# Air Tightness in New and Retrofitted US Army Buildings

ERDC
Engineer Research and Development Center

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## Major Army Drivers for Energy Use Reduction

- Building Site Energy Use Reduction:
  - The Energy Policy Act of 2005 - Federal facilities be built to achieve at least a 30 percent energy savings over the 2004 International Energy Code or ASHRAE Standard 90.1 as appropriate, and that energy efficient designs must be life cycle cost effective
  - ECB 2010-14 – Reduce building site energy consumption by 40% compared to a facility designed in accordance with ASHRAE 90.1-2007
- Fossil Fuel Reduction: The Energy Independence and Security Act of 2007 - doesn't require site energy reduction
- Army Policy: 8 NZE Installations by 2020; 25 NZE Installations by 2031, all NZE by 2058

# New Construction Site Energy: Baseline EUIs and Energy Reduction Target EUIs (barracks/dormitories)

| Climate Zone | ASHRAE 90.1-2004 EUI (kBTU/sq ft-yr) | ASHRAE 90.1-2007 EUI (kBTU/sq ft-yr) | EPACT 2005 Target EUI + plug loads (kBTU/sq ft-yr) | ASHRAE 189.1 Target EUI incl. plug loads (kBTU/sq ft-yr) | ECB 2010-14 Target EUI + plug loads (kBTU/sq ft-yr) |
|---|---|---|---|---|---|
| 1A | 102 | 98 | 78 | 78 | 67 |
| 2A | 102 | 98 | 78 | 78 | 67 |
| 2B | 65 | 62 | 52 | 49 | 45 |
| 3A | 91 | 87 | 70 | 69 | 60 |
| 3B | 63 | 60 | 50 | 48 | 44 |
| 3C | 67 | 64 | 53 | 51 | 47 |
| 4A | 95 | 91 | 73 | 72 | 63 |
| 4B | 68 | 65 | 54 | 52 | 47 |
| 4C | 80 | 76 | 62 | 61 | 54 |
| 5A | 97 | 93 | 74 | 74 | 64 |
| 5B | 75 | 72 | 58 | 57 | 51 |
| 6A | 103 | 98 | 78 | 78 | 67 |
| 6B | 88 | 84 | 68 | 67 | 59 |
| 7A | 111 | 106 | 84 | 84 | 72 |
| 8A | 143 | 137 | 106 | 109 | 90 |

# New Construction and Major Renovation Source Energy: EISA 2007 Energy Goals

| Requirement | % Energy Reduction |
|---|---|
| CBECS (2003) | Baseline |
| EISA 2010 -source | 55 |
| EISA 2015 -source | 65 |
| EISA 2030 -source | 100 |

**Source Fossil Fuel Energy Baseline (CBECS 2003), kBTU/ft2 per year**

| Climate Zone | Barracks | Maintenance Facilities | Company Operations Facilities | Brigade HQ | Dining Facilities |
|---|---|---|---|---|---|
| | Median Total Fossil Fuel Generated EUI - Dormitory | Median Total Fossil Fuel Generated EUI - Other Services | Median Total Fossil Fuel Generated EUI (Composite ) | Median Total Fossil Fuel Generated EUI – Gov't Office) | Median Total Fossil Fuel Generated EUI – Fast Food |
| 1A | 136 | 200 | 129 | 165 | 888 |
| 2A | 133 | 186 | 122 | 157 | 856 |
| 2B | 111 | 152 | 99 | 128 | 728 |
| 3A | 127 | 163 | 107 | 139 | 737 |
| 3B | 114 | 150 | 98 | 127 | 737 |
| 3C | 105 | 132 | 86 | 109 | 629 |
| 4A | 144 | 164 | 109 | 142 | 746 |
| 4B | 95 | 114 | 75 | 97 | 585 |
| 4C | 106 | 116 | 78 | 99 | 592 |
| 5A | 153 | 164 | 108 | 141 | 731 |
| 5B | 131 | 157 | 96 | 124 | 681 |
| 6A | 183 | 184 | 125 | 163 | 818 |
| 6B | 142 | 144 | 97 | 126 | 761 |
| 7A | 181 | 175 | 117 | 153 | 880 |
| 8A | 248 | 219 | 158 | 210 | 1028 |

# Proposed ASHRAE Std 100 Energy Target EUI for Existing Buildings (53 bldg types)

| No. | Commercial Building Type | EUIs by Building Type by Climate Zone (kBtu/sf-yr) ASHRAE Climate Zone 1A | 2A | 2B | 3A | 3B-Coast | 3B-Other | 3C | 4A | 4B | 4C | 5A | 5B | 5C[1] | 6A | 6B | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Admin/professional office | 39 | 40 | 39 | 42 | 33 | 39 | 33 | 46 | 40 | 40 | 48 | 42 | 39 | 54 | 47 | 58 | 81 |
| 2 | Bank/other financial | 55 | 57 | 56 | 59 | 46 | 55 | 47 | 65 | 56 | 57 | 68 | 59 | 56 | 76 | 67 | 82 | 115 |
| 3 | Government office | 49 | 50 | 49 | 52 | 41 | 48 | 42 | 57 | 49 | 50 | 60 | 52 | 49 | 67 | 59 | 72 | 101 |
| 4 | Medical office (non-diagnostic) | 33 | 34 | 33 | 35 | 28 | 33 | 28 | 39 | 34 | 34 | 41 | 36 | 33 | 46 | 40 | 49 | 69 |
| 5 | Mixed-use office | 45 | 46 | 45 | 48 | 38 | 45 | 39 | 53 | 46 | 47 | 56 | 48 | 45 | 62 | 55 | 67 | 94 |
| 6 | Other office | 38 | 39 | 38 | 40 | 32 | 37 | 32 | 44 | 38 | 39 | 47 | 40 | 38 | 52 | 46 | 56 | 78 |
| 7 | Laboratory | 178 | 176 | 171 | 175 | 147 | 165 | 159 | 194 | 173 | 179 | 209 | 187 | 181 | 232 | 211 | 249 | 331 |
| 8 | Distribution/shipping center | 12 | 16 | 16 | 20 | 11 | 18 | 14 | 27 | 23 | 22 | 36 | 30 | 24 | 49 | 40 | 60 | 113 |
| 9 | Non-refrigerated warehouse | 6 | 8 | 8 | 10 | 5 | 9 | 7 | 13 | 11 | 11 | 17 | 14 | 12 | 24 | 19 | 29 | 54 |
| 10 | Convenience store | 135 | 146 | 135 | 152 | 127 | 139 | 141 | 166 | 150 | 157 | 178 | 162 | 167 | 193 | 179 | 208 | 263 |
| 11 | Convenience store with gas | 108 | 118 | 109 | 122 | 102 | 112 | 114 | 133 | 121 | 126 | 144 | 130 | 135 | 156 | 144 | 168 | 212 |
| 12 | Grocery/food market | 112 | 122 | 113 | 127 | 106 | 116 | 118 | 138 | 125 | 131 | 149 | 135 | 139 | 161 | 149 | 174 | 219 |
| 13 | Other food sales | 34 | 37 | 34 | 38 | 32 | 35 | 36 | 42 | 38 | 40 | 45 | 41 | 42 | 49 | 45 | 53 | 66 |
| 14 | Fire/police station | 66 | 65 | 63 | 64 | 54 | 61 | 59 | 71 | 64 | 66 | 77 | 69 | 67 | 85 | 78 | 92 | 122 |
| 15 | Other public order & safety | 60 | 59 | 57 | 59 | 49 | 55 | 53 | 65 | 58 | 60 | 70 | 63 | 61 | 78 | 71 | 84 | 111 |
| 16 | Medical office (diagnostic) | 33 | 32 | 32 | 32 | 30 | 32 | 27 | 32 | 30 | 28 | 30 | 30 | 28 | 31 | 30 | 31 | 35 |
| 17 | Clinic/other outpatient health | 50 | 48 | 49 | 48 | 45 | 48 | 40 | 48 | 46 | 42 | 46 | 45 | 42 | 47 | 45 | 46 | 52 |
| 18 | Refrigerated warehouse | 69 | 68 | 66 | 68 | 57 | 64 | 62 | 75 | 67 | 69 | 81 | 72 | 70 | 90 | 82 | 96 | 128 |
| 19 | Religious worship | 23 | 23 | 22 | 23 | 19 | 22 | 21 | 25 | 23 | 23 | 27 | 25 | 24 | 30 | 28 | 33 | 43 |
| 20 | Entertainment/culture | 23 | 23 | 22 | 23 | 19 | 21 | 21 | 25 | 23 | 23 | 27 | 24 | 24 | 30 | 28 | 32 | 43 |
| 21 | Library | 61 | 61 | 59 | 60 | 50 | 57 | 55 | 67 | 60 | 61 | 72 | 64 | 62 | 80 | 73 | 86 | 114 |
| 22 | Recreation | 26 | 26 | 25 | 26 | 22 | 24 | 24 | 29 | 26 | 26 | 31 | 28 | 27 | 34 | 31 | 37 | 49 |
| 23 | Social/meeting | 28 | 27 | 26 | 27 | 23 | 26 | 25 | 30 | 27 | 28 | 32 | 29 | 28 | 36 | 33 | 39 | 51 |
| 24 | Other public assembly | 28 | 28 | 27 | 28 | 23 | 26 | 25 | 31 | 27 | 28 | 33 | 30 | 29 | 37 | 33 | 39 | 52 |
| 25 | College/university | 62 | 61 | 60 | 62 | 45 | 58 | 50 | 72 | 60 | 65 | 78 | 65 | 65 | 90 | 78 | 99 | 147 |
| 26 | Elementary/middle school | 38 | 37 | 36 | 37 | 30 | 35 | 32 | 41 | 36 | 36 | 42 | 37 | 35 | 46 | 41 | 49 | 72 |
| 27 | High school | 45 | 45 | 44 | 46 | 33 | 42 | 37 | 52 | 44 | 47 | 57 | 48 | 47 | 66 | 57 | 72 | 107 |
| 28 | Preschool/daycare | 49 | 48 | 46 | 48 | 39 | 45 | 41 | 52 | 46 | 47 | 54 | 47 | 46 | 60 | 53 | 63 | 93 |
| 29 | Other classroom education | 25 | 25 | 25 | 25 | 18 | 24 | 21 | 29 | 25 | 26 | 32 | 27 | 27 | 37 | 32 | 40 | 60 |
| 30 | Fast food | 261 | 268 | 263 | 277 | 237 | 266 | 253 | 305 | 280 | 284 | 332 | 301 | 295 | 364 | 333 | 393 | 497 |
| 31 | Restaurant/cafeteria | 141 | 145 | 141 | 150 | 126 | 143 | 137 | 166 | 151 | 156 | 179 | 163 | 166 | 195 | 181 | 213 | 268 |
| 32 | Other food service | 77 | 79 | 77 | 82 | 69 | 78 | 75 | 91 | 83 | 85 | 98 | 89 | 91 | 107 | 99 | 116 | 146 |
| 33 | Hospital/inpatient health | 142 | 143 | 140 | 141 | 134 | 138 | 130 | 143 | 129 | 135 | 139 | 126 | 135 | 142 | 130 | 144 | 166 |
| 34 | Nursing home/assisted living | 84 | 83 | 81 | 83 | 69 | 78 | 75 | 91 | 82 | 84 | 99 | 88 | 85 | 109 | 100 | 118 | 156 |

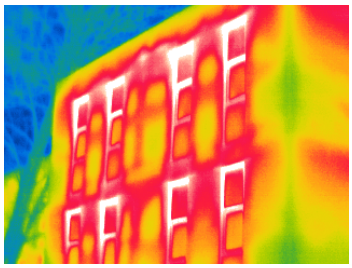
# Federal Agency Building Portfolio – Site Energy Reduction Goals (2003 Baseline)

| FY | % Reduction |
|---|---|
| 2006 | 2 |
| 2007 | 4 |
| 2008 | 9 |
| 2009 | 12 |
| 2010 | 15 |
| 2011 | 18 |
| 2012 | 21 |
| 2013 | 24 |
| 2014 | 27 |
| 2015 | 30 |

## Major Building Envelope Related Factors Contributing to Energy Inefficiency and Mold

- Many older buildings have significant problems with exterior walls that would affect their useful life and allow air and water penetration
- High cooling and heating loads due to problems with the building envelop (insulation, air barrier)
- Poor control of moisture penetrating the building (moisture dams, vapor barrier)
- Most of energy wastes and mold issues come hand-in-hand

## ERDC Energy Audit: Poor Windows, Thermal Bridges and Failure of Seals



## Extended envelope surface, e.g., open courtyard

Excessive heat losses and gains through the extended building envelope (external wall surface can be reduced), additional sensible and latent load on heating and cooling systems.

## Poor Air Tightness Before and After Renovation

Some holes for new pipes through pipe-chase walls are much larger than the size of these pipes

Holes from old pipes are left open

Unsealed chases between floors and the attic

## Problems with the building envelope design and construction: Standing Seam Metal Roofs Have Openings to the Interior or Attic Space



## Air leaks may result not only from poor workmanship but also by design





New
Retrofit

## oldiers' rooms are open directly to the utside in humid climates result in a huge latent ad on AC, which can't be satisfied

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Training barrack door is kept permanently open (Ft. Sill Starship barrack)

## Doors Lacking Door Seals

Excessive heating and cooling losses due to air leaks through poorly sealed doors resulting in increased sensible and latent load on heating and cooling systems.

## Air Barrier and Mold Problems

## ERDC Air barrier Testing 2006-2008

## Existing Army Barracks Constructed without Air Tightness Requirement – Test Results

**Ft Meyer UEPH tested Feb06**

- Tested by ERDC/CERL
- Measured leakage rate was 0.57 CFM/sq ft (2.89 L/s*m$^2$) envelope area @ 75Pa

**Ft Bragg UEPH tested May 06**

- Tested by ERDC/CERL
- Measured leakage rate unrenovated was 0.56CFM/sq ft (2.84 L/s*m$^2$) envelope area @ 75Pa
- Measured leakage rate for renovated was 0.77CFM/sq ft

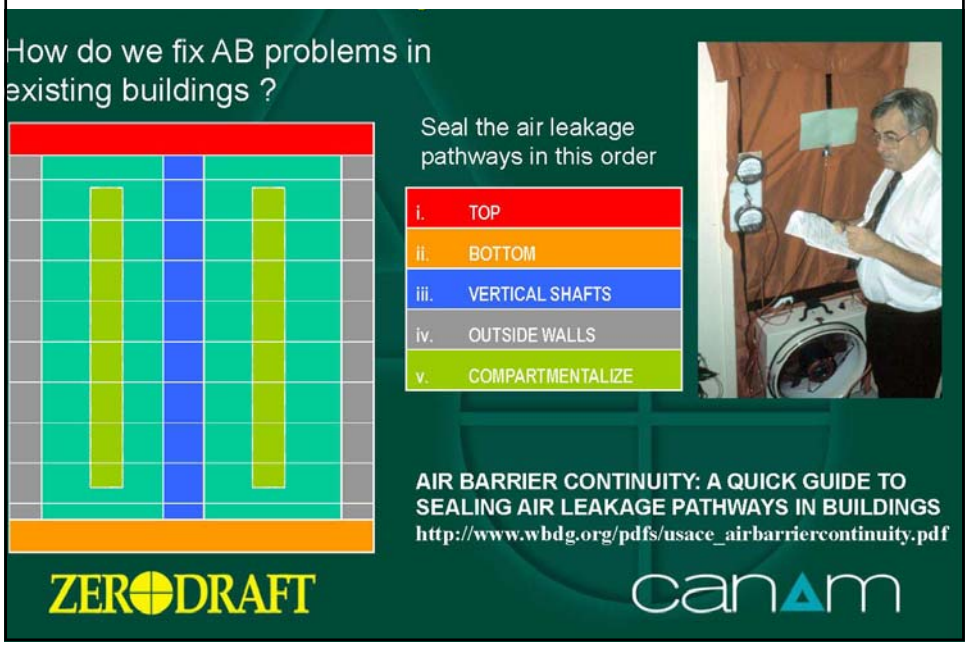
## Unrenovated VOLAR at Ft Polk – Sep06

**Individual soldier rooms measured average tightness: 0.75 cfm/ft$^2$**

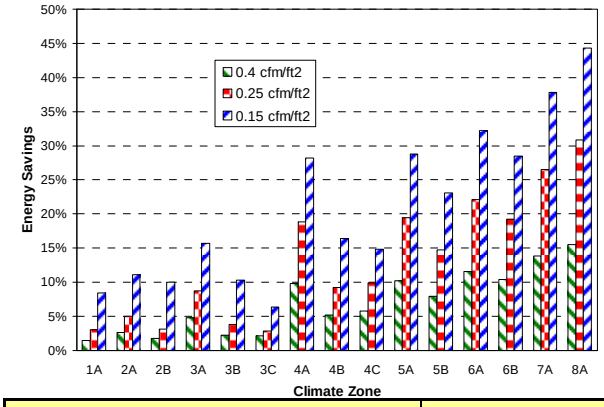
## Initial Issues/Barriers for AB (2009)

- Lack of skills on the market resulting in resistance and temptation to overturn/negotiate new requirements or inadequate pricing
- Inadequate understanding of new requirements from Army garrisons and project managers resulting in elimination or misinterpretation of new requirements in RFP and inadequate QC
- Perceived significant increase in costs
- Problems with adaptation of specific requirements to existing buildings
- Lack of incentives/perseverance

## Air Barrier Continuity in Existing Buildings

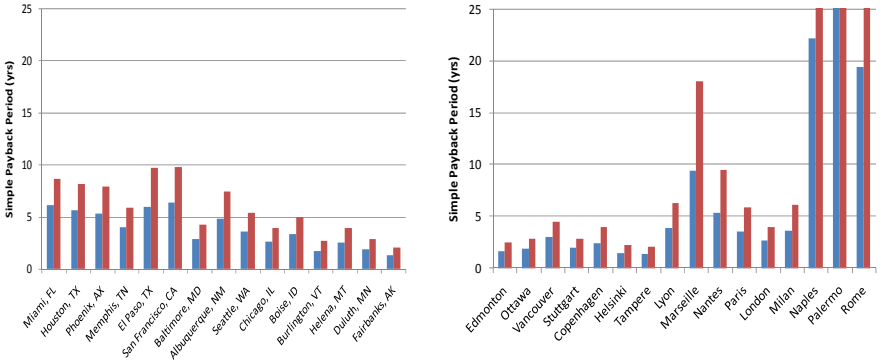


# Percent Annual Energy Savings due to Improved Building Air Tightness (Modeling results from Annex 46)




| Source | Leakage Rate at 0.3 in w.g. (75 Pa) cfm/ft² |
|---|---|
| Baseline | 1.0 |
| ASHRAE Std 189.1 requirement for air sealing | 0.40 |
| Current Army requirement for air sealing | 0.25 |
| Proposed requirement for air sealing | 0.15 |

# SPB Period for improving air tightness in renovated buildings (U.S. and International Locations)

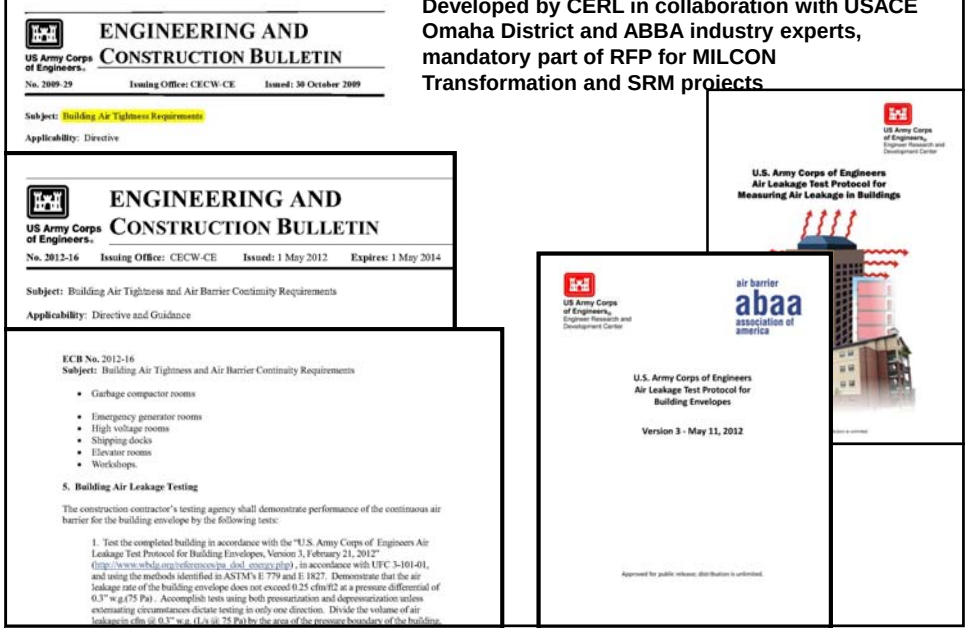



| Source | Leakage Rate at 0.3 in w.g. (75 Pa) cfm/ft² (L/s/m²) | Leakage Rate at 0.016 in w.g. (4 Pa) cfm/ft² (L/s/m²) | Air Changes per Hour at 0.016 in w.g. (4 Pa) |
|---|---|---|---|
| Baseline | 1.0 (5.07) | 0.15 (0.65) | 0.97 |
| Good practice for air sealing retrofit | 0.50 (2.54) | 0.074 (0.33) | 0.48 |
| Best practice for air sealing retrofit | 0.25 (1.27) | 0.037 (0.16) | 0.24 |

# Air Tightness Requirements to New Construction and Major Retrofit Projects

## US Army Air Leakage Requirements and Testing Protocol

**Developed by CERL in collaboration with USACE Omaha District and ABBA industry experts, mandatory part of RFP for MILCON Transformation and SRM projects**



ENGINEERING AND CONSTRUCTION BULLETIN

US Army Corps of Engineers

No. 2009-29 Issuing Office: CECW-CE Issued: 30 October 2009

Subject: Building Air Tightness Requirements

Applicability: Directive

ENGINEERING AND CONSTRUCTION BULLETIN

US Army Corps of Engineers

No. 2012-16 Issuing Office: CECW-CE Issued: 1 May 2012 Expires: 1 May 2014

Subject: Building Air Tightness and Air Barrier Continuity Requirements

Applicability: Directive and Guidance

ECB No. 2012-16

Subject: Building Air Tightness and Air Barrier Continuity Requirements

- Garbage compactor rooms
- Emergency generator rooms
- High voltage rooms
- Shipping docks
- Elevator rooms
- Workshops.

5. Building Air Leakage Testing

The construction contractor's testing agency shall demonstrate performance of the continuous air barrier for the building envelope by the following tests:

1. Test the completed building in accordance with the "U.S. Army Corps of Engineers Air Leakage Test Protocol for Building Envelopes, Version 3, February 21, 2012" (http://www.wbdg.org/references/pa_dod_energy.php) , in accordance with UFC 3-101-01, and using the methods identified in ASTM's E 779 and E 1827. Demonstrate that the air leakage rate of the building envelope does not exceed 0.25 cfm/ft2 at a pressure differential of 0.3" w.g.(75 Pa) . Accomplish tests using both pressurization and depressurization unless extenuating circumstances dictate testing in only one direction. Divide the volume of air leakage in cfm @ 0.3" w.g. (1/s @ 75 Pa) by the area of the pressure boundary of the building.

US Army Corps of Engineers Engineer Research and Development Center

U.S. Army Corps of Engineers Air Leakage Test Protocol for Measuring Air Leakage in Buildings

US Army Corps of Engineers Engineer Research and Development Center

air barrier abaa association of america

U.S. Army Corps of Engineers Air Leakage Test Protocol for Building Envelopes

Version 3 - May 11, 2012

Approved for public release; distribution is unlimited.

## USACE Protocol Includes

1. **USACE Requirements for Building Air Tightness**
2. **Specifier and Witness Guidance**
3. **Testing Agency Guide**

Appendices:
**Air Leakage Test Form**
**Airtightness Standards**

## How does it compare?

| Country | Source | Requirement | cfm/ ft$^2$ at 75Pa |
|---|---|---|---|
| USA | ASHRAE 189 | | 0.40 |
| UK | TS-1Commercial Best Practice | 5 m3/h/m2 at 50 Pa | 0.36 |
| USA | LEED | 1.25 in2 EfLA @ 4 Pa / 100 ft$^2$ | 0.30 |
| Germany | DIN 4108-2 | 1.5 1/h at 50 Pa | 0.28 |
| **USACE Requirement is 0.25 cfm/ft2 at 75 Pa** | | | |
| UK | TS-1Commercial Tight | 2 m3/h/m2 at 50 Pa | 0.14 |
| CAN | R-2000 | 1 in$^2$ EqLA @10 Pa /100ft$^2$ | 0.13 |
| Germany | Passive House Std | 0.6 1/h at 50 Pa | 0.11 |

Looser

Tighter

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

## USACE Requirements

- Design and construct the building envelope for office buildings, office portions of mixed office and open space (e.g., company operations facilities), dining and barracks facilities with a continuous air barrier to control air leakage into, or out of, the conditioned space.
- Clearly identify all air barrier components of each envelope assembly on construction documents and detail the joints, interconnections and penetrations of the air barrier components.
- On the design drawings, clearly identify the boundary limits of the building air barriers, and of the zone or zones to be tested for building air tightness.

## USACE Design Requirements

- a) A continuous plane of air-tightness must be traced throughout the building envelope with all moving joints made flexible and sealed.
- b) The air barrier material(s) must have an air permeance not to exceed 0.004 cfm / sf at 0.3" wg [0.02 L/s.m2 @ 75 Pa] when tested in accordance with ASTM E 2178
- c) The air barrier material of each assembly shall be joined and sealed in a flexible manner to the air barrier material of adjacent assemblies, allowing for the relative movement of these assemblies and components.

## Specified Testing Requirements

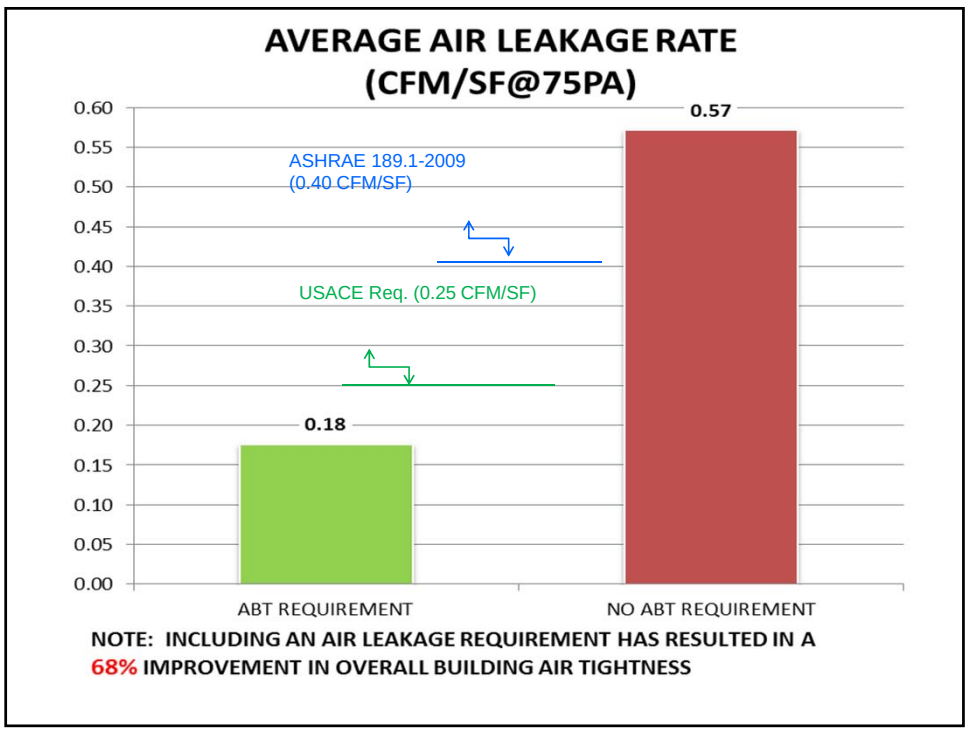
- Submit the qualifications and experience of the testing entity for approval.
- (a) Test the completed building and demonstrate that the air leakage rate of the building envelope does not exceed 0.25 cfm/ft$^2$ at a pressure differential of 0.3" w.g.(1.25 L/s.m$^2$ @ 75 Pa) in accordance with ASTM E 779 (2003) or E-1827-96 (2002)

## Specified Testing Requirements

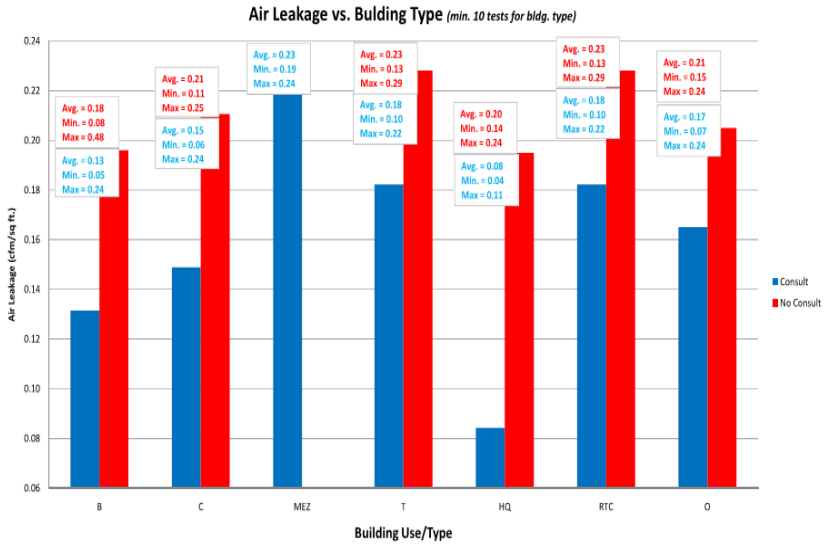
1. Test the completed building in accordance with the "U.S. Army Corps of Engineers Air Leakage Test Protocol for Building Envelopes, Version 3, February 21, 2012" (http://www.wbdg.org/references/pa_dod_energy.php) , in accordance with UFC 3-101-01, and using the methods identified in ASTM's E 779 and E 1827. Demonstrate that the air leakage rate of the building envelope does not exceed 0.25 cfm/ft2 at a pressure differential of 0.3" w.g.(75 Pa) . Accomplish tests using both pressurization and depressurization unless extenuating circumstances dictate testing in only one direction. Divide the volume of air leakage in cfm @ 0.3" w.g. (L/s @ 75 Pa) by the area of the pressure boundary of the building,

## 370+ USACE New and Renovated Buildings "Passed" 0.25 CFM/ft²

| Location | Building Type / # | Air Barrier Envelope Size (ft²) | Result (CFM / ft²) | % Better than 0.25 CFM/ft² |
|---|---|---|---|---|
| Ft. Bliss, TX | IBCT 1 UEPH 1 | 71,312 | **0.05** | **81%** |
| Ft. Bliss, TX | IBCT 1 UEPH 2 | 71,312 | **0.06** | **76%** |
| Ft. Sam Houston, TX | BRAC METC Dorm 1 | 371,099 | **0.07** | **73%** |
| Ft. Bliss, TX | IBCT 1 UEPH 7 | 71,312 | **0.07** | **72%** |
| Ft. Bliss, TX | BCT 3 UEPH 1 | 72,573 | **0.10** | **62%** |
| Ft. Polk, LA | Barracks (Renovation) | 52,476 | **0.10** | **60%** |
| Ft. Sam Houston, TX | METC Dorm 1 | 141,893 | **0.10** | **60%** |
| Ft. Bliss, TX | BCT 3 TEMF1 | 24,632 | **0.13** | **48%** |
| Ft. Riley, KS | COF | 43,115 | **0.14** | **44%** |
| Ft. Leonard Wood, MO | Battalion HQ | 63,276 | **0.14** | **44%** |



## Summary of Air Leakage Test Results of 270 Buildings by a Building Type.




## VOLAR Barracks Renovation, 2010

**0.75 cfm/ft$^2$ at 75 PA**

**0.1 cfm/ft$^2$ at 75 PA**

**Current U.S.A. Air Sealing – Air Barrier Requirements**

- International Energy Conservation Code
  - "Openings and penetrations in the building envelope shall be sealed with caulking materials or closed with gasketing systems compatible with the construction materials and location. Joints and seams shall be sealed in the same manner or taped or covered with a moisture vapor-permeable wrapping material…"
  - No quantitative requirements
    - Require insulation without specifying R-value

**Current U.S.A. Air Sealing – Air Barrier Requirements**

- Minnesota Commercial Energy Code
  - Incorporates ASHRAE Standard 90.1
    - Similar language to IECC, no quantitative requirement
  - Requires "air barrier materials" but no standard defined
  - Requires air barrier to be shown on the drawings

## Current U.S.A. Air Sealing – Air Barrier Requirements

- ASHRAE Green Building Standard 189.1
  - Provides three options for compliance:
    1. Use air barrier materials on walls (0.004cfm/ft2), or
    2. Use tested assemblies on walls (0.04 cfm/ft2), or
    3. Whole building test (0.4cfm/ft2)
  - Path of least resistance is #1

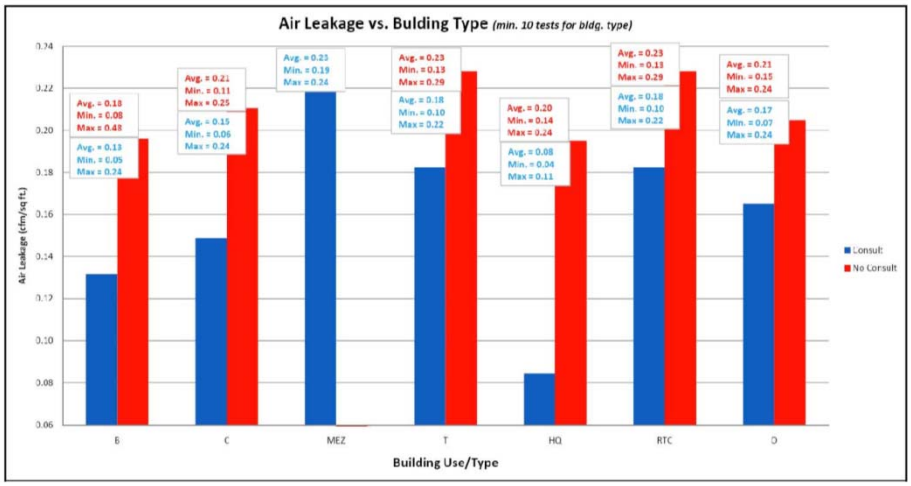
## Conclusion

- Specified requirements to air tightness of conditioned buildings or parts of buildings (0.25 cfm/ft2 at 0.3 in w.g.[1.27 L/s*m$^2$ at 75Pa]) result in sustainable buildings, energy use reduction and improved soldiers wellbeing
- Contractor is provided with specific requirements to continuous air barrier and specific air tightness testing protocol
- US Army Corps of engineers conducts training in collaboration with the industry for involved actors (USACE and DPW engineers, architects and Project Managers, as well as to contractors to ensure understanding of requirements resulting in high quality of design and construction work

## Conclusion

- USACE requires performance measurements after completion
- These efforts result in development of the market in the USA for high quality construction and energy efficient retrofits
- Since 2009, more than 300 buildings have been built and renovated to meet or exceed the Army requirement
- Estimated first cost increase is $0.50/sq ft of floor area for new construction
- Simple pay-back is 2-10 years

## Test Results by Building Type (based on BCRA and PIE data)



## Conclusions

- Air barriers play an important role in building durability, energy use and occupants wellbeing;
- Till recently AB in the USA have been poorly integrated in the design and construction industry;
- Since 2009 industry has corroborated the USACE implementation of the air leakage requirement, which includes whole building performance verification testing.
- US Army has built and renovated more than 370 buildings to meet or exceed requirement for BE air tightness of 0.25 cfm/sq  level.
- Based on experience, it is recommended that requirements for envelopes under 15,000 sq ft remain at the 0.25 cfm/sq ft level.

## Conclusions (Cont)

- The data show the importance of including an experienced independent building envelope consultant on the project to review drawings and to perform site visits for quality control review;
- The USACE requirement has proven to be achievable and applicable to all building types and locations; it does not limit the design and construction process to any one set of materials or systems.
- The USACE move toward tighter buildings will continue, beginning with the tightening of the USACE requirement for an air tightness of 0.15 cfm/sq ft @75Pa for High-Performance Buildings. The data presented in this paper clearly indicate that these results are already achievable.

## What information do we need in the future and what do we measure?

- Current AB testing protocol is designed to test design and workmanship of the BE fabric when all intended penetrations sealed
- Building performance depends upon overall air leakage, including mechanical systems inlets and outlets and flues
- There are no air leakage requirements for building performance which reflects total building air leakage “as is” with all unsealed intended openings
- Buildings such as offices, residential buildings, schools probably may have air barrier requirements similar to current ones tested with all openings sealed (central system BE duct penetration area is relatively small;

## What information do we need and what do we measure? (Cont)

- However, hospitals, restaurants, labs, laundries and other buildings with significant areas of mechanical systems penetrations of the building envelope, probably will need different targets for air tightness
- Testing for this requirement will not be much more expensive, since buildings can be tested before or after penetrations are sealed.

**Questions or Comments??**

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