NEEC
NORTHWEST ENERGY EFFICIENCY COUNCIL

Air Barrier Management Fact Sheet

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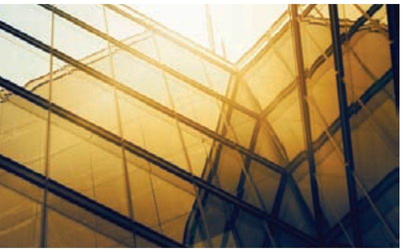




WHAT IS THE PURPOSE OF THIS REQUIREMENT?

Infiltration/exfiltration is uncontrolled air leakage through the building envelope. Air leakage increases building energy usage in two ways:

> ***Infiltration of cold outside air –*** This lowers the temperature within the space, causing the heating coil at the air terminal to have to produce higher temperature supply air and/or a greater volume of supply air to meet the desired space temperature. The result is an increase in heating energy.

> ***Exfiltration of conditioned indoor air –*** The loss of building air (warm or cool) has to be made up by the air handler by increasing the volume of outside air beyond what would normally be needed for ventilation. In addition, the volume of supply air needed to condition the space and maintain positive pressurization is greater. The result is an increase in fan, heating and cooling energy.

In cold climates, it has been estimated that air leakage is responsible for 43% of heating loads in office buildings.[2] Using whole-building computer simulation and benchmark models of commercial office buildings from the U.S. Department of Energy, a 12-story office building in the Seattle area could reduce its annual heating energy by 33% by sealing the building envelope to the new WSEC requirements.[3] Air leakage is also the main contributor to condensation problems in building envelope assemblies and it is also linked to increased wind-driven rain penetration problems. Since 2008 the US Army Corps of Engineers has been requiring air leakage testing on new facilities and a maximum air leakage rate of 0.25 cfm/sq ft tested at 0.3 in. w.g. Since then, several buildings have been built with air leakage rates between 0.16 and 0.25 cfm/sq ft. The requirement has been achieved on multiple projects using traditionally available air barrier systems.

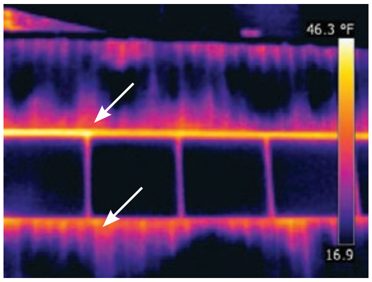


Figure 1.
Air leakage around windows was detected with an infrared camera. The wave-like pattern above and below windows indicated that the air seals at the window heads and sills were not continuous and warm air was exfiltration from the inside of the building.

WHAT DOES THE WSEC REQUIRE?

The air barrier is defined as material(s) that are assembled and joined together to provide a barrier to air leakage through the building envelope.

All Commercial and Multifamily Residential Buildings

The following is a list of key areas of the building envelope that shall be sealed, caulked, gasketed or weather-stripped to minimize air leakage:

> *Joints around manufactured and site-built fenestration and door frames;*

> *Junctions between walls and foundations, between walls at building corners, between walls and structural floors or roofs, and between walls and roof or roof panels;*

> *Openings at penetrations of utility services through the roofs, walls and floors;*

> *Building assemblies used as ducts or plenums;*

> *Joints, seams and penetrations of vapor retarders;*

> *Recessed lighting fixtures;*

In a sample of 203 commercial buildings, the average measured air leakage was 1.55 cfm per square foot of above grade envelope area when tested at 0.3 inch w.g. (1.57 psf, 75 Pa) pressure difference.

Commercial and Multifamily Residential Buildings Greater Than Five Stories

The building envelope shall be designed and constructed with a continuous air barrier to control air leakage into, or out of, the conditioned space. Specific requirements include:

> *Air barrier components of each envelope assembly shall be clearly identified on construction documents.*

> *Joints, interconnections and penetrations of the air barrier components shall be detailed.*

> *The air barrier component of each assembly shall be joined and sealed in a flexible manner to the air barrier component of adjacent assemblies.*

> *It shall be capable of withstanding positive and negative combined design wind, fan and stack pressures without damage or displacement, and shall transfer the load to the structure.*

Continuous Air Barrier Compliance

Compliance shall be demonstrated by performing a whole building test of the completed building and documenting the results of the test. A final certificate of occupancy shall not be issued for the building, or portion thereof, until the building official determines that the building, or portion thereof, has been field tested in accordance with the WSEC. The WSEC does not require that testing results demonstrate achievement of the target maximum allowed leakage to receive a certificate of occupancy. It is anticipated that buildings will have to demonstrate achievement of this target under future Codes.

Testing Requirements

The completed air barrier shall be tested using one of the approved testing methods. The WSEC target air leakage rate of the building envelope is **0.40 cfm/ft2 or less at a pressure differential of 0.3 inch w.g. (1.57 psf)**. The approved testing procedure is *ASTM E779 - Standard Test Method for Determining Air Leakage Rate by Fan Pressurization* or an approved similar test. This standard requires that the testing be accomplished via pressurization, depressurization or both. Most technical resources for air barrier testing recommend testing both. Particularly for multi-story buildings where bias pressures due to wind and stack effect may impact testing results. For multi-story buildings the building should be tested floor-by-floor.

There are three approved testing methods defined in this ASTM standard:

> *Portable fan pressurization method (blower door)*

> *Building HVAC system pressurization method*

> *Tracer gas test*

If using the portable fan pressurization method, multiple fans may be used simultaneously as long as a single zone with uniform pressure differential is achieved.

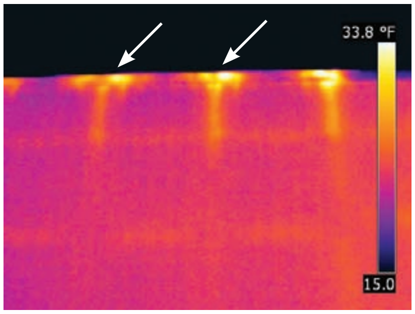


Figure 2.
Air leakage at the top of a precast concrete wall with metal parapet flashing was detected with Infrared camera. The pattern of brighter areas at the top of the wall indicated that the air seals at the top of the precast panels were not continuous and warm air was exfiltration from the inside of the building.

The approved standard for the building HVAC system method is *CAN/CGSB-149.15-96 Determination of the Overall Envelope Airtightness of Buildings by the Fan Pressurization Method Using the Building's Air Handling Systems, Canadian General Standards Board, Ottawa.*

Both fan pressurization and HVAC system pressurization will also allow pinpointing the location of leakage with the aid of a smoke pencil. This is a necessary step to aid the general contractor in determining where the air barrier is not continuous.

The approved standard for the tracer gas method is *ASTM Standard E 741 - Standard Test Method for Determining Air Change Rate in a Single Zone by Means of a Tracer Dilution.* This procedure requires expensive and specialized equipment. And although it will provide the leakage rate, it will not assist in determining where leakage is occurring.

WHAT ARE THE RESPONSIBILITIES OF EACH TEAM MEMBER?

All team members contribute to the integrity of the air barrier, therefore it is important to make sure each understands what is required of them. With the right materials, proper detailing, and quality control, an air leakage rate less than 0.4 cfm/sq ft has already been achieved on numerous projects. But lack of planning and poor quality control can lead to costly failures.

Architect

The architect is responsible for specifying the air barrier material for each assembly, detailing all transitions, and defining the air barrier enclosure or the "enclosure under test." This includes the calculated surface area of the air barrier enclosure. **This surface area value is used in the testing calculation to identify the rate of air leakage in cfm/ft^2.**

Note that spaces such as mechanical rooms with large louvers open to the outdoors, loading docks, and unconditioned spaces are considered outside the air barrier enclosure provided they are isolated from conditioned spaces by the continuous air barrier. The walls, ceilings and floors of these

Figure 3.
Installation of fully adhered air-barrier (orange membrane) including self-adhering flashing in progress in Central Washington.

areas may be required to meet air barrier sealing requirements. For example, if the floor and doors separating a mechanical penthouse from the building are airtight it can be excluded from the air barrier testing. Likewise receiving docks with roller doors can be excluded provided that the area is enclosed by airtight partitions and floors. For multi-story buildings being tested by the floor-by-floor method it is important to identify chases, shafts and wall cavities that communicate one floor to another.

Mechanical Engineer

In multi-story buildings, air barrier testing via the HVAC system pressurization method may be more practical than testing via fan pressurization. The mechanical engineer may facilitate this approach by providing the following in their HVAC system design:

> *A central supply or exhaust fan with a total outdoor airflow capacity capable of producing a pressure difference of approximately 60 Pa.*

> *An airflow control apparatus to vary the outdoor air supply rate (such as a speed control or a control damper in series with the fan).*

> *Tightly fitting dampers or access to cover intake.*

> *Airflow measurement methods such as pitot tube, hot-wire anemometer traverse, or pressure compensated shrouds on rooftop fans are provided on all outdoor air and exhaust air-handling equipment.*

General Contractor

Testing of the air barrier may occur anytime during the construction schedule when it is determined that the air barrier enclosure is complete. However, the key to a successful air barrier test requires advance planning. The main steps include: pre-construction review, selection of trades, review trade submittals, sequencing of trades, mock-up assemblies, field testing of assemblies, air barrier QA/QC, whole building air barrier pre-test, trouble shooting, and final testing. Sufficient time for testing and diagnostics should be included in the construction schedule. Note that the ASTM testing standard recommends performing the tests when outdoor wind conditions are less than 4 mph and outdoor temperatures are between 41-95 degrees F.

The following preparation list provides an example of the steps necessary to ensure a safe and accurate test:

> *Seal or isolate all intentional openings in the building such as air intake and exhaust louvers, dampers, etc.*

> *Exterior windows and doors are not intentional openings and therefore should be included in the enclosure under test in the normal closed position.*

> *Open all interior doors.*

> *Remove some ceiling tiles, approximately 1 per 500 ft^2.*

> *Fill all plumbing traps with water.*

> *Disabled all combustion equipment.*

ASTM E1186 Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems is a recommended resource to assist the general contractor in identifying and eliminating sources of air leakage. Air leaks can consist of many small openings, a few very large openings unnoticed during test preparation, or a combination of both. Procedures include neutral buoyancy or theatrical smoke and infrared diagnostic evaluation by a certified thermographer.

Sub-Contractors

It is important to inform all sub-contractors that any penetration through the air barrier can impact the building air leakage performance. All penetrations for electrical wiring, plumbing, ductwork, technology cabling, etc. must be sealed, caulked or gasketed to ensure these penetrations do not impact air barrier integrity.

ADDITIONAL RESOURCES

> ***U.S. Army Corps of Engineers Air Leakage Test Protocol for Measuring Air Leakage in Buildings –*** *Available on the NEEC website under Energy Codes.*

> ***American Air Barrier Association –*** *www.airbarrier.org*

> ***NIBS Guideline 3-2006: Exterior Enclosure Technical Requirements for the Commissioning Process, National Institute of Building Sciences, 2006. –*** *http://www.wbdg.org/ccb/browse_doc.php?d=7167. Refer to section related to air barriers.*

Source:

1 Emmerich, S.J. and A.K. Persily. 2005. Airtightness of commercial buildings in the U.S. Proceedings of the 26th IEA Conference of the Air Infiltration and Ventilation Center, Brussels, pp 65-70. in ASHRAE 2009 Handbook of Fundamentals p 16.25.

2 Emmerich, S.J., A.K. Persily, and T.P. McDowell. 2005. *Impact of infiltration on heating and cooling loads in U.S. office buildings*. Building and Fire Research Laboratory, National Institute of Standards and Technology Gaithersburg, MD. TESS, Inc., Madison, WI. 9 p.

3 Marceau, M.L. and C.J. Norris. April 2010. Demystifying air barriers. *Construction Today Magazine.*

AIR LEAKAGE CASE STUDY:

An Energy Concern but also a Source of Envelope Failure

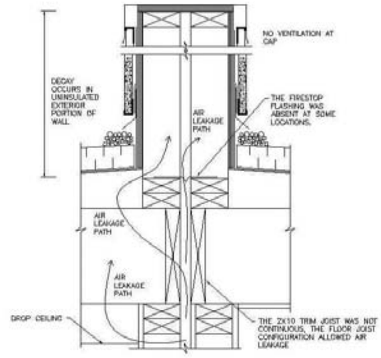
There are a number of ongoing discussions in the design and construction community regarding new air leakage requirements proposed and implemented by the International Energy Conservation Code, the International Green Building Code, as well as State and Municipal Codes. Most of the discussions focus on minimizing air leakage to reduce energy usage and lower carbon footprint. But there is another equally important reason to design with a continuous air barrier: durability. This case study describes a building envelop failure that was due in part to lack of continuity of the air barrier.

Air leakage is by no means a new issue to designers or builders; however, compared to water leakage, air leakage is sometimes overlooked as a significant contribution to envelope failure. Under certain conditions, air leakage can be equally as destructive as water leakage.

In the case of a 1976 low-rise wood-framed residential complex in the Pacific Northwest, air leakage was the cause of 25% of the damage, which required complete envelope rehabilitation. Stucco clad exterior partition walls separate roof decks, suite entrances, and balconies. These architectural features were extended to include stucco wall build-outs and metal capped roof build-ups. The roof consists of inverted flat roofs and sloped metal roofs.

After previous waterproofing repairs proved unsuccessful, a detailed building envelope investigation was conducted. Black staining and mold growth were consistently observed on the interior surfaces of the partition walls and roof build-ups. Damage was often greater on the interior surfaces of the framing and sheathing rather than on the exterior.

The party walls consist of 2x4 double stud walls with a gap of one to two inches between the walls. Partition walls, roof decks, and roof build-outs consist of wood frame extensions of the party walls.



Heated air in a building is buoyant and exerts pressure on the envelope. By the principle of Stack Effect, warm moist air migrated from the interior of the building into the party walls, then up into the partition walls above the roof/deck line. Acting as a chimney from the crawlspaces to the roof, the party wall configuration allowed interior air to rise and accumulate in the uninsulated partitions and roof build-outs, where it condensed on the cold surfaces, leading to rot and failure. The leakage of warm air through the partition wall was so significant that during rehabilitation, condensation was observed on the plastic tarps used to cover the partition walls that were being repaired.

The areas of most advanced decay were those affected by the combination of water leakage (from outside) and air leakage (from inside). As in this case, problems due to air leakage are not often visible from either the interior or exterior of the building. As such, air leakage issues can go overlooked and unaddressed for years. In this case, building configuration and architectural elements, lack of air barrier continuity, and a lack of designed ventilation for the affected elements, and extended exposure of exterior void spaces to warm air were contributing factors to the failure.

The successful repair consisted of creating a plane of air tightness using expanding polyurethane spray foam insulation where party walls penetrate the plane of the flat roof and venting the partition walls. The repair minimizes the amount of air leakage into the partition walls and uses venting to allow any moisture that does migrate from interior spaces into the partition walls to evaporate to the outside.

Air leakage should be considered as a potential source of envelope failure for both new construction and rehabilitation projects. Appropriate design and construction review of the air barrier is important to improve energy efficiency as well as building envelope durability.

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[1] For the complete case study refer to Deamer, D., Air Leakage as a Source of Envelope Failure in Lowrise Residential Buildings in the Lower Mainland, Morrison Hershfield, 2002. http://www.morrisonhershfield.com/Newsroom/TechnicalPapers/Pages/default.aspx.

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