abaa 2026 building enclosure conference

Code Compliance Paths for Air Leakage Through the Building Envelope

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AIA Continuing Education Provider

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Learning Objectives

- Discuss the requirements for air barrier material and impacts on the performance of an assembly
- Review code compliance paths as they relate to air leakage in recent versions of the energy code and identify key changes as the code has evolved.
- Discuss considerations for implementing various compliance paths.
- Identify ways to coordinate with the project team to implement design and construction phase requirements.

Jodi Knorowski, PE

- 13 years experience as a building envelope consultant
- Post-occupancy failure evaluations and new construction consulting
- ASHRAE member (SSPC 160, TC 1.12, and TC 4.4)
- ASTM member (E06 and C16)

Agenda

- Definitions
- Evolution of air barrier requirements and impacts
- Limits of this presentation
- Detailed review of code compliance paths
- Comparison of code compliance paths
- Implementation in design and construction phases

Definitions

IECC – 2024

Air Barrier: One or more materials joined together in a continuous manner to restrict or prevent the passage of air through the building thermal envelope and its assemblies.

ASHRAE 90.1 – 2022

Continuous Air Barrier: The combination of interconnected materials, assemblies, and sealed joints and components of the building envelope that minimize air leakage into or out of the building envelope.

Definitions

IECC – 2024

Air Leakage: The uncontrolled airflow through the building thermal envelope caused by pressure differences across the building thermal envelope. Air leakage can be inward (infiltration) or outward (exfiltration) through the building thermal envelope.

ASHRAE 90.1 – 2022

Air Leakage: The uncontrolled airflow through the building envelope due to factors such as wind, inside and outside temperature differences, stack effect, and imbalance between supply and exhaust air systems. Air leakage can move inward (infiltration) or outward (exfiltration) through the building envelope.

Definitions

IECC – 2024

Building Thermal Envelope: The basement walls, exterior walls, floors, ceilings, roofs, and any other building element assemblies that enclose conditioned space or provide a boundary between conditioned space and exempt or unconditioned spaces.

ASHRAE 90.1 – 2022

Building Envelope: The exterior plus the semi-exterior portions of a building.

- **Exterior Building Envelope**: The elements of a building that separate conditioned spaced from the exterior.
- **Semi-exterior Building Envelope**: The elements of a building that separate conditioned space from unconditioned space or that enclose semi-heated spaces through which thermal energy may be transferred to or from the exterior, to or from the unconditioned space, or to or from conditioned spaces.

Extents of the Building Envelope

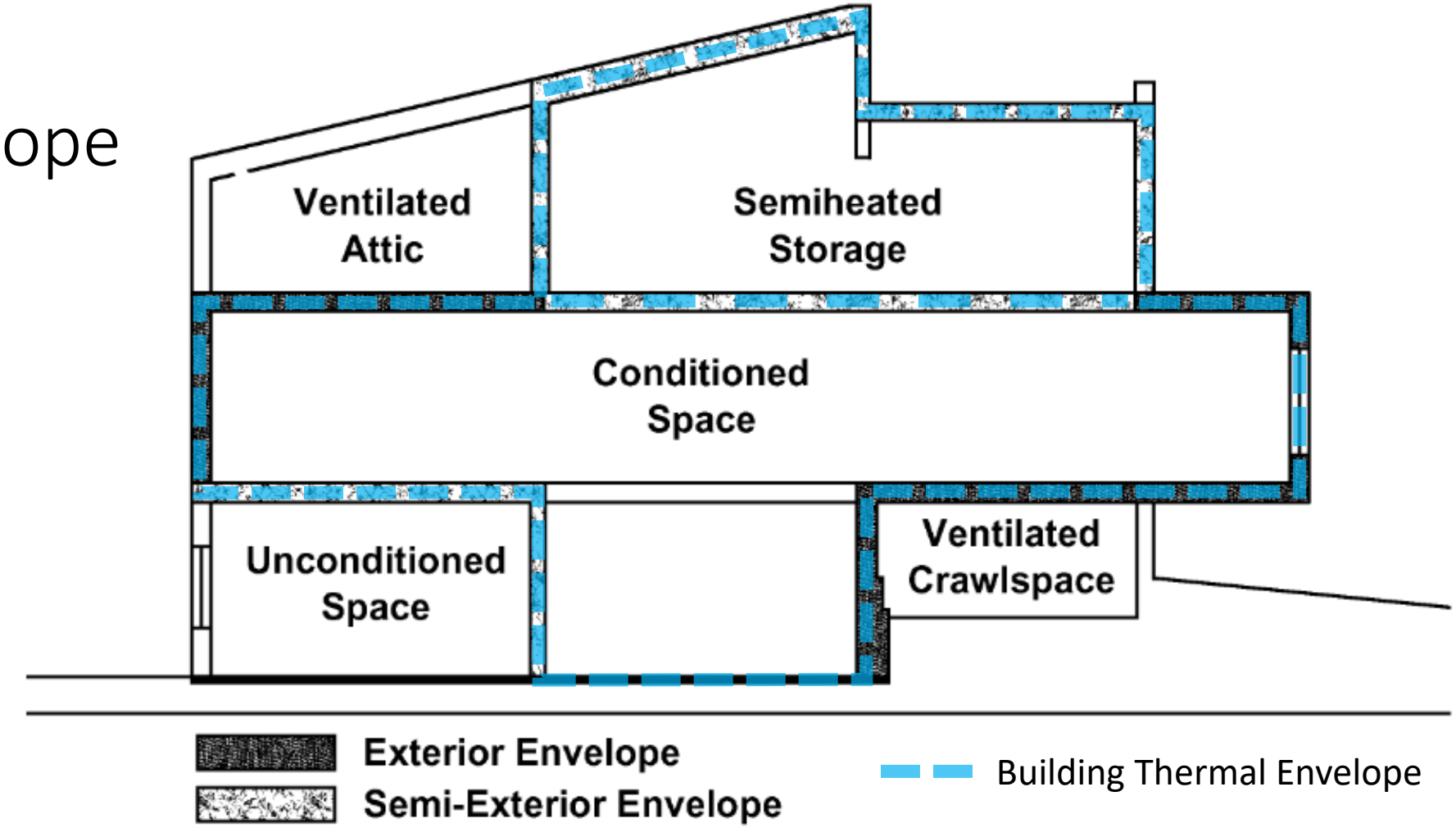
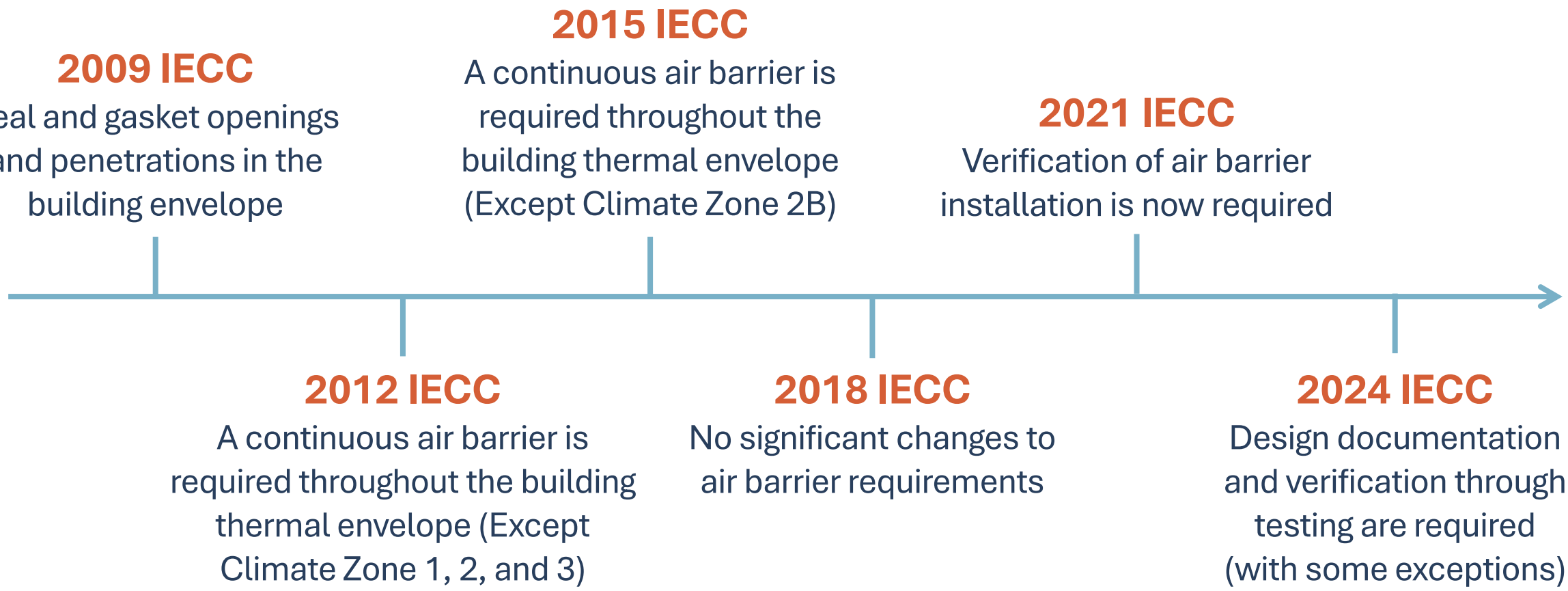


Figure 5.5.2 Exterior and Semi-exterior building envelope
ASHRAE 90.1 - 2022

Air Barrier Materials (C402.6.2.3.1 – 2024 IECC)

- Plywood (min 3/8”)
- OSB (min 3/8”)
- XPS (min 1/2”)
- Foil Faced Polyiso (min 1/2”)
- Closed Cell Spray Foam (1.5 pcf, min 1-1/2”)
- Open Cell Spray Foam (0.4-1.5 pcf, min 4-1/2”)
- Gypsum Board (min 1/2”)
- Cement Board (1/2”)
- Built-up Roofing Membrane
- Modified Bituminous Roof Membrane
- Single-ply Roof Membrane
- Portland Cement/Gypsum Plaster (Min 5/8”)
- Cast-in-place or Precast Concrete
- Fully Grouted CMU
- Sheet Steel or Aluminum
- Solid or Hollow Masonry (clay or shale)

Air Barrier Requirements in the IECC



Impacts of a Continuous Air Barrier

- Reduces heat loss through the building envelope
- Reduces uncontrolled moisture (vapor) migration through the building envelope
- Improved occupant comfort from reduced drafts
- Hygrothermal performance of the building envelope is more critical with reduced drying potential for incidental moisture

Limits of this Presentation

Included	Not Included
Air Barrier/Leakage Requirements	Thermal Requirements Moisture Requirements Vapor Requirements
Commercial Buildings	Residential Buildings
New Construction	Alterations, Renovations, Repairs
When is Whole Building Air Leakage Testing Required	In-Depth Review of Whole Building Air Leakage Testing Procedures
When is Building Envelope Commissioning Required	Commissioning Process
IECC Code Compliance	State and Local Jurisdictions

Building Code Compliance

IBC

IECC Compliance

IECC (Prescriptive)

IECC (Total Building Performance)

ASHRAE 90.1

C105 - Construction Documents

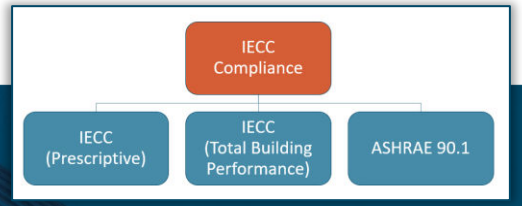
2018 | 2021 | **2024**

Information on construction documents

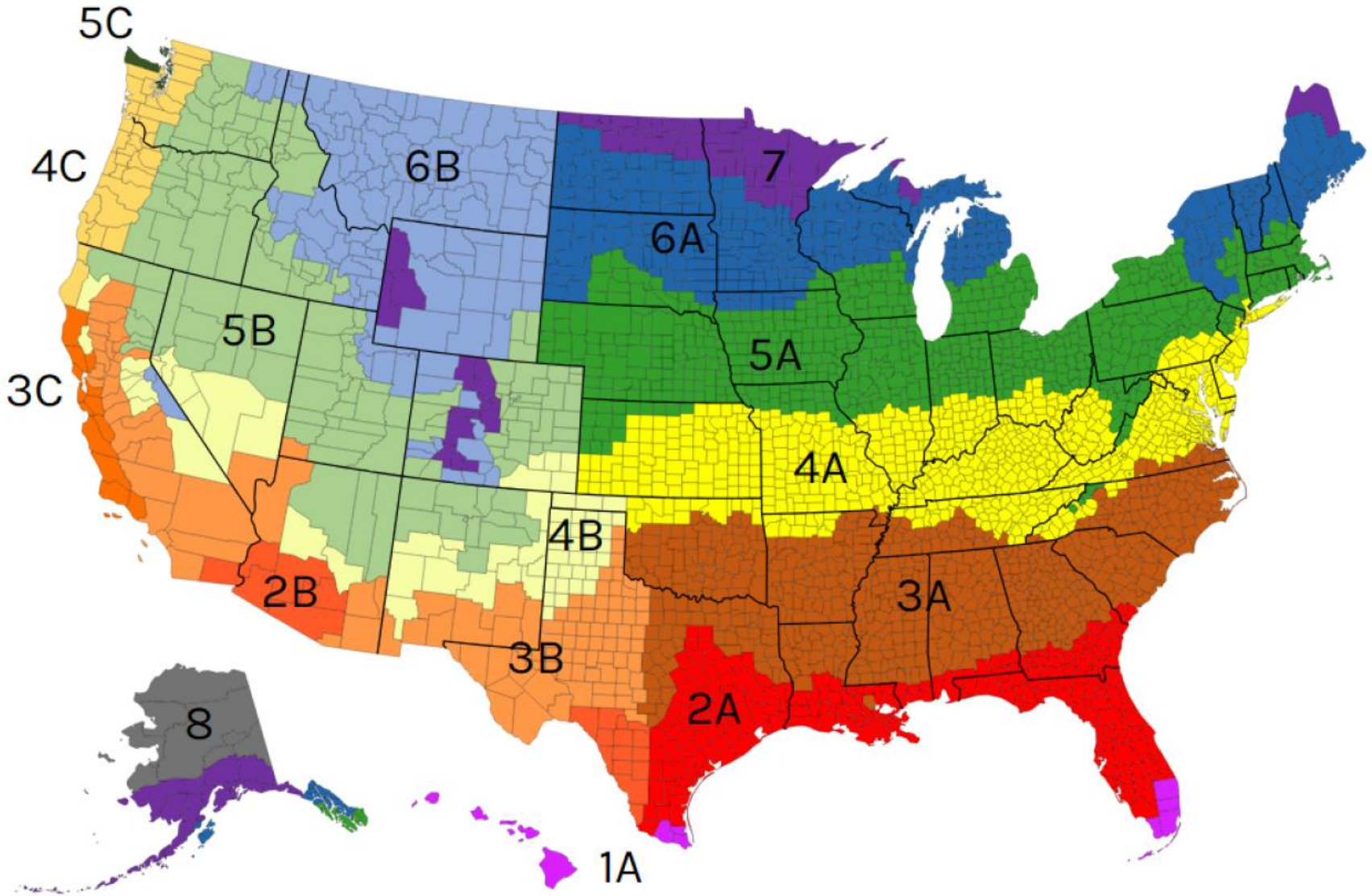
- *Air barrier and sealing details, including the location of the air barrier*
- *Energy compliance path*

Building Thermal Envelope Depiction

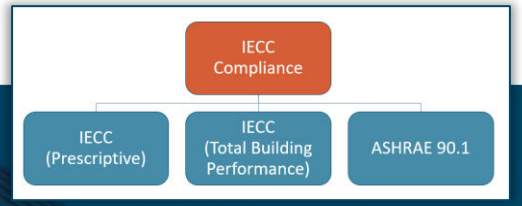
- *The building thermal envelope shall be represented on the construction documents*



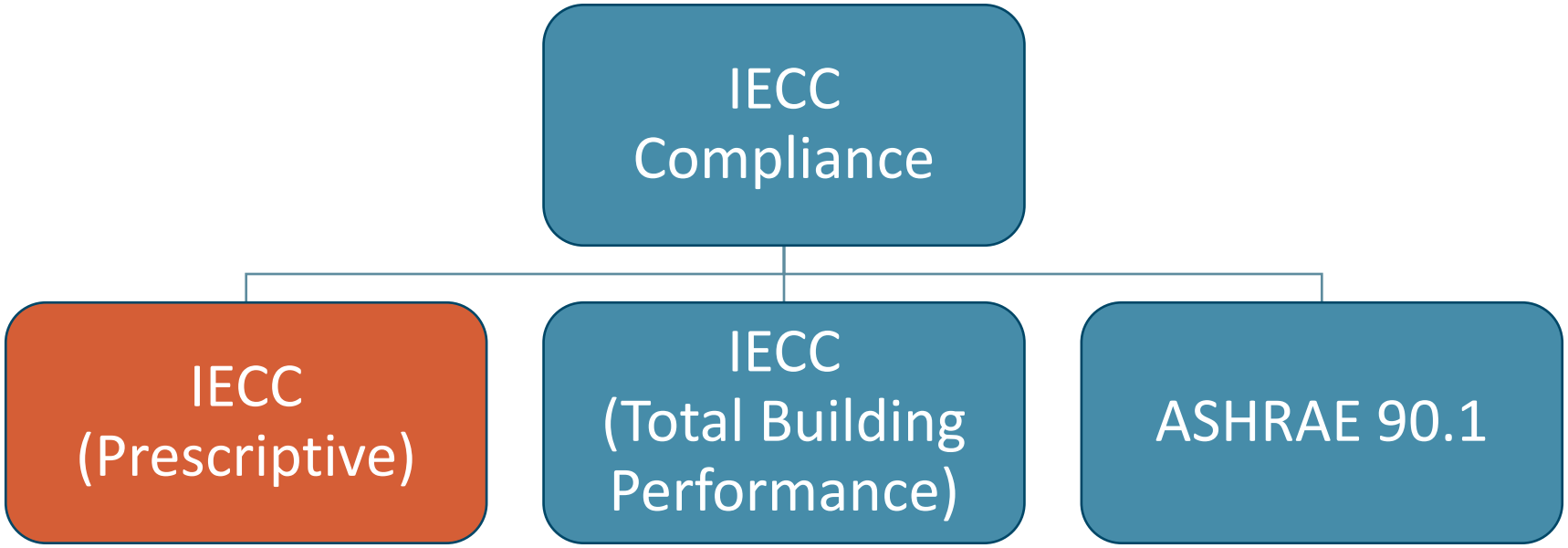
US Climate Zone Map



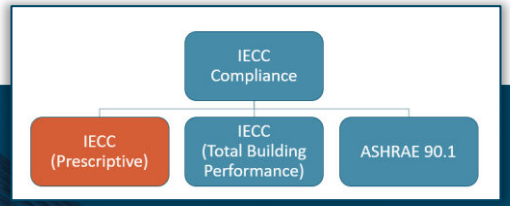
2021 IECC – energy.gov



Building Code Compliance



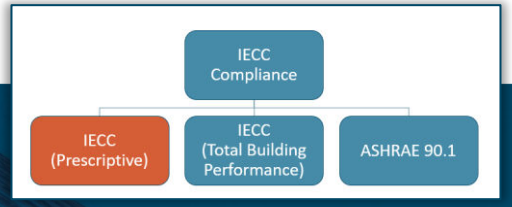
- IECC (Prescriptive)
  - Building Envelope
    - General
    - Insulation Requirements
    - Wall Solar Reflectance (2024)
    - Roof Solar Reflectance
    - Fenestration
    - Air Leakage (Mandatory)
    - Thermal Bridging (2024)
  - Mechanical
  - Service Water Heating
  - Electrical Power and Lighting
  - Additional Efficiency Requirements
    - Enhanced Building Envelope (Thermal)
    - Reduced Air Leakage
  - Maintenance Information and Commissioning



C401.3 – Building Thermal Envelope Certificate

2018 | 2021 | 2024

- Provide a permanent building envelope certificate
- Posted in approved location (mechanical or utility room)
- Results from any building thermal envelope air leakage testing performed on the building

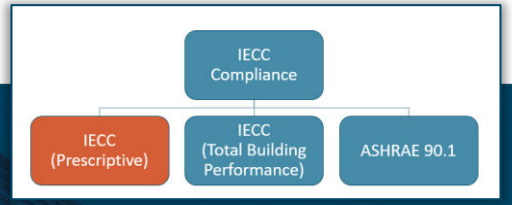


Air Leakage – Building Thermal Envelope

- **2018** (C402.5): *"The thermal building envelope shall comply with Sections C402.5.1 through C402.5.8, **or** the building thermal envelope shall be tested…"*

- **2021** (C402.5): *"The building thermal envelope shall comply with Section C402.5.1 through C402.5.11.1, **or** the building thermal envelope shall be tested in accordance with C402.5.2 or C402.5.3…"*

- **2024** (C402.6): *"The building thermal envelope shall comply with Sections C402.6.1 through C402.6.7."*



2018

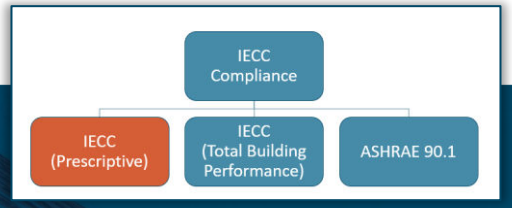
- **.1 – Air Barriers**
- .2 – Air leakage of fenestration
- .3 – Rooms containing fuel-burning appliances
- .4 – Doors and access openings to shafts, chutes, stairways, and elevator lobbies
- .5 – Air intakes, exhaust openings, stairways, and shafts
- .6 – Loading dock weatherseals
- .7 – Vestibules
- .8 – Recessed Lighting

2021

- **.1 – Air Barriers**
- **.2 – Dwelling and sleeping unit enclosure testing**
- **.3 – Building thermal envelope testing**
- .4 – Air leakage of fenestration
- .5 – Rooms containing fuel-burning appliances
- .6 - Doors and access openings to shafts, chutes, stairways, and elevator lobbies
- .7 – Air intakes, exhaust openings, stairways, and shafts
- .8 – Loading dock weatherseals
- .9 – Vestibules
- .10 – Recessed Lighting
- .11 – Operable openings interlocking

2024

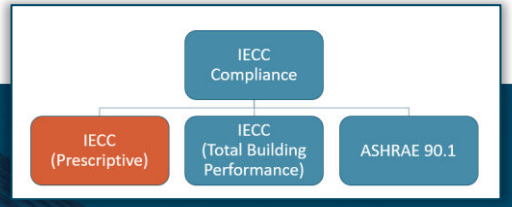
- **.1 – Air Barriers**
- **.2 – Air Leakage Compliance**
- .3 – Air leakage of fenestration and opaque doors
- .4 – Doors and access openings to shafts, chutes, stairways, and elevator lobbies
- .5 – Air intakes, exhaust openings, stairways, and shafts
- .6 – Vestibules
- .7 – Loading dock weatherseals



Air Barriers (.1)

2018	2021	2024

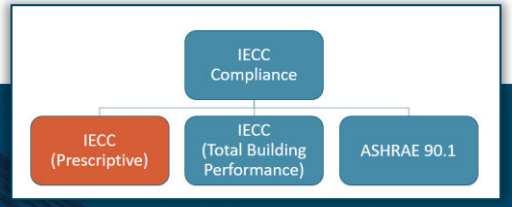
• **Air barrier construction**
• Compliance
  • **Materials or**
  • **Assemblies**
	• **Air barrier construction**
	• Compliance
	  • Dwelling and sleeping unit enclosure testing (Group R and I), **or**
	  • Building envelope performance Testing (All Other Groups), **or sometimes**
	  • **Materials or Assemblies and** Building Envelope Performance Verification
		• **Air barrier construction**
		• Compliance
		  • Whole Building Testing, **or**
		  • Dwelling and sleeping unit enclosure testing, **or sometimes**
		  • Building Envelope Performance Verification
		  • **Materials and Assemblies**
		• Design and documentation requirements



Air Barrier Construction

2018 2021 2024

- The **air barrier shall be continuous** for all assemblies that are the building thermal envelope of the building and across the joints and assemblies
- Air barrier **joints and seams shall be sealed**, including sealing transitions in place and changes in materials…
- **Penetrations** of the air barrier shall be caulked, gasketed, or otherwise sealed in a manner compatible with the construction materials and locations…
- Requirements for **recessing lighting fixtures** and similar objects
- Requirements for **electrical and communication boxes**



Materials & Assemblies

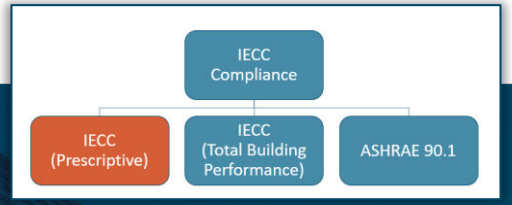
2018 2021 2024

Materials with an air permeability not greater than 0.004 cfm/ft^2 under a pressure differential of 0.3 inch water gauge when tested in accordance with ASTM E2178.

List of common materials complying with this requirement

Assemblies of materials and components with an average air leakage not greater than 0.04 cfm/ft^2 under a pressure differential of 0.3 inch water gauge when tested in accordance with ASTM E2357, ASTM E1677, ASTM D8052, or ASTM E283.

List of common assemblies complying with this requirement

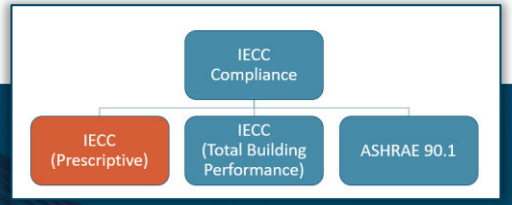


Air Leakage Testing

2018 | 2021 | 2024

C402.5 Air Leakage

- Air leakage rate less than 0.40 cfm/ft^2 at 0.3 inch water gauge (75 Pa)
- Acceptable Test Methods: ASTM E779 or equivalent

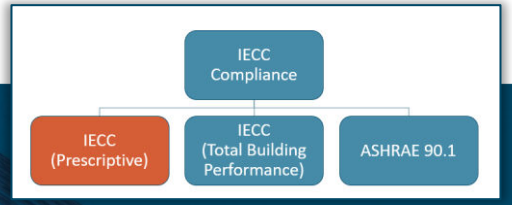


Air Leakage Testing

2018 | 2021 | 2024

C402.5.1.2

- Group R and I buildings comply with *Dwelling and sleeping unit enclosure testing*
  - Exceptions: Climate Zone 2B, 3C, and 5C
- All other buildings comply with *Building thermal envelope testing*
  - Exceptions:
    - Climate Zone 2B, 3B, 3C, and 5C
    - Buildings larger than 5,000 sf in Climate Zone 0B, 1, 2A, 4B, and 4C
    - Buildings between 5,000 sf and 50,000 sf in Climate Zone 0A, 3A, and 5B
- Buildings that do not complete air barrier testing shall meet provisions of *Materials* or *Assemblies* in addition to *Building Envelope Performance Verification*

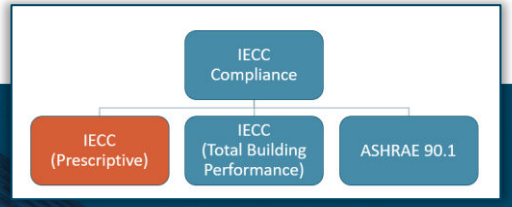


Air Leakage Testing

2018 | 2021 | 2024

C402.5.2 Dwelling and sleeping unit enclosure testing

- Air leakage rate less than 0.30 cfm/ft^2 at 0.2 inch water gauge (50 Pa)
- Acceptable Test Methods: ASTM E779, ANSI/RESNET/ICC 380, ASTM E1827 or equivalent
- Each dwelling or sleeping unit should be considered an individual testing unit

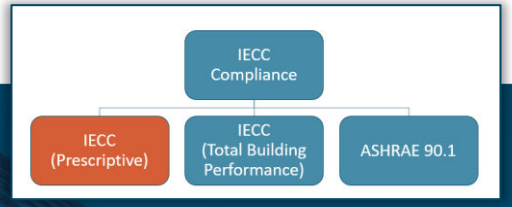


Air Leakage Testing

2018 | 2021 | 2024

C402.5.3 Building thermal envelope testing

- Air leakage rate less than 0.40 cfm/ft^2 at 0.3 inch water gauge (75 Pa)
- Acceptable Test Methods: ASTM E779, ANSI/RESNET/ICC 380, ASTM E3158, ASTM E1827, or equivalent
- Portions of the building can be tested and then area weighted
- Air Leakage from 0.40 cfm/ft^2 to 0.60 cfm/ft^2 requires diagnostics, sealing, and reporting



Air Leakage Testing

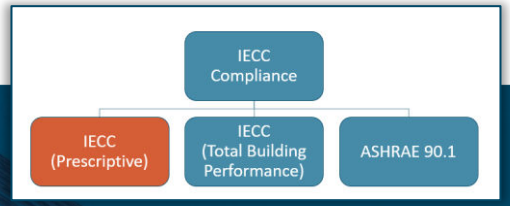
2018 | 2021 | **2024**

C402.6.2 Air Leakage Compliance

- Air leakage of the building thermal envelope shall be tested by an approved third party in accordance with *Whole building test method and reporting*

Exceptions

- Buildings in Climate Zone 2B
- Buildings larger than 25,000 sf in Climate Zone 0 through 4, other than Group I and R, that comply with *Building thermal envelope design and construction verification criteria*
- Buildings in Group I-1 and R-2 can be tested per *Dwelling and sleeping unit enclosure method and reporting*

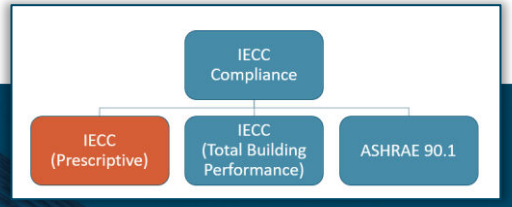


Air Leakage Testing

2018 | 2021 | **2024**

C402.6.2.1 Whole Building Test Method and Reporting

- Air leakage rate less than 0.35 cfm/ft^2 at 0.3 inch water gauge (75 Pa)
- Acceptable Test Methods: ASTM E3158 or equivalent method
  - For buildings < 10,000 sf, acceptable test methods also include ASTM E779, ASTM E1827, or equivalent
- For buildings > 50,000 sf, portions of the building can be tested and area weighted
- Air Leakage from 0.35 cfm/ft^2 to 0.45 cfm/ft^2 requires diagnostics, sealing, and reporting
- Air leakage greater than 0.45 cfm/ft^2 requires diagnostics, sealing, and retesting

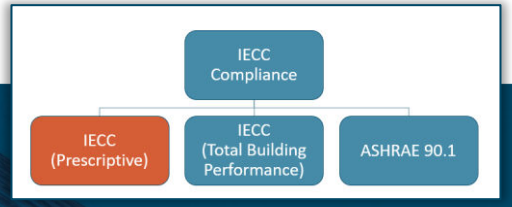


Air Leakage Testing

2018 | 2021 | **2024**

C402.6.2.2 Dwelling and sleeping unit enclosure method and reporting

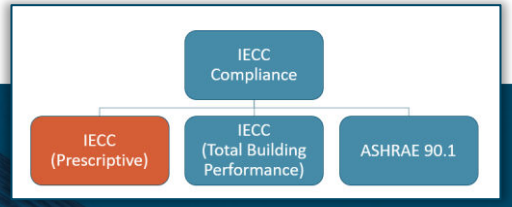
- Air leakage rate less than 0.27 cfm/ft^2 at 0.2 inch water gauge
- Acceptable Test Methods: ASTM E779, ANSI/RESNET/ICC 380, ASTM E1827, or equivalent
- Each dwelling or sleeping unit should be considered an individual testing unit



Building Envelope Performance Verification

2018 | 2021 | 2024

- Installation of the continuous air barrier verified by the code official, a registered design professional, or approved agency
- Review construction documents and other supporting data
- Inspect air barrier components and assemblies during construction while still accessible
- Provide a final report identifying deficiencies found during the ~~review of the construction documents and~~ inspection and details of corrective measures taken.

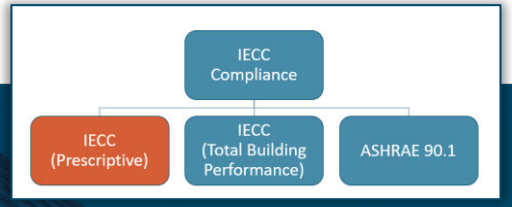


Air Barrier Design and Documentation

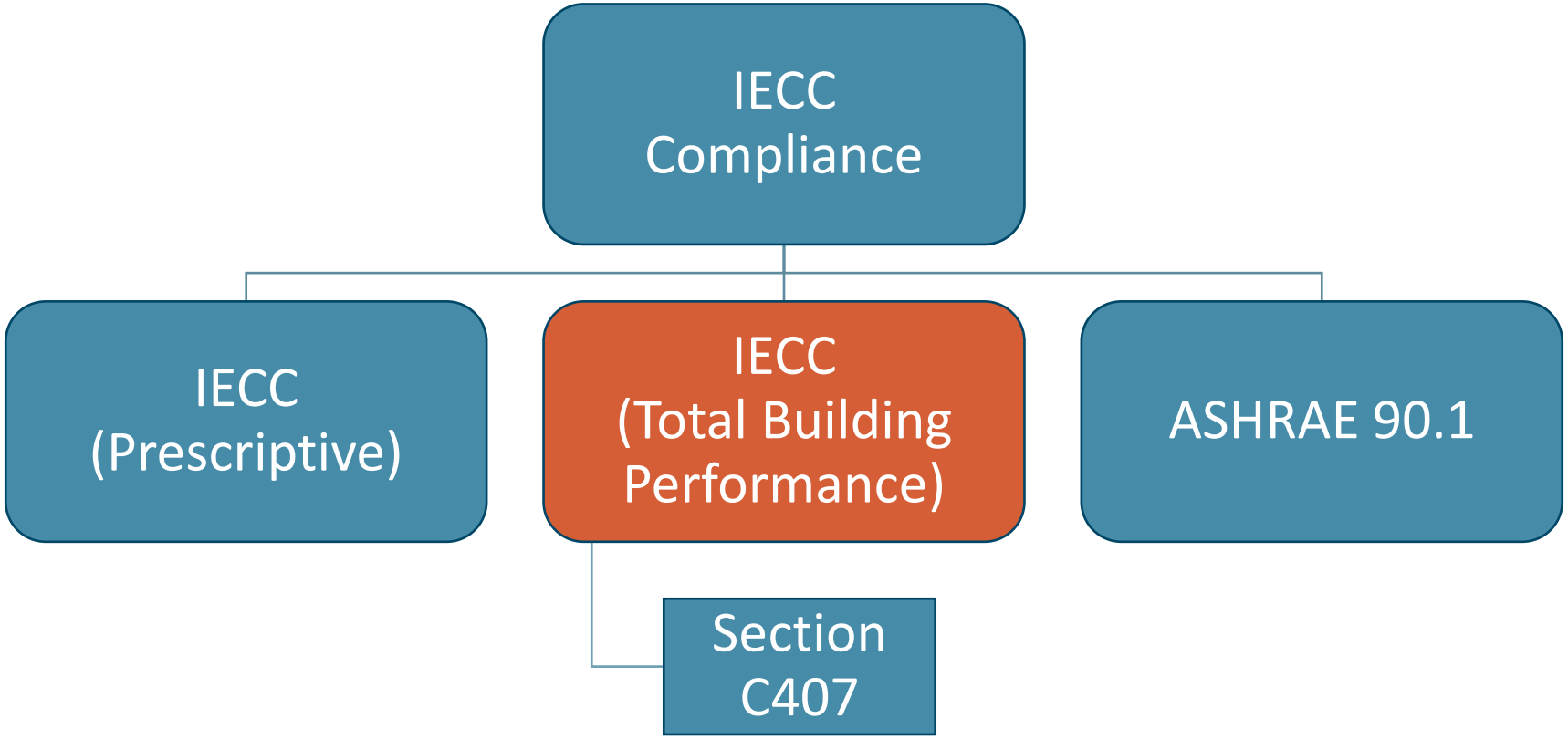
2018 | 2021 | 2024

C402.6.1.1 Air barrier design and documentation requirements

- Components, penetrations, joints, and changes in the air barrier materials and assemblies
- Integrations with fenestration, walls-to-floors, walls-to-roofs, building corners
- Continuity of air barrier between conditioned and unconditioned spaces
- Identify whole building testing plan or a plan for field inspections that includes:
  - Schedule for periodic inspections, continuous air barrier scope of work, critical inspection items, inspection documentation, and provisions for corrective actions

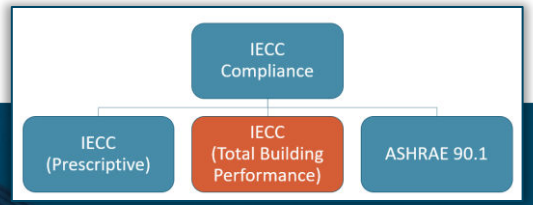


Building Code Compliance

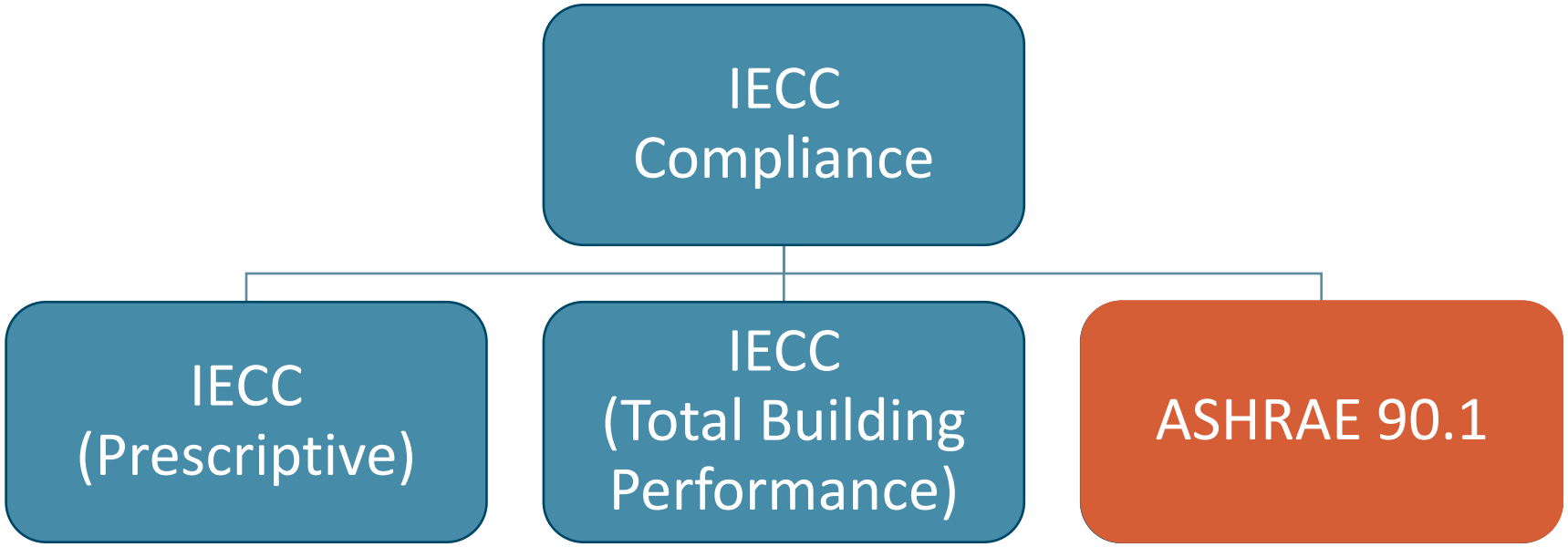


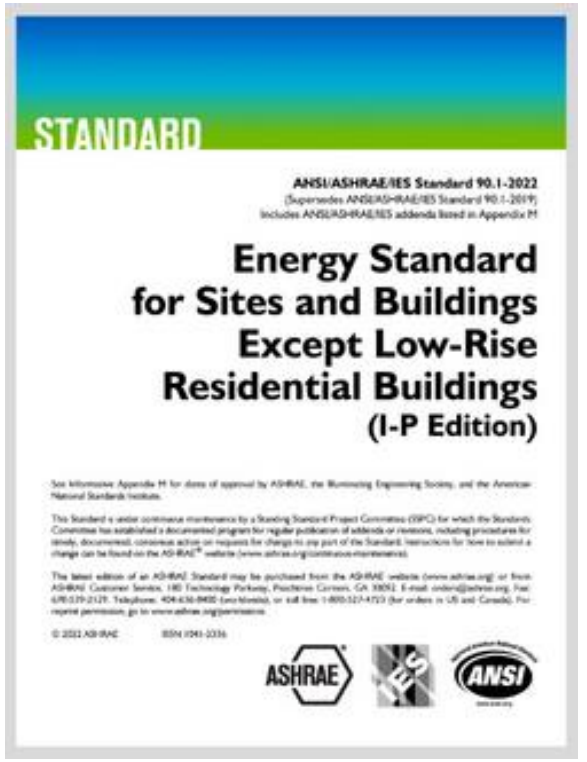
Total (Simulated) Building Performance

- Mandatory Requirements
  - Air Leakage – Thermal Envelope
- Annual energy cost …. of the standard reference design
  - less than or equal to the annual energy cost (2018)
  - less than or equal to 85% of the annual energy cost (2021)
  - less than or equal to the percentage of the annual energy cost (PAEC) (2024)



Building Code Compliance





Code References

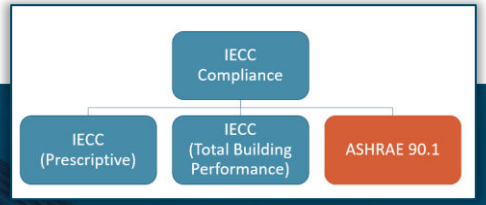
IECC		ASHRAE 90.1
2018	⇨	2016
2021	⇨	2019
2024	⇨	2022

Building Code Compliance

ASHRAE 90.1

Administration & Enforcement
Section 4.2.2 through 4.2.5

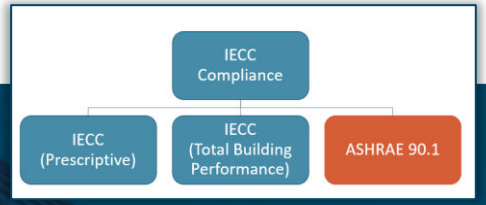
- Building Envelope (Section 5)
- Energy Cost Budget Method (Section 11 / 12)
- Performance Rating (Appendix G)



Section 4.2.2 – Compliance Documents

2016 2019 2022

- Construction Details: All pertinent data and features of the building, equipment, and systems in sufficient detail…to indicate compliance with the requirements of this standard.
- Supplemental Information: Calculations, worksheets, compliance forms, vendor literature, or other data shall be made available when required
- Manuals: Operation and maintenance information shall be provided to the building owner.
    - For each component of the building envelope requiring maintenance (2019 and 2022)



Section 4.2.3 – Labeling of Material and Equipment

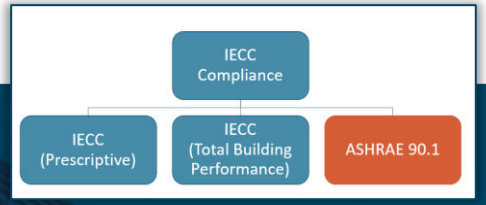
2016 2019 2022

- Materials and equipment shall be labeled in a manner that will allow for determination of their compliance with the applicable provisions of this standard.

Section 4.2.4 – Inspections

2016 2019 2022

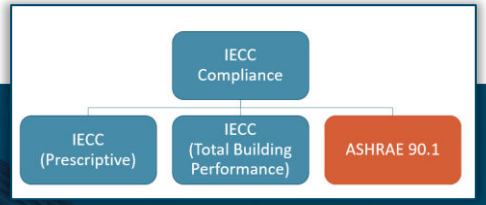
- All building construction subject to the provisions of this standard shall remain accessible and exposed for inspection purposes…



Section 4.2.4 – Inspections

2016 | 2019 | **2022**

- Fenestration
- Opaque Assembly Thermal Insulation
- Continuous Air Barrier
  - Air barrier inspected in accordance with Section 5.8.3.1 [*Testing, Acceptable Materials, and Assemblies*]
  - Integrations with adjoining fenestration inspected in accordance with Section 5.4.3.1 [*Whole-Building Air Leakage*]
- Operable Fenestration and Door
- Loading-Dock Weatherseals
- Other (MEP, Lighting, Equipment)



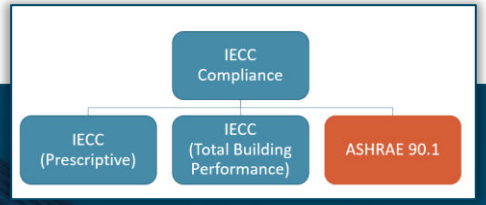
Section 4.2.5 – Verification, Testing, and Commissioning

2016

- The building official or other approved agencies shall report to the contractor their findings of conformance and nonconformance for correction

2019 2022

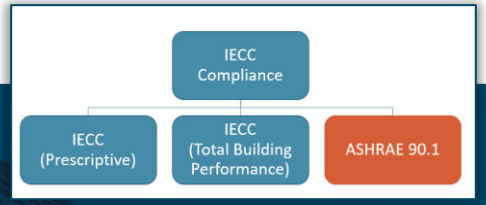
- Building systems, controls, and the building envelope shall comply with Sections 4.2.5.1, 4.2.5.2, and 4.2.5.3
  - See Informative Appendix H for additional commissioning guidelines



Section 4.2.5.1 – Building System Verification and Testing Requirements

2016 | 2019 | 2022

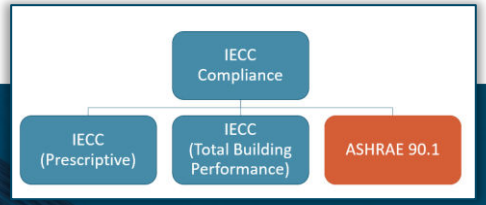
- Verification or functional performance testing (FPT) to confirm compliance with requirements for the building envelope per Section 5.9.1 [*Verification, Testing, and Commissioning*]
- Information on Building Permit Application
  - Identify Verification & Testing (V&T) Providers
  - V&T Providers review construction documents
  - Verification and FPT processes are included in construction documents
- Verification and FPT documentation provided to the Owner and building official, if requested



Section 4.2.5.2 – Building Commissioning Requirements

2016 | 2019 | 2022

- Performed in accordance with Section 5.9.2 [*Commissioning*]
- Follow ASHRAE/IES 202 or other generally accepted standard
- Who can be a commissioning provider?
  - Necessary training, experience, and FPT equipment
  - A third-party entity not associated with the building project
  - Owner's qualified employee
  - An individual associated with the design firm or contractor but not directly associated with the design or installation of the building systems being commissioned

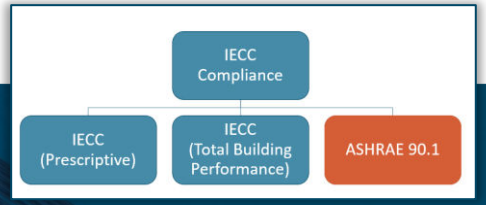


Section 4.2.5.2 – Building Commissioning Requirements

2016 | 2019 | 2022

Prior to issuing a building permit:

- Provide Commissioning Plan to Owner and building official, if requested
- Designate commissioning provider and indicate on construction documents
- Commissioning provider submits design review to Owner
- Construction phase commissioning requirements are in the construction documents



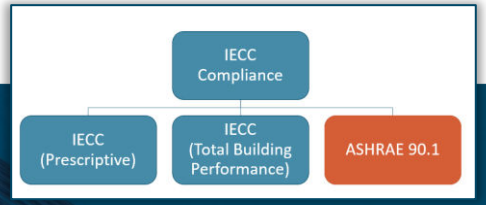
Section 4.2.5.2 – Building Commissioning Requirements

2016 | 2019 | 2022

- Project Commissioning Documents
  - Commissioning Plan
  - Design Review Report
  - Preliminary Commissioning Report
    - Required performance and results of FPT and verification
    - Summary of compliance with provisions of this standard
    - Issues and resolutions logs
    - Deferred tests
    - Documentation of training & plan for completion of training and deferred tests
  - Final Commissioning Report

<u>ASHRAE 90.1 does NOT require</u>

- Owner's Project Requirements (OPR)
- Basis of Design (BOD) Document



Informative Appendix H

2016 | 2019 | 2022

- References ASTM E2947, “Standard Guide for Building Enclosure Commissioning” and ASTM E2813, “Standard Practice for Building Enclosure Commissioning”
- Recommended Minimum Qualifications for Commissioning Providers
- Overview of the Commissioning Process
  - Core verification requirements, established construction documents, documented results
- Commissioning Activities per ASHRAE 90.1

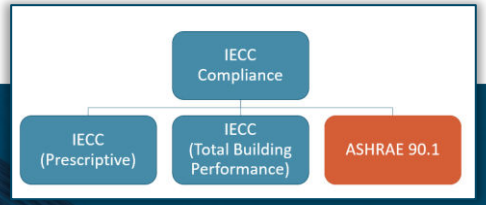


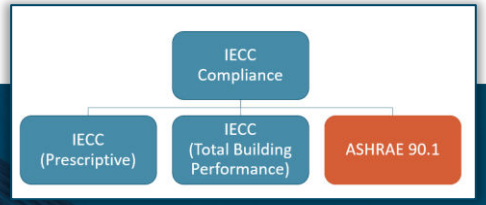
Table H-3 Standard 90.1 Items to Verify

Subsection	Subsection Title	Standard 90.1 Items to Verify for Proper Operation or Inclusion
4.2.5.2	Building Commissioning Requirements	Document in sufficient detail compliance of the *building* and its components, assemblies, controls, and *systems* with required provisions of this standard.
5.4.1	Insulation	Design details maintain continuity of thermal barrier.

5.4.3.2	Continuous Air Barrier Design and Installation	Air barriers meet the following:
		• Air barrier design and installation per Section 5.4.3.2 and either
		  • whole-*building air leakage* testing per Section 5.4.3.1 or
		  • design and installation verification program performed in accordance with Section 5.4.3.1 and Section 5.9.1.2.

5.8.3.1	Testing, Acceptable Materials, and Assemblies	Continuous air barrier materials and assemblies comply with specific *manufacturer* requirements or are tested for leakage resistance.
5.8.3.2	Fenestration and Doors	*Fenestration* and *doors* have *manufacturer* documentation that *air leakage* does not exceed allowable *air leakage* rates.
5.5.4.2	Fenestration Area	*Fenestration* to *wall* ratio and *skylight* to *roof* ratio meet either the prescriptive requirements or the *proposed design* in the performance path, depending on the compliance path used.
5.8.1	Insulation	Insulation material meets design specifications and is continuous.
5.9	Verification, Testing, and Commissioning	Envelope assemblies and *fenestration* comply with requirements. *Building envelope* performance is tested or verified.

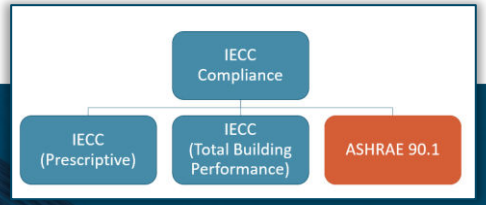
ASHRAE 90.1 – 2022, Informative Appendix H



Section 4.2.5.3 – Activities Prior to Building Occupancy

2016 | 2019 | 2022

- Verification and FPT of the systems are completed and documented
- Owner is provided with verification and FPT documentation or a preliminary commissioning report
- The Owner provides the building official with one of the following:
  - A letter acknowledging the building owner or owner's authorized agent has received and accepted all required documentation
  - A copy of the reports listed herein, if required by the building official

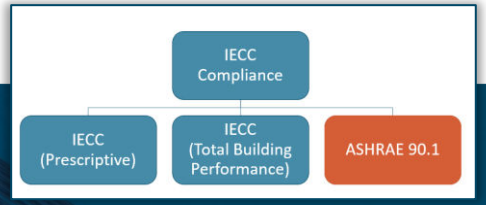


Building Code Compliance

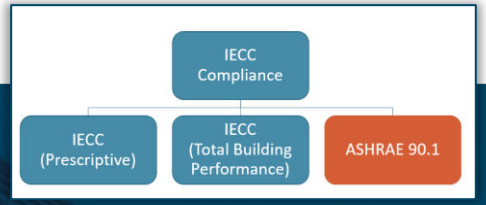
ASHRAE 90.1

Administration & Enforcement
Section 4.2.2 through 4.2.5

- Building Envelope (Section 5)
- Energy Cost Budget Method (Section 11 / 12)
- Performance Rating (Appendix G)



- Building Envelope (Section 5)
  - 5.1 - General
  - 5.4 - Mandatory Provisions
    - 5.4.3 – Air Leakage
  - 5.7 - Submittals
  - 5.8 - Product Information and Installation Requirements
    - 5.8.3 – Air Leakage (2019 and 2022)
  - 5.9 - Verification, Testing, and Commissioning
  - Additional Requirements
    - 5.5 - Prescriptive Building Envelope Compliance Path
    - 5.6 - Building Envelope Trade-Off Compliance Path



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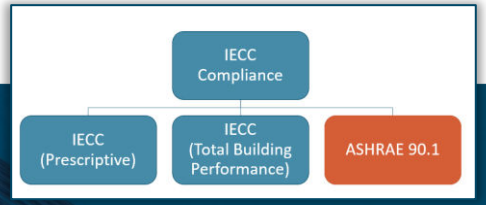
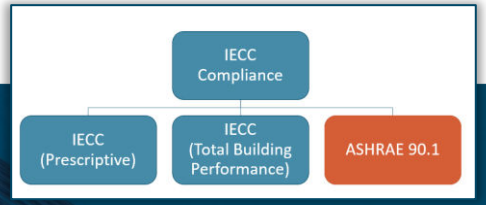


2016	2019	2022

• .1 – Continuous Air Barrier
  • **Design and**
  • **Installation and**
  • **Testing or** Acceptable Materials or Assemblies
• .2 – Fenestration and Doors
• .3 – Loading Docks and Weatherseals
• .4 – Vestibules
	• .1 – Continuous Air Barrier
	  • **Whole-Building Air Leakage and**
	  • **Design and Installation**
	• 2. – Loading Docks and Weatherseals
	• .3 – Vestibules and Revolving Doors
	
	Fenestration and Doors moved to Section 5.8.3 [Product Information and Installation Requirements, Air Leakage]
		• Continuous Air Barrier
		  • .1 – **Whole-Building Air Leakage and**
		  • **.2 – Design and Installation**
		• .3 – Loading Docks and Weatherseals
		• .4 – Vestibules and Revolving Doors
		
		Fenestration and Doors moved to Section 5.8.3 [Product Information and Installation Requirements, Air Leakage]



Design and Installation

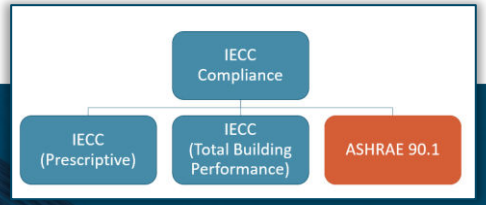
2016 | 2019 | 2022

Design

- Air barrier components are clearly identified
- Joints, interconnections, and penetrations are detailed
- Air barrier extends over all surfaces of the building envelope
- Resists positive and negative pressures from wind, stack effect, and mechanical ventilation

Installation

- Detail areas to minimize air leakage:
  - Joints at fenestration and doors
  - Wall/Floor, Corners, Wall/Roofs
  - Penetrations
  - Ducts and plenums
  - Joints, seams, connections, and changes in the air barrier materials
  - Building and service components
  - Junctions that separate conditioned from unconditioned/semi-heated spaces

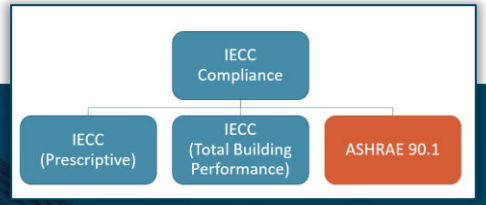


Air Leakage Testing

2016 | 2019 | 2022

5.4.3.1.3 Testing, Acceptable Materials, and Assemblies

- Air leakage rate less than 0.40 cfm/ft^2 at 0.3 inch water gauge (75 Pa)
- Acceptable Test Method: ASTM E779 or ASTM E1827
- For buildings > 50,000 sf, portions of the building can be tested and area weighted
- Air Leakage from 0.40 cfm/ft^2 to 0.60 cfm/ft^2 requires diagnostics, sealing, and reporting
- OR Compliance with continuous air barrier requirements for Materials or Assemblies

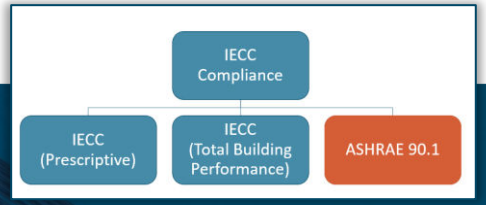


Air Leakage Testing

2016 | 2019 | 2022

5.4.5.1.1 Whole-Building Air Leakage

- Air leakage rate less than 0.40 cfm/ft^2 at 0.3 inch water gauge (75 Pa)
- Acceptable Test Methods: ASTM E779 or ASTM E1827
- For buildings > 50,000 sf, portions of the building can be tested and area weighted
- Air Leakage from 0.40 cfm/ft^2 to 0.60 cfm/ft^2 requires diagnostics, sealing, and reporting
- OR Comply with Section 5.9.1.2, *Verification of the Design and Installation of the Continuous Air Barrier*

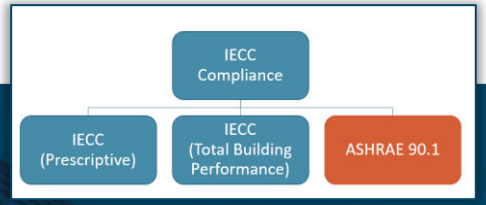


Air Leakage Testing

2016 | 2019 | 2022

5.4.3.1 Whole-Building Air Leakage

- Air Leakage rates less than 0.35 cfm/ft^2 at 0.3 inch water gauge (75 Pa)
- Acceptable Test Methods: ASTM E1827
  - For buildings < 10,000 sf, acceptable test methods also include ASTM E779, ASTM E1827, or equivalent
- Air Leakage from 0.35 cfm/ft^2 to 0.45 cfm/ft^2 requires diagnostics, sealing, and reporting
- Air leakage greater than 0.45 cfm/ft^2 requires diagnostics, sealing, and retesting

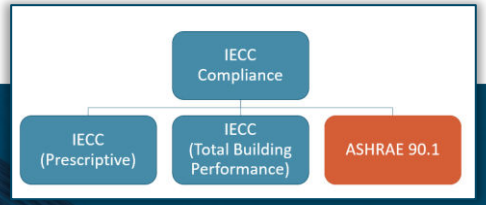


Air Leakage Testing

2016 | 2019 | **2022**

5.4.3.1 Whole-Building Air Leakage

- Buildings < 10,000 sf: Whole-Building Air Leakage Testing
- Buildings > 10,000 sf
  - Whole-building air leakage testing, **or**
  - Section 5.9.1.2, Verification of the Design and Installation of the Continuous Air Barrier
- Provisions for buildings with both conditioned and semi-heated spaces



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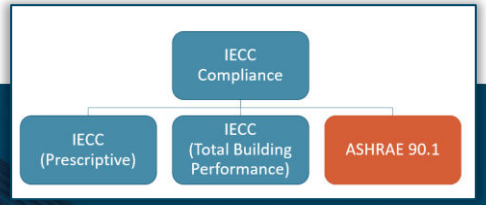


5.8.3 Product Information & Installation – Air Leakage

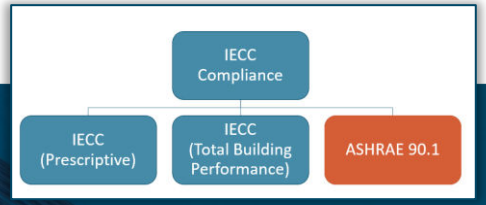
2016 | 2019 | 2022

Testing, Acceptable Materials, and Assemblies

- Requirements for laboratory testing of air leakage of materials or assemblies

Fenestration and Doors

- Requirements for laboratory testing for air leakage of fenestration and doors
- Labeled and certified by the manufacturer
- Exceptions:
  - Field fabricated fenestration and doors, metal coiling doors (under some conditions), products in buildings where whole-building pressurization is performed



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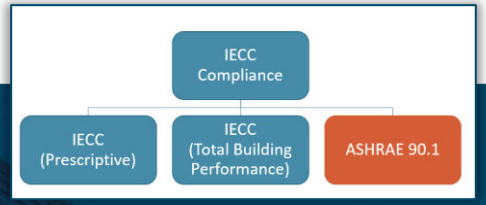


5.9 – Inspection, Verification, Testing, Commissioning

Inspection

2016

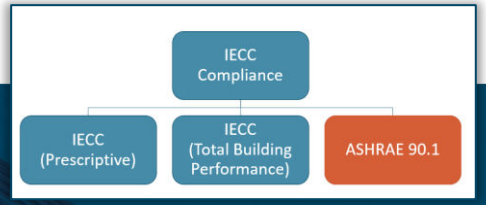
- Section 4.2.4, *Inspections*
- Inspections of Fenestration and Door Requirements
- Inspection of Loading Dock Weatherseals
- Inspection of Opaque Building Envelope Air Tightness Requirements
- Fenestration Inspections

2019

- Section 4.2.4, *Inspections*
- Inspections of Fenestration and Door Requirements
- Inspection of Loading Dock Weatherseals
- Inspection of Opaque Building Envelope Air Tightness Requirements
- Fenestration Inspections

2022

- Included in Section 4.2.4
  - Operable Fenestration and Door
  - Loading-Dock Weatherseals
  - Opaque Assembly Thermal Insulation
  - Continuous Air Barrier
  - Fenestration



5.9 – Inspection, Verification, Testing, Commissioning

Verification & Testing

2016

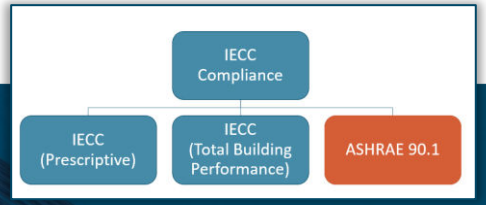
- Building envelope performance per Section 4.2.5, *Verification and Commissioning Reporting*
- Air Leakage Verification per:
  - Air barrier design and installation verification program, **or**
  - Whole building air leakage testing

2019

- Building envelope energy performance per Section 4.2.5.1, *Building Systems Verification and Testing Requirements*
- Air Barrier Verification per:
  - Air barrier design and installation verification program

2022

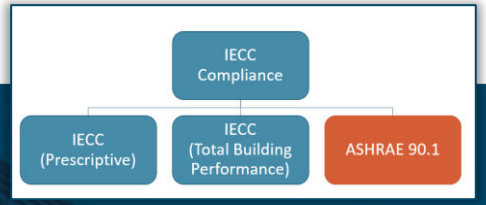
- Building envelope verified per Section 4.2.5.1, *Building Systems Verification and Testing Requirements*
- Air Barrier Verification per:
  - Verification of Design & Installation of Air Barrier
  - Dynamic Glazing testing



Design and Installation Verification Program

2016 | 2019 | 2022

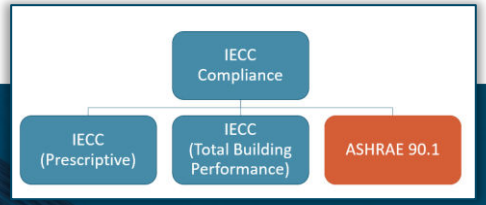
- Determined in accordance with an independent third party
- Conduct a design review
- Periodic field inspections conducted during construction
- Reporting per Section 4.2.5.1.2 [*FPT and Verification Documentation*]
- Requirements for field inspection plan included in contract documents
  - Schedule for periodic inspections, scope of work, list of critical inspection items, inspection documentation requirements, provisions for corrective actions



5.9 – Inspection, Verification, Testing, Commissioning

Commissioning

2016	2019	2022
• No requirements	• Per Section 4.2.5.2, *Building Commissioning Requirements*	• Per Section 4.2.5.2, *Building Commissioning Requirements*



Building Code Compliance

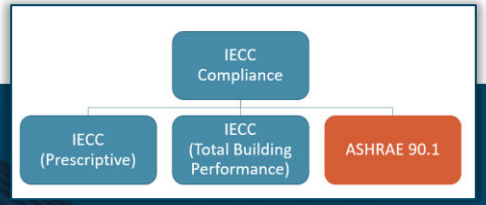
ASHRAE 90.1

Administration & Enforcement
Section 4.2.2 through 4.2.5

Building Envelope
(Section 5)

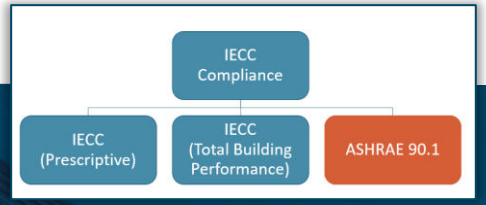
Energy Cost Budget
Method
(Section 11 / 12)

Performance Rating
(Appendix G)



Energy Cost Budget Method

- Mandatory Requirements
  - Section 5.4 (2016) – Mandatory Provisions (Air Leakage)
  - Section 5.2.1 (2019 & 2022) – Requirements for all Compliance Paths
- The design energy cost does not exceed the energy cost budget (adjusted in 2022)
- The energy efficiency levels of components in the building design meet or exceed the efficiency levels used to calculate the design energy cost
- Verification, Testing, and Commissioning Requirements per Section 4.2.5 (2019 and 2022)
- Requirements for meeting Prescriptive Envelope Compliance or Building Envelope Trade Off Compliance Options (2022)



Building Code Compliance

ASHRAE 90.1

Administration & Enforcement
Section 4.2.2 through 4.2.5

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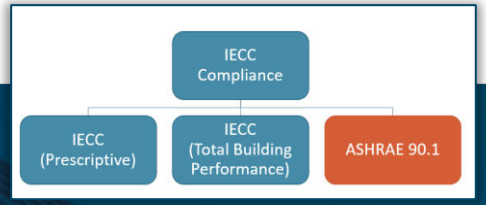
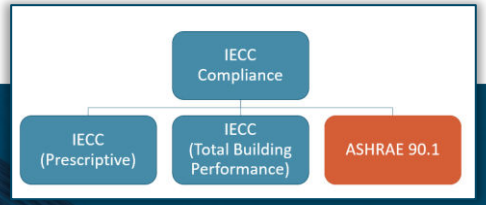
- Energy Cost Budget Method (Section 11 / 12)
- Performance Rating (Appendix G)



Performance Rating

- Mandatory Requirements
  - Section 5.4 (2016) – Mandatory Provisions (Air Leakage)
  - Section 5.2.1 (2019 & 2022) – Requirements for all Compliance Paths
- Performance Cost Rating $= \dfrac{\text{Proposed building performance}}{\text{Baseline building performance}}$



Stretch Codes

LEED

- ASHRAE 90.1-2016 (v4.1)
- Building Enclosure Commissioning
  - ASHRAE Guideline 0
  - ASTM E2947
  - Energy, air and water tightness, indoor environmental quality, and durability

IgCC

- The building envelope shall be designed to achieve air leakage less than 0.2 cfm/ft^2 under a pressure differential of 0.3 inches of water (75 Pa)

Passive House

- The building envelope shall be designed to achieve air leakage less than 0.11 cfm/ft^2 under a pressure differential of 0.3 inches of water (75 Pa)

Considerations of Compliance Paths

Performance / Trade Off Compliance Paths

- ASHRAE 90.1 (2016, 2019, and 2022) & IECC (2018, 2021, and 2024)
  - Must comply with air leakage requirements

Performance Verification

- ASHRAE 90.1 (2016, 2019, and 2022) & IECC (2021 and 2024)
  - Design Review
  - Inspections
  - Final Report

Commissioning

- ASHRAE 90.1 (2019 and 2022) require Building Envelope Commissioning
- IECC does not require Building Envelope Commissioning

Considerations of Compliance Paths

Whole Building Air Leakage Testing

IECC (2018)

- Whole building air leakage testing or comply with Material or Assembly requirements
- No dwelling unit specific requirements (Residential Section)

ASHRAE 90.1 (2016)

- Whole building air leakage testing or comply with Material or Assembly requirements
- No dwelling unit specific requirements (ASHRAE 90.2)

Considerations of Compliance Paths

Whole Building Air Leakage Testing

IECC (2021)

- Whole building air leakage testing unless within a Climate Zone and/or Building Size that meets exceptions
- Dwelling unit specific requirements with exceptions

ASHRAE 90.1 (2019)

- Whole building air leakage testing or comply with Design and Verification program
- No dwelling unit specific requirements (ASHRAE 90.2)

Considerations of Compliance Paths

Whole Building Air Leakage Testing

IECC (2024)

- Climate Zone 2B
- Buildings > 25,000 sf in Climate Zone 0 through 4 can comply with Design and Verification program
- Dwelling unit specific requirements

ASHRAE 90.1 (2022)

- Buildings >10,000 sf can comply with Design and Verification program
- No dwelling unit specific requirements (ASHRAE 90.2)

Integration into the Design Process

- Clearly depict air barrier components within the drawings
- Understanding desired compliance path early in the design process
- Development of functional performance testing requirements
- Development of verification plan for continuous air barrier components
- Consulting versus Commissioning

Integration into the Construction Process

- Understanding of functional performance testing requirements and coordinate a plan early in the construction process
- Coordination of periodic inspections when air barrier components are exposed
- Verification of installation of air barrier
- Whole building air leakage testing
- Reporting requirements

Key Take Aways

- Air leakage requirements are mandatory regardless of the compliance path
- Evolution of verification of continuous air barrier installation
- Introduction of commissioning when following the ASHRAE 90.1 compliance path
- Movement towards whole building air leakage testing

Code Compliance Paths for Air Leakage Through the Building Envelope

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