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USACE / NAVFAC / AFCEC / NASA **UFGS-07 08 27.00 10 (February 2013)**

Preparing Activity: USACE **UFGS-07 27 00.45 10 (May 2012)**

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2014
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BUILDING AIR BARRIER SYSTEM TESTING FOR COMMISSIONING

02/13

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SECTION 07 08 27.00 10

BUILDING AIR BARRIER SYSTEM TESTING FOR COMMISSIONING
02/13

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NOTE: This guide specification covers contractor responsibilities, quality control, and functional requirements of the constructed air barrier system; it also covers the thermography and building air barrier leakage testing to verify that the building air barrier system and envelope are constructed properly. This guide specification is to be used in the preparation of project specifications in accordance with ER 1110-345-700.

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable items(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).
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PART 1 GENERAL

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NOTE: This specification is applicable to new building construction and major renovations involving upgrade to the building envelope; it is not applicable to unconditioned buildings. This specification is intended to define Contractor responsibilities for the construction of the air barrier system across the six sides of a building that when installed properly will control the infiltration or exfiltration of air through the air barrier system. A tight building is essential to a

properly functioning HVAC system, to reduce energy consumption and to prevent of problems arising from excessive infiltration or exfiltration into or out of the environmentally conditioned spaces.

The following is recommended reading for the designer:

- Building Air Tightness and Air Barrier Continuity Requirements, Alexander Zhivov, Ph.D and Wagdi Anis

AIR BARRIER CONCEPTS AND DESIGNER NOTES:

The Designer shall design a continuous air barrier to control air leakage into, or out of, the conditioned space.

On drawings dedicated to the air barrier system, identify the surface boundary of the building air barrier system in plan and in section views. Think of the air barrier system as a sealed balloon.

Keep in mind that window and door components are part of the building air barrier system. One must be able to trace a continuous plane of air-tightness throughout each air barrier system envelope.

Walls of ventilated crawl spaces logically cannot be the boundary of the air barrier. Nor can the roof above a ventilated attic be part of an air barrier. The openings in such spaces represent holes in the balloon.

Plan views shall show the horizontal extent (by dashed lines) of the air barrier and any individual air barrier zones. Plans shall exclude areas such as mechanical rooms with permanent fixed openings where outside air (ventilation) is allowed to enter the room.

Building and/or wall sections shall show the vertical extent (by dashed lines) of the air barrier from floor to roof or ceiling. Ventilated attics must be excluded.

Note that air barrier materials and assemblies located within the building thermal envelope experience less expansion and contraction when located within to the inside of the thermal envelope. Ideally the air barrier is in contact with the insulation and located on inside of the insulation. Defining the air barrier limits and boundaries is the responsibility of the building designer.

Air barrier materials that also serve as interior finishes are discouraged because such materials are subject to damage.

The designer is advised to consider the vapor permeance of the air barrier membranes as they relate to their location within the thermal envelope. Air barrier materials with low water vapor permeance are also vapor barriers or retarders. Careful consideration regarding the location of such material is crucial to avoid condensation within the thermal envelope with ensuing mold problems and material failure problems.

Keep in mind that air barrier membranes may have to withstand forces due to positive and negative pressures caused by wind. As a point of reference, many roofs are designed for a wind uplift pressure of 90 lb/sq.ft. Building wraps are considered inappropriate for air barriers because of the excessive flexing and stressing and point loading of the securing pins.

On the drawings, identify each air barrier material, membrane, coating, window component, door component, and other components that compose the air barrier system.

Detail the connection of roof and wall air barrier materials. (The roof-wall interface has been the source of major leaks in the past due to the many irregularly shaped decking and support members intersecting and insufficient attention to detail to the air barrier at this location.)

Detail the connection of wall and floor air barrier materials.

Detail the connection of the wall air barrier materials to window and door components.

Detail the penetrations of the air barrier boundary by pipe, ducts, and conduit showing the method of sealing the penetration.

Detail the air barrier to be continuous under or around all electrical boxes and panels, plumbing fixture boxes, and other items affecting air barrier continuity. Do not penetrate the air barrier with lighting fixtures.

In other specification sections, specify the air barrier materials used in the system. As defined by The Air Barrier Association of America (ABAA) all air barrier material must have an air permeance less than 0.004 CFM/sq-ft @ 0.30 in.w.c when tested in accordance with ASTM E2178.

In other specification sections, identify the allowable leakage rates of windows, exterior doors, curtain wall assemblies, skylights, and all other such air barrier components in the associated specification sections covering these components.

Note that Energy Star program has no air leakage requirement for windows and doors. ASHRAE 90.1 contains maximum leakage values determined in accordance with NFRC 400. These are minimal requirements and do not represent state of the art. The IECC standard contains leakage limits for doors and windows that may be useful as a guideline.

There is no known tight sealing overhead door. There is no known manufacturer who publishes tested leakage rates for overhead door assemblies. Specify the best weatherstripping available in the specification section covering overhead doors. This specification requires that overhead doors be masked with plastic and sealed during the building air tightness test. This allows the remainder of the air barrier system envelope to be tested without adjustment for the unknown leakage of the overhead doors.

For any fixed open louvers such as at elevator shafts, provide a motorized damper in the closed position and connected to the fire alarm system to open on call from the fire alarm system; also the damper must fail in the open position.

Provide tight sealing dampers and controls to close all ventilation or make-up air intakes and exhausts during inactive or unoccupied periods. In the HVAC and building controls specification sections, specify all intake, relief, and exhaust dampers to be AMCA 511 leakage Class 1A.

Often, there is but one air barrier system in a building. Sometimes this single system encloses the entire volume of the building.

However, there is sometimes a need for multiple air barrier systems in a given building. The lack of interior doorways connecting all areas of a building may preclude a single testable air barrier system. An example is a building with multiple living quarters but without interior corridors to connect the rooms into a single system. Individual rooms may become separate air barrier systems in this case.

Another example of when multiple air barrier systems are required is in a vehicle maintenance facility; the administrative area must have an air barrier system complete and separate from the air barrier system serving the maintenance bay area so that the admin area air barrier system is not nullified during warm weather when bay doors are open. Again, separate testing is required for each system, and the common wall between the test zones must be a part of the air barrier envelope for both air barrier systems to be tested. Therefore, the common wall must be tightly constructed and must include an

air barrier. Note that, in this case, the the common wall is included in the calculation of the surface area of both systems to be tested.

With multiple air barrier systems, the designer must decide which system will be leak tested. Individual air barrier systems selected for leakage testing become Test Zones.

Each test zone is enclosed by a single air barrier system; it is a balloon unto itself.

On the drawings, the designer must identify the Test Zones, usually by number.

Calculate the air barrier envelope surface area (sq.ft.) for each Test Zone. This is the surface area of the volume enclosed by each air barrier system to be tested and includes floors, walls, fenestration, doors, and roof. On the drawings or in this spec section, indicated the air barrier system surface area for each Test Zone.

Indicate the allowable leakage rate of each Test Zone (CFM/sq.ft. @ 0.30 in.w.g.) Current guidance is 0.25 CFM/sq.ft. at a test differential pressure of 0.30 in.w.g. (75 Pascals) based on the surface area of air barrier system envelope.

Calculate the maximum test leakage in CFM at 75 Pascals. Indicate this value for each Test Zone in the functional requirements.

Copy and complete the checklist below and include it in the Architectural Design Analysis.

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AIR BARRIER DESIGNER CHECKLIST

Drawings:

___ Air barrier system drawings are included in the plans. (More than one drawing may be required. It may be necessary to provide a plan for each floor.)

___ A reduced size plan and elevation views of the building indicating the desired perimeter boundary of each air barrier system is included.

___ The air barrier systems to be tested are shown and given a unique number for reference.

___ Details showing how the wall air barrier is joined to the roof air barrier are provided.

___ Details showing how the wall air barrier is

joined to the floor / foundation are provided.

___ Details showing how the wall air barrier is joined to the window components are provided.

___ Details showing how the wall air barrier is joined to the door components are provided.

___ Details are provided showing the method of sealing penetrations of the air barrier at the wall, roof, or floor by conduit, piping, cables, etc.

___ Details showing how the air barrier is routed around wall and roof discontinuities are provided (soffits, overhangs, offsets, vestibules, gables, ridges, eaves, etc).

___ In the wall and roof sections, materials and accessories that constitute the air barrier system are clearly identified. Examples:board materials, liquid applied coatings, spray applied foams, tape, calks, sealants.

___ In the wall and roof sections, components and assemblies that constitute the air barrier system are clearly identified. Examples: windows, doors, skylights.

Note: The following are examples for air barrier materials:
- **Modified bitumen membranes**
- **Drywall**
- **Cast-in-place concrete**
- **Glass**
- **Metal**
- **Polyethylene film**
- **Spray polyurethane foam**
- **Spray polyethylene foam**
- **Extruded polystyrene**
- **Low permeance building wrap products.**
- **Liquid applied one and two component materials**
- **Concrete block with 3 coats of paint**

Note: The following cannot serve as air barrier materials:
- **Concrete block**
- **Expanded polystyrene foam**
- **Building paper**
- **Open cell foam**
- **High permeance house wraps**
- **Perlite board**
- **Fiberboard**
- **Glass fiber rigid board**
- **Cellulose insulation**

Specifications:

___ The air permeance and water vapor permeance of

the air barrier membranes is specified in other spec sections. Examples: Adhered films or membranes, liquid applied films / membranes / coatings.

Note: Air barrier materials have a maximum air permeance of 0.004 CFM/ft2 of surface area at a pressure difference of 0.30 inches of water (1.56 lb/ft2). Films, membranes, and coatings intended as air barrier components must meet this rating when tested in accordance with ASTM E 2178.

___ The leakage functional requirements of window, curtain wall, and door components is specified in other specification sections.

___ The leakage functional requirements of HVAC intake and exhaust dampers is specified in other specification sections.

Calculations:

___ The surface area (sq.ft.) of each air barrier system to be tested has been calculated.

___ The maximum leakage functional requirements (CFM) of each air barrier system to be tested, that is, for each test zone has been calculated.

___ Moisture migration and dewpoint calculations have been performed.

Note: Air barrier materials will have low air permeance by definition. However, beware of the vapor permeance of air barrier membranes. For example if the air barrier material has a low vapor permeance, it may act as an effective vapor retarder. With this in mind, the location of the membrane within the wall or roof relative to the thermal insulation becomes important. Be sure that the vapor permeance and location has been considered by the design. Perform vapor transmission calculations or dew point calculations as required to assure that moisture condensation within the building envelope will not occur.

(End Designer Checklist)

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1.1 SUMMARY

The air barrier shall be contiguous and connected across the six surfaces of the enclosed air barrier envelope indicated. Perform building thermography and air barrier leakage tests to demonstrate that the air barrier materials are properly installed and joined; that windows, doors, dampers, and ducts are sufficiently air tight; and that the overall air barrier envelope is sealed. The quality of the construction of the air

barrier systems, including the joining and sealing of the air barrier materials and accessories must be sufficient to limit leakage under pressure to the maximum leakage functional requirements outlined in this specification.

Passing an air barrier leakage test and thermography test to demonstrate that the building envelope is properly sealed and insulated will result in system acceptance. Report the results of the thermograph and leakage tests. The testing and reporting shall be performed in accordance with the procedures outlined in this specification.

1.2 REFERENCES

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NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a RID outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.
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The publications listed below form a part of this specification to the extent referenced. The publications are referenced within the text by the basic designation only.

AMERICAN SOCIETY FOR NONDESTRUCTIVE TESTING (ASNT)

ASNT CP-105	(2011) ASNT Standard Topical Outlines for Qualification of Nondestructive Testing Personnel - Item No. 2821
ASNT SNT-TC-1A	(2011; Text Correction 2013) Recommended Practice for Personnel Qualification and Certification in Nondestructive Testing

ASTM INTERNATIONAL (ASTM)

ASTM C1060	(2011a) Standard Practice for Thermographic Inspection of Insulation Installations in Envelope Cavities of Frame Buildings
ASTM D4541	(2009; E 2010) Pull-Off Strength of Coatings Using Portable Adhesion Testers
ASTM E1105	(2000; R 2008) Standard Test Method for

	Field Determination of Water Penetration of Installed Exterior Windows, Skylights, Doors, and Curtain Walls, by Uniform or Cyclic Static Air Pressure Difference
ASTM E1186	(2003; R 2009) Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems
ASTM E1827	(2011) Standard Test Methods for Determining Airtightness of Buildings Using an Orifice Blower Door
ASTM E779	(2010) Standard Test Method for Determining Air Leakage Rate by Fan Pressurization
ASTM E783	(2002; R 2010) Standard Test Method for Field Measurement of Air Leakage Through Installed Exterior Windows and Doors

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 6781	(1983) Thermal Insulation - Qualitative Detection of Thermal Irregularities in Building Envelopes - Infrared Method

1.3 DEFINITIONS

The following terms as they apply to this section:

1.3.1 Air Barrier Accessory

Products designated to maintain air tightness between air barrier materials, air barrier assemblies and air barrier components, to fasten them to the structure of the building, or both (e.g., sealants, tapes, backer rods, transition membranes, fasteners, strapping, primers).

1.3.2 Air Barrier Assembly

The combination of air barrier materials and air barrier accessories that are designated and designed within the environmental separator to act as a continuous barrier to the movement of air through the environmental separator.

1.3.3 Air Barrier Component

Pre-manufactured elements such as windows, doors and service elements that are installed in the environmental separator.

1.3.4 Air Barrier Material

A building material that is designed and constructed to provide the primary resistance to airflow through an air barrier assembly.

1.3.5 Air Barrier System

The combination of air barrier assemblies and air barrier components, connected by air barrier accessories that are designed to provide a

continuous barrier to the movement of air through an environmental separator. This includes the roof, wall, and floor assemblies, and the wall and roof components, and may include interior walls or partitions. There may be more than one air barrier system in a single building.

1.3.6 Air Leakage Rate

The rate of airflow (CFM) driven through a unit surface area (sq.ft.) of an assembly or system by a unit static pressure difference (in.w.g or Pa) across the assembly. (examples: CFM/sq.ft. @ 0.30 in.w.g, or CFM/sq.ft. @ 75 Pa)

1.3.7 Air Permeance

The rate of airflow (CFM) through a unit area (sq.ft.) of a material driven by unit static pressure difference (in.w.g. or Pa) across the material.

1.3.8 Environmental Separator

The parts of a building that separate the controlled interior environment from the uncontrolled exterior environment, or that separate spaces within a building that have dissimilar environments.

1.3.9 Test Zone

The portion of or volume within a building enclosed by an air barrier system which is to be tested for air leakage. The test zones are indicated.

1.4 PRECONSTRUCTION CONFERENCE

Organize pre-construction conferences between the air barrier inspector and the sub-contractors involved in the construction of or penetration of the air barrier system to discuss where each sub-contractor begins and ends, the sequence of installation, and each sub-contractor's responsibility to ensure airtight joints, junctures, penetrations and transitions between materials, products, and assemblies of products specified in the different sections to be installed by the different sub-contractors.

1.5 SUBMITTALS

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NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project.

The Guide Specification technical editors have designated those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a "G" to an item, if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation to indicate the approving authority.

Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.

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Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for [Contractor Quality Control approval.] [information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

[SD-04 Samples

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NOTE: Deleting the requirement for a Mock-up is recommended on projects having a Project Amount (PA) less than $4 million.

****

Mock-up[; G][; G, [_____]]

Build one as specified prior to building construction.

] SD-07 Certificates

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NOTE: Deleting the requirement for an Air Barrier Inspector is recommended on projects having a PA less than $4 million.

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[Air Barrier Inspector[; G][; G, RO]

[Two] [_____] copies 30 days after Notice to Proceed.]

Thermography Test Firm

[Two] [_____] copies 60 days prior to thermography testing.

Thermography Test Technician

[Two] [_____] copies 60 days prior to thermography testing.

Air Barrier Leakage Test Firm[; G][; G, DO]

[Two] [_____] copies 60 days prior to leakage testing.

Air Barrier Leakage Test Technician[; G][; G, DO]

[Two] [_____] copies 60 days prior to leakage testing.

SD-06 Test Reports

Thermography Test Procedures[; G][; G, [_____]]

[Two] [_____] copies 30 day prior to thermographic testing / examination.

Building Air Barrier Leakage Test Procedures[; G][; G, [_____]]

[Two][_____] copies OF detailed test procedures indicating the test apparatus, the test methods and procedures, and the analysis methods to be employed for the Building Air Barrier Leakage Test 30 prior to leakage testing.

Design Review Report[; G][; G, DO]

[Two] [_____] copies not later than [14] [_____] days after approval of the Air Barrier Inspector Qualifications.

Thermographic Test Report[; G][; G, RO]

[Two] [_____] copies of interim reports 10 days after completion.
[Four] [_____] copies of the final report 14 days after completion.

Air Barrier Leakage Test Report[; G][; G, DO]

Two copies of interim reports 10 days after completion.
[Four] [_____] copies of the final report 14 days after completion.

1.6 AIR BARRIER SYSTEM SURFACE AREA AND FUNCTIONAL REQUIREMENTS

The building air barrier systems shall meet the following leakage functional requirements. The allowable leakage rate and the maximum leakage are at a pressure of 0.30 in.w.g.

a. Test Zone 1 Air Barrier System

(1) Surface Area: [_____] square meter square feet
(2) Allowable leakage rate: [1.27][_____] L/s per square meter [0.25][_____] CFM/sq.ft
(3) Maximum leakage: [_____] total L/s CFM

b. Test Zone 2 Air Barrier System

(1) Surface Area: [_____] square meter square feet
(2) Allowable leakage rate: [1.27][_____] L/s per square meter [0.25][_____] CFM/sq.ft
(3) Maximum leakage: [_____] total L/s CFM

c. Test Zone 3 Air Barrier System

(1) Surface Area: [_____] square meter square feet
(2) Allowable leakage rate: [1.27][_____] L/s per square meter [0.25][_____] CFM/sq.ft
(3) Maximum leakage: [_____] total L/s CFM

1.7 QUALITY CONTROL

1.7.1 Qualifications

[1.7.1.1 Air Barrier Inspector

Two years experience in the installation of air barrier materials and assemblies including the experience in joining and sealing various components, and sealing of penetrations of air barriers. Experience coordinating and instructing personnel involved in the installation, joining, and sealing of air barrier materials and components. The Air Barrier Inspector shall have training and certification as an Air Barrier Installer from the Air Barrier Association of America (ABAA).

]1.7.1.2 Thermography Test Firm

Minimum 2 years experience in thermographic testing and analysis, with a minimum of 3 successful projects of similar type and scope in the previous 3 years, using the specified testing standard, and employing qualified test technicians under the supervision of a Level III Certified Infrared Thermographer.

1.7.1.3 Thermography Test Technician

Possess Level II Training and Certification from a firm whose training and certification program complies with the recommended practice established by ASNT SNT-TC-1A and ASNT CP-105. Possess a certificate indicating successful completion of a course and examination specifically related to building envelope thermography. Document demonstration of 2 years experience in infrared thermography testing including interpreting and reporting findings in accordance with the requirements of ASTM C1060.

1.7.1.4 Air Barrier Leakage Test Firm

Minimum 2 years experience in air tightness testing and analysis, with a minimum of 3 successful projects of similar type and scope in the previous 3 years, using the specified testing standard, and employing qualified test technicians.

1.7.1.5 Air Barrier Leakage Test Technician

Two years experience in air tightness testing using the specified testing standard and equipment.

1.7.2 Design Review

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NOTE: This Design Review is similar to the Design Review Report required by UFGS 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC where the TAB specialists reviews the plans and specs and submits a report either indicating that the system can be balanced or describing deficiency that preclude the TAB team from accomplishing their work and describing necessary changes. Similarly, the contractor is asked to review the air barrier design and point out any deficiencies that prevent a successful installation.

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The Air Barrier Inspector shall review the Contract Plans and Specifications and advise the Contracting Officer of any deficiencies that would prevent the construction of an effective air barrier system. The Air Barrier Inspector shall provide a Design Review Report individually listing each deficiency and the corresponding proposed corrective action necessary for proper air barrier system.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

3.1 QUALITY CONTROL

3.1.1 Documentation and Reporting

Document the entire installation process on daily job site reports. These reports include information on the Installer, substrates, substrate preparation, products used, ambient and substrate temperature, the location of the air barrier installation, the results of the quality control procedures, and testing results.

[3.1.2 Construction Mock-Up

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NOTE: Delete the requirement for a Mock-up on projects having a PA less than $4 million. If the project is a complex of buildings, the designer must select and specify in the paragraph below, the building on which the Mock-up shall be based.

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a. Prepare a construction mock-up to demonstrate proper installation of the air barrier. The mock-up shall include air barrier connections between floor and wall, wall and window, wall and roof. The mock-up shall include the sealing method between membrane joints at transitions from one material or component to another, at pipe or conduit penetrations of the wall and roof, and at duct penetration of the wall and roof. Work will not begin until the mock-up is satisfactory to the Contracting Officer.

b. The mock-up shall be approximately 2 m long by 2 m high 8 feet long by 8 feet high. The mock-up shall be representative of primary exterior wall assemblies and glazing components including backup wall and typical penetrations as acceptable to the Contracting Officer.

c. Mock-Up Tests for Air and Water Infiltration: Test the mock-up for air and water infiltration in accordance with ASTM E1186 or ASTM E783 and ASTM E1105. Use smoke tracer to locate sources of air leakage. If deficiencies are found, reconstruct the mock-up and retest until satisfactory results are obtained. Deficiencies include air leakage beyond the values specified, uncontrolled water leakage, and insecure materials. Perform the air leakage tests and water penetration test of the mock-up prior to installation of cladding and trim but after installation of all fasteners for cladding and trim and after installation of other penetrating elements.

d. Mock-Up Tests for Adhesion: Test the mock-up of materials for adhesion in accordance with manufacturer's recommendations. Perform the test after the curing period recommended by the manufacturer. Record the mode of failure and the area which failed in accordance with ASTM D4541. When the air barrier material manufacturer has established a minimum adhesion level for the product on the particular substrate, the inspection report shall indicate whether this requirement has been met. Where the manufacturer has not declared a minimum adhesion value for their product/substrate combination, then the inspector shall simply record the value.

]3.1.3 Quality Control Testing

Conduct the following qualitative and quantitative tests and inspections in the presence of the Contracting Officer during installation of the air barrier system.

a. Qualitative Testing and Inspection As Applicable:

(1) Provide a Daily Report of Observations with a copy to the Contracting Officer.

(2) Ensure continuity of the air barrier system throughout the building enclosure and that all gaps are covered, the covering is structurally sound, and all penetrations are sealed allowing for no infiltration or exfiltration through the air barrier system.

(3) Ensure structural support of the air barrier system to withstand design air pressures.

(4) Ensure masonry surfaces receiving air barrier materials are smooth, clean, and free of cavities, protrusions and mortar droppings, with mortar joints struck flush or as required by the manufacturer of the air barrier material.

(5) Ensure site conditions for application temperature, and dryness of substrates are within guidelines.

(6) Ensure substrate surfaces are properly primed.

(7) Ensure laps in materials are at least a 2-inch minimum, shingled in the correct direction or mastic applied on exposed edges with no fishmouths.

(8) Ensure that mastic is applied on cut edges.

(9) Ensure that a roller has been used to enhance adhesion.

(10) Measure application thickness of liquid applied materials to manufacturer's specifications for the specific substrate.

(11) Ensure that the correct materials are installed for compatibility.

(12) Ensure proper transitions for change in direction and structural support at gaps.

(13) Ensure proper connection between assemblies (membrane and

sealants) for cleaning, preparation and priming of surfaces, structural support, integrity and continuity of seal.

b. Quantitative Tests:

(1) Provide written test reports of all tests performed with a copy to the Contracting Officer.

(2) Determine the bond strength of coatings to substrate in accordance with ASTM D4541.

3.2 THERMOGRAPHY TEST

Upon completion of construction, and completion of quality control measures for the air barrier system and the thermal envelope, infrared thermography tests shall be conducted.

3.2.1 Field Conditions

Perform testing under conditions stipulated in test standards, in instrument manufacturer's instructions, and in this Section. Perform testing on dry building surfaces after sunset and prior to sunrise under the following environmental conditions:

a. Wind speed: Not greater than 15 mph.

b. Outside Air Temperature: Either a minimum of 18 degrees F above building interior temperature or a minimum of 18 degrees F below building interior temperature, for a minimum of 4 hours prior to test, and not varying more than 30 percent during the test.

c. Indoor Air Temperature: At constant temperature varying not more than 4 degrees F.

d. Direct Solar Exposure of Surfaces: No direct solar radiation on inspected surfaces during and for minimum 4 hours prior to inspection for frame construction, 8 hours for masonry veneer construction, at acceptable outside air temperature.

3.2.2 Thermography Test Procedures

The building envelope shall be tested using Infrared Thermography technology. The thermography testing shall be completed in accordance with the requirements of ASTM C1060 and ISO 6781. Perform a complete thermographic inspection consisting of full exterior and interior inspection of the complete thermal envelope and air barrier system. Note areas of the envelope that the inspection cannot cover due to limited or no access. The Contracting Officer shall be given the opportunity to witness the testing. Conduct testing just before the Building Air Barrier Leakage Test. Also, conduct testing during the Building Air Barrier Leakage Test so that air leaks are detected. If the building air barrier leakage test is failed, Thermographic testing shall be repeated just before and during subsequent air barrier leakage tests until the leakage test is successful. Address the cause and required corrective action for all anomalous thermal images resulting from the examination.Submit detailed test procedures indicating the test apparatus, the test methods and procedures, and the analysis methods to be employed for the Thermography Test.

3.2.3 Thermographic Test Report

Include thermographs in color and a color temperature scale to define the temperature indicated by the various colors. Identify the high temperature reading, the outdoor air temperature, the building indoor air temperature, and the wind speed and direction. Note any areas of compromise in the building envelope, and note all actions required and taken to correct those areas. Final thermography test report shall demonstrate that the problem areas have been corrected. Submit the complete test and analysis.

3.3 AIR BARRIER LEAKAGE TEST

Upon completion of construction, and quality control measures for the air barrier system, building air barrier leakage tests shall be conducted.

3.3.1 Building Air Barrier Leakage Test Procedures

Perform the air leakage test in accordance with ASTM E779 with the following additions and exceptions:

a. The test consists of measuring the flow rates required to establish a minimum of 12 positive and 12 negative building pressures. The lowest test pressure shall be 0.10 in.w.g or 25 Pa; the highest test pressure shall be 0.30 in.w.g or 75 Pa; and there must be at least 0.10 in.w.g or 25 Pa difference between the lowest and highest test pressures.

b. Measure the test pressure in a representative location such that pressures in the extremities of the enclosure can be shown to not exceed 10 percent of the measured test pressure. At least 12 bias pressure readings must be taken across the envelope and averaged over at least 20 seconds each before and after the flow rate measurements. None of the bias pressure readings must exceed 30 percent of the minimum test pressure when testing in both directions.

[c. Where it can be shown that it is impossible to test in both directions, then the building may be tested in the positive direction only, provided the bias pressure does not exceed 10 percent of the minimum test pressure.]

d. The mean value of the air leakage flow rate calculated from measured data at 75 Pa 0.3 in.w.g shall not exceed the air barrier functional requirements specified and the upper confidence limit as defined by ASTM E779. Reference measurements at standard conditions of 14.696 psi and 68 degrees F.

e. Conduct the test with ventilation fans and exhaust fans turned off and the outdoor air intake dampers and exhaust dampers closed. Provide a responsible HVAC technician with the authority to place the HVAC system in the correct mode for the pressure test. The test technician shall have unhindered access to mechanical rooms, air handlers, exhaust fans, and outdoor air and exhaust dampers.

f. Ensure that all windows in the test enclosure are kept closed. Prohibit entry and exit through doors in the test enclosure during the test. Discard data collected while the pressures and flows are affected by a door opening and closing. The openings of roll-up or roll-back type overhead doors shall be masked with plastic and sealed. Internal doors within the air barrier test enclosure shall be open; this includes access doors to attics enclosed by the air barrier system.

g. Perform a diagnostic evaluation in accordance with ASTM E1186, whether the building achieves the air barrier system functional requirement or not. Use the diagnostic evaluation to assist in identifying and eliminating air leakage so the system meets the functional requirement upon retesting. Also, express the testing results in terms of the Equivalent Leakage Area (EqLA) at 0.30 in.w.g or 75 Pa. The EqLA is the equivalent area of a flat plate orifice that leaks the same amount as the building envelope at 0.30 in.w.g or 75 Pa.

3.3.2 Fan Pressurization Test

Conduct the fan pressurization test to determine final compliance with the air barrier system functional requirement when all components of the air barrier system have been installed and inspected, and have passed any intermediate testing procedures. The test may be conducted before finishes that are not part of the air barrier system have been installed. For example, if suspended ceiling tile, interior gypsum board, or cladding systems are not part of the air barrier system, the test may be conducted before they are installed.

3.3.3 Air Barrier Leakage Test Report

Submit a certified written report of each inspection, test, or similar service. Written reports of each inspection and test or similar service shall include all the Report items described in ASTM E1827. Additionally, the report shall also include the following information:

a. Date of Issue
b. Project title and number
c. Name, address, and telephone number of testing agency
d. Dates and locations of samples and tests or inspections
e. Names of individuals making the inspection or test
f. Designation of the Work and test method
g. Identification of product and Specification Section
h. Complete inspection or test data
i. Test results and an interpretation of test results for each test zone
j. Name and signature of laboratory inspector
k. Recommendations on retesting
l. Comments or professional opinion on whether inspected or tested Work complies with Contract Document requirements

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NOTE: The penalty indicated below is based on an analysis and computer model study of a typical Army Reserve Center located in central U.S. The building energy costs for two models were calculated; one for a building having an air barrier with the specified leakage functional requirements and one having an air barrier with a higher air barrier leakage functional requirements. The difference in modeled leakage generated a difference in the annual energy cost. The present worth of that annual energy cost differential over a 40 year building life at an OMB 2 percent discount rate was determined. The present worth was then normalized to a cost per CFM of excess leakage at test pressure resulting in the figure of $6.74 / CFM of excess leakage measured at a pressure of 0.30 in.w.g. If a test zone is representative of multiple air barrier systems

(example: one living quarters tested as representative of many), the penalty paragraph must be edited to make it clear that the penalty is multiplied for the number of air barrier systems represented by the tested zone.

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3.4 AIR BARRIER FUNCTIONAL REQUIREMENTS FAILURE

If the final air barrier test indicates that the leakage of the constructed air barrier system exceeds the maximum leakage specified, coordinate with the Designer of Record, the subcontractors, and the Government to immediately determine the cause of the failure, develop a method to change or repair the air barrier system. Then, develop and schedule a re-test of the air barrier system. Repeat until the air barrier system test is passed.

3.5 REPAIR AND PROTECTION

Upon completion of inspection, testing, or sample taking and similar services, repair damaged construction and restore substrates and finishes, protect construction exposed by or for quality control service activities, and protect repaired construction.

-- End of Section --