

*Understanding Air Barriers and the
USACE Air Leakage Test Protocol for
Measuring Air Leakage in Buildings*

May 27th, 2010

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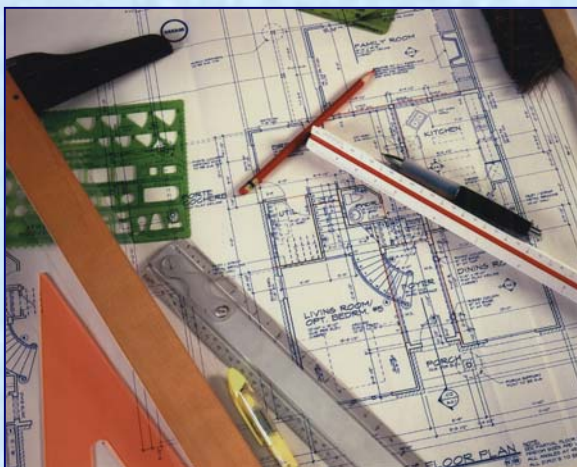
*LEED A.P., HERS Rater & QAD,
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Engineers - Consultants - Inspectors

What We Do...

- Building Science Consulting & Training
- Energy Audits & House Diagnostics
- HERS Rater Training
- Biocontamination Assessment
- 3rd Party IECC Inspections
- Professional Engineers in 20 States



- Commercial MEP Design
- Federal Tax Deduction Validation
- Air Barrier Consulting, Inspection, Testing
- Building Commissioning
- Green Building Consulting



Energy Efficiency - What does it mean?

- Technologies and measures that reduce the amount of electricity and/or fuel required to do the same work, such as powering homes, offices, and industries



Building Science - What does it mean?

- Study of how all systems of a structure function together to optimize building performance and prevent building failure
- This includes the detailed analysis of energy and moisture flows, building materials, building enclosures, and mechanical systems



Building Enclosure - What does it mean?

- A building enclosure is an environmental separation. It separates the interior environment from the exterior environment. A building enclosure controls heat flow, air flow, water vapor flow, rain, groundwater, light and solar radiation, noise and vibrations, contaminants hazards, odors, insects, rodents, and fire.



Building Enclosure - What does it mean?

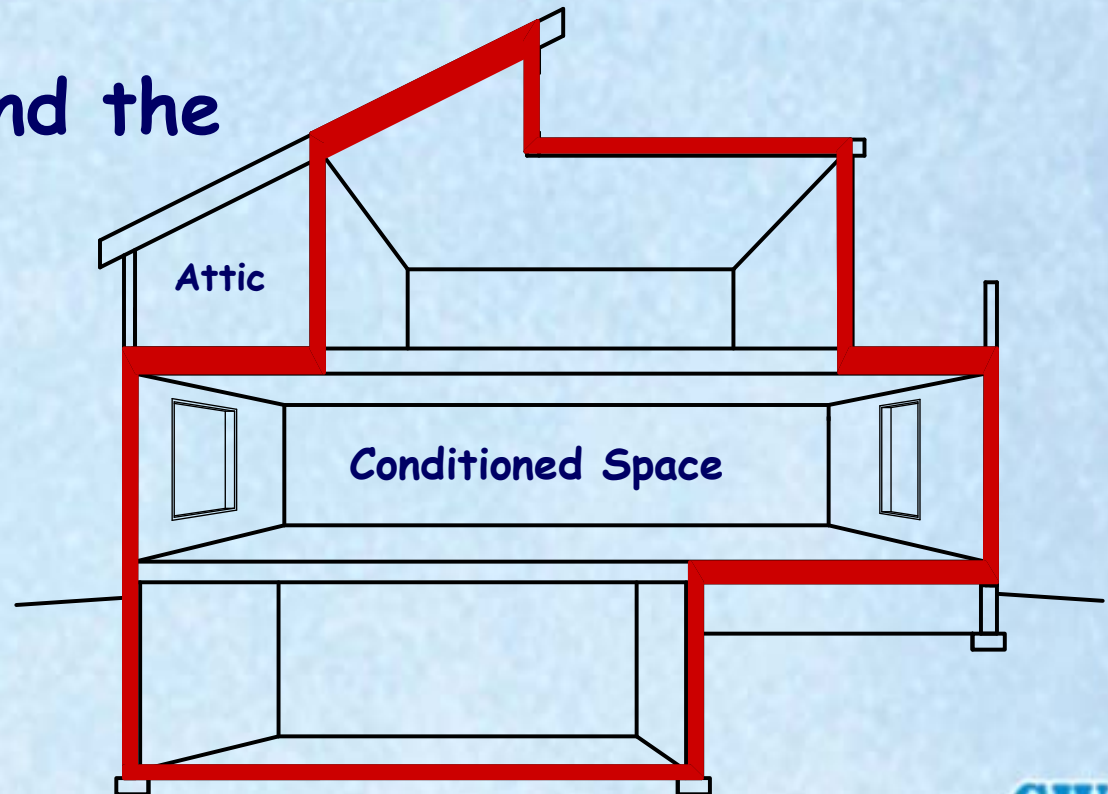
- The effectiveness of the building enclosure has a very large influence on heating and cooling loads, moisture control, utility cost, HVAC equipment size, durability of the structure, and occupant health, safety, and comfort.



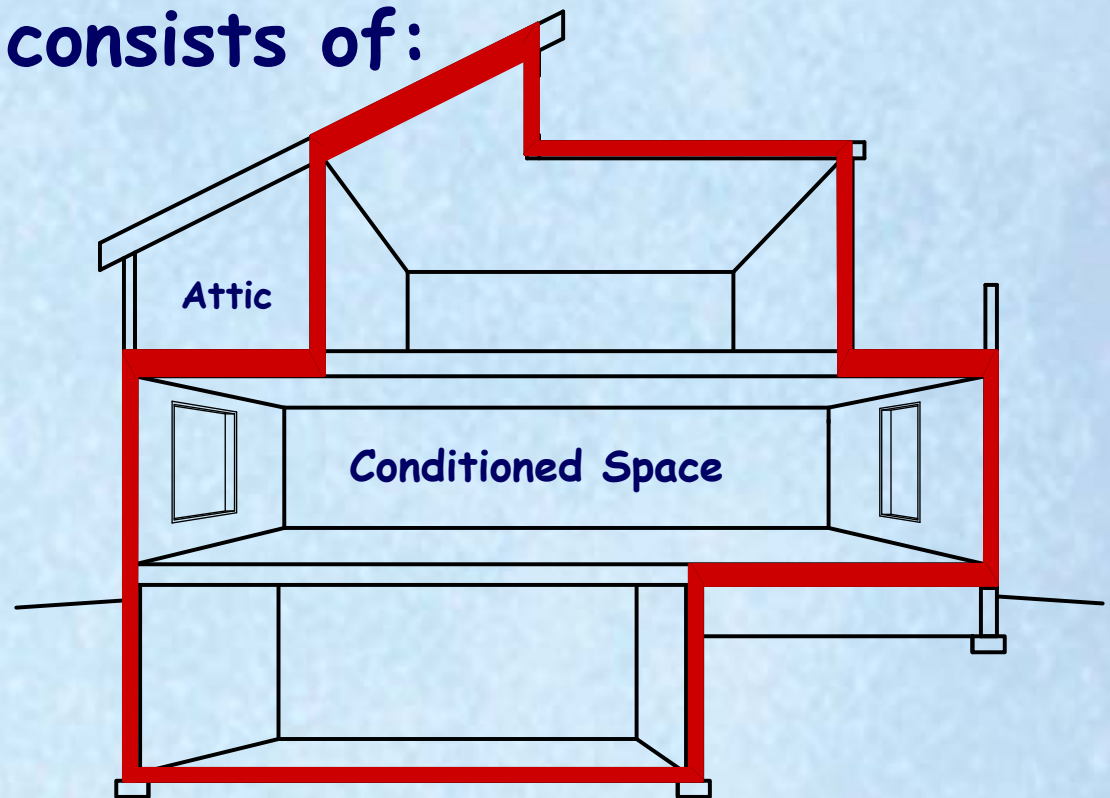
Building Enclosure

The **Thermal Boundary** and **Air Barrier** define the building enclosure.

The **Air Barrier** and the **Thermal Boundary** must align with each other.



- **Building Enclosure consists of:**
 - Fenestration
 - Ceilings
 - Walls
 - Above grade
 - Below grade
 - Mass walls
 - Floors
 - Slab
 - Crawl space



Thermal Boundary - What does it mean?

- The layer in a building enclosure that controls the transfer of energy (heat) between the interior and the exterior.



Air Barrier - What does it mean?

- Air Barriers are systems of materials designed and constructed to control airflow between a conditioned space and an unconditioned space. The air barrier system is the primary air enclosure boundary that separates indoor (conditioned) air and outdoor (unconditioned) air. The air barrier and in the insulation should be aligned.



- Air Barriers typically are assembled from materials incorporated in assemblies that are interconnected to create enclosures.
- Each of these three elements has a measurable resistance to air flow.
- The recommended minimum resistances for the three components are:
 - Material $0.02 \text{ l}/(\text{s}\cdot\text{m}^2)$ at 75Pa
 - Assembly $0.20 \text{ l}/(\text{s}\cdot\text{m}^2)$ at 75Pa
 - Enclosure $2.00 \text{ l}/(\text{s}\cdot\text{m}^2)$ at 75Pa

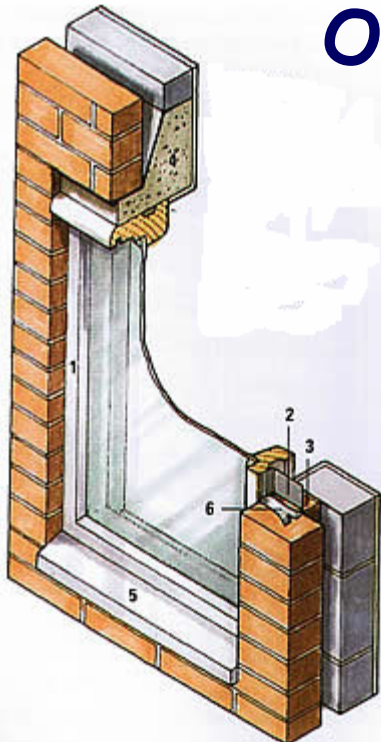


0.25 CFM/SF-Shell @75 Pascals

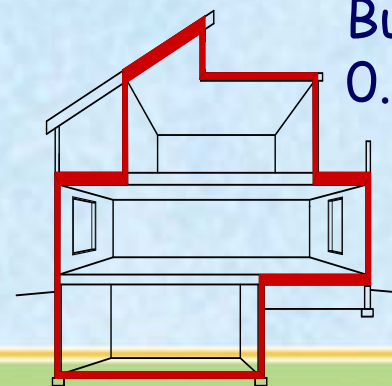


Orders of magnitude of Air Barrier:

- 0.02 l/(s-m²) @75Pa for Materials
- 0.20 l/(s-m²) @75Pa for Assemblies
- 2.001 l/(s-m²) @75Pa for Enclosures



Wall assembly test
0.04 CFM/SF @75p



Building test
0.25 CFM/SF @75p



- **Controlling factors which affect the physical elements of a building, its occupants, and the environment:**
 - **Airflow, Heat Flow, Moisture Flow, Solar and other Radiation.**
- **Airflow is the largest of these concerns because it has influences on both heat and moisture flows.**
- **The use of an air barrier is one of the key strategies in the control of airflow.**



Airflow Impacts

- Heating/Cooling and thermal energy use
- Moisture content of the building
- A material's long-term performance (serviceability) and structural integrity (durability)
- Indoor air quality affected by distribution of pollutants and location of microbial reservoirs
- A building's behavior in a fire (through the spread of smoke and other toxic gases, supply of oxygen)



Air Leakage Testing



Air Leakage Testing - What is it?

- Means used to determine and verify an enclosure's air leakage rate.
- Enclosure specifications for air leakage can only be verified in the field.
- Two verification approaches can be used.
 - Portable Fans (i.e. Blower Doors)
 - Building Air Handling Systems (usually used for buildings over 500,000 sf of enclosure.)



Air Leakage Testing - Portable Fans

- Portable Fan (Blower Door) to determine air leakage in a building by inducing a pressure difference in a building enclosure.
- ASTM-E 779-03 Standard Test Method for Determining Air Leakage Rate by Fan Pressurization Method
- May require multiple fan assemblies, simultaneously pressurizing/de-pressurizing for larger leakage volumes.



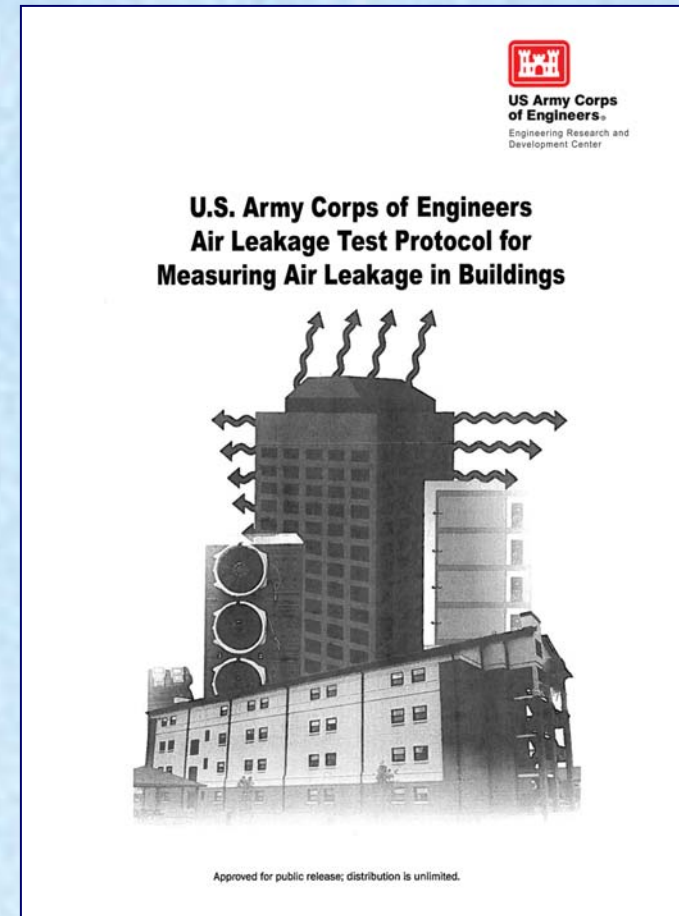
Air Leakage Testing - Building Air Handling Units

- Using building Air Handling Systems to induce a pressure difference on the building enclosure.
- CAN/CGSB-149.15-96, "Determination of the Overall Airtightness of Buildings by the Fan Pressurization Method Using the Building's Air Handling Systems"
- Used for larger buildings (>500K Enclosure SF, Much Larger Fans-Truck Mounted)



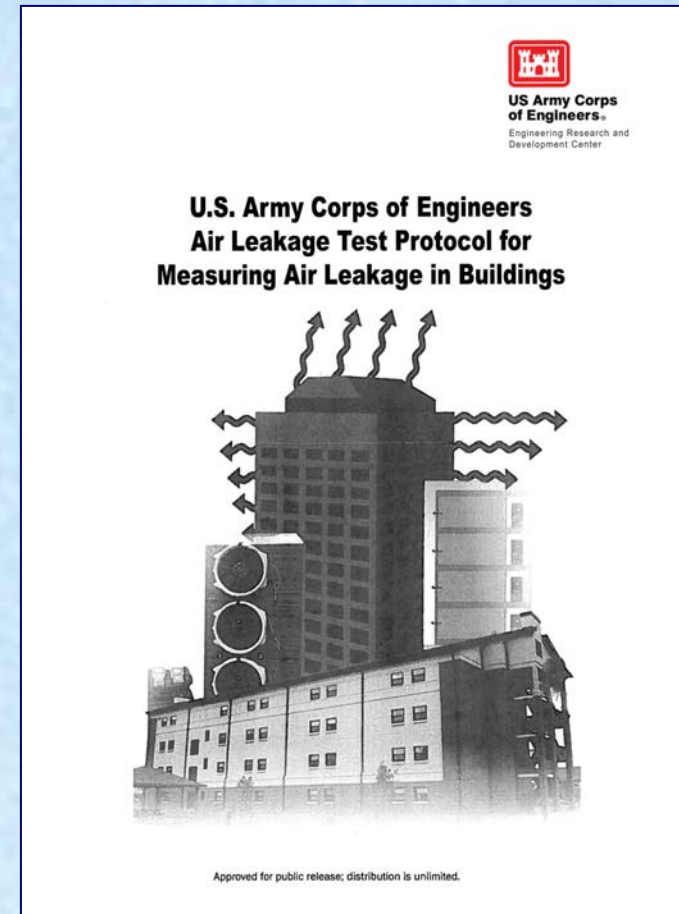
Air Leakage Test Protocol - What is it?

- The USACE requirements for building air tightness and building air leakage for new Army construction.
- Specifier and Witness Guidance
- Testing Agency Guidance
 - Equipment Selection
 - Inspections
 - Results Reporting



Air Leakage Test Protocol - Why?

- ...to help the U.S. Department of Defense (DOD) achieve at least 30 percent energy savings of a baseline built to the minimum requirements of the ASHRAE Standard 90.1-2004 for new buildings to be constructed under the Military Transformation Program.



Air Leakage Test Protocol - Usefulness?

- Depending on the climate, the total building energy cost savings due improved building air tightness can range from 5 to 25 percent.
- Improved building air tightness can improve building's long term durability
- When properly ventilated, buildings with improved air tightness can have better IAQ



Air Leakage Test Protocol-Requirements

Air Leakage Test Protocol:

- Addresses building air tightness and building air leakage for new Army construction
- Defines minimum air permeance values for air barrier materials at 0.004 CFM/sq. ft @75Pa, (0.02 l/s-m² @75Pa) when tested in accordance with ASTM E-2178
- Defines the minimum performance requirement and substation. Completed buildings must demonstrate that air leakage rates ≤ 0.25 CFM/Sq. Ft. of the exterior enclosure at 0.3 in. of water gage (75 Pa) pressure difference using BOTH pressurization and depressurization.



Air Leakage Test Protocol Requirements- Design

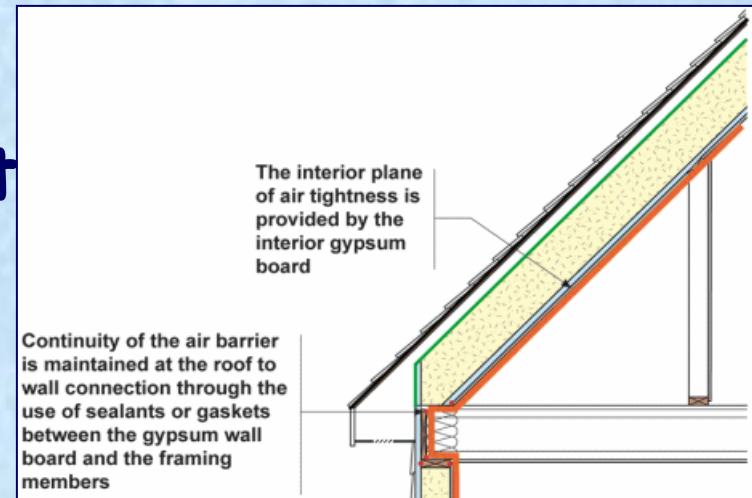
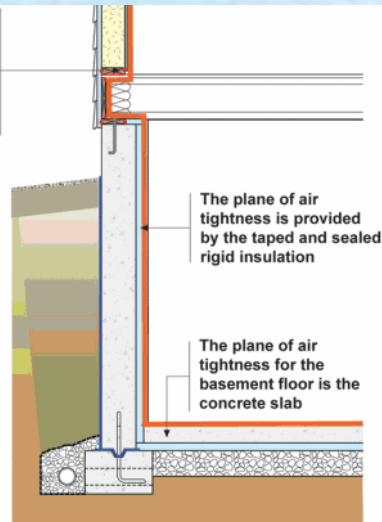
- Specify air barrier materials that meet the minimum air permeance levels as set forth in the protocol
- Clearly identify all air barrier components of each envelope assembly on construction drawings and detail the joints, interconnections and penetrations of the air barrier components...THIS IS A BIG ONE!!!
- Identify the boundary limits of the air barrier on the construction drawings.



Air Leakage Test Protocol Requirements- Design

- Trace a continuous line of air barrier throughout the enclosure and make flexible and seal all moving joints.

Continuity of the air barrier is maintained at the wall to foundation connection through the use of sealants or gaskets between the gypsum board and the framing members



Air Leakage Test Protocol Requirements-Construction

- Support the air barrier so as to withstand max positive and negative pressures to be placed on enclosure without displacement or damage.
- Seal all penetrations made in field. Penetrations are made by various trades at various times during construction.
- Inspect the air barrier installation from start of construction to end of construction.



USACE Air Leakage Test Protocol

Air Leakage Test Protocol Requirements-Construction



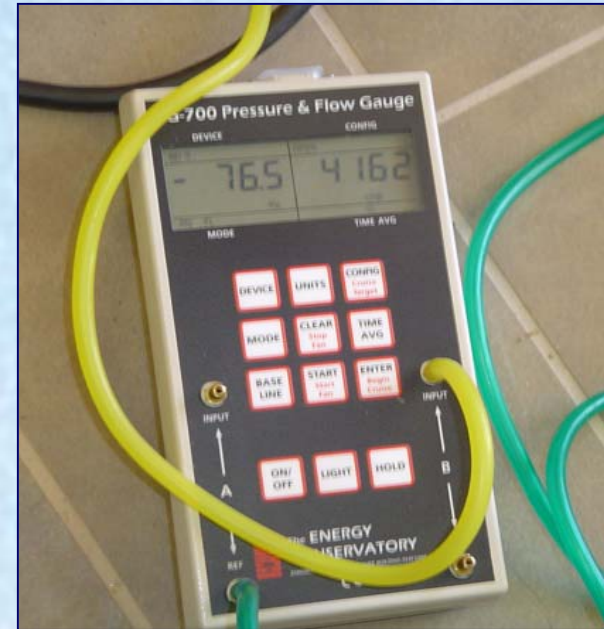
- Inspect the air barrier installation from start of construction to end of construction.



USACE Air Leakage Test Protocol

Air Leakage Test Protocol Requirements-Testing

- Demonstration of performance of the air barrier is accomplished by two tests.
 - Leakage Test
 - Infrared Thermography Test



Air Leakage Test Protocol Requirements-Air Leakage Test

- Test results must demonstrate that the air leakage rate for the entire enclosure does not exceed 0.25 CFM/sq. ft at 75Pa.
- Test must be in accordance with ASTM E-779
- Accomplish tests using both pressurization and de-pressurization.
- Divide the average measured air leakage flow rates in both directions in CFM@75Pa by the surface area of the enclosure.



Air Leakage Test Protocol Requirements-Air Leakage Test

- Surface Area of the enclosure includes roof (or ceiling), fenestration, walls, and floors as enclosed by the continuous air barrier.
- Architect or design engineer is responsible for determining the boundary of the air barrier.
- Calculated area of the air barrier boundary should be indicated on the design drawings.
- Enclosures that fail to meet requirement must have diagnostic evaluation, repair, and re-tested.



Air Leakage Test Protocol Requirements-Infrared Test

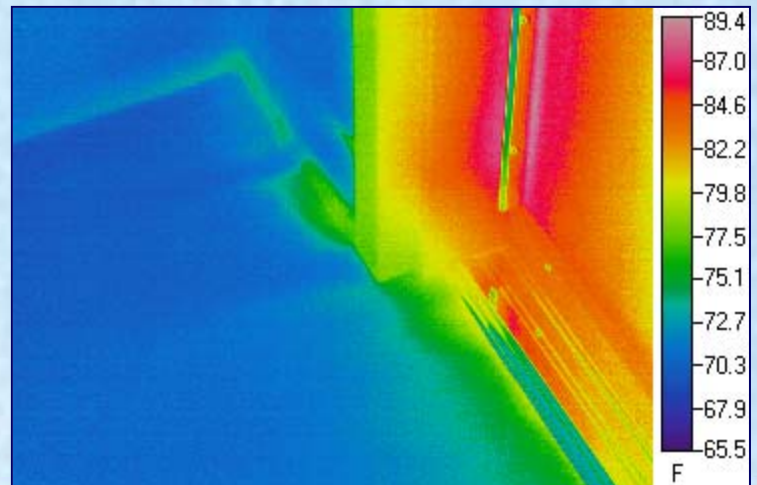
- All buildings must be tested using infrared thermography whether they pass or fail the air leakage requirement
- Infrared thermography test must be in accordance with ISO 6781-1983 and ASTM C-1060-90.



USACE Air Leakage Test Protocol

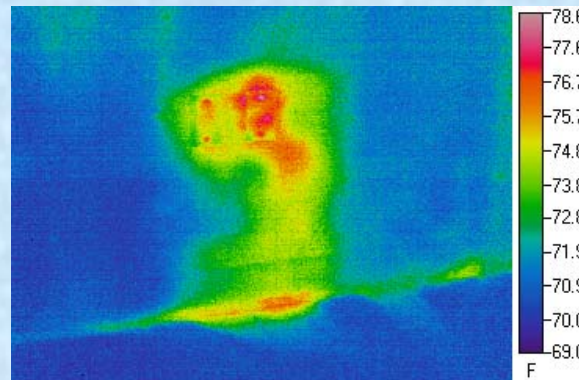
Air Leakage Test Protocol Requirements-Infrared Test

- Must use infrared cameras with a resolution of 0.1 deg C resolution.
- Protocol requires ITC Level 1 Certified Infrared Thermographer to perform infrared diagnostic evaluation.



Air Leakage Test Protocol Requirements-Infrared Test

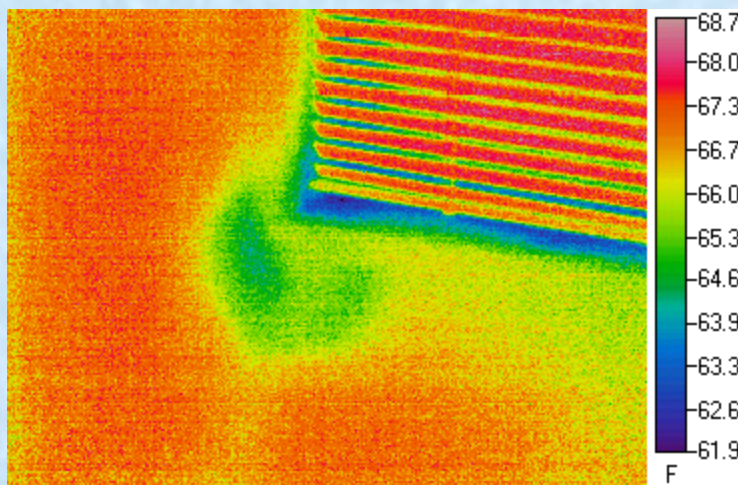
- Infrared thermography is used as a tool to aid in locating leakage sites and leakage pathways.
- Determine air leakage pathways using ASTM E-1186-03 Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems



USACE Air Leakage Test Protocol

Air Leakage Test Protocol Requirements-Infrared Test

- Diagnostic evaluation in accordance with ASTM E-1186 will assist the contractor and responsible party in identifying and eliminating air leakage so that the building meets protocol requirements upon re-testing.



Air Leakage Test Protocol Requirements-Infrared Test

- Diagnostic evaluation will aid the testing agency determine leakage site locations, pathways, and whether leakage is direct or indirect.
- Direct air leakage occurs at windows, doors, and other concentrations of seams, where air leaks directly through the enclosure.
- Indirect air leakage enters the building shell in one location, flows through building cavities, and emerges at a different location



Air Leakage Test Protocol Requirements- Results

- Results of testing must be documented per requirements of this protocol in content and format.
- Results must include the following:
 - Pass or Fail Declaration
 - Normalized Leakage CFM@75Pa
 - Equivalent Leakage Area at 75Pa
 - Air Leakage Coefficient "C" and Pressure Exponent "n" in accordance with ASTM E 779-03
 - Determination of accuracy of data collected.
 - Infrared Photos, Photo Documentation, Data



- 2005 Energy Policy Act requires Federal Facilities to be built to achieve at least 30% energy savings over the 2004 ASHRAE Standard 90.1-2004.
- Among the major factors contributing to mold prevention and reduced energy use in all climate zones is the air leakage through building enclosures.
- Understanding air barriers is necessary in order to develop effective enclosure design, set achievable performance requirements and verify compliance.



- In order to design and build safe, durable, comfortable, and economical buildings airflow must be controlled.
- Airflow carries moisture that impacts a materials long-term performance (serviceability) and structural integrity (durability), behavior in fire (spread of smoke), indoor air quality (distribution of pollutants and location of microbial reservoirs) and thermal energy.
- One of the key strategies in the control of airflow is use of air barriers.



- The test results must be less than or equal to 0.25 CFM/sq ft of exterior enclosure at 0.3 in. of water gage (75 Pa) pressure difference.
- When buildings are designed & constructed with attention to details, they can meet U.S. Army requirements for air tightness with only a minimal cost increase (due primarily from development of architectural details & testing).
- Depending on the climate, the total building energy cost savings due to improved building air tightness can range from 5% to 25%





Engineers - Consultants - Inspectors

Thank You For Your Time

