ENGINEERING CONSULTING SERVICES

DEMYSTIFYING AIR CONTROL

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BUILDING THERMAL ENVELOPE

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Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

COURSE DESCRIPTION

Energy codes have recognized the importance of envelope air leakage and water resistance control, and have become mandatory code requirements for the building envelope (ASHRAE 90.1 2010+, IECC 2012+, others). However, simple inclusion of control layers in the design documents does not guarantee performance or durability under field application conditions. Assembly air and water tightness impacts code compliance, building performance, and combustibility requirements. Energy codes generally focus on air tightness and insulation. Owners, manufacturers and designers utilize many tests and specifications to promote durability. Differences between laboratory test conditions and field requirements are important to understand to promote effective and deliver performance in practice.

LEARNING OBJECTIVES

Upon completing the course be able to:

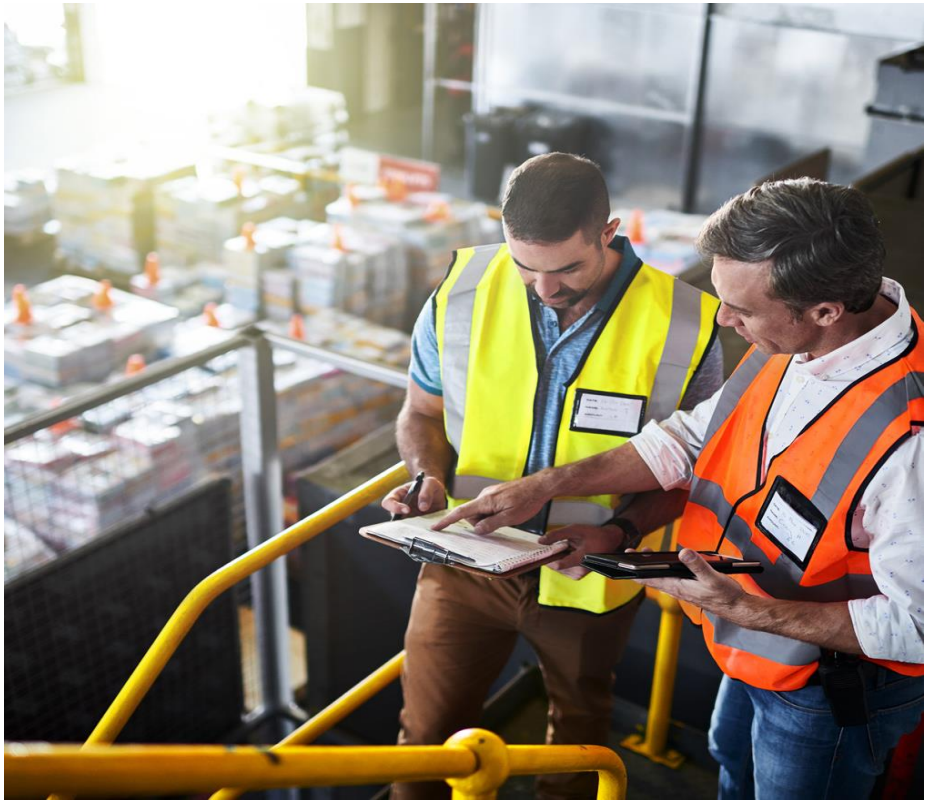
1. Discuss of how assembly air and water performance impacts code compliance in the building and model energy codes and standards;
2. Explain the desired air and water design specifications by project type and included assembly components;
3. Discuss the methodology of laboratory-based air, water, thermal, and fire resistance as materials, assemblies, and whole buildings;
4. Describe examples of how field installation details and testing can impact the performance level for a given enclosure system.

DEMYSTIFYING THE IECC:

ENCLOSURE DESIGN AND AIR BARRIER

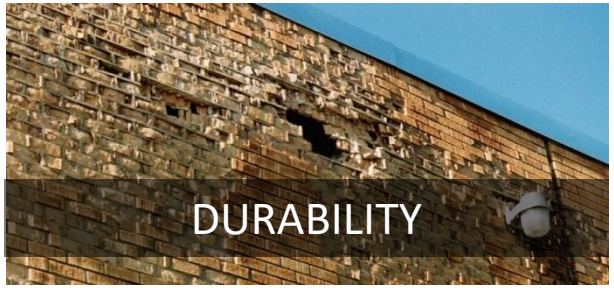
1. Introduction
2. The Building Enclosure
3. Energy Code and Compliance Paths
4. Thermal Envelope
5. Air Barrier
6. Testing
7. Inspections and Verifications
8. Fenestration

INTRODUCTION



THE BUILDING ENCLOSURE

THE BUILDING ENCLOSURE



THE BUILDING ENCLOSURE

COMPLEX

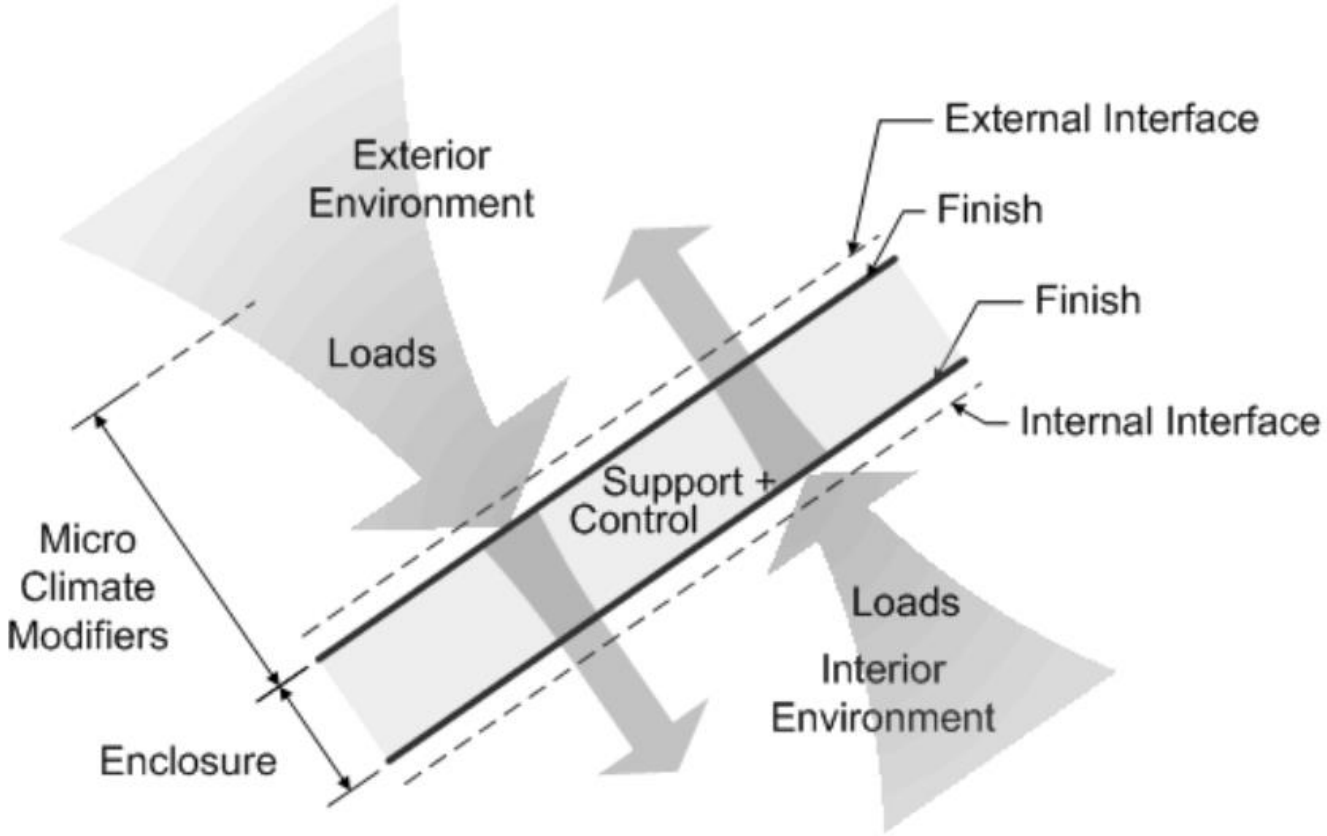
SIMPLE

THE BUILDING ENCLOSURE

The primary function of the building enclosure is to separate environmental conditions – Interior from the exterior OR interior to interior – and typically include the following components:

- Roof
- Above-Grade Walls
- Fenestration (Windows, Doors, Louvers)
- Below-Grade Walls
- Slab-on-Grade or Exposed Floor Systems

THE BUILDING ENCLOSURE



THE BUILDING ENCLOSURE

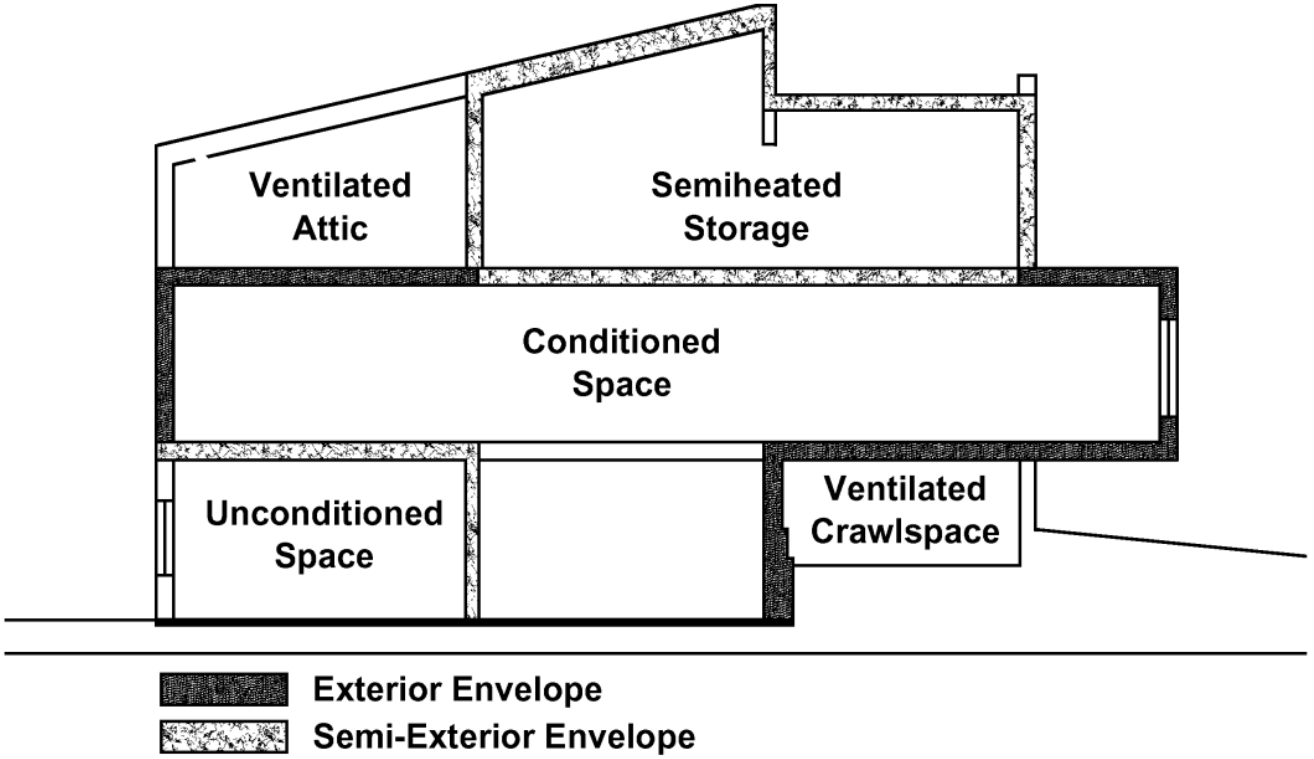


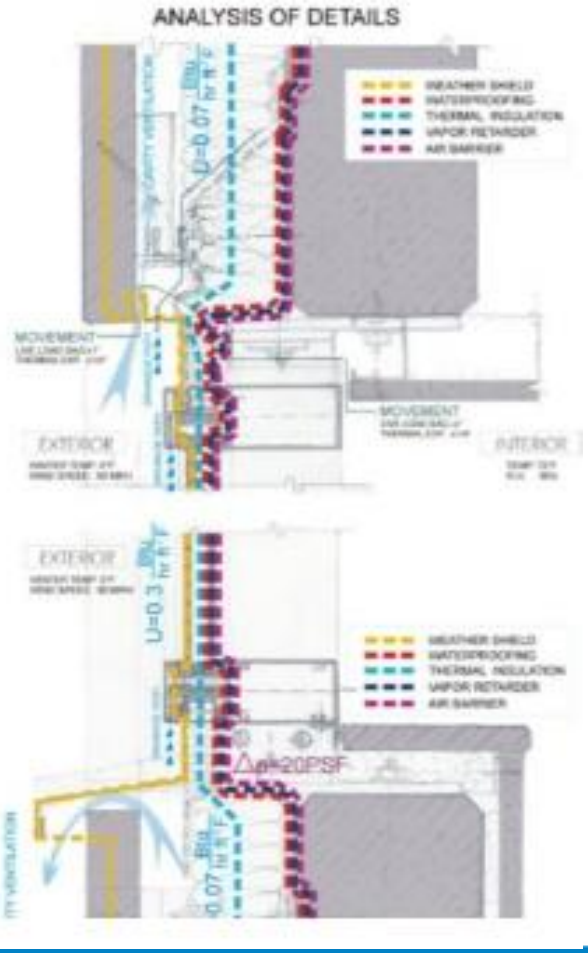
Figure 5.5.2 Exterior and *semiexterior building envelope*.

THE BUILDING ENCLOSURE

CONTROL LAYERS

Building Enclosures are designed to control multiple loadings this presentation will primarily be concerned with the following in order of importance:

1. Water Control Layer
2. **Air Control Layer**
3. Vapor Control Layer
4. Thermal Control Layer



THE BUILDING ENCLOSURE

WATER CONTROL LAYER

The continuous layer (comprised of one of several materials and formed into planes to form a three dimensional boundary) that is designed, installed, or acts to control the passage of liquid water even after long or continuous exposure to moisture.

- Interconnected with flashings, window and door openings, and other penetrations
- Overlap each other shingle fashion or are sealed so that water flow is downward and outward
- Goal is to evacuate water from the assembly and away from the building as quickly as reasonably possible

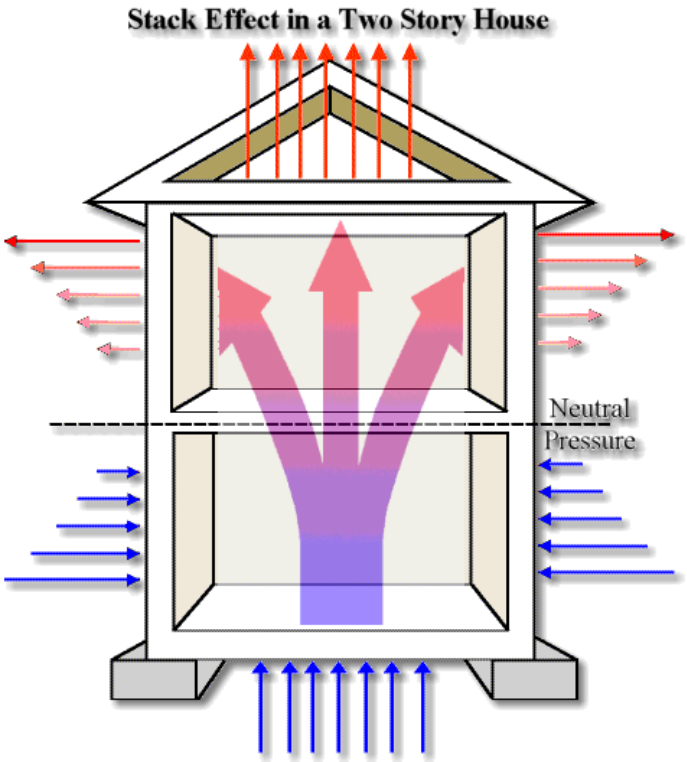
THE BUILDING ENCLOSURE

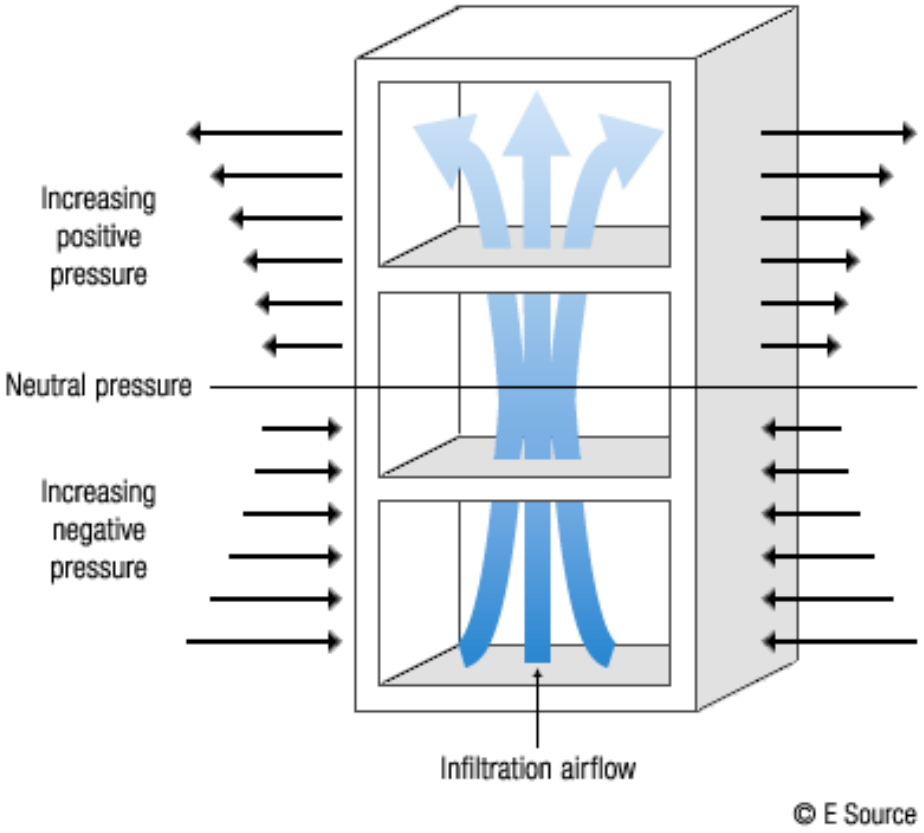
AIR CONTROL LAYER

Three-dimensional systems of materials designed, constructed, and/or acting to control air flow across a building enclosure, or between a conditioned space and an unconditioned space. The pressure boundary of the enclosure should, by definition, be coincident with the plane of a functional air control layer system.

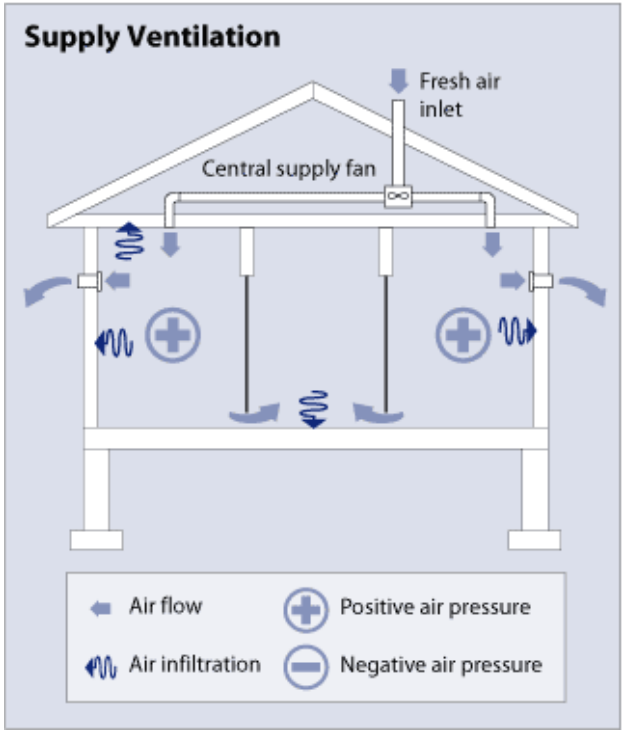
- Interconnected with flashings, window and door openings, and other penetrations
- Continuity is Critical
- Moisture-Laden-Airflow can carry 100 to 300x’s more moisture than diffusion over the same time period

AIR FLOW – STACK EFFECT

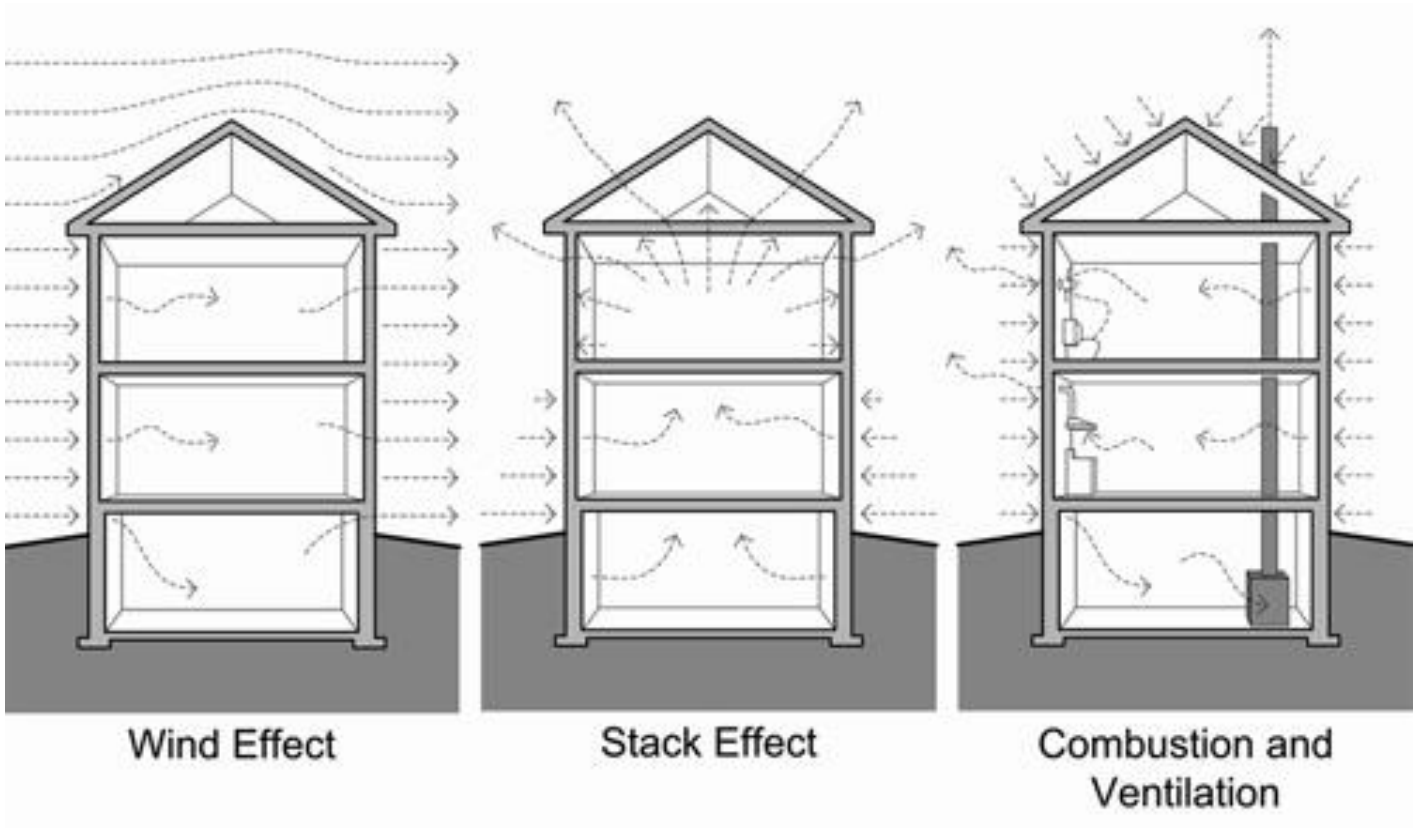




AIR FLOW – MECHANICAL EFFECTS



AIR FLOW - COMBINED



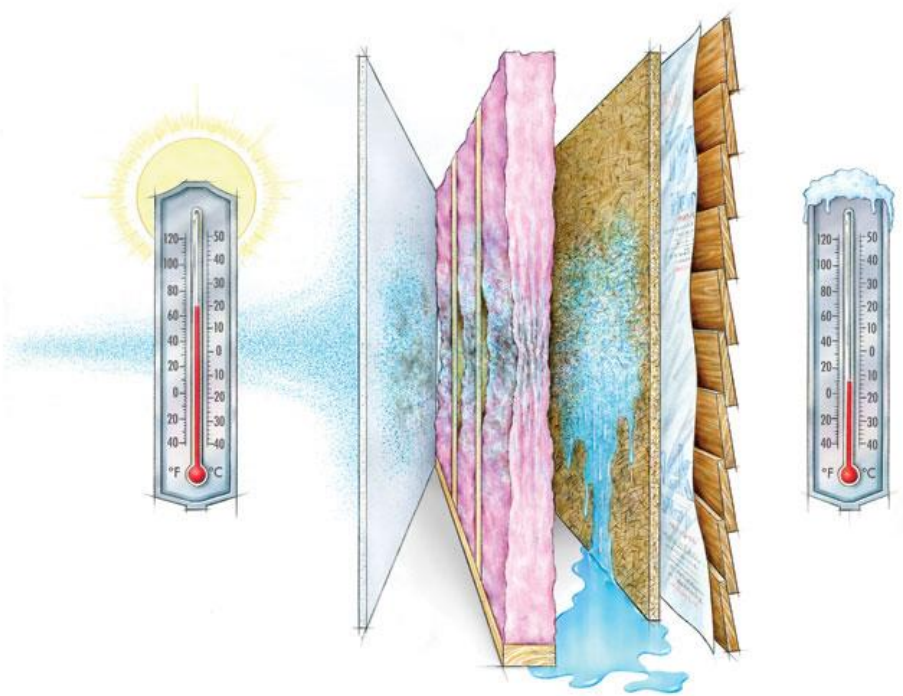
THE BUILDING ENCLOSURE

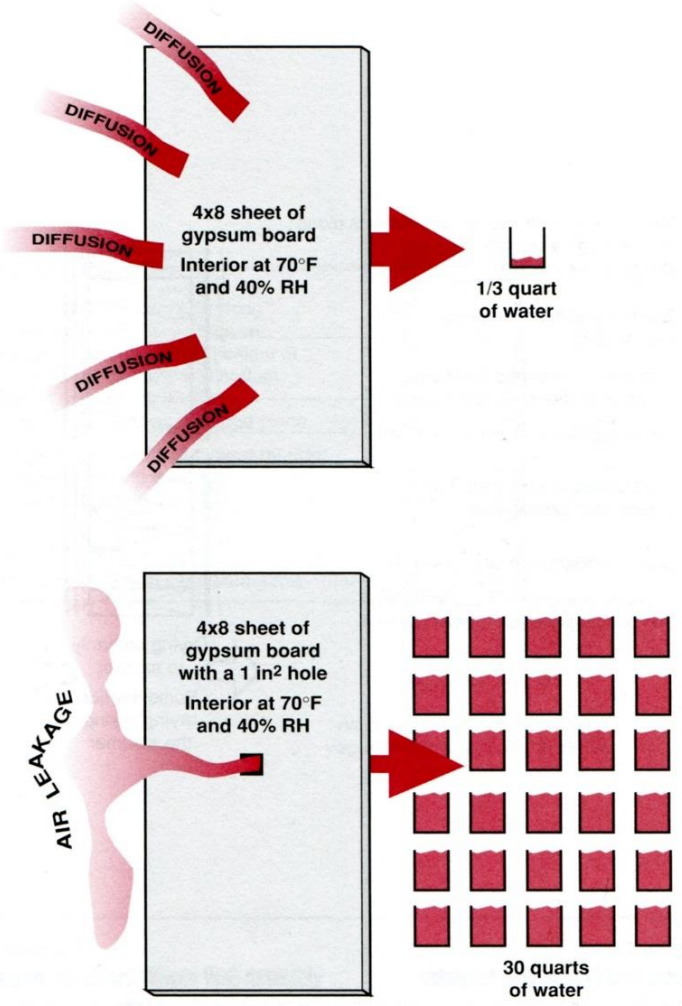
VAPOR CONTROL LAYER

The component or components that are designed and installed in an assembly to control the movement of water by vapor diffusion.

- Vapor diffusion is a linear process of moisture transport through a material
- “Continuity” of a Vapor Control Layer may be significantly dis-continuous (10% +) and still perform as a vapor control

Diffusion vs Air Leakage





THE BUILDING ENCLOSURE

THERMAL CONTROL LAYER

The component or components that are designed and installed in an assembly to control the transfer of thermal energy (heat). Typically, these are comprised of insulation products, radiant barriers, or trapped gaps filled with air or other gases.

- Interrupted by flashings, window and door openings, and other penetrations
- Understand the Impact of Thermal Bridging (see ASHRAE 90.1- Appendix A)

THE BUILDING ENCLOSURE

HISTORIC BUILDING ENCLOSURE

- Simpler building systems
- Fewer layers
- Master tradesmen
- Apprenticeship training
- Lower expectations?

https://en.wikipedia.org/wiki/Old_Stone_House_(Washington,_D.C.)#/media/File:Old_Stone_House_-_ca._1890.jpg

THE BUILDING ENCLOSURE

TODAY'S BUILDING ENCLOSURE

- Complex building materials
- Multi-layer construction / multiple trades
- Thinner construction
- Limited on-the-job training
- Higher expectations
- Schedule critical
- Cost sensitive

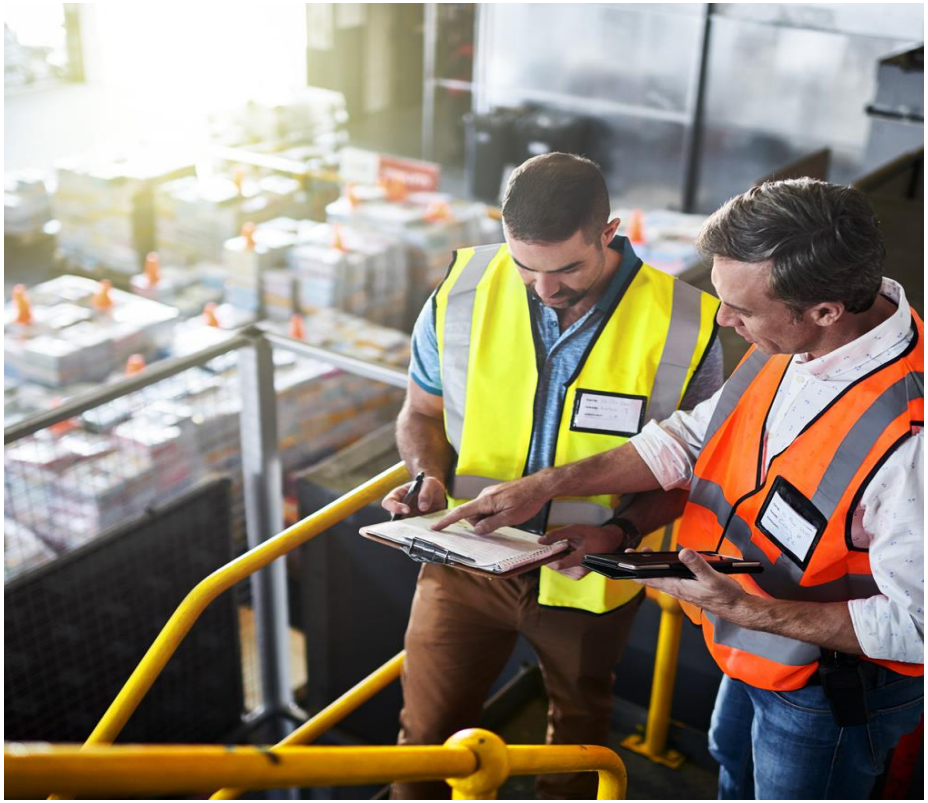
http://www.mgac.com/projects/house-of-sweden/33

THE BUILDING ENCLOSURE

WHY THE BUILDING ENCLOSURE

- Risk/lost/delay mitigation
- Avoid failure/lawsuit
- Occupant Comfort/Indoor Environmental Quality (IEQ)
- Load reduction/energy efficiency
- Chemical, Biological, Radiological (CBR) Security
- Blast resistance
- Maintenance and serviceability

ENERGY CODE COMPLIANCE PATHS



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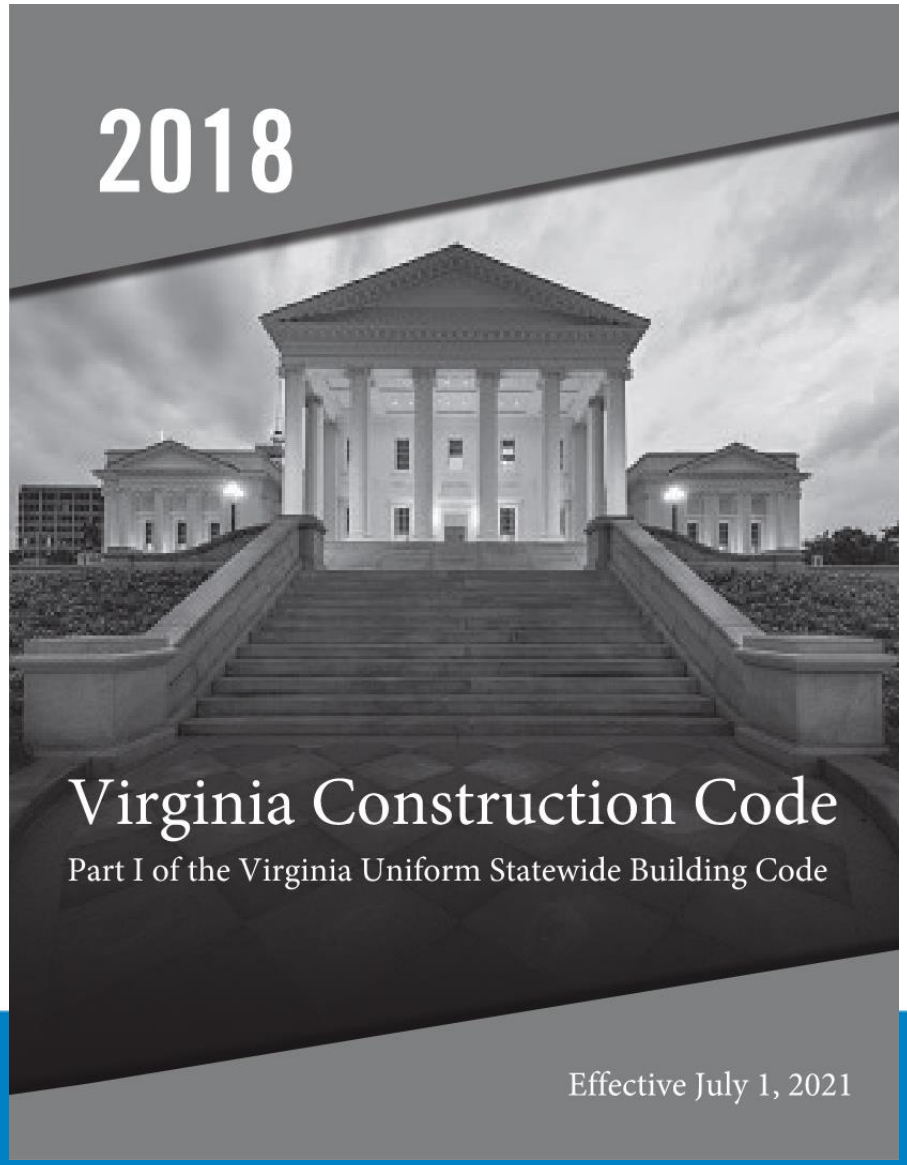
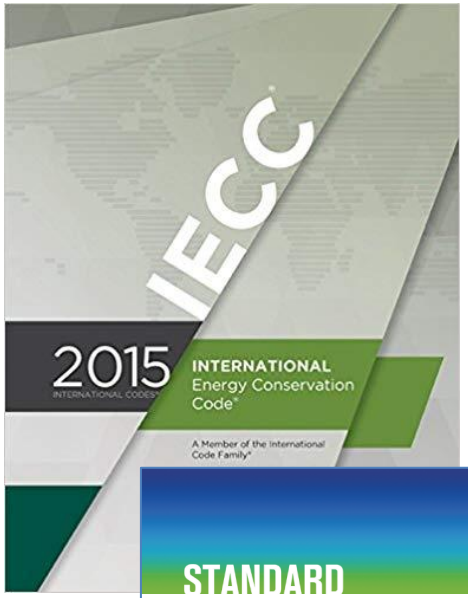
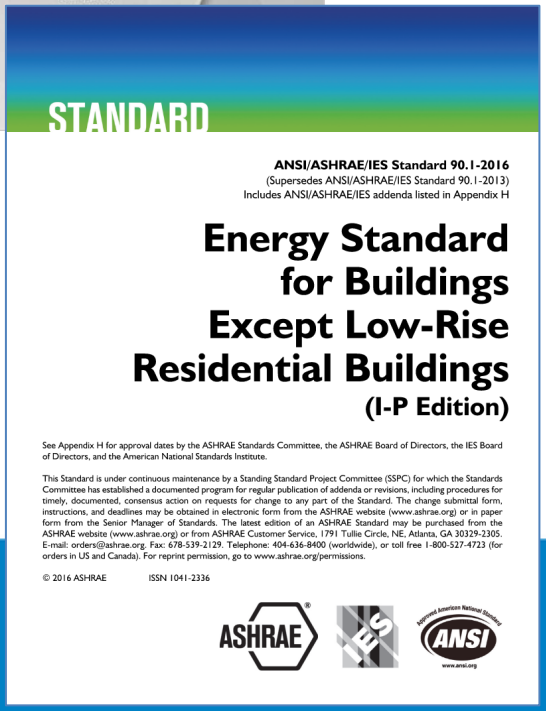
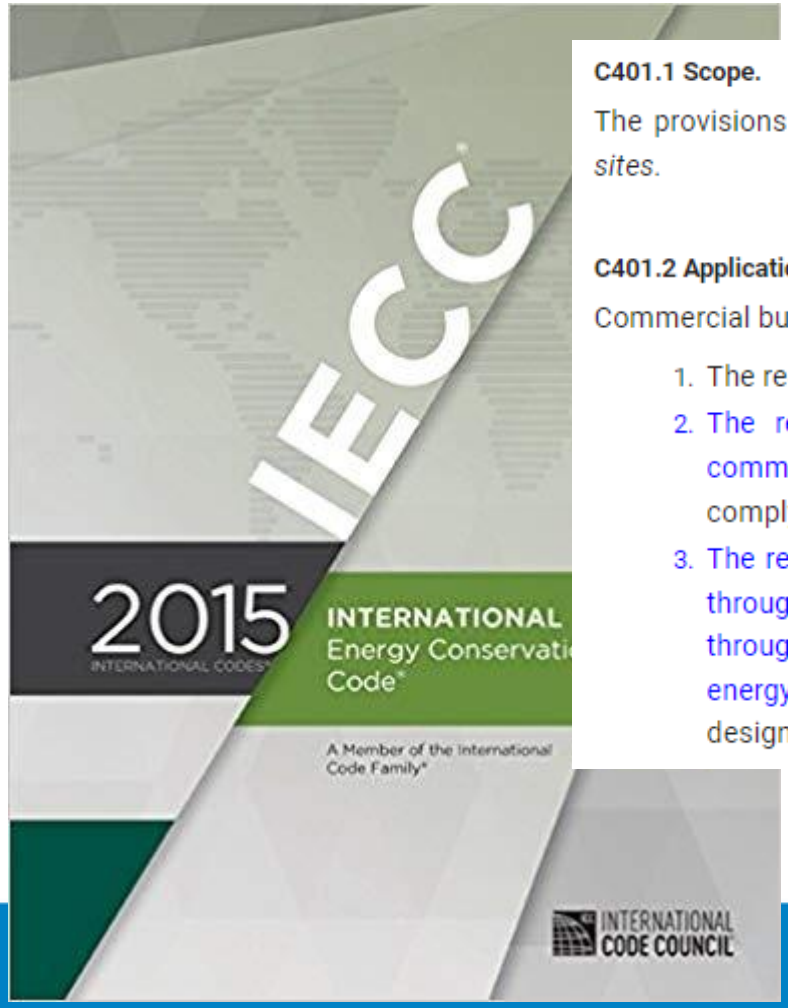






BUILDING THERMAL ENVELOPE

2018 INTERNATIONAL ENERGY CONSERVATION CODE



C401.1 Scope.

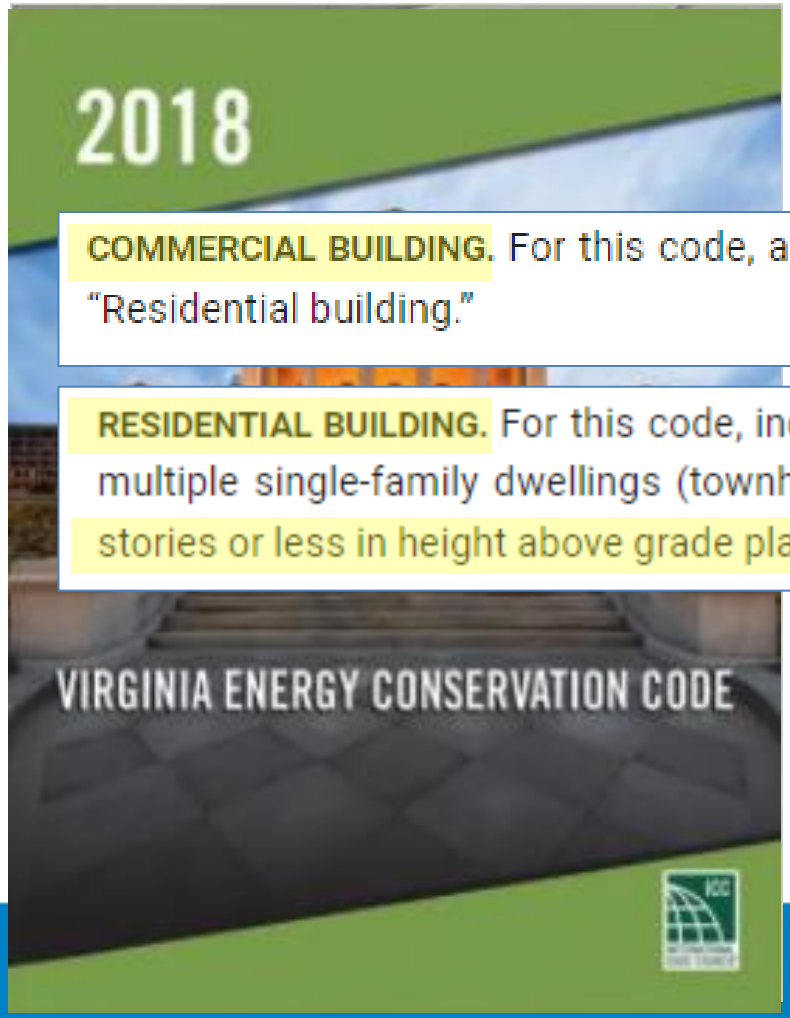
The provisions in this chapter are applicable to commercial *buildings* and their *building sites*.

C401.2 Application.

Commercial buildings shall comply with one of the following:

1. The requirements of ANSI/ASHRAE/IESNA 90.1.
2. The requirements of Sections C402 through C405 and C408. In addition, commercial buildings shall comply with Section C406 and tenant spaces shall comply with Section C406.1.1.
3. The requirements of Sections C402.5, C403.2, C403.3 through C403.3.2, C403.4 through C403.4.2.3, C403.5.5, C403.7, C403.8.1 through C403.8.4, C403.10.1 through C403.10.3, C403.11, C403.12, C404, C405, C407 and C408. The building energy cost shall be equal to or less than 85 percent of the standard reference design building.

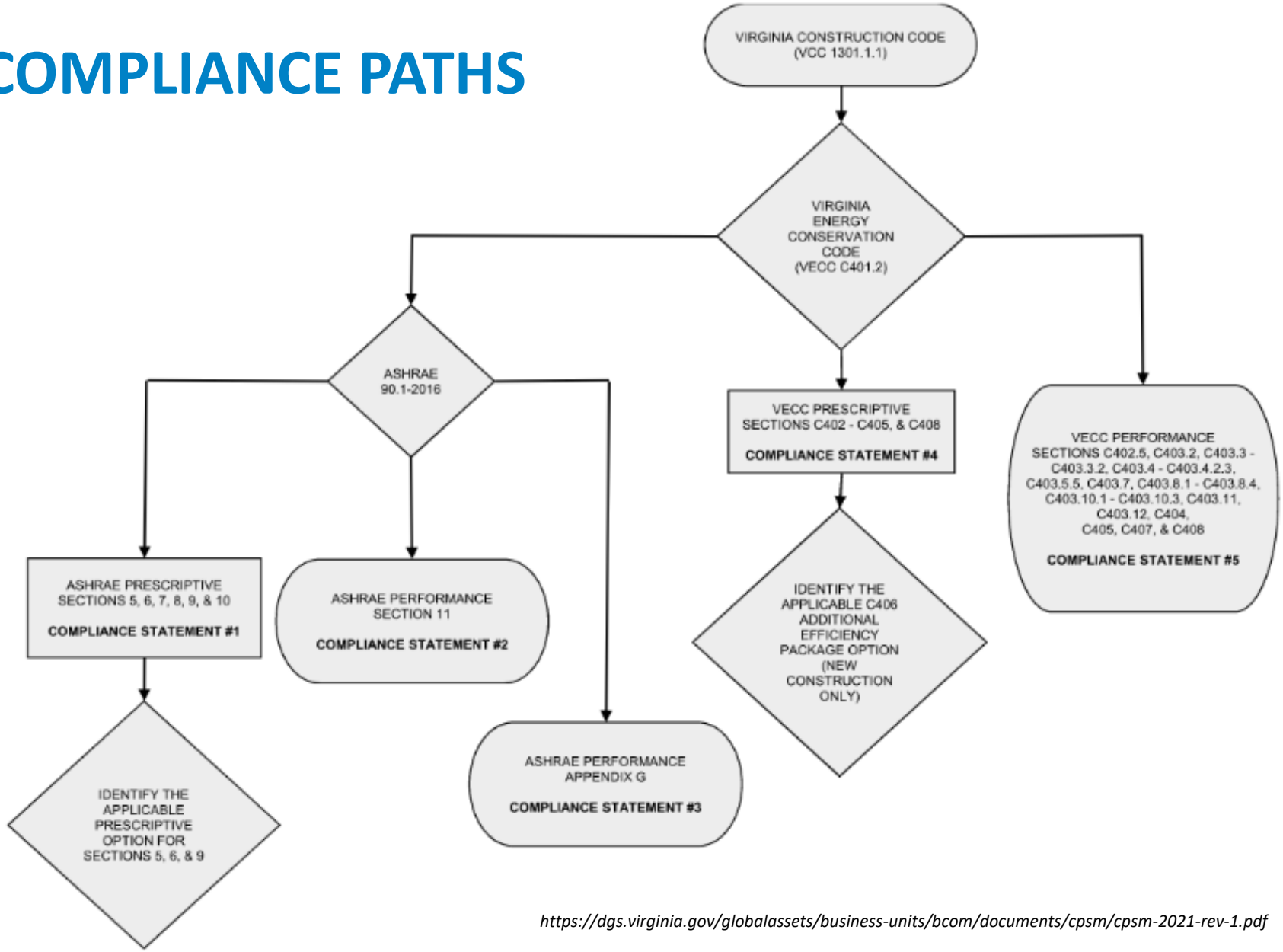
2018 INTERNATIONAL ENERGY CONSERVATION CODE



COMMERCIAL BUILDING. For this code, all buildings that are not included in the definition of "Residential building."

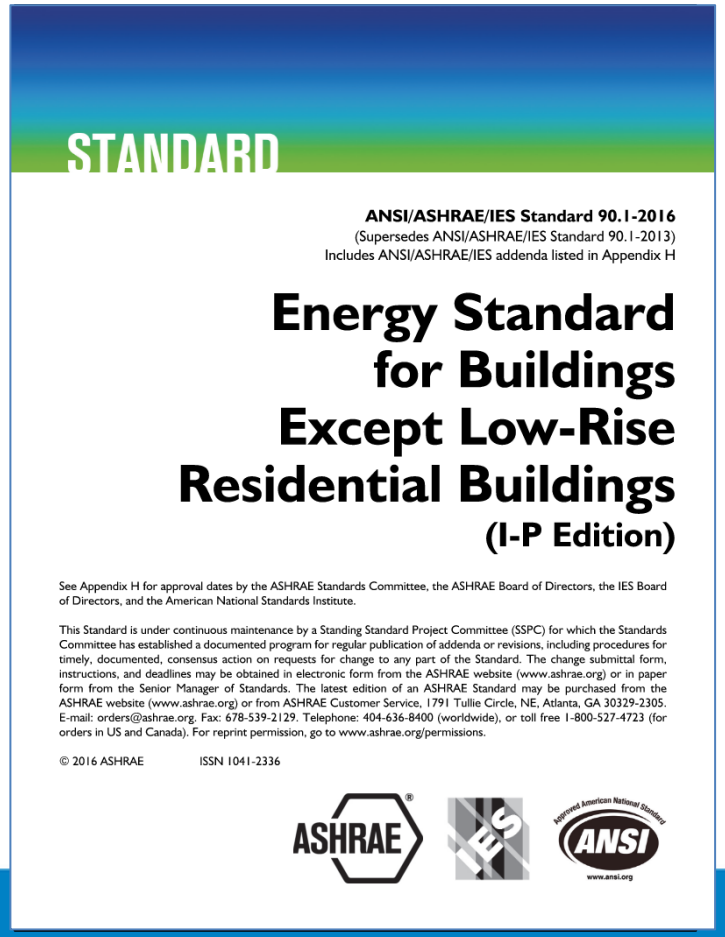
RESIDENTIAL BUILDING. For this code, includes detached one- and two-family dwellings and multiple single-family dwellings (townhouses) and *Group R*-2, R-3 and R-4 buildings three stories or less in height above grade plane.

COMPLIANCE PATHS



https://dgs.virginia.gov/globalassets/business-units/bcom/documents/cpsm/cpsm-2021-rev-1.pdf

ASHRAE 90.1-2016



STANDARD

ANSI/ASHRAE/IES Standard 90.1-2016
(Supersedes ANSI/ASHRAE/IES Standard 90.1-2013)
Includes ANSI/ASHRAE/IES addenda listed in Appendix H

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

See Appendix H for approval dates by the ASHRAE Standards Committee, the ASHRAE Board of Directors, the IES Board of Directors, and the American National Standards Institute.

This Standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the Standard. The change submittal form, instructions, and deadlines may be obtained in electronic form from the ASHRAE website (www.ashrae.org) or in paper form from the Senior Manager of Standards. The latest edition of an ASHRAE Standard may be purchased from the ASHRAE website (www.ashrae.org) or from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: orders@ashrae.org. Fax: 678-539-2129. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in US and Canada). For reprint permission, go to www.ashrae.org/permissions.

 ISSN 1041-2336

ASHRAE IES Approved American National Standard ANSI www.ansi.org

2. SCOPE

2.1 This standard provides:

a. minimum *energy*-efficient requirements for the design, *construction*, and a plan for operation and maintenance of:

1. new buildings and their *systems*
2. new portions of buildings and their *systems*
3. new *systems* and *equipment* in existing buildings
4. new *equipment* or building *systems* specifically identified in the standard that are part of industrial or manufacturing processes

b. criteria for determining compliance with these requirements.

2.2 The provisions of this standard do not apply to:

a. single-family houses, multi-family structures of three stories or fewer above *grade*, manufactured houses (mobile homes), and manufactured houses (modular), or

b. buildings that use neither electricity nor *fossil fuel*.

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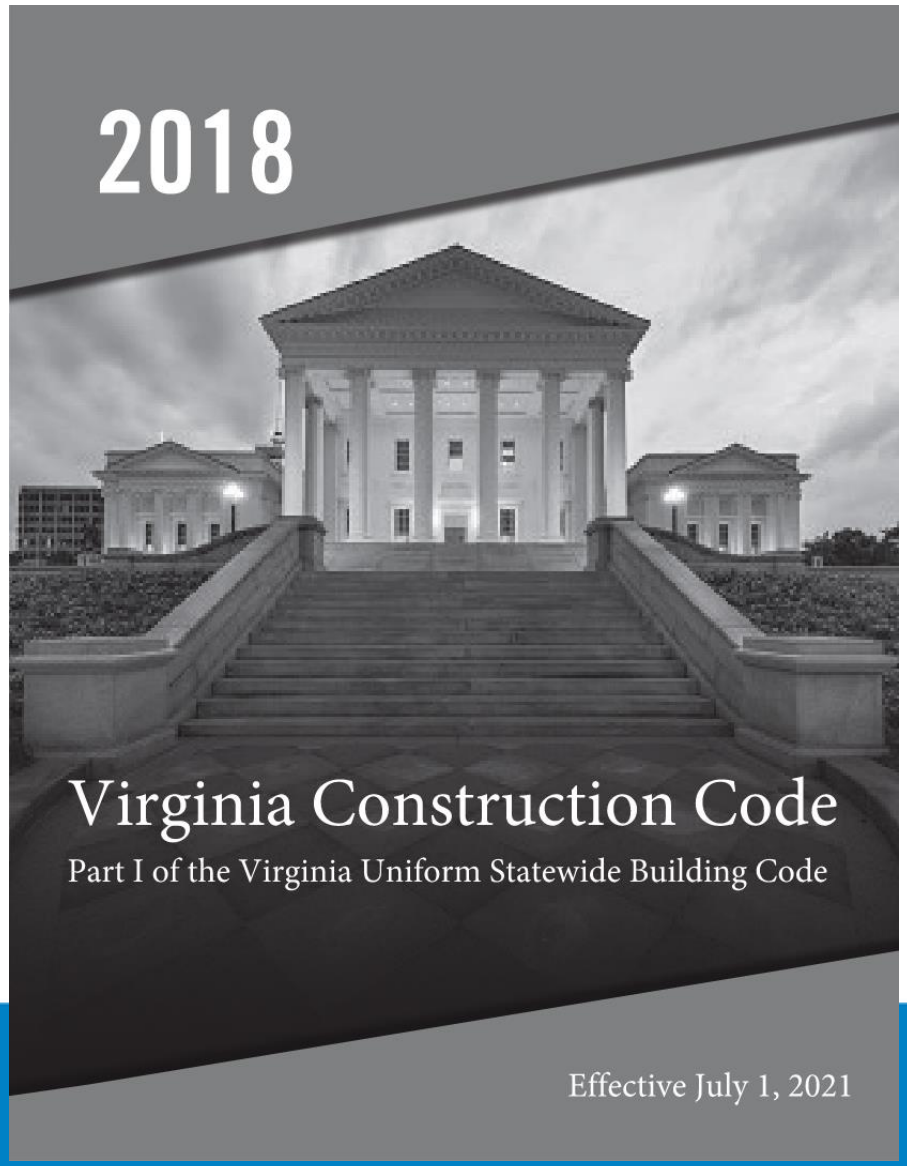
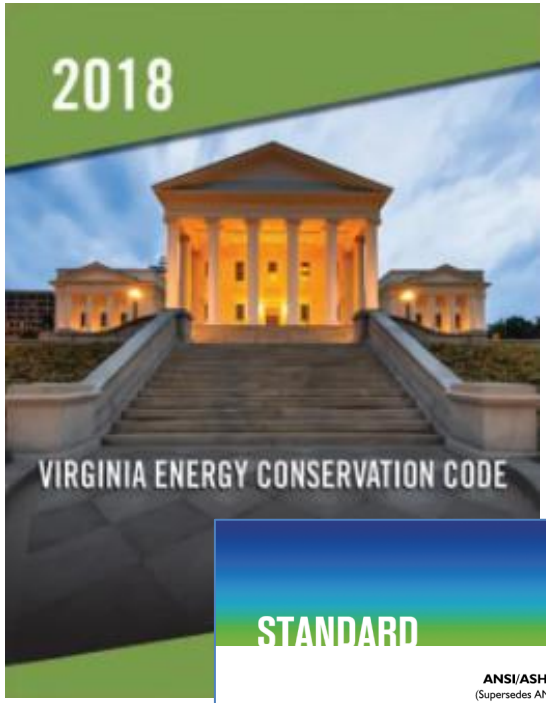
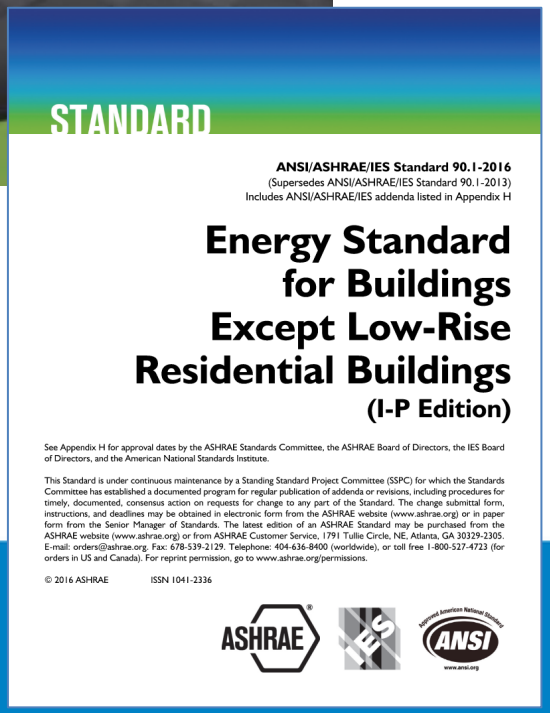
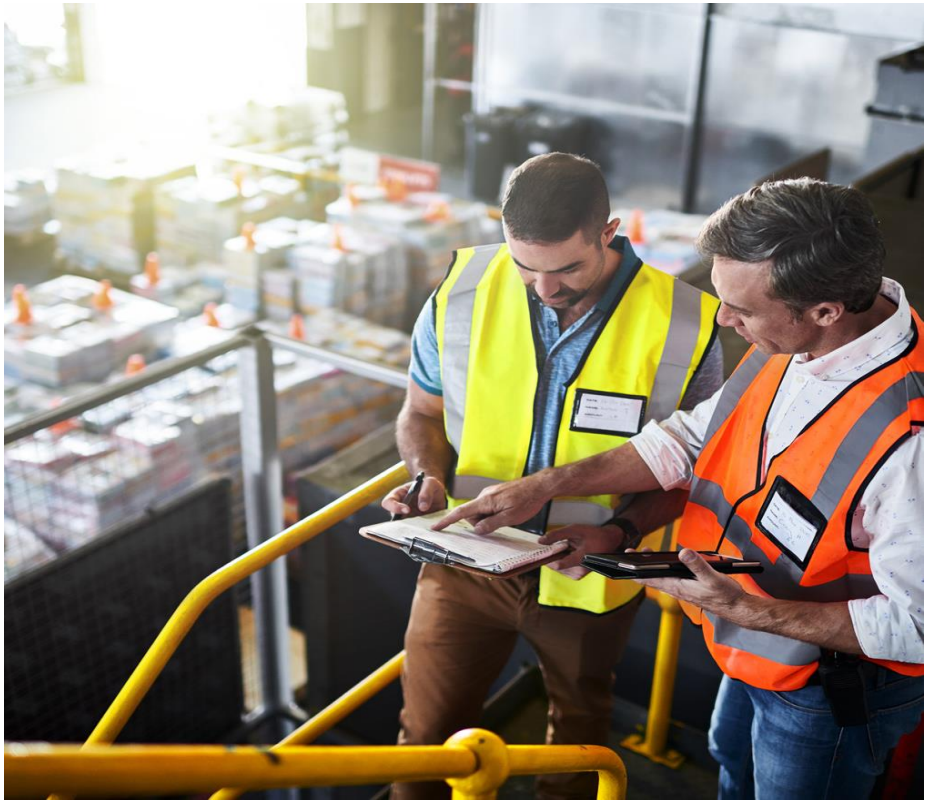


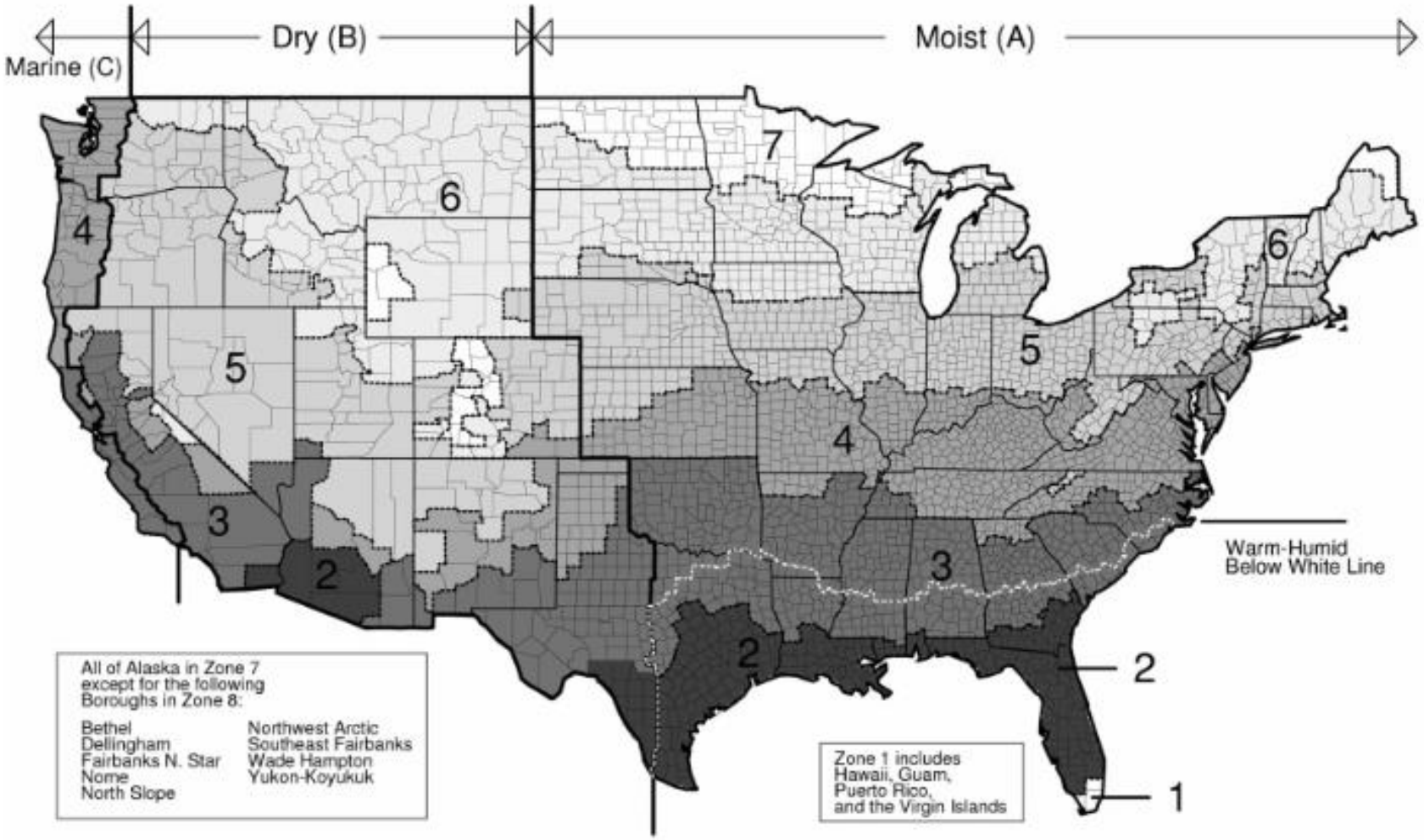




KNOW YOUR CLIMATE



CLIMATE ZONE – VIRGINIA & DC ARE 4a



CLIMATE ZONE – VIRGINIA and DC are 4a

TABLE C301.3(2)
INTERNATIONAL CLIMATE ZONE DEFINITIONS

ZONE NUMBER	THERMAL CRITERIA	
	IP Units	SI Units
1	9000 < CDD50°F	5000 < CDD10°C
2	6300 < CDD50°F ≤ 9000	3500 < CDD10°C ≤ 5000
3A and 3B	4500 < CDD50°F ≤ 6300 AND HDD65°F ≤ 5400	2500 < CDD10°C ≤ 3500 AND HDD18°C ≤ 3000
4A and 4B	CDD50°F ≤ 4500 AND HDD65°F ≤ 5400	CDD10°C ≤ 2500 AND HDD18°C ≤ 3000
3C	HDD65°F ≤ 3600	HDD18°C ≤ 2000
4C	3600 < HDD65°F ≤ 5400	2000 < HDD18°C ≤ 3000
5	5400 < HDD65°F ≤ 7200	3000 < HDD18°C ≤ 4000
6	7200 < HDD65°F ≤ 9000	4000 < HDD18°C ≤ 5000
7	9000 < HDD65°F ≤ 12600	5000 < HDD18°C ≤ 7000
8	12600 < HDD65°F	7000 < HDD18°C

For SI: °C = [(°F)-32]/1.8.

CLIMATE ZONE – VIRGINIA and DC are 4a

TABLE C301.3(1)
INTERNATIONAL CLIMATE ZONE DEFINITIONS

MAJOR CLIMATE TYPE DEFINITIONS
Marine (C) Definition—Locations meeting all four criteria: 1. Mean temperature of coldest month between -3°C (27°F) and 18°C (65°F). 2. Warmest month mean < 22°C (72°F). 3. At least four months with mean temperatures over 10°C (50°F). 4. Dry season in summer. The month with the heaviest precipitation in the cold season has at least three times as much precipitation as the month with the least precipitation in the rest of the year. The cold season is October through March in the Northern Hemisphere and April through September in the Southern Hemisphere.
Dry (B) Definition—Locations meeting the following criteria: Not marine and $P_{in} < 0.44 \times (TF - 19.5)$ [$P_{cm} < 2.0 \times (TC + 7)$ in SI units] where: P_{in} = Annual precipitation in inches (cm) T = Annual mean temperature in °F (°C)
Moist (A) Definition—Locations that are not marine and not dry.
Warm-humid Definition—Moist (A) locations where either of the following wet-bulb temperature conditions shall occur during the warmest six consecutive months of the year: 1. 67°F (19.4°C) or higher for 3,000 or more hours; or 2. 73°F (22.8°C) or higher for 1,500 or more hours.

For SI: °C = [(°F)-32]/1.8, 1 inch = 2.54 cm.

CLIMATE ZONE – ASHRAE DATA

RONALD REAGAN WASHINGTON NATL, VA, USA (WMO: 724050)

Lat:38.848N	Long:77.034W	Elev:3	StdP: 101.29	Time zone:-5.00	Period:90-14	WBAN:13743

Annual Heating and Humidification Design Conditions

Coldest Month	Heating DB		Humidification DP/MCDB and HR						Coldest month WS/MCDB				MCWS/PCWD to 99.6% DB	
			99.6%			99%			0.4%		1%			
	99.6%	99%	DP	HR	MCDB	DP	HR	MCDB	WS	MCDB	WS	MCDB	MCWS	PCWD
1	-7.8	-5.8	-18.9	0.7	-6.2	-16.5	0.9	-3.8	11.8	2.5	11.0	1.2	5.3	330

Annual Cooling, Dehumidification, and Enthalpy Design Conditions

Hottest Month	Hottest Month DB Range	Cooling DB/MCWB						Evaporation WB/MCDB						MCWS/PCWD to 0.4% DB	
		0.4%		1%		2%		0.4%		1%		2%			
		DB	MCWB	DB	MCWB	DB	MCWB	WB	MCDB	WB	MCDB	WB	MCDB	MCWS	PCWD
7	8.9	34.8	24.2	33.3	23.7	31.9	23.1	25.8	31.7	25.2	30.8	24.5	29.6	4.5	180

Dehumidification DP/MCDB and HR									Enthalpy/MCDB						Extreme Max WB
0.4%			1%			2%			0.4%		1%		2%		
DP	HR	MCDB	DP	HR	MCDB	DP	HR	MCDB	Enth	MCDB	Enth	MCDB	Enth	MCDB	
24.3	19.2	28.4	23.6	18.4	27.8	22.9	17.7	27.3	79.5	31.9	76.5	30.8	73.9	29.7	29.4

Extreme Annual Design Conditions

Extreme Annual WS				Extreme Annual Temperature				n-Year Return Period Values of Extreme Temperature							
				Mean		Standard deviation		n=5 years		n=10 years		n=20 years		n=50 years	
1%	2.5%	5%		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
10.4	8.9	8.1	DB	-10.7	37.0	3.0	1.8	-12.8	38.3	-14.5	39.3	-16.2	40.4	-18.4	41.7
			WB	-12.2	27.2	2.7	1.0	-14.2	28.0	-15.7	28.6	-17.2	29.2	-19.2	29.9

Monthly Climatic Design Conditions

		Annual	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temperatures, Degree-Days and Degree-Hours	DBAvg	14.8	2.9	4.1	8.4	14.1	19.1	24.1	26.7	25.8	21.8	15.5	9.7	4.9
	DBStd	9.34	5.30	4.83	5.10	4.53	4.05	3.32	2.68	2.57	3.59	4.26	4.47	4.53
	HDD10.0	739	228	172	93	13	0	0	0	0	0	5	60	168
	HDD18.3	2167	479	398	311	142	41	2	0	0	10	108	260	416
	CDD10.0	2495	7	8	42	136	281	423	517	489	355	176	51	11
	CDD18.3	882	0	0	2	14	63	176	258	231	115	21	1	0
	CDH23.3	7869	0	0	21	134	497	1552	2653	2114	780	114	3	0
	CDH26.7	2989	0	0	4	34	153	587	1149	812	230	22	0	0
Wind	WSAvg	3.9	4.3	4.3	4.6	4.4	4.0	3.8	3.6	3.4	3.6	3.7	3.9	4.0
Precipitation	PrecAvg	981	69	69	80	69	93	86	96	99	84	77	79	79
	PrecMax	1315	181	143	140	136	173	293	240	233	314	197	170	166
	PrecMin	725	31	11	37	20	30	28	17	9	5	29	11	11
	PrecStd	159	40	42	30	31	37	68	60	61	74	48	47	44
Monthly Design Dry Bulb and Mean Coincident Wet Bulb Temperatures	0.4% DB	19.0	20.6	26.4	30.2	32.9	35.7	37.3	35.7	33.7	29.4	23.4	20.2	
	0.4% MCWB	14.1	13.5	17.2	19.2	23.3	24.3	25.1	24.4	22.9	21.2	16.6	15.3	
	2% DB	15.8	16.8	21.7	27.2	30.3	33.4	35.3	34.0	31.2	26.3	20.6	16.5	
	2% MCWB	12.7	11.6	14.4	17.6	21.5	23.5	24.3	24.2	22.4	20.0	15.7	13.4	
	5% DB	13.0	13.8	19.0	24.3	28.2	31.7	33.7	32.3	29.2	24.1	18.6	14.0	
	5% MCWB	10.1	8.6	13.0	16.6	20.7	22.8	24.1	23.4	21.6	18.6	14.7	11.3	
	10% DB	10.1	11.2	16.3	21.8	26.2	30.1	32.1	30.8	27.6	22.2	16.7	11.4	
	10% MCWB	6.8	7.4	11.0	15.4	19.4	22.3	23.5	22.7	21.0	17.5	13.0	8.3	

Example: DCA (Regan National)

- 99.6% Heating DB = 17.9 dF
- 99% Heating DB = 21.6 dF
- Avg Temp Coldest Month = 37.2 dF (Jan)
- PrecAvg = 38.6”
- HDD65 = 3901
- Climate Zone 4A (Cold-Wet)

Figure 1: Hygrothermal regions

Legend

Subarctic/Arctic

A subarctic and arctic climate is defined as a region with approximately 12,600 heating degree days (65 F basis) or greater

Very Cold

A very cold climate is defined as a region with approximately 9,000 heating degree days (65 F basis) or greater and less than approximately 12,600 heating degree days (65 F basis)

Cold

A cold climate is defined as a region with approximately 5,400 heating degree days (65 F basis) or greater and less than approximately 9,000 heating degree days (65 F basis)

Mixed-Humid

A mixed-humid climate is defined as a region that receives more than 20 inches of annual precipitation, has approximately 5,400 heating degree days (65 F basis) or less, and where the monthly average outdoor temperature drops below 45 F during the winter months

Hot-Humid

A hot-humid climate is defined as a region that receives more than 20 inches of annual precipitation and where one or both of the following occur:

- a 67 F or higher wet bulb temperature for 3,000 or more hours during the warmest six consecutive months of the year; or
- a 73 F or higher wet bulb temperature for 1,500 or more hours during the warmest six consecutive months of the year[1]

Hot-Dry

A hot-dry climate is defined as a region that receives less than 20 inches of annual precipitation and where the monthly average outdoor temperature remains above 45 F throughout the year

Mixed-Dry

A mixed-dry climate is defined as a region that receives less than 20 inches of annual precipitation, has approximately 5,400 heating degree days (50 F basis) or less, and where the monthly average outdoor temperature drops below 45 F during the winter months

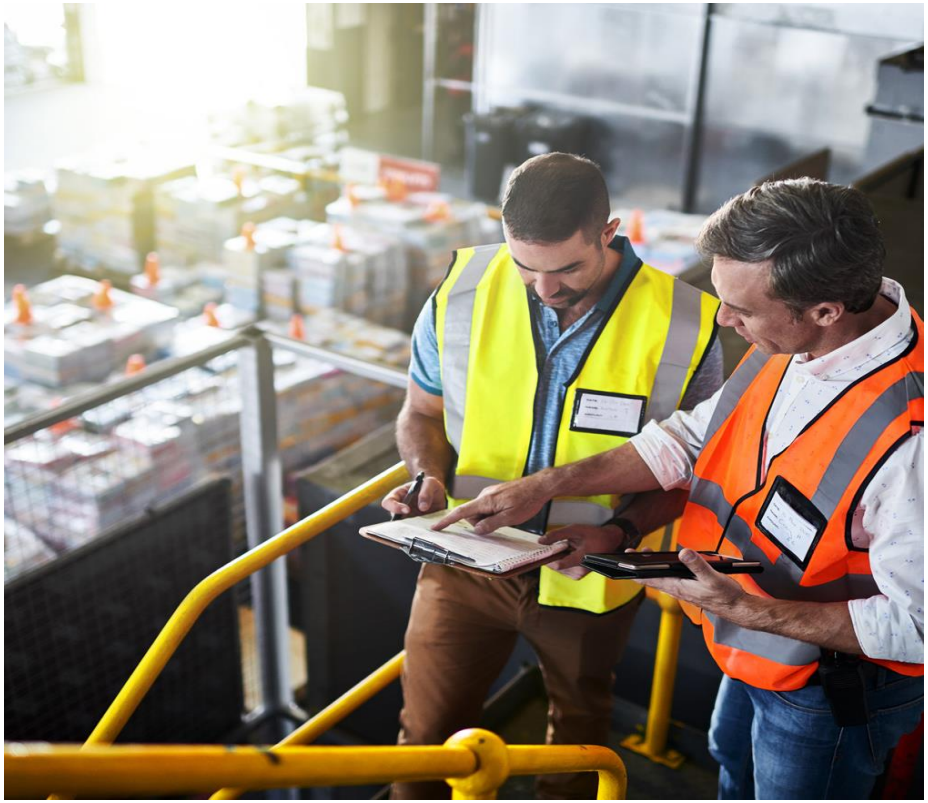
Marine

A marine climate meets all of the following criteria:

- A mean temperature of coldest month between 27 F and 65 F
- A warmest month mean of less than 72 F
- At least four months with mean temperatures over 50 F
- A dry season in summer. The month with the heaviest precipitation in the cold season has at least three times as much precipitation as the month with the least precipitation in the rest of the year. The cold season is October through March in the Northern Hemisphere and April through September in the Southern Hemisphere.

[1] These last two criteria are identical to those used in the ASHRAE definition of warm-humid climates and are very closely aligned with a region where the monthly average outdoor temperature remains above 45 F throughout the year.

CHOOSE YOUR COMPLIANCE PATH



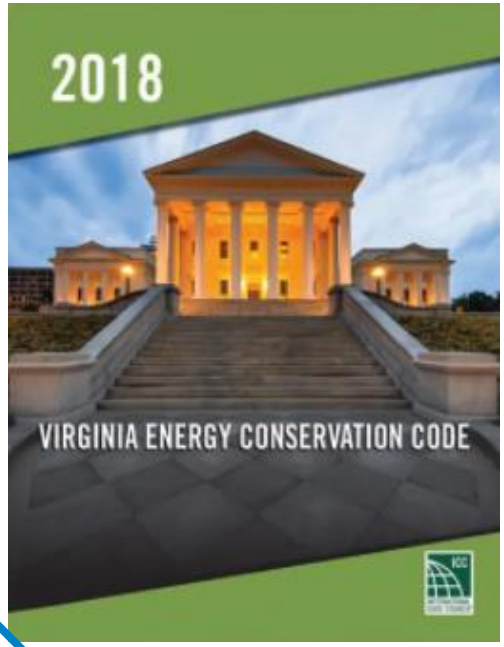
COMPLY WITH THE IECC

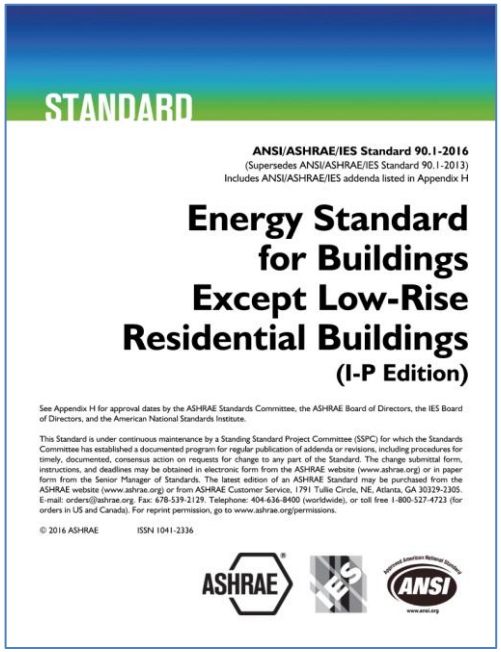
SECTION C401
GENERAL

C401.1 Scope. The requirements contained in this chapter are applicable to commercial buildings, or portions of commercial buildings.

C401.2 Application. Commercial buildings shall comply with one of the following:

1. The requirements of ANSI/ASHRAE/IESNA 90.1.
2. The requirements of Sections C402, C403, C404 and C405. In addition, commercial buildings shall comply with either Section C406.2, C406.3 or C406.4.
3. The requirements of Section C407, C402.4, C403.2, C404, C405.2, C405.3, C405.4, C405.6 and C405.7. The building energy cost shall be equal to or less than 85 percent of the standard reference design building.





4.2 Compliance

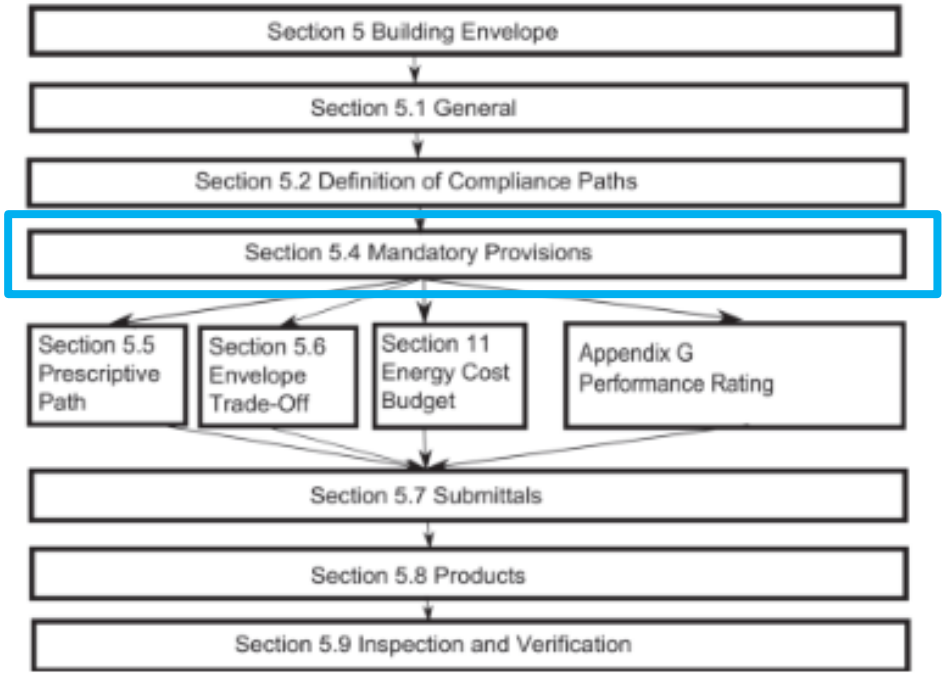
4.2.1 Compliance Paths

4.2.1.1 New Buildings. New buildings shall comply with either the provisions of Sections 5, 6, 7, 8, 9, and 10 or Section 11.

COMPLY WITH THE IECC (ASHRAE 90.1)

ASHRAE 90.1-2016 (5.4)

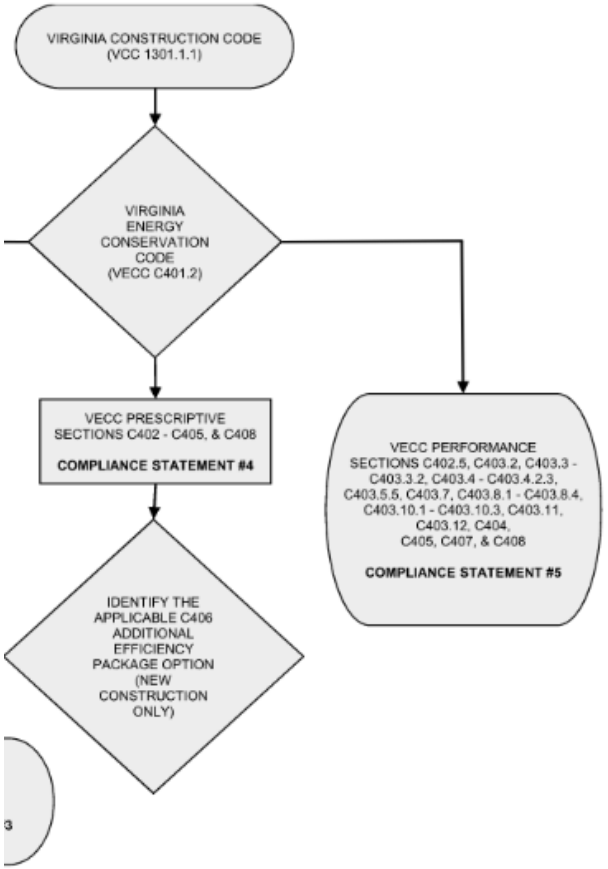
- **Continuous air barrier**
  - **Design (section 5.4.3.1.1)**
    - **noted on construction documents, detailed, and designed to resist positive and negative pressures**
  - **Construction/Installation (5.4.3.1.2)**
    - **Joints, Junctions, penetrations, etc.**
- **Testing, Acceptable Materials, and Assemblies**
  - **Whole Building Pressurization (**Section 5.4.3.1.3(a) - ASTM E779 or E1827**)**
    - In case of failure, diagnostic testing option for compliance
    - Options for large building testing
  - **90.1-2016 Continuous Air Barrier Requirements** (Section 5.4.3.1.3(b)and(c)
    - Materials (0.004 cfm/ft^2) or Assemblies (0.04 cfm/ft^2)



COMPLY WITH THE IECC

2015 IECC (C402.5)

- Compliance through testing in accordance with ASTM E779 and also comply with:
  - C402.5.5 - Air intakes, exhaust openings, stairways and shafts
  - C402.5.6 - Loading dock weather seals
  - C402.5.7 - Vestibules
- Compliance with Sections C402.5.1 through C402.5.8
  - Air Barrier Construction
  - Materials (0.004 cfm/ft^2) or Assemblies (0.04 cfm/ft^2)
  - Fenestration, openings, etc.



THERMAL ENVELOPE

BUILDING THERMAL ENVELOPE

BUILDING THERMAL ENVELOPE. The basement walls, exterior walls, floor, roof and any other building elements that enclose *conditioned space* or provide a boundary between *conditioned space* and exempt or unconditioned space.

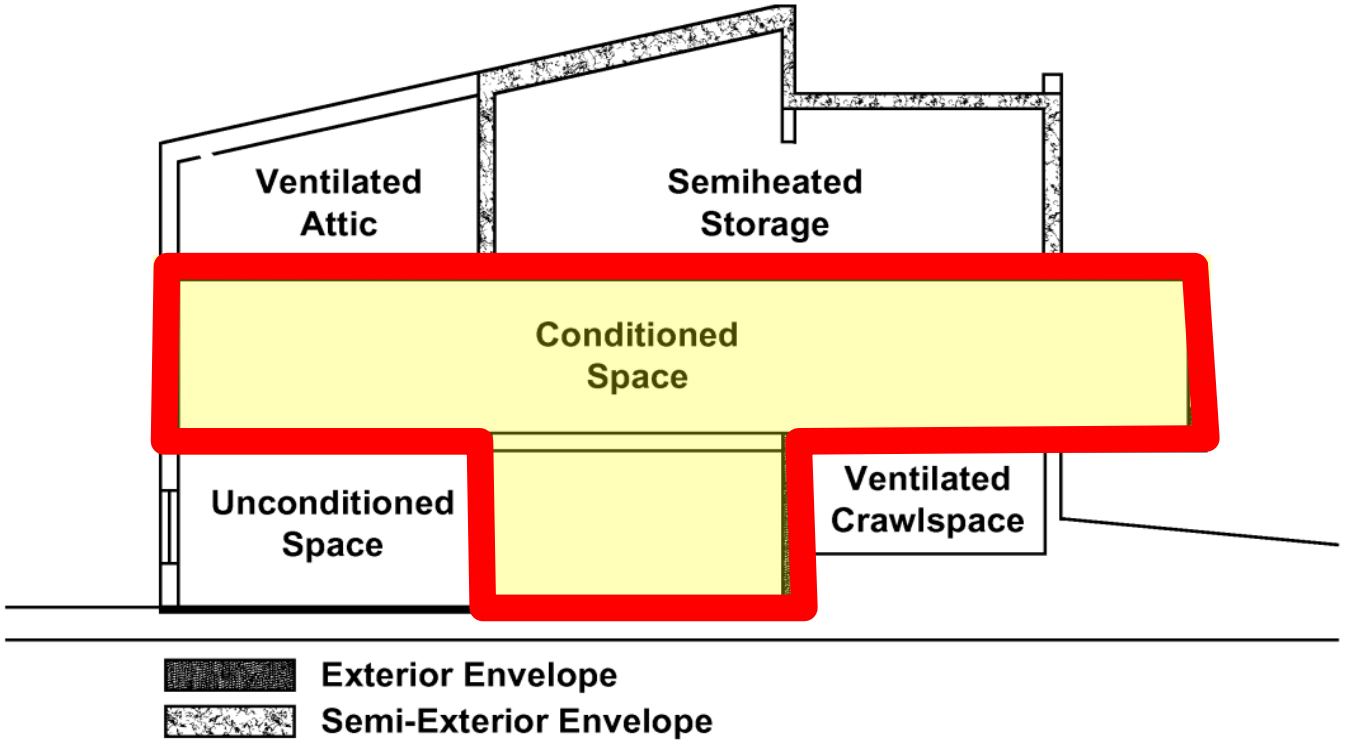


Figure 5.5.2 Exterior and *semiexterior building envelope*.

BUILDING THERMAL ENVELOPE

BUILDING THERMAL ENVELOPE. The basement walls, exterior walls, floor, roof and any other building elements that enclose *conditioned space* or provide a boundary between *conditioned space* and exempt or unconditioned space.

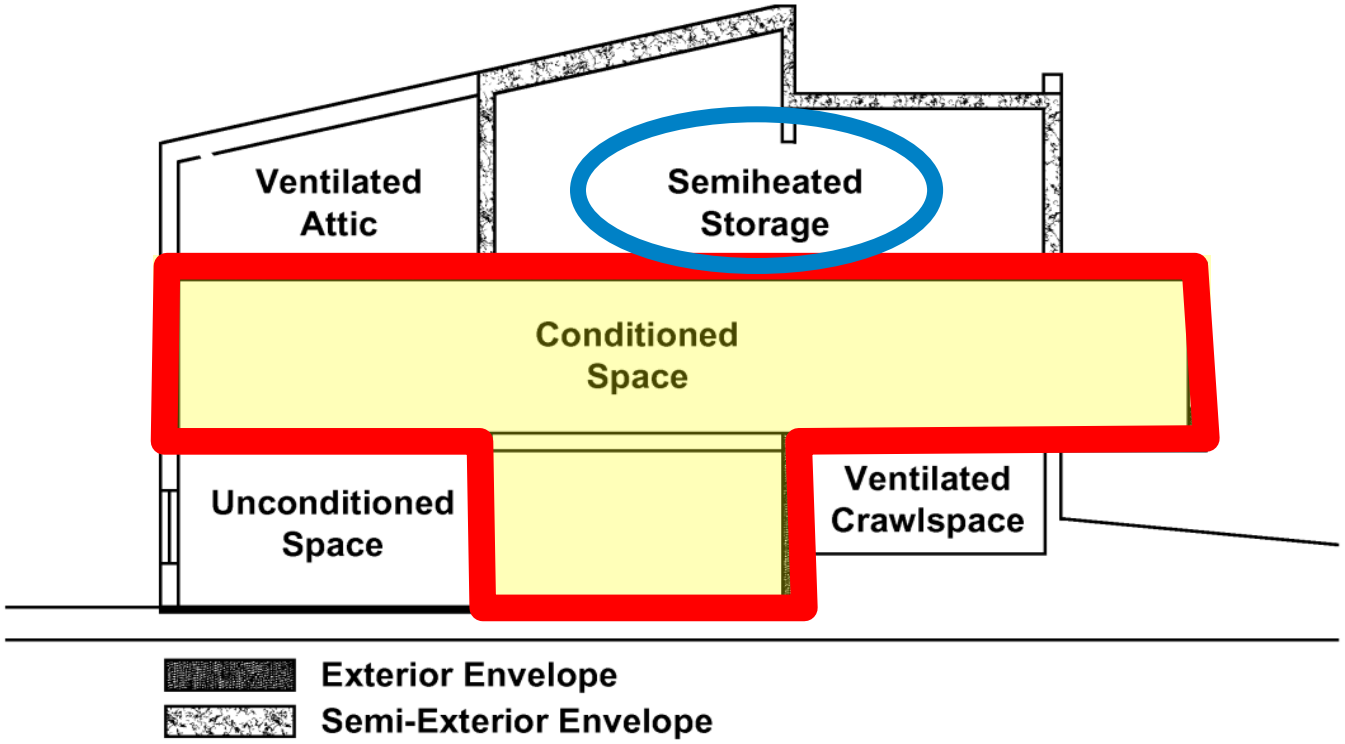


Figure 5.5.2 Exterior and *semiexterior building envelope*.

BUILDING THERMAL ENVELOPE

CONDITIONED SPACE. An area, room or space that is enclosed within the building thermal envelope and is directly or indirectly heated or cooled. Spaces are indirectly heated or cooled where they communicate through openings with conditioned spaces, where they are separated from conditioned spaces by uninsulated walls, floors or ceilings, or where they contain uninsulated ducts, piping or other sources of heating or cooling.

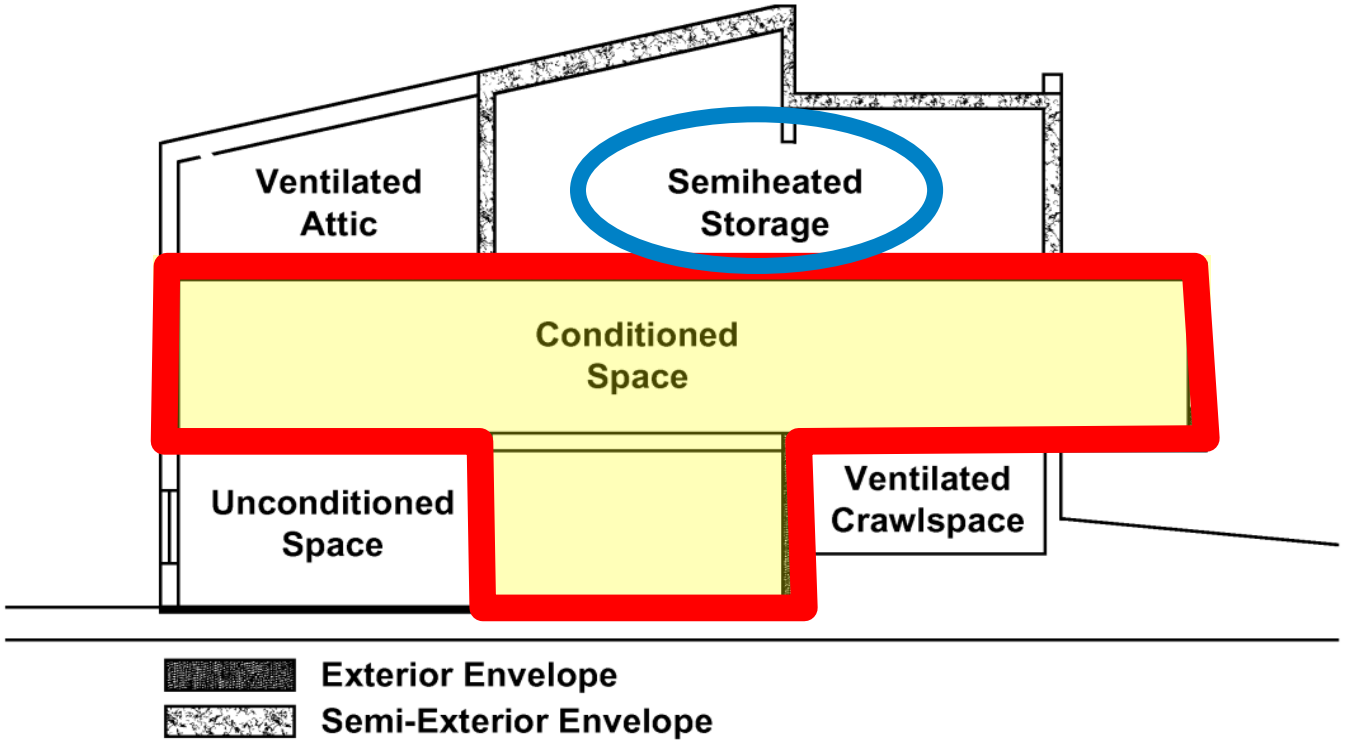


Figure 5.5.2 Exterior and *semiexterior building envelope*.

BUILDING THERMAL ENVELOPE

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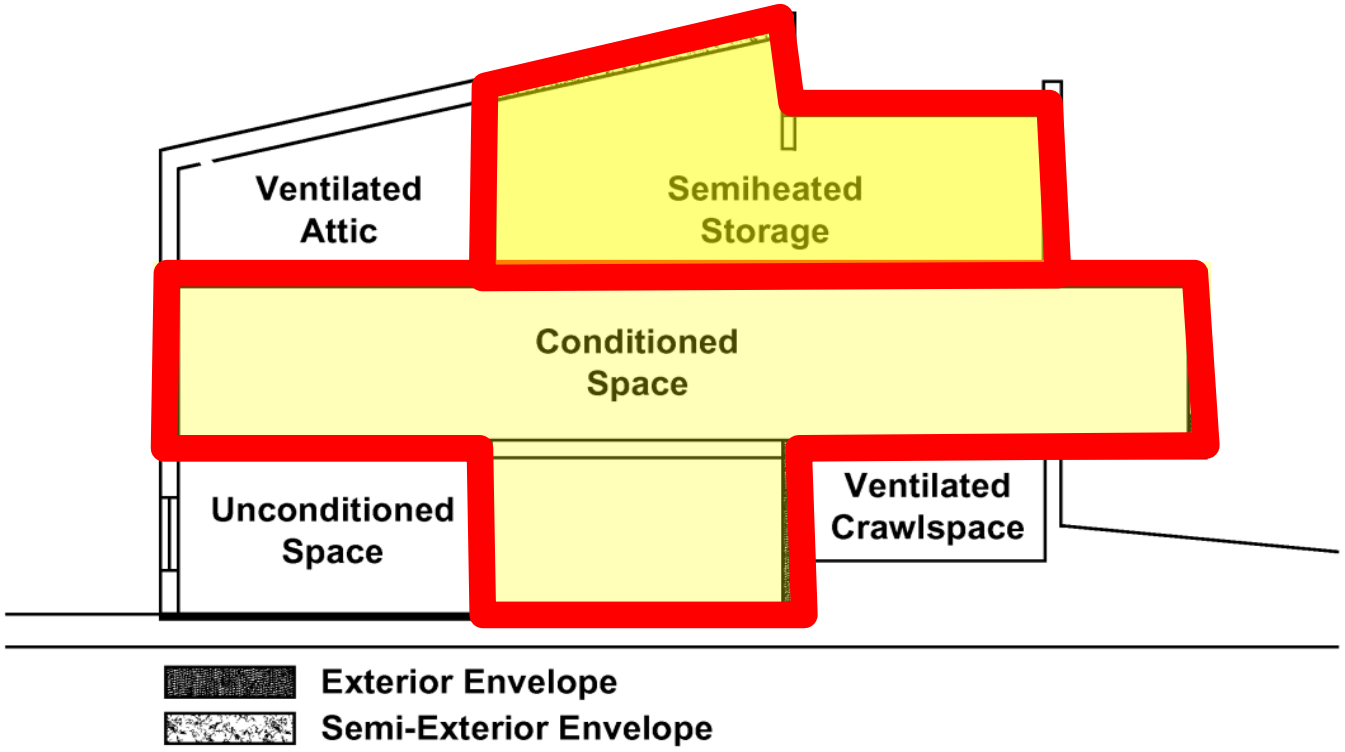
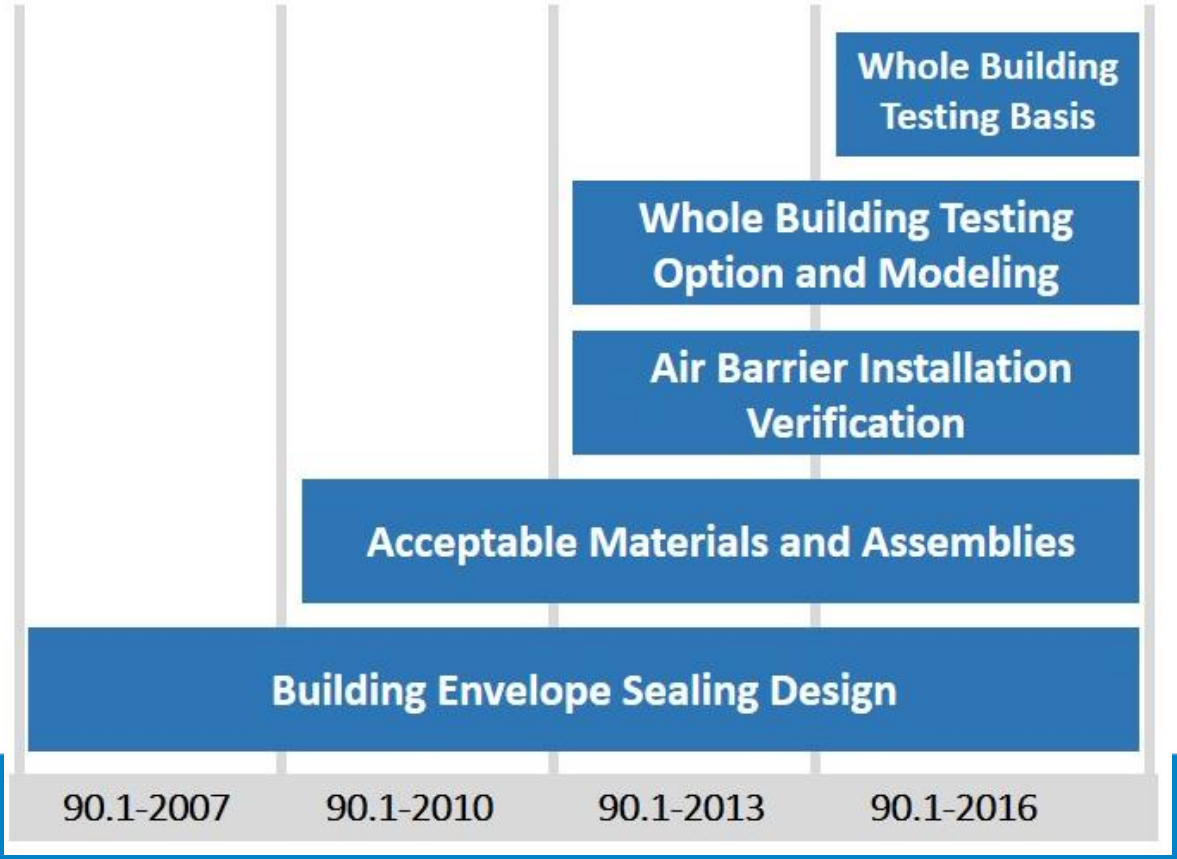


Figure 5.5.2 Exterior and *semiexterior building envelope*.

Air Barrier

CONTINUOUS AIR BARRIER REQUIREMENTS IN ASHRAE STANDARD 90.1 OVERTIME



ASHRAE 90.1 - INSPECTIONS

ASHRAE 90.1-2016 (4.24)

- As required by the *building official*

ASHRAE 90.1-2016 (5.9.1)

- Fenestration
- Opaque Assemblies

ASHRAE 90.1 - Verifications

ASHRAE 90.1-2016 (5.9.2)

- Air barrier design and verification
  - Design Review
  - Periodic Field Inspections
- Whole Building Air Leakage (5.4.3.1.3a)

AIR INFILTRATION RESISTANCE

Materials

- **ASTM E2178**
- 0.004 cfm/sq.ft. @75 Pa

Assemblies

Whole Building

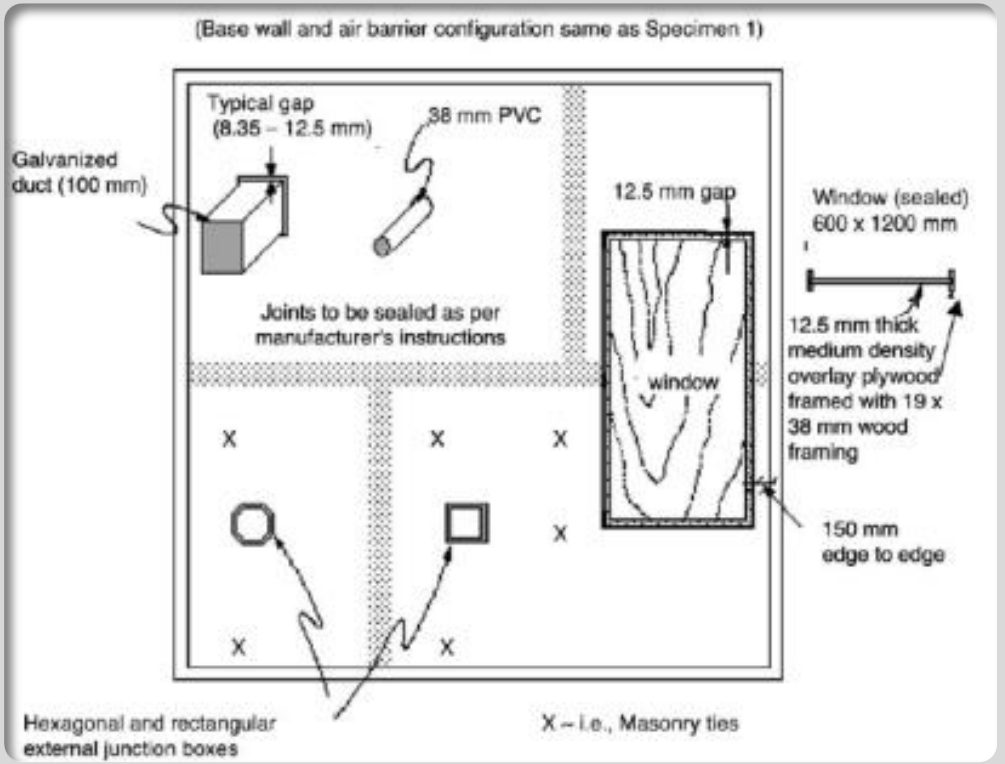
AIR INFILTRATION RESISTANCE

Materials

Assemblies

- **ASTM E2357** (*or* E1677)
- 0.04 cfm/sq.ft. @75 Pa

Whole Building



AIR INFILTRATION RESISTANCE

Materials

Assemblies

Whole Building

- **ASTM E779**
- 0.4 cfm/sq.ft.@75 Pa

(a) pressurize

(b) Infrared thermogram

(c) Smoke test

Photos courtesy Pie Forensic Consultants

BUILDING THERMAL ENVELOPE

Materials

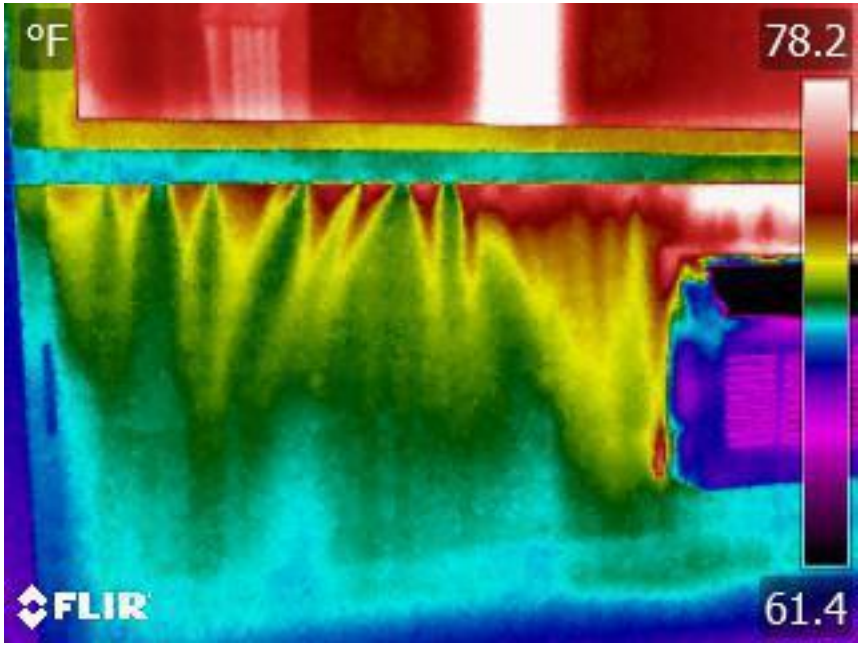
Assemblies

Whole Building

Air Infiltration Requirements [cfm/ft^2 @ 0.3 in w.g., 75Pa]	**Materials** (ASTM E2178)	**Assemblies** (ASTM E2357 or E1677)	**Whole Building** (ASTM E779)
ASHRAE 90.1 (2013)	**0.004**	**0.04**	**0.4**
USACE(2008); **NAVFAC** (2011)	**0.004**	**--**	**0.25**
Washington State (2010)	**0.004**	**--**	**0.25**
GSA (2010) **USAF** (2011)	**0.004**	**0.04**	**0.40**
I**ECC** (2018)	**0.004**	**0.04**	**0.40**
IgCC (2018)	--	**--**	**0.25**

Abbreviations: ASHRAE – American Society of Heating, Refrigeration and air Conditioning Engineers; USACE - US Army Corps of Engineers; GSA - General Services Administration; NAVFAC - Naval Facilities Engineering Command; USAF- United States Air Force; IgCC – International Green Construction Code

ASTM E1186 (4.2.2) Infrared



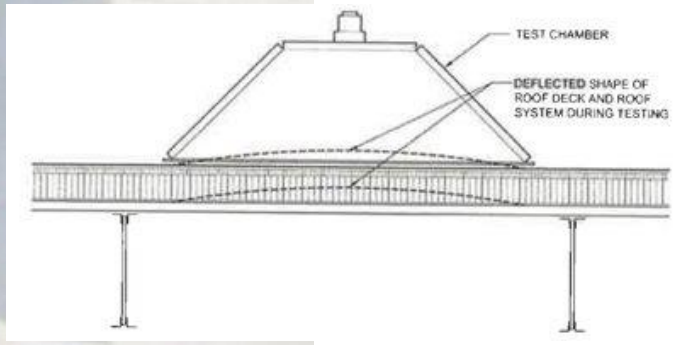
ASTM E1186 (4.2.6) – “Smoke Tracer”

ASTM E1186 (4.2.7) “ Bubble Gun”

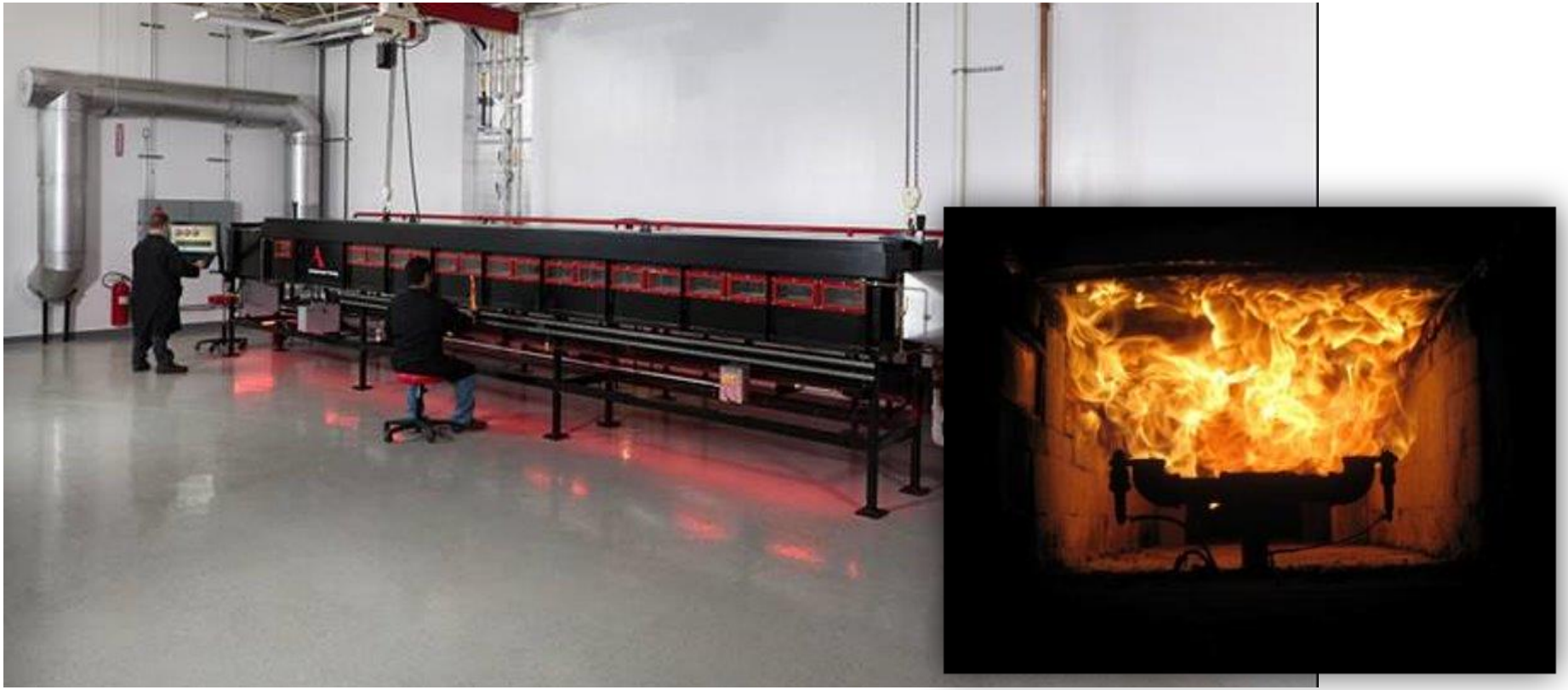
ASTM E1186 (4.2.7) “ Bubble Gun”

ASTM D4541 (4.2.7) Adhesion Testing

ASTM E907/FM 1-52 Roof Uplift Testing



ASTM E84 “Steiner Tunnel”



NFPA 285 Vertical and Lateral Flame Spread

- A **"reduced scale"** at 16ft tall
- Simulates **"flash over"**
- An **Assembly Test**
  - This is important!
  - Includes multiple specific and necessary materials
  - Includes details in compliant specimen
  - Details in the specimen may or may not match "manufacturers standard" details.

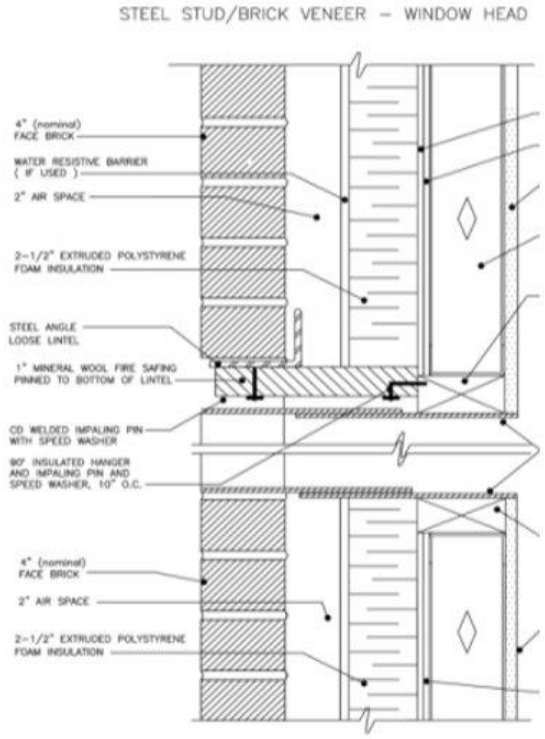
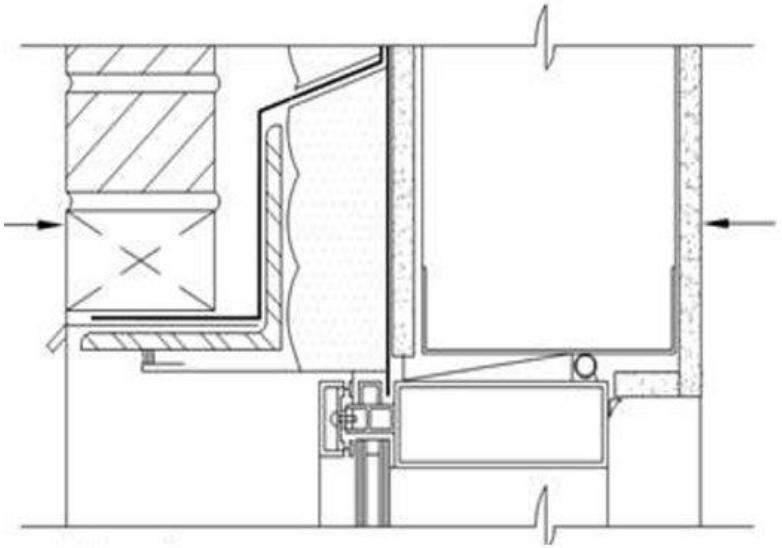


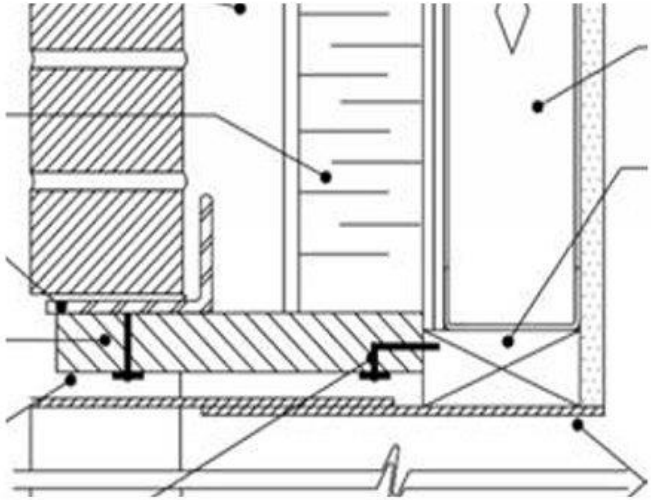
Figure 1 – Window / Door Opening Detai

NFPA 285 Vertical and Lateral Flame Spread

Product Literature

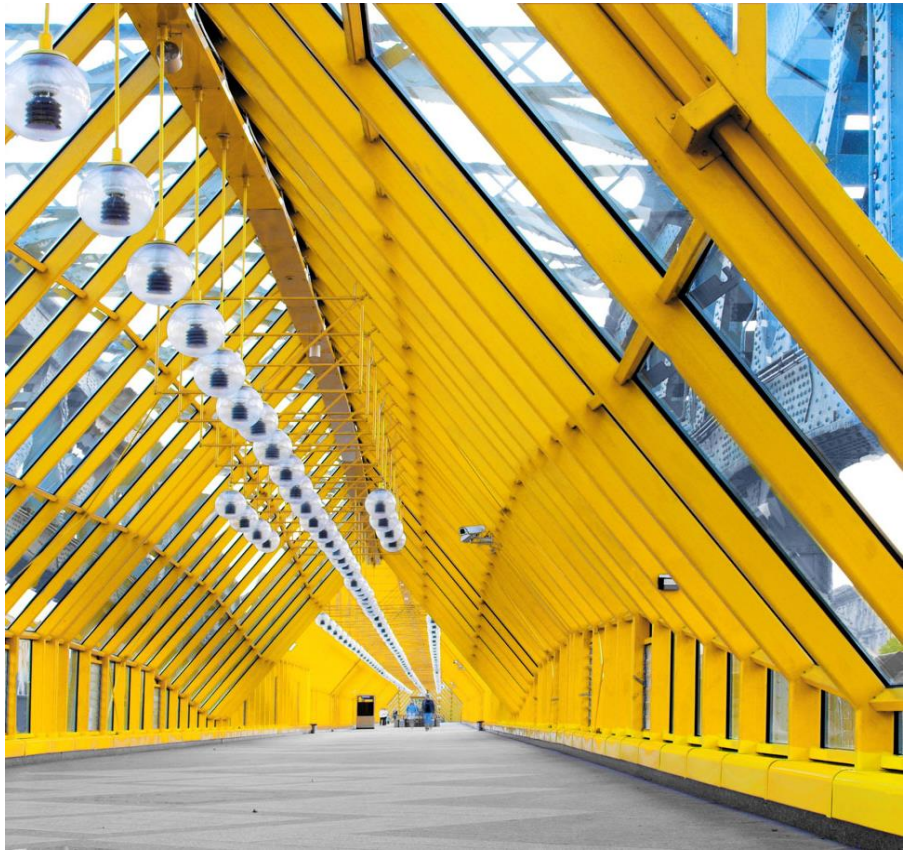


NFPA 285 Compliance



Window Head Detail

FENESTRATION



BUILDING ENVELOPE – ALLOWABLE AIR LEAKAGE THROUGH FENESTRATION

FENESTRATION ASSEMBLY	MAXIMUM RATE (CFM/ft^2)	TEST PROCEDURE
Windows	0.20 [a]	AAMA/WDMA/ CSA101/I.S.2/A440 or NFRC 400
Sliding doors	0.20 [a]	
Swinging doors	0.20 [a]	
Skylights – with condensation weepage openings	0.30	
Skylights – all other	0.20 [a]	
Curtain walls	0.06	NFRC 400 or ASTM E283 at 1.57 psf (75 Pa)
Storefront glazing	0.06	
Commercial glazed swinging entrance doors	1.00	
Power-operated sliding doors and power-operated folding doors	1.00	
Revolving doors	1.00	
Garage doors	0.40	ANSI/DASMA 105, NFRC 400, or ASTM E283 at 1.57 psf (75 Pa)
Rolling doors	1.00	
High-speed doors	1.30	

ASTM E783 Air Leakage Windows and Doors

ASTM E330 Structural Loading

ASTM E330 Structural Loading

THANK YOU!

Presented by: Andrew Fix, PE, Senior Engineer
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