It Deliver The Required Airtightness...?
- Is System Detailed Correctly...?
- Are There Compatibility Problems...?
- Is There A Simpler/Cheaper System...?





SUBCONTRACTOR QUALIFICATIONS

- Training
- Experience
- Manufacturer Approval/Certification
- ABAA Certification





MOCK-UP

- Allows Early Coordination
- Confirms Sequence Of Construction
- Establishes Standard Of Quality
- Identifies Possible Efficiencies
- Identifies If You Are In Trouble.....



MANAGING THE WORK SEQUENCE

- Acceptable substrate
- Weather considerations
- Sequencing system interfaces
- Trade damage
- Coordination with work by other trades





INDEPENDENT AUDITS

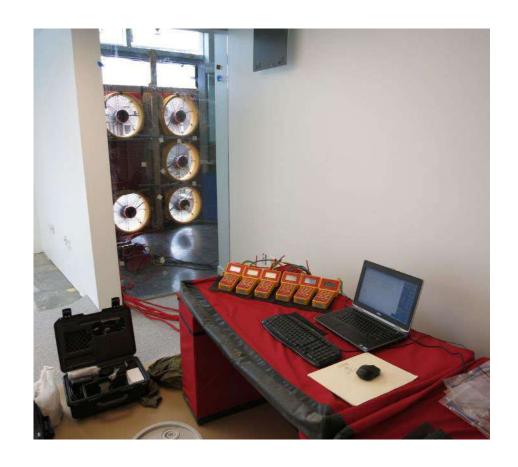
- ABAA quality assurance program
- Enclosure Consultant
- Pre-installation meeting
- Review mock-up
- Review installation in progress
- Testing





SPECIFYING TESTING

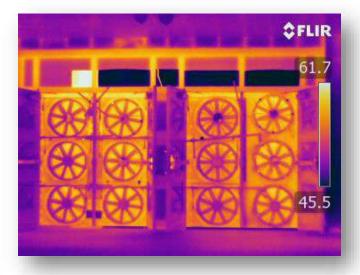
- Location in the Specifications
- Test Method
- Leakage Rate
- Who pays for the testing? Owner?
- What is the impact of failing the test?
 Contractor pays?
- What measures should be considered to minimize risk of failure?





TESTING AGENCY VERSUS ENCLOSURE CONSULTANT

- Testing Agency
 - Just the testing for code compliance
 - No assistance with diagnosing reason for failure
 - No assistance with recommending how to air seal
- Enclosure Consultant
 - Pre-test assistance
 - Understanding of air barrier systems
 - Recommendations for how to air seal if failure







PERFORMANCE VERIFICATION

- ASHRAE 90.1 2019 = not to exceed 0.40 cfm/sf @ 75 Pa
- IECC 2019= not to exceed 0.40 cfm/sf @ 75 Pa
- IECC 2021= not to exceed 0.30 cfm/sf @ 75 Pa
- USACE = not to exceed 0.25 cfm/sf @ 75 Pa
- LEED-H= not to exceed
 0.35 ACH @ 50 Pa
- Washington State Energy Code 0.30 cfm/sf @75Pa
- City of Fort Collins= not to exceed 0.25 cfm/sf @ 75 Pa
- Others





WE WERE WARNED.....

- 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





SEND IT!





Approved for public release; distribution is unlimited.

WBALT TESTING STUDY











- 208 DoD buildings
- Time range of 29 months
- 34 DoD installations
- All climate zones in the United States
- One to nine stories
- Building envelope areas ranging from 1,000 ft2 to 370,000 ft2
- All building types

Air Tightness in New and Retrofitted US Army Buildings

Alexander Zhivov," Dale Herron, J. Lee Durston, 2 Matthew Heron, 3 and George Lea⁴

The Engineer Research and Development Center, Construction Engineering Resea The Engineer Research and Development Center, Construction Lagrangian newsons, Laboratory (ERDC-CERL) recently developed design/construction strategies that Landandy (Endo, C., Erd.) (recently developed design construction manages man improve the energy efficiency, prevent mold, and improve indoor air quality in newly asperve me energy eurorency, prevers most, ane improve moster art quanty in new constructed buildings and buildings undergoing major renovations. ERDC CERL constructed naturally and naturally analogoung major renovations. ERLA—LERL performed building envelope leakage tests on Army facilities to test their general Actionizes outstaing envelope reastage tests on Army facilities to test men general integrity and the effect of increased air tightness on building energy consumption. magnity and the effect of increased as upmness on minimig energy consumption.

Results were used to develop air tightness criteria and performance requirements for assume were to develop an inguising structure and performance requirements for new construction and major renovation projects, which have been included in Army

Since 2009, the US Army Corps of Engineers (USACE) has implemented an air tightness requirement in all new construction and building enclosure renovations and construction and building enclosure renovations. Building (ECID, 2012, 16 and books of fair regionas requirecirem in an new construction and rounding encrosure renovation projects. Engineering and Construction Bulletin (ECB) 2012-16 set levels of air projects engineering and construction trusted (e.g. to) data-to set even or air ightness for building enclosures at the material, assembly, and system level. ECB 2012tigniness tor normang encanaries at the internal, amorniny, and system level, is 16 requires whole building air leakage text to be conducted at completion of The conducted and the conducted at completion of the conducted at conducted at completion of the conducted at conducted at completion of the conducte To requires winoue outsing our remarge test to be commonwed at compounds or construction to verify the constructed air barrier system's performance. The current Air construction to verny me constructes are current system a personnance, the current of charge Test Protocol for Building Envelopes developed by ERDC-CERL, the Air Learning ten Protocor for Issuamp Linvelopes neveropeu ny ERLA.—LERL, ne Aus-Barrier Association of America (ABAA), and other industrial partners was published in

This paper presents the results of air tightness tests before and after the new Into paper presents the resums or air infinitest tests between an aner one new requirements were established, updated results for air leakage tests of more than 285 requirements were established, updated resums for an reasuge teas or more than an early constructed and renovated large buildings, and a performance analysis of the newsy constructed and renovated rarge oundings, and a performance analysis of the design and construction process, air barrier materials, building use, and construction uesign and construction process, air nurser materians, vanuing use, and comstruction. These data may support future decisions regarding air tightness levels to be

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)



CASE STUDY – DETROIT ARSENAL BUILDING 270



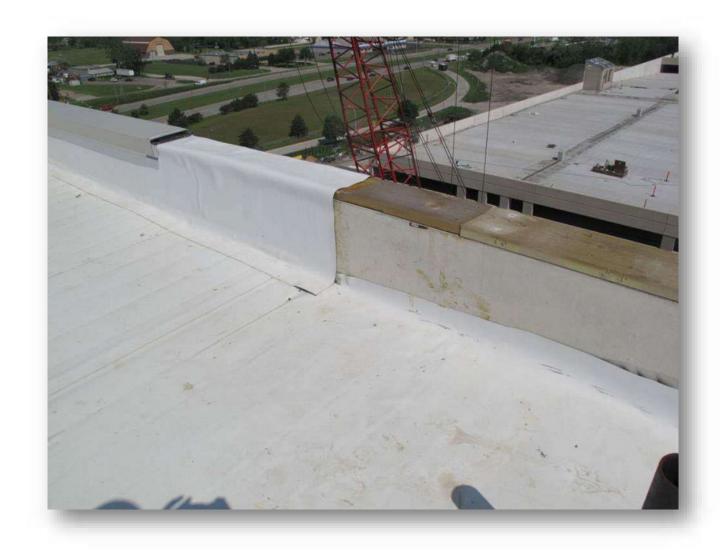


DETROIT ARSENAL BLDG. 270





DETROIT ARSENAL BLDG. 270



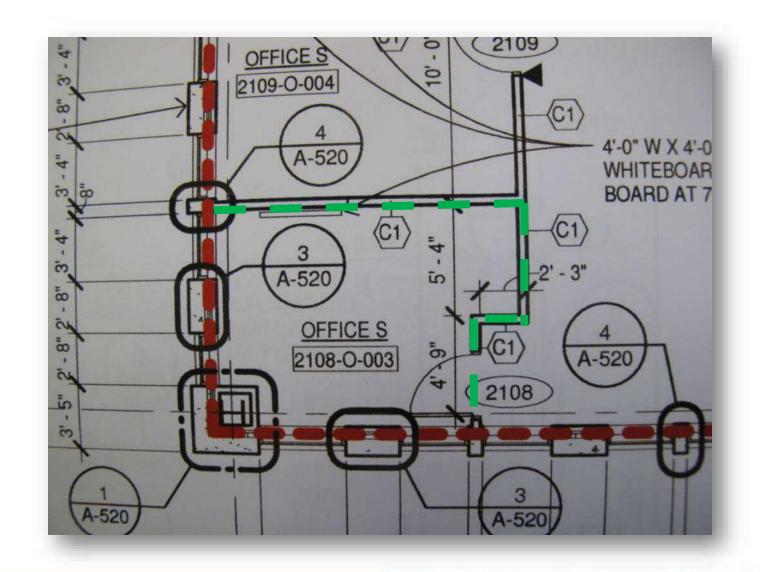


DETROIT ARSENAL BLDG. 270





CONFIDENCE TEST/MOCK-UP





BUILDING PREP



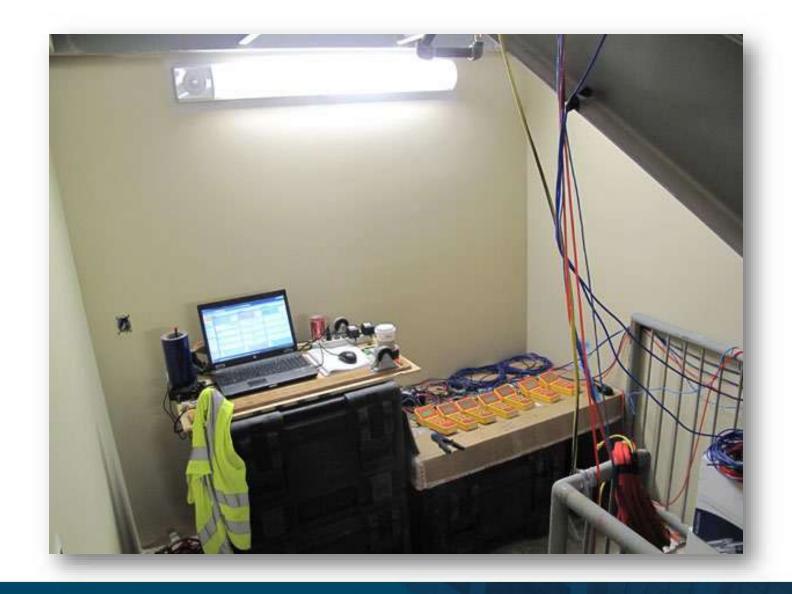








TEST SET-UP





TEST SET-UP



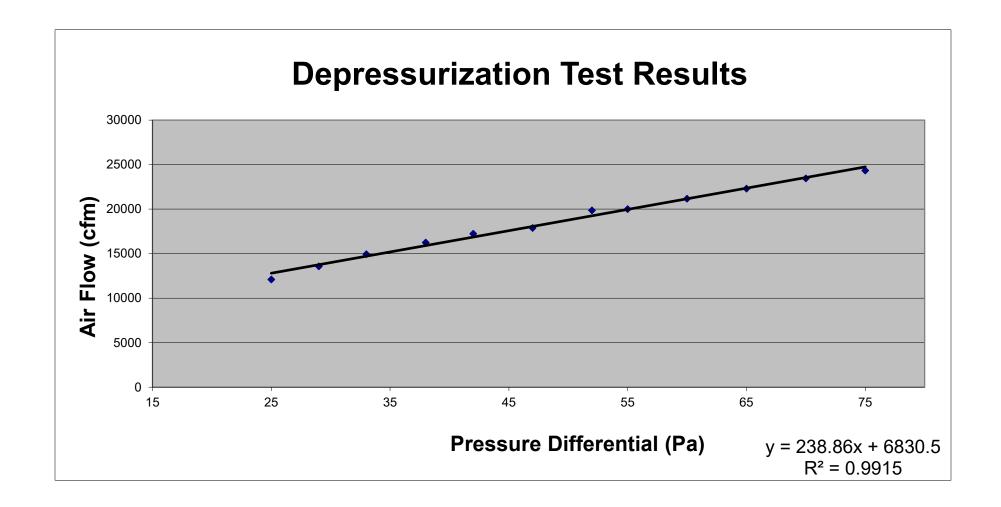


TARGET AIR LEAKAGE

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

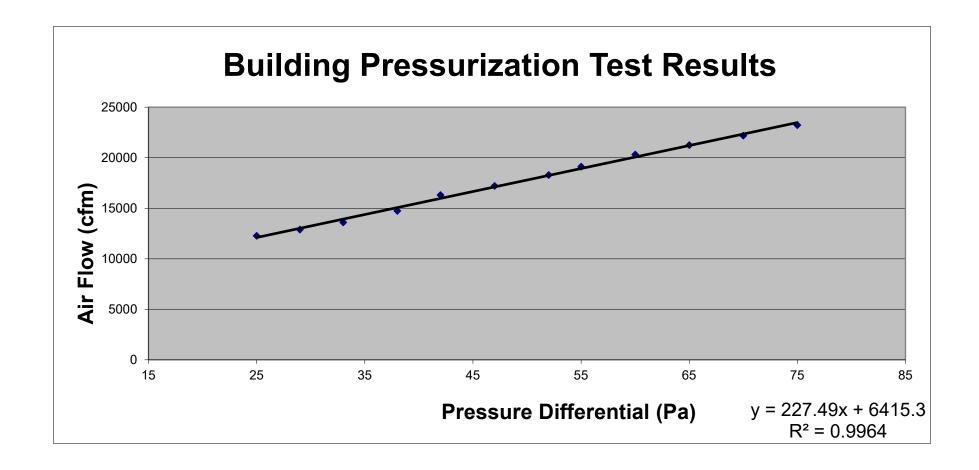


DATA





DATA



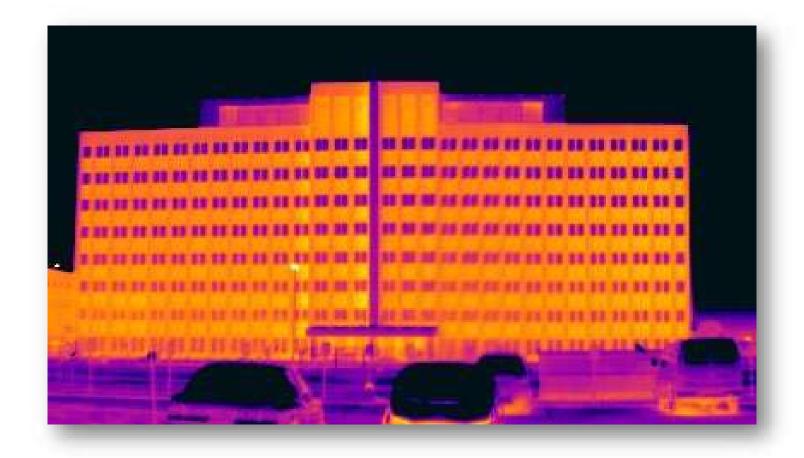


RESULTS

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



WHOLE BUILDING TEST





WHOLE BUILDING TEST



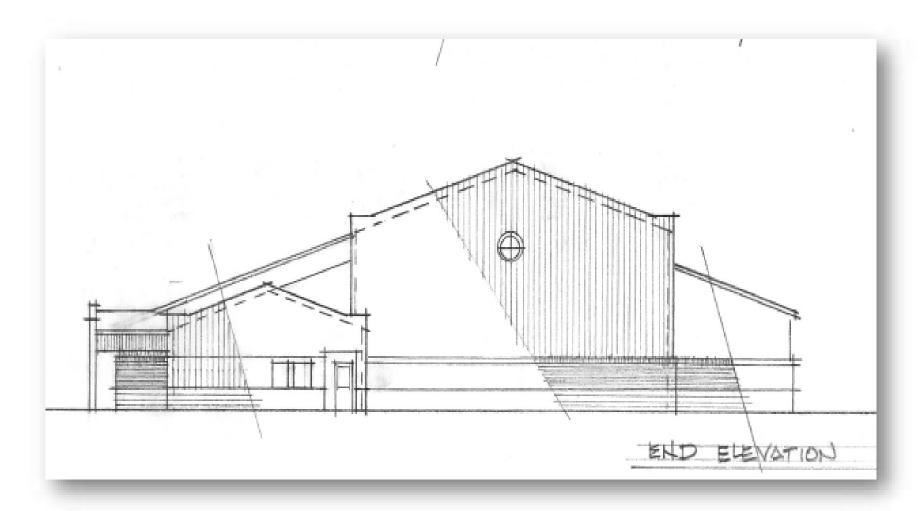


DEFINING PATHWAYS



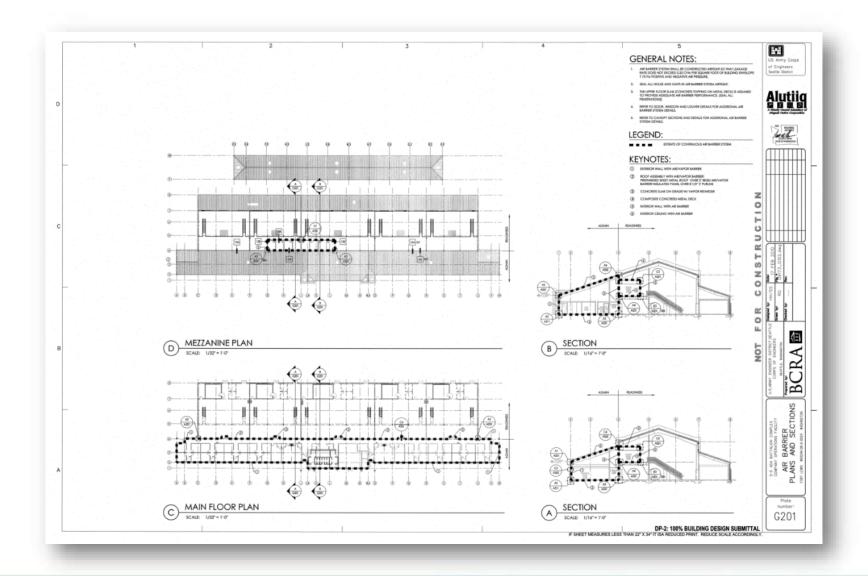


CASE STUDY – 5-5 ADA COF - JOINT BASE LEWIS-MCCHORD,WA



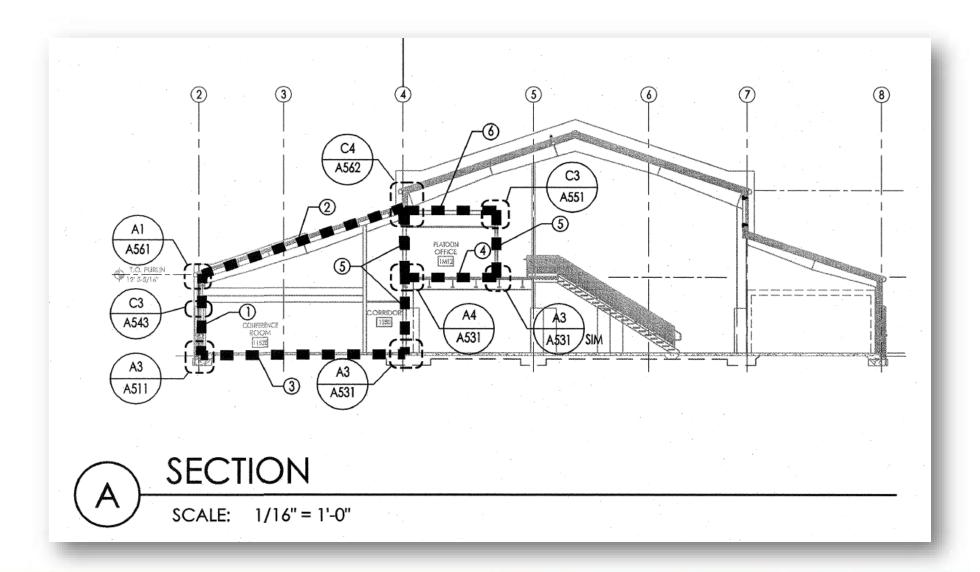


EXTENTS OF AIR BARRIER





EXTENTS OF AIR BARRIER



CONSTRUCTION





CONSTRUCTION





CONSTRUCTION





TARGET AIR LEAKAGE

USACE	cfm/sf@75Pa
RFP Requirement	.25cfm/sf @75PA
5-5 COF Admin Office Area	Envelope SF 51,352
Allowable leakage rate	12,838 cfm
5-5 ADA COF Mezzanine Office	Envelope SF 4,887
Allowable leakage rate	1222 cfm



RESULTS

Admin Area	Mezzanine Offices
0.063	0.209
3,260 cfm/75	1,020 cfm/75

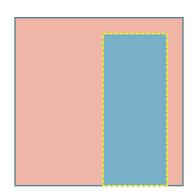


PROPORTION OF OPERATIONAL LEAKS

10,000 sf of envelope area Allowable leakage = 2,500cfm @75Pa

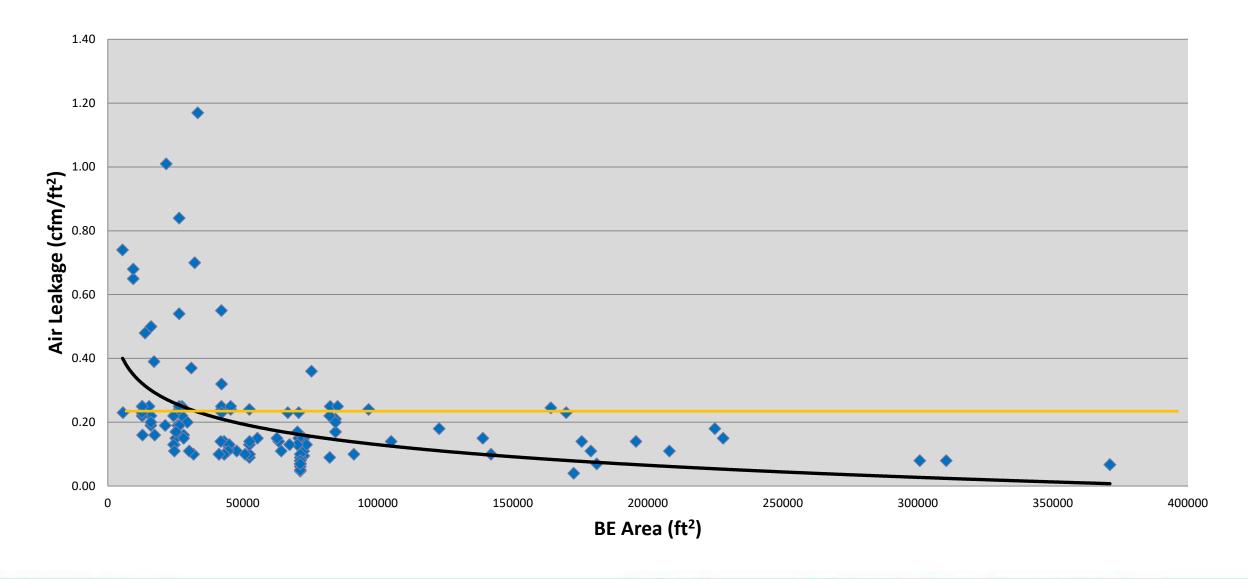
1,000 sf of envelope area Allowable leakage = 250cfm @75Pa

150cfm @ 75Pa



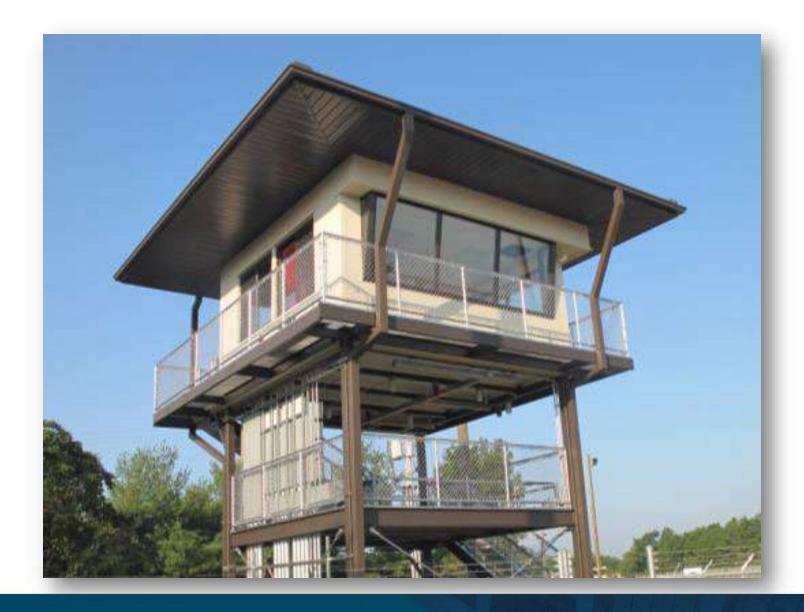


LEAKAGE RATE VS. BUILDING SIZE





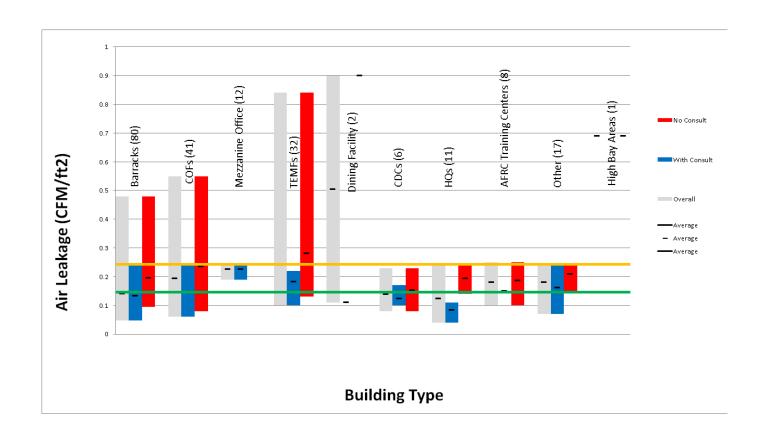
LEAKAGE RATE VS. BUILDING SIZE





LT

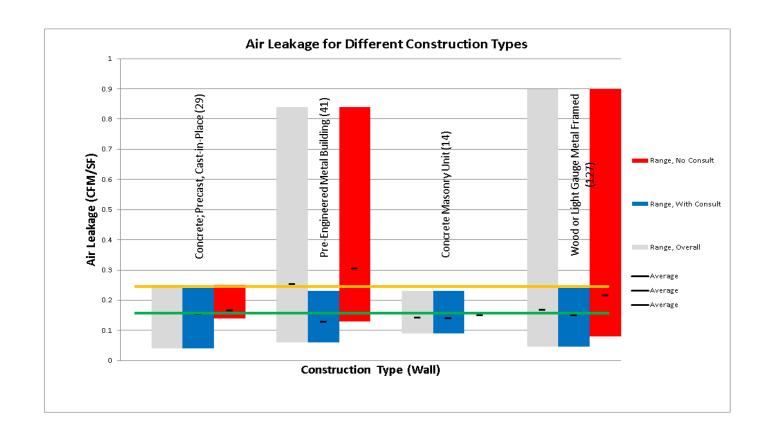
- Range (standard deviation) w/ no expert consultation
- TEMFs are challenging
- 0.25 CFM/SF & 0.15 CFM/SF





LT

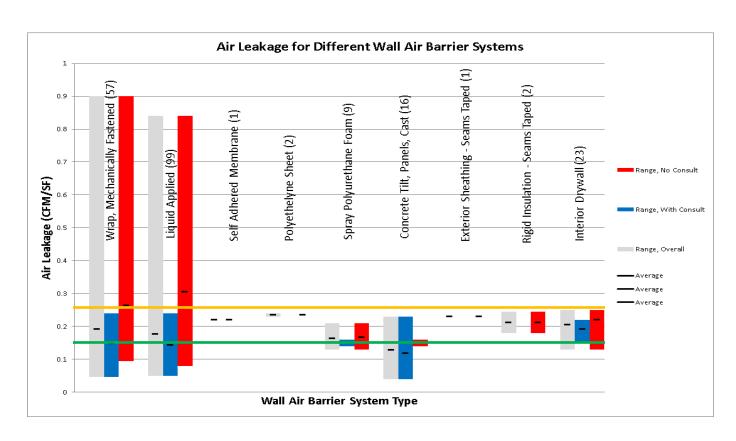
- Averages, expert consultation vs. no consultation
- Range (standard deviation) w/ no consultation
- Concrete is an excellent air barrier
- 0.25 CFM/SF & 0.15 CFM/SF





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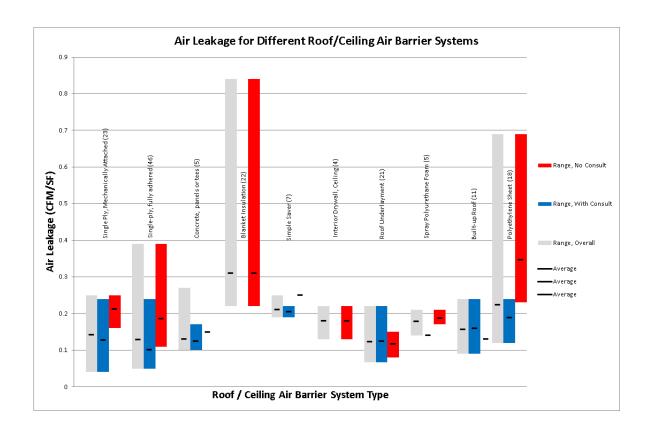
- Averages & range, w/ no consultation
- 0.25 CFM/SF & 0.15 CFM/SF







- Blanket Insulation Doesn't Work
- Average & range, w/ no consultation
- 0.25 CFM/SF & 0.15 CFM/SF





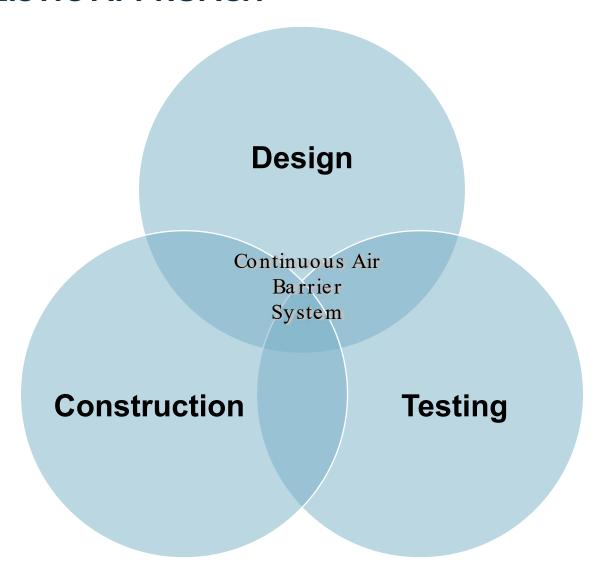
SUCCESS OF THE AIR TIGHTNESS REQUIREMENT

- Achievable
- Applicable
- Does not limit construction type
- Does not limit construction materials
- Building envelope discipline
- ENERGY SAVINGS WERE MEASURED!





MULTI-PHASED HOLISTIC APPROACH





WBALT FOR ALL BUILDINGS

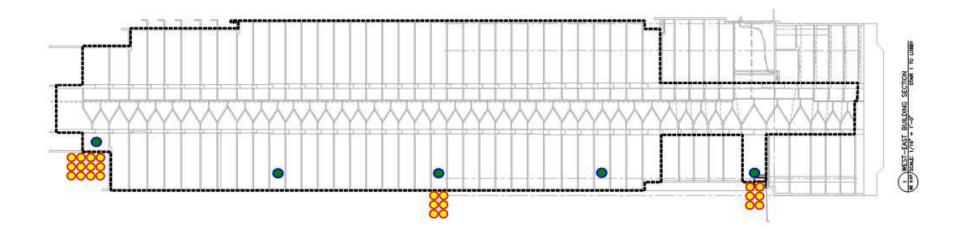






COMPARTMENTALIZE OR WHOLE BUILDING?

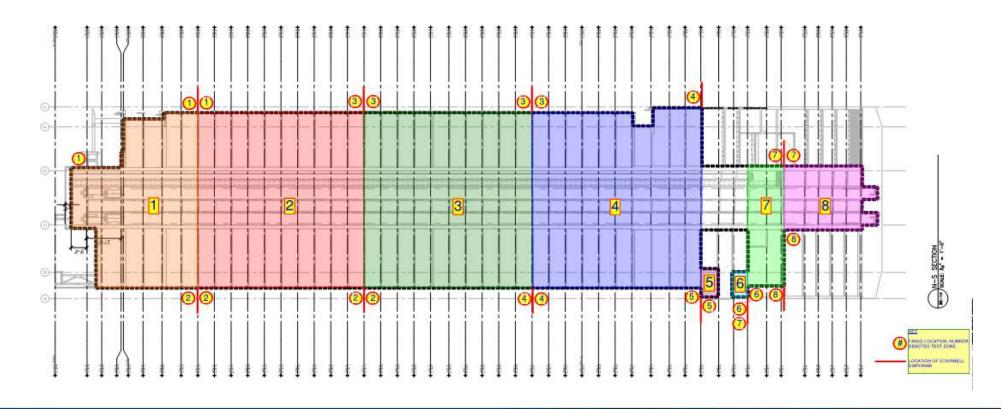
- Tall tower tested as one zone
 - Preparation is less complicated
 - Distributed equipment





COMPARTMENTALIZE OR WHOLE BUILDING?

- Tall tower broken up for phased move-in
 - Extensive preparation and testing effort
 - Diaphragms in Stairwells
 - Pressure-equalize above and below test zones



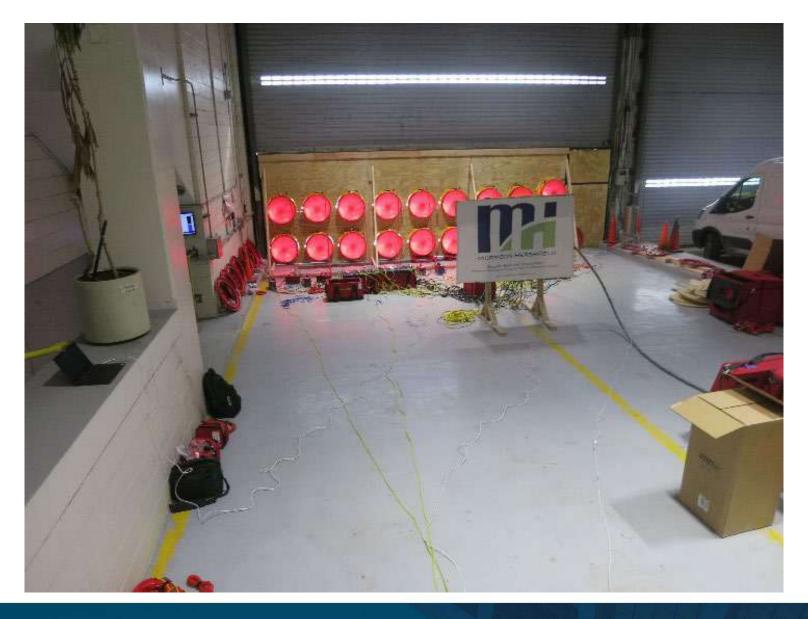


TESTING THE BEHEMOTHS- ASTM 3158





ASTM 3158

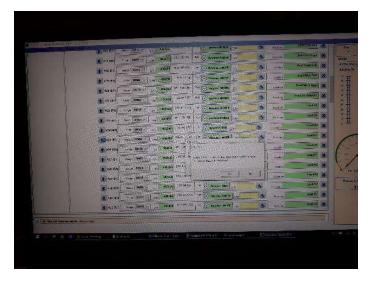




ASTM 3158











ASTM 3158











THE MONSTERS

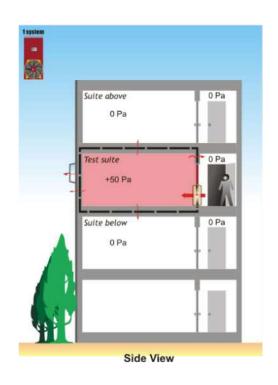


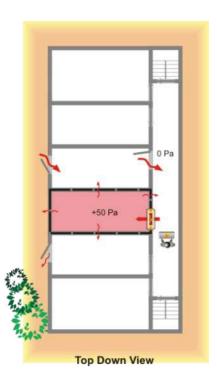




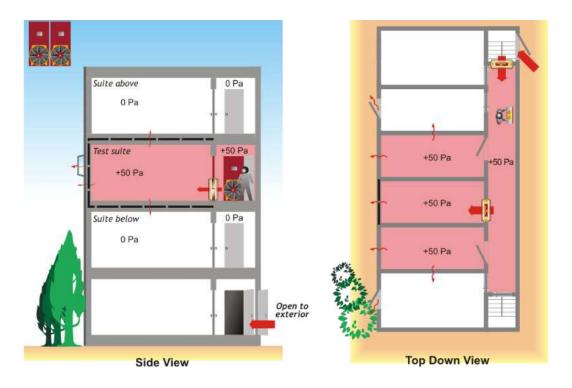
THE MONSTERS

Total Air Leakage





Isolating the Sample





THE MONSTERS





QUESTIONS STILL REMAIN...

- What is the right number for air leakage?
- Who is qualified to test?
- What Standard Governs Testing?
- Can you test with the building's HVAC System?
- Pressurization/Depressurization Both?
- Multi-point Test? Single Point Test?
- Appropriateness of all buildings? Sample Testing?
- What happens when it fails?
- Exemptions?!







CONCLUSIONS

Air barrier testing of all buildings is coming. However, a lot of questions and grey areas still exist.

An effective air barrier starts in design. A quality assurance program is required at every stage of construction to assure an air-tight envelope

Coordination between all team members is key

Design and construction issues all effect the planning, execution, and cost of the test

Testing Agents and Consultants need Certification

QUESTIONS & DISCUSSION



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