Top 40 Requirements You Should Know: 2018 IECC

Part 2 (Commercial HVAC & Residential)

4.30.2020

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Providing effective energy strategies for buildings and communities

ICC Preferred Provider # 2396
ICC Course #24121

SEDAC is a Preferred Education Provider with the International Code Council (ICC). Credits earned on completion of this program will be reported to ICC for ICC members. Certificates of Completion will be issued to all participants.

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This workshop is approved for 1.5 LU/HSW CES credits from the American Institute of Architects (AIA). Credits earned on completion will be reported for AIA members.

AIA Continuing Education Provider

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Learning Objectives

1. Learn about the changes in the updated Illinois Energy Conservation Code (2015 IECC to 2018 IECC).
2. Identify the 20 most important Illinois Energy Conservation Code compliance issues in the commercial HVAC and residential provisions
3. Understand how to comply with the current Illinois Energy Conservation Code for commercial and residential building design and construction

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Who We Are

The Smart Energy Design Assistance Center (SEDAC) is an applied research program at University of Illinois.

Our mission: Reduce the energy footprint of Illinois and beyond.

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SEDAC is the Illinois Energy Conservation Code Training Provider

This training program is sponsored by **Illinois State Energy Office**

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Energy Code Training Program

- Technical support

  energycode@sedac.org

  800.214.7954
- Online resources at sedac.org/energy-code
  - Workshops
  - Webinars
  - Online on-demand training modules

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Illinois Energy Conservation Code

Illinois Energy Conservation Code

Effective date of 2018 IECC for State of Illinois: July 1, 2019

The updated Illinois Energy Conservation Code based on the 2018 IECC with Illinois Amendments became effective on **July 1, 2019**. For permit applications started on or after July 1, 2019, this code applies.

In accordance with the Energy Efficient Building Act, the Capital Development Board (CDB) is required to review and adopt the most current version of the International Energy Conservation Code (IECC) within one year of its publication date. The Code will then become effective in Illinois within 6 months following its adoption by the CDB. The CDB, in conjunction with the Illinois Environmental Protection Agency and the Illinois Energy Conservation Advisory Council, initiates the cycle for the Illinois Energy Conservation Code to be updated every three years.

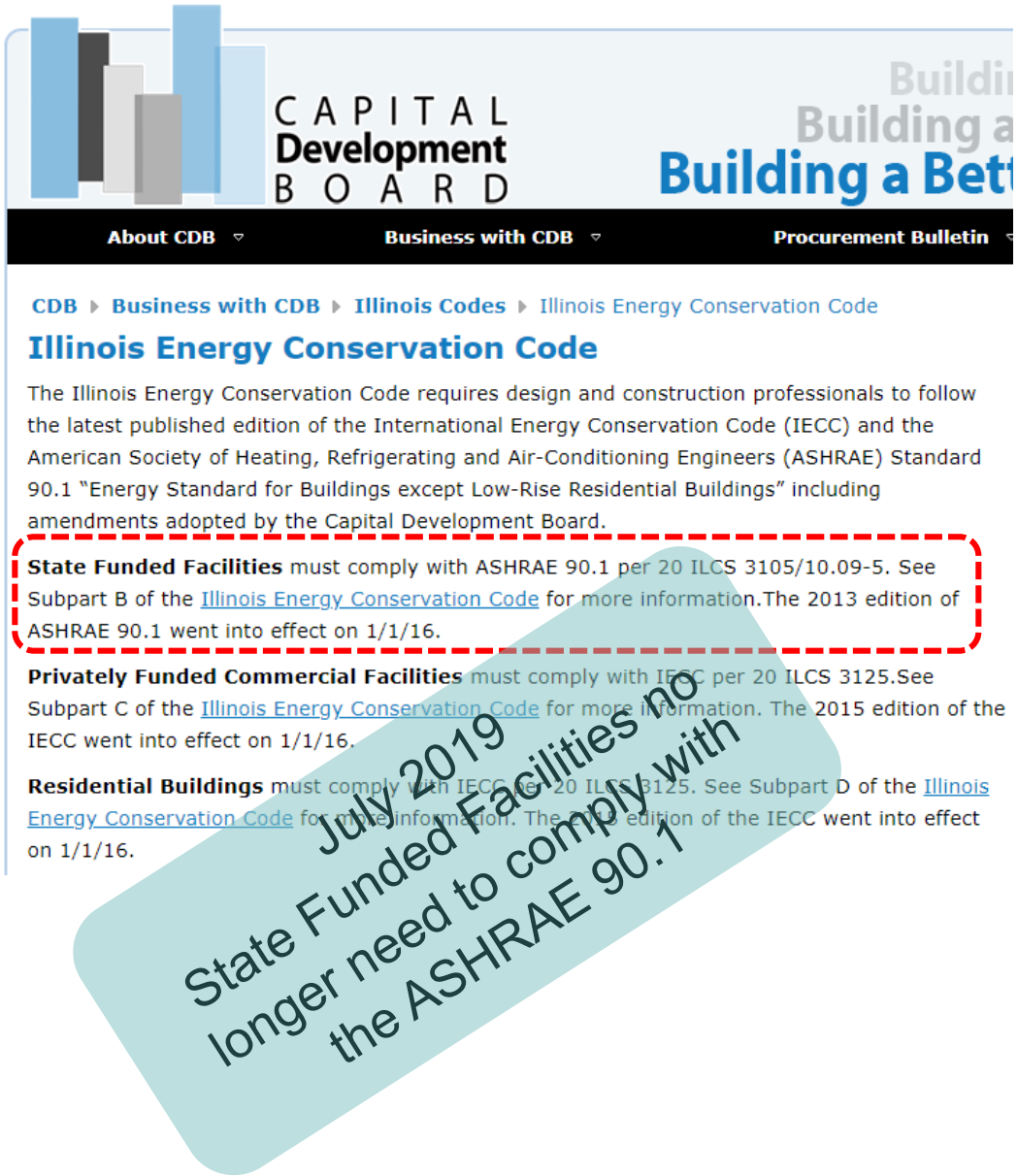
The 2018 Illinois Energy Conservation Code can be accessed here:

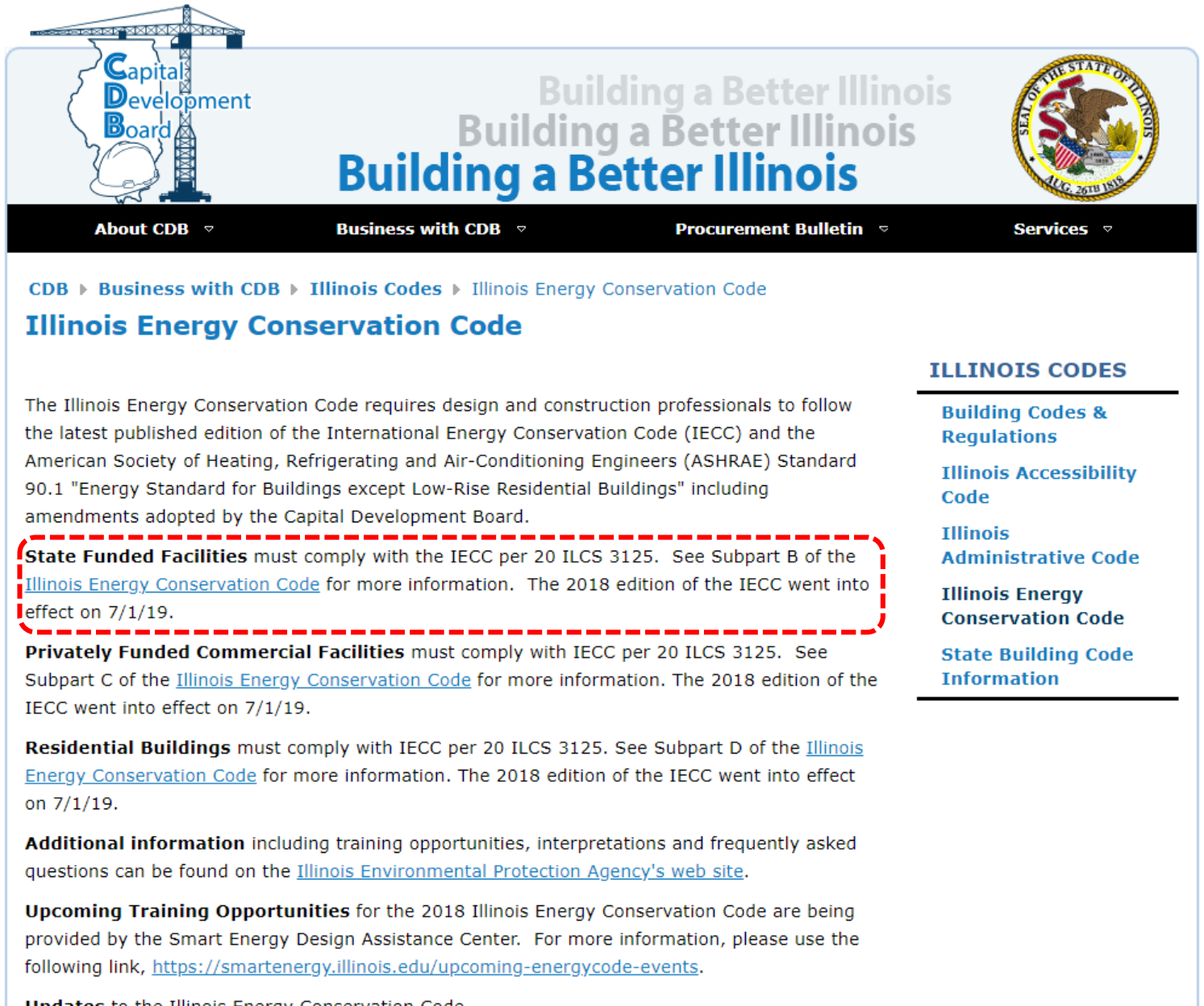
- 2018 IECC
- Illinois amendments

Effective date of 2018 IECC for City of Chicago: June 1, 2019

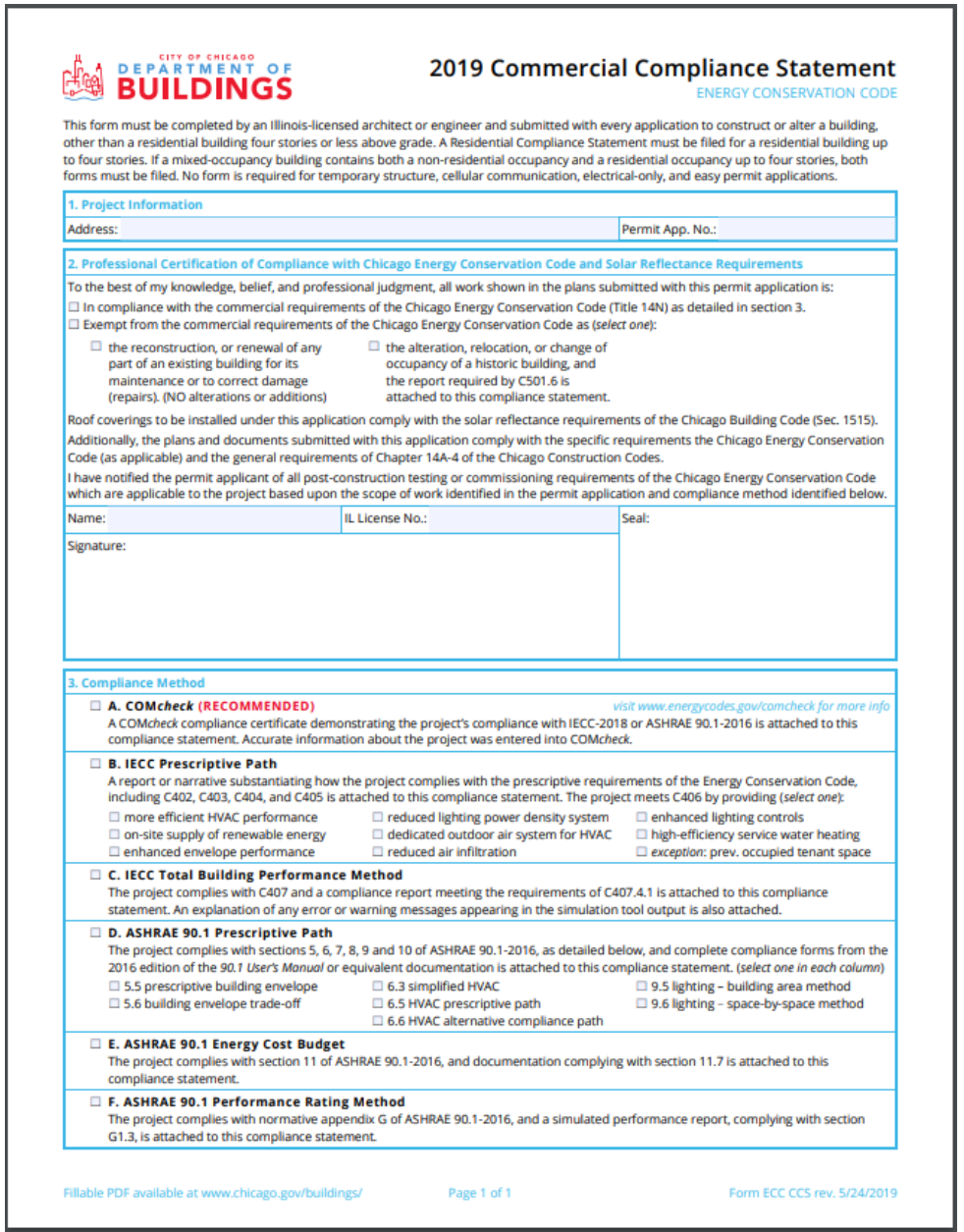
For permit applications started on or after June 1, 2019, the Chicago Energy Conservation Code (Title 14N of the Municipal Code), based on the 2018 edition of the International Energy Conservation Code applies. Solar requirements for roof coverings are still applicable and can be found in Section 1515 of the Chicago Building Code (Title 14B). For more details on the Chicago Energy Conservation Code and required Energy Conservation Compliance Statement, please visit the Department of Buildings, City of Chicago website.

Illinois Energy Conservation Code





Chicago Building Dept. Energy Code Compliance Statement



CITY OF CHICAGO DEPARTMENT OF BUILDINGS

2019 Commercial Compliance Statement

ENERGY CONSERVATION CODE

This form must be completed by an Illinois-licensed architect or engineer and submitted with every application to construct or alter a building, other than a residential building four stories or less above grade. A Residential Compliance Statement must be filed for a residential building up to four stories. If a mixed-occupancy building contains both a non-residential occupancy and a residential occupancy up to four stories, both forms must be filed. No form is required for temporary structure, cellular communication, electrical-only, and easy permit applications.

1. Project Information

Address:	Permit App. No.:

2. Professional Certification of Compliance with Chicago Energy Conservation Code and Solar Reflectance Requirements

To the best of my knowledge, belief, and professional judgment, all work shown in the plans submitted with this permit application is:

☐ In compliance with the commercial requirements of the Chicago Energy Conservation Code (Title 14N) as detailed in section 3.

☐ Exempt from the commercial requirements of the Chicago Energy Conservation Code as (*select one*):

- ☐ the reconstruction, or renewal of any part of an existing building for its maintenance or to correct damage (repairs). (NO alterations or additions)
- ☐ the alteration, relocation, or change of occupancy of a historic building, and the report required by C501.6 is attached to this compliance statement.

Roof coverings to be installed under this application comply with the solar reflectance requirements of the Chicago Building Code (Sec. 1515).

Additionally, the plans and documents submitted with this application comply with the specific requirements the Chicago Energy Conservation Code (as applicable) and the general requirements of Chapter 14A-4 of the Chicago Construction Codes.

I have notified the permit applicant of all post-construction testing or commissioning requirements of the Chicago Energy Conservation Code which are applicable to the project based upon the scope of work identified in the permit application and compliance method identified below.

Name:	IL License No.:	Seal:
Signature:		

3. Compliance Method

☐ **A. COM*check* (RECOMMENDED)** *visit www.energycodes.gov/comcheck for more info*

A COM*check* compliance certificate demonstrating the project's compliance with IECC-2018 or ASHRAE 90.1-2016 is attached to this compliance statement. Accurate information about the project was entered into COM*check*.

☐ **B. IECC Prescriptive Path**

A report or narrative substantiating how the project complies with the prescriptive requirements of the Energy Conservation Code, including C402, C403, C404, and C405 is attached to this compliance statement. The project meets C406 by providing (*select one*):

- ☐ more efficient HVAC performance
- ☐ on-site supply of renewable energy
- ☐ enhanced envelope performance
- ☐ reduced lighting power density system
- ☐ dedicated outdoor air system for HVAC
- ☐ reduced air infiltration
- ☐ enhanced lighting controls
- ☐ high-efficiency service water heating
- ☐ *exception*: prev. occupied tenant space

☐ **C. IECC Total Building Performance Method**

The project complies with C407 and a compliance report meeting the requirements of C407.4.1 is attached to this compliance statement. An explanation of any error or warning messages appearing in the simulation tool output is also attached.

☐ **D. ASHRAE 90.1 Prescriptive Path**

The project complies with sections 5, 6, 7, 8, 9 and 10 of ASHRAE 90.1-2016, as detailed below, and complete compliance forms from the 2016 edition of the *90.1 User's Manual* or equivalent documentation is attached to this compliance statement. (*select one in each column*)

- ☐ 5.5 prescriptive building envelope
- ☐ 5.6 building envelope trade-off
- ☐ 6.3 simplified HVAC
- ☐ 6.5 HVAC prescriptive path
- ☐ 6.6 HVAC alternative compliance path
- ☐ 9.5 lighting – building area method
- ☐ 9.6 lighting - space-by-space method

☐ **E. ASHRAE 90.1 Energy Cost Budget**

The project complies with section 11 of ASHRAE 90.1-2016, and documentation complying with section 11.7 is attached to this compliance statement.

☐ **F. ASHRAE 90.1 Performance Rating Method**

The project complies with normative appendix G of ASHRAE 90.1-2016, and a simulated performance report, complying with section G1.3, is attached to this compliance statement.

Fillable PDF available at www.chicago.gov/buildings/ Page 1 of 1 Form ECC CCS rev. 5/24/2019

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Access to 2018 IECC, Illinois Amendments & Chicago Energy Conservation Code

https://codes.iccsafe.org/content/IECC2018P3

https://www2.illinois.gov/cdb/business/codes/IllinoisAccessibilityCode/Documents/2018%20Illinois%20Specific%20Amendments%20with%20Modifications%20Shown.pdf

https://codes.iccsafe.org/content/document/1491

CHAPTER 1 [CE]
SCOPE AND ADMINSTRATION

SECTION C101
SCOPE AND GENERAL REQUIREMENTS

C101.1 Title. This code shall be known as the ~~*International Energy Conservation Code* of **[NAME OF JURISDICTION]** and shall be cited as such.~~ *Illinois Energy Conservation Code* or "this Code" and shall mean:

With respect to the State facilities covered by 71 Ill. Adm. Code 600.Subpart B:

This Part, all additional requirements incorporated within Subpart B (including the 2018 International Energy Conservation Code, including all published errata but excluding published supplements that encompass ASHRAE 90.1-2016), and any statutorily authorized adaptations to the incorporated standards adopted by CDB are effective July 1, 2019.

With respect to the privately funded commercial facilities covered by 71 Ill. Adm. Code 600.Subpart C:

This Part, all additional requirements incorporated within Subpart C (including the 2018 International Energy Conservation Code, including all published errata and excluding published supplements that encompass ASHRAE 90.1-2016), and any statutorily authorized adaptations to the incorporated standards adopted by CDB, are effective July 1, 2019.

C101.1.2 Adoption. The Board shall adopt

C101.1.3 Adaptation. The Board may appropriately adapt the International Energy Conservation Code to apply to the particular economy, population, distribution, geography and climate of the Sate and construction within the State, consistent with the public policy objectives of the EEB Act.

C101.5 Compliance. ~~*Residential buildings* shall meet the provisions of IECC—Residential Provisions.~~ *Commercial buildings* shall meet the provisions of ~~IECC-Commercial Provisions~~ the *Illinois Energy Conservation Code* covered by 71 Ill. Adm. Code 600.Subpart C. The local authority having jurisdiction (AHJ) shall establish its own procedures for enforcement of the Illinois Energy Conservation Code. Minimum compliance shall be demonstrated by submission of:

1. Compliance forms published in the ASHRAE 90.1 User's Manual; or
2. Compliance Certificates generated by the U.S. Department of Energy's COMcheck™ Code compliance tool; or
3. Other comparable compliance materials that meet or exceed, as determined by the AHJ, the compliance forms published in the ASHRAE 90.1 User's Manual or the U.S. Department of Energy's COMcheck™ Code compliance tool; or
4. The seal of the architect/engineer as required by Section 14 of the Illinois Architectural Practice Act [225 ILCS 305], Section 12 of the Structural Engineering Licensing Act [225 ILCS 340] and Section 14 of the Illinois Professional Engineering Practice Act [225 ILCS 325].

ARTICLE XIII.
CHICAGO ENERGY CONSERVATION CODE

SECTION 1. The Municipal Code of Chicago is hereby amended by inserting a new Title 14N, as follows:

TITLE 14N ENERGY CONSERVATION CODE

PART I – COMMERCIAL PROVISIONS

CHAPTER 14N-C1 SCOPE AND PURPOSE

14N-C1-C001 Adoption of the commercial provisions of the International Energy Conservation Code by reference.

The commercial provisions of the *International Energy Conservation Code*, 2018 edition, second printing, and all erratum thereto identified by the publisher (hereinafter referred to as "IECC-CE"), except Appendix CA, are adopted by reference and shall be considered part of the requirements of this title except as modified by the specific provisions of this title.

If a conflict exists between a provision modified by this title and a provision adopted without modification, the modified provision shall control.

14N-C1-C002 Citations.

Provisions of IECC-CE which are incorporated into this title by reference may be cited as follows:

14N-C[IECC-CE chapter number]-[IECC-CE section number]

14N-C1-C003 Global modifications.

The following modifications shall apply to each provision of IECC-CE incorporated into this title:

1. Replace each occurrence of "*International Codes*" with "*Chicago Construction Codes*."
2. Replace each occurrence of "*International Building Code*" with "*Chicago Building Code*."
3. Replace each occurrence of "ASME A17.1" or "ASME A17.1/CSA B44" with "the *Chicago Conveyance Device Code*."
4. Replace each occurrence of "NFPA 70" with "the *Chicago Electrical Code*."

SEDAC TOP 10 Series Webinars

Top 10 Requirements You Should Know: 2018 IECC

- Residential: September 12 (Archived)
- Commercial Envelope: October 16 (Archived)
- Commercial Lighting: December 18 (Archived)
- Commercial HVAC: January 29 (Archived)

- COM*check*™ & RES*check*™ Walk-through: May 6

https://smartenergy.illinois.edu/energy-code-training/webinars

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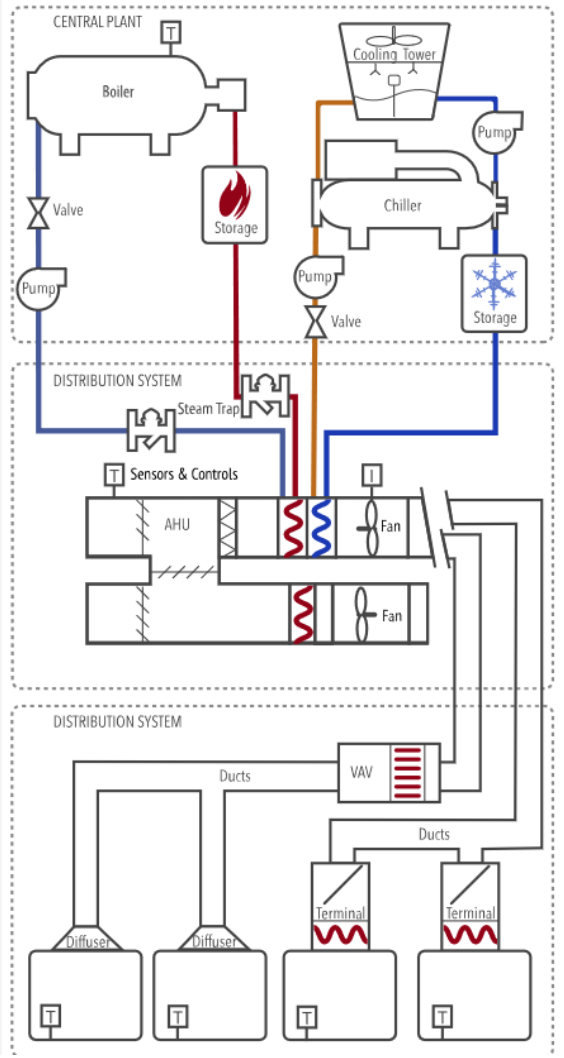
Top 40 Requirements (Part 2): 2018 IECC Commercial HVAC

21. Energy Recovery Ventilation Systems [C403.7.4]
22. Equipment Sizing [C403.3.1]
23. Economizer Fault Detection & Diagnostics [C403.5.5]
24. Maintenance Info. And System Commissioning [C408]
25. Shut-Off Dampers [C403.7.7]
26. Duct Sealing & Construction [C403.11.1, C403.11.2]
27. Demand Control Ventilation [C403.7.1]
28. Protection of Piping Insulation [C403.11.3.1]
29. Circulation Systems & Demand Recirculation Controls [C404.6.1, C404.7]
30. Freeze Protection System Controls [C403.12.3]



NREL HVAC Resource Map

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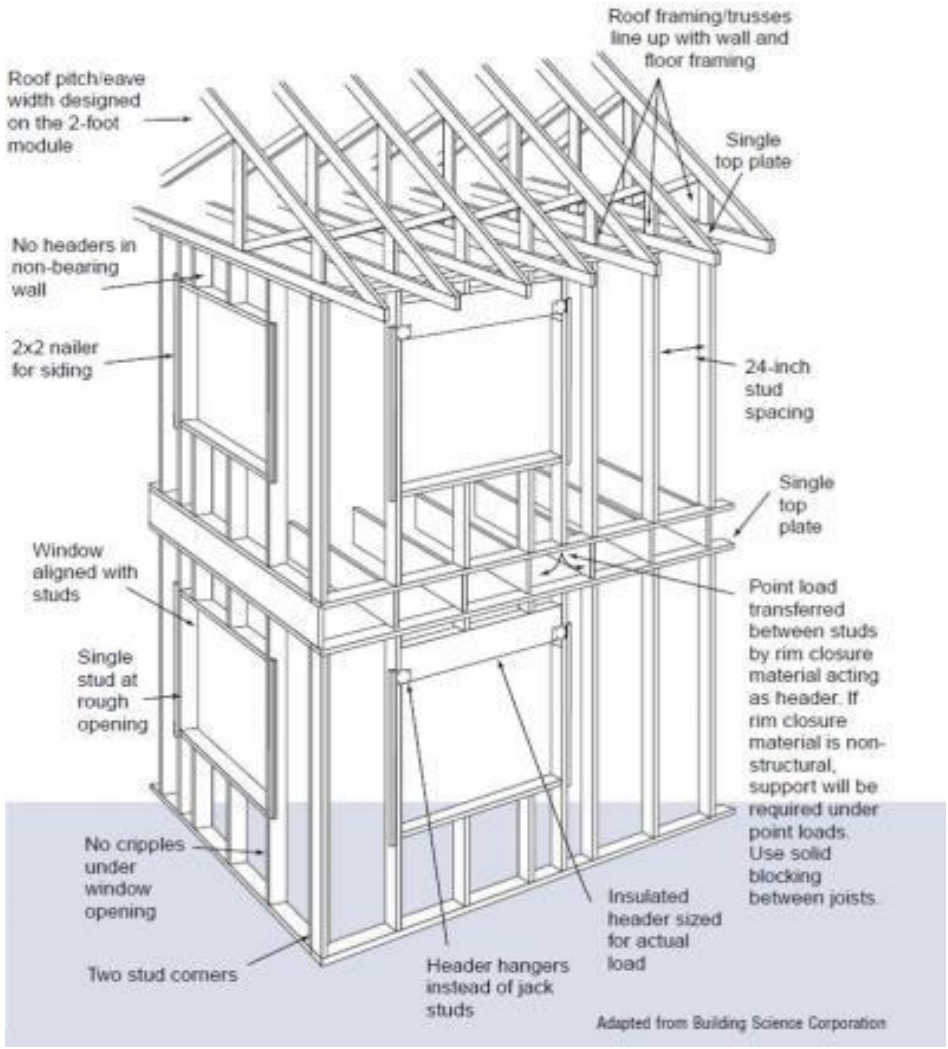
Top 40 Requirements (Part 2): 2018 IECC Residential Provisions

31. Energy Certificate [R401.3]
32. Insulation [R402.1, R402.2]
33. Envelope Sealing [R402.4]
34. Blower Door Testing [R402.4.1.2]
35. Duct Insulation, Sealing & Testing [R403.3]
36. Pipe Insulation [R403.4, R403.5.3]
37. HVAC Load & Sizing [R403.7]
38. Ventilation [R403.6]
39. Lighting [R404.1, R402.4.5]
40. Additions / Alterations [R502, R503]



https://basc.pnnl.gov/images

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#21. C403.7.4 Energy Recovery Ventilation Systems (Mandatory)

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C403.7.4 Energy Recovery Ventilation systems

Where the supply airflow rate of a fan system exceeds the values specified in Tables C403.7.4(1) and C403.76.4(2), the system shall include an energy recovery system.

Table C403.7.4(1) and (2) CZ 4A and 5A

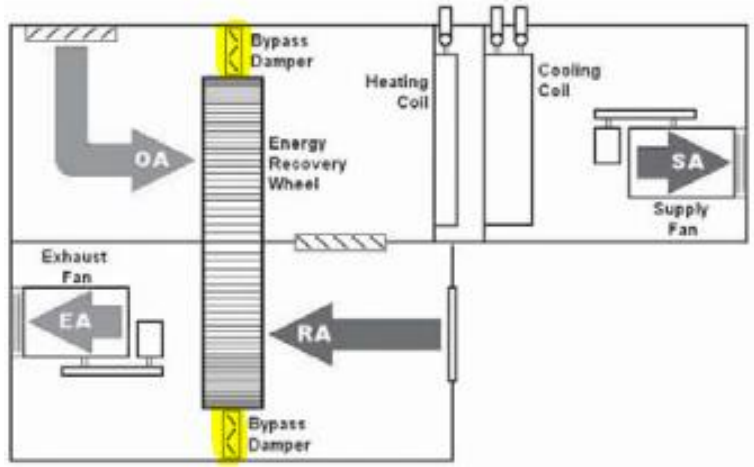
Operation	Percent (%) Outside Air at Full Design Airflow Rate (CZ 4A and 5A)							
	≥10% <20%	≥20% <30%	≥30% <40%	≥40% <50%	≥50% <60%	≥60% <70%	≥70% <80%	≥80%
<8,000 hr/yr	≥26,000	≥16,000	≥5,500	≥4,500	≥3,500	≥2,000	≥1,000	≥120
>8,000 hr/yr	≥200	≥130	≥200	≥200	≥200	≥200	≥200	≥200

Energy recovery device must recover 50% of enthalpy difference between outside and return air streams.

Recovery devices need to have bypass or controls to allow economizer operation as per C403.5

- Bypass can be VFD on wheel that stops rotation, or bypass dampers

Annual energy reduction potential of 25%-50%



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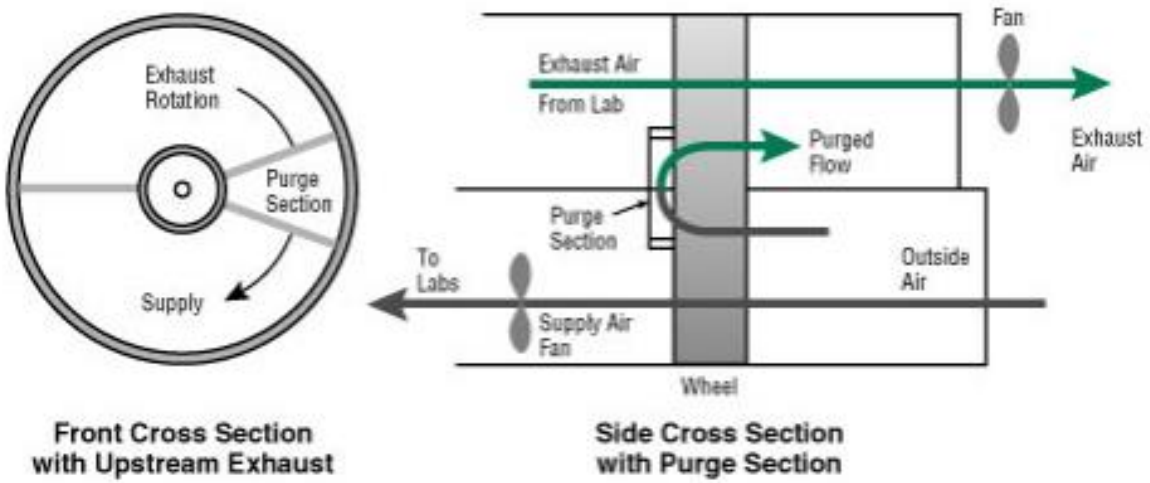
C403.7.4 Energy Recovery Ventilation Limitations

- ERVs prohibited by IMC for hazardous exhaust fumes (smoke, chemicals, grease etc…)
  - Potential for carry-over of exhaust to outside air with wheels and vapor-permeable exchangers
- Does not prevent the use of heat recovery devices!
  - Runaround loops
  - Sensible heat exchangers
  - Heat pipes



Exceptions to ERVs don't prevent use of HRVs

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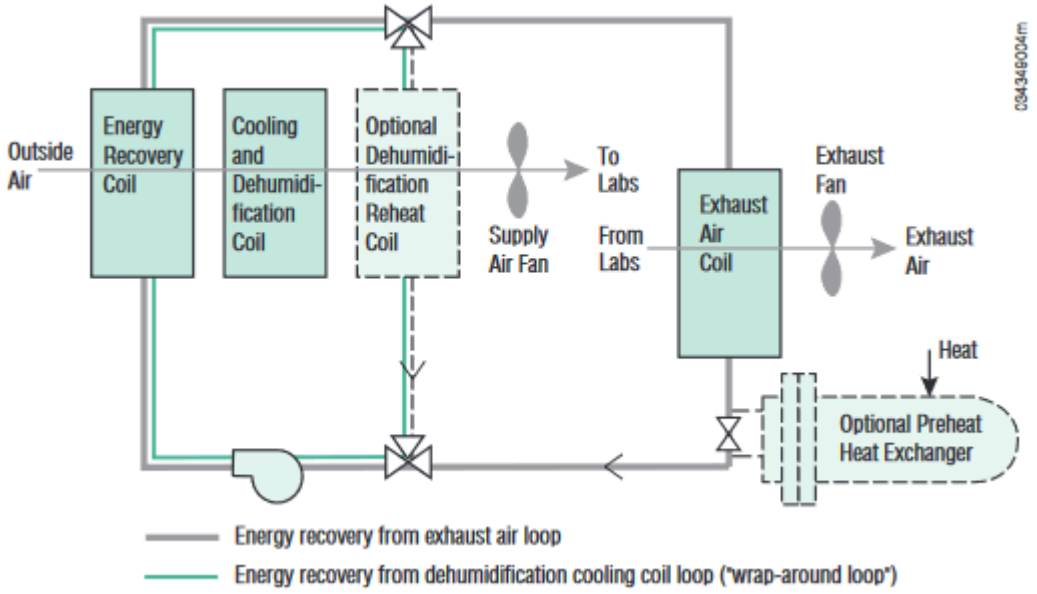
C403.7.4 Energy Recovery Ventilation Exceptions

1. Where prohibited by IMC
2. Lab hoods with VAV configured to reduce to ≤50% design airflow or make-up air is ≥75% exhaust & not conditioned to >2°F warmer or <3°F cooler than room temperature.
3. Serving a space without cooling and heated to <60°F
4. >60% of OA heating provided by recovered/solar heat
5. Systems requiring dehumidification w/ energy recovery in series with cooling
6. Largest source of exhaust is <75% of system OA design
7. Systems operating <20hr per week at OA% in Table C403.7.4(1)



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#22. C403.3.1 Equipment Sizing

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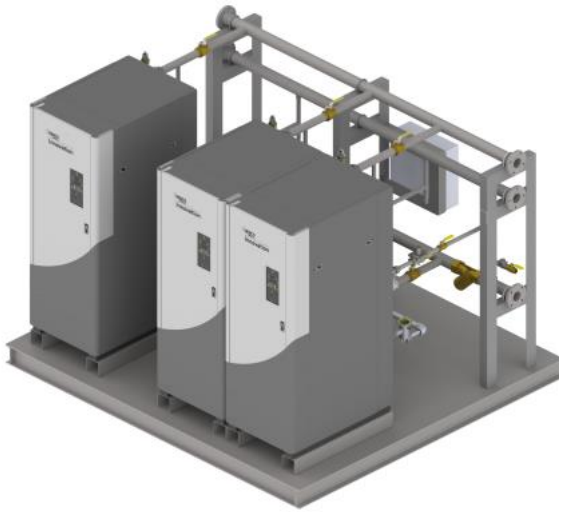
C403.3.1 Equipment Sizing

- The output capacity of heating and cooling equipment shall not be greater than that of the smallest available equipment size that exceeds the loads calculated in accordance with Section C403.1.1.

- Code allows for installation of stand-by equipment (N+1)
- Code allows for multiple units exceeding capacity provided controls limit operation of units based on load.
    - Modular systems are a good example of this compliance method, providing redundancy and built-in staging control.



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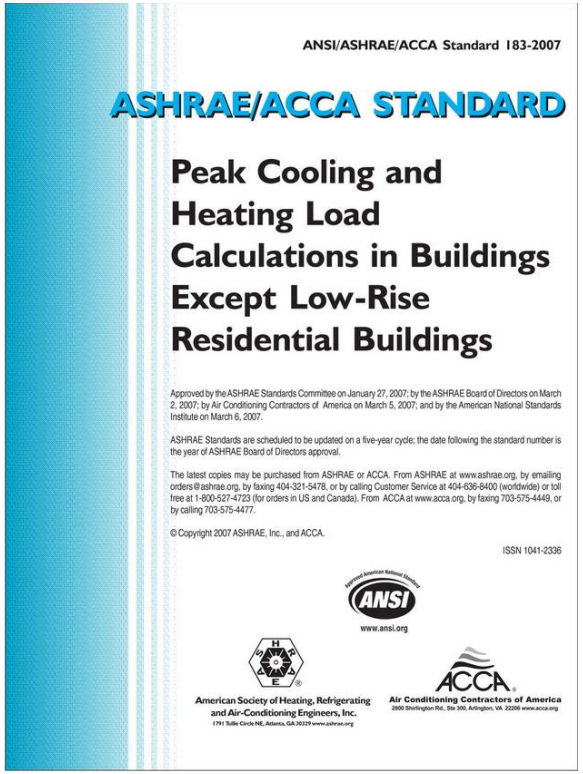
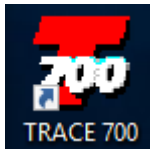
C403.3.1 Equipment Sizing

- Over-sizing issues
  - Unnecessary increased capital costs
  - Continual low part-load can reduce equipment life and efficiency
- Under-sizing issues
  - Unmet loads and comfort issues
- Right-size using load calculation software or sheets
  - ASHRAE/ANSI/ACCA Standard 183
  - eQuest/Energy Plus/Trane Trace/Carrier and others





#23. C403.5.5 Economizer Fault Detection and Diagnostics

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C403.5.5 Economizer Fault Detection and Diagnostics

- Air-cooled unitary DX units listed in Tables C403.3.2(1) – (3) and VRF units that are equipped with an economizer in accordance with C403.5-C403.5.4 shall include a fault detection and diagnostics system…

Previous code text stated systems shall be *capable* of fault detection, 2018 IECC states shall be *configured* for fault detection

Monitor supply, return, and outside air temperatures

Provide status on key system operations

Report air temperature sensor faults, improper economizing, damper malfunctions, and excess OA flow.

Failed economizers can dramatically increase energy consumption for heating/cooling.

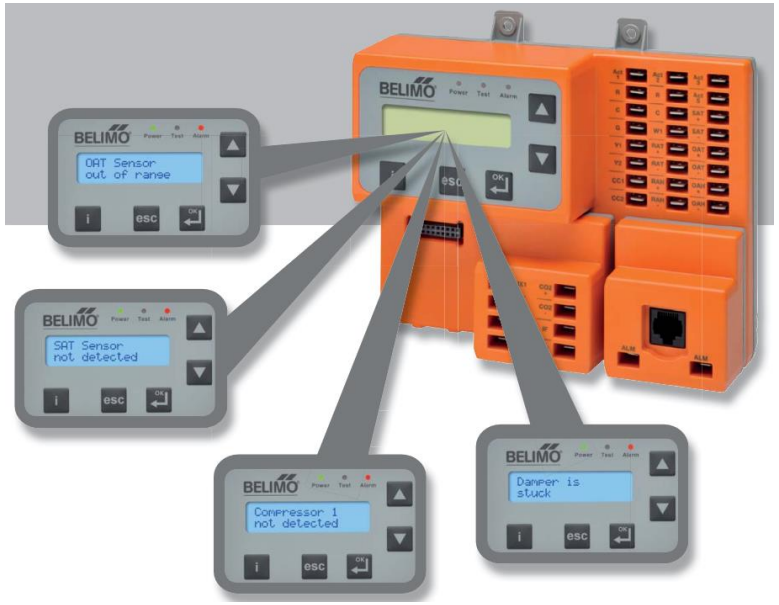

Image source: Honeywell

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Example Economizer Compliance

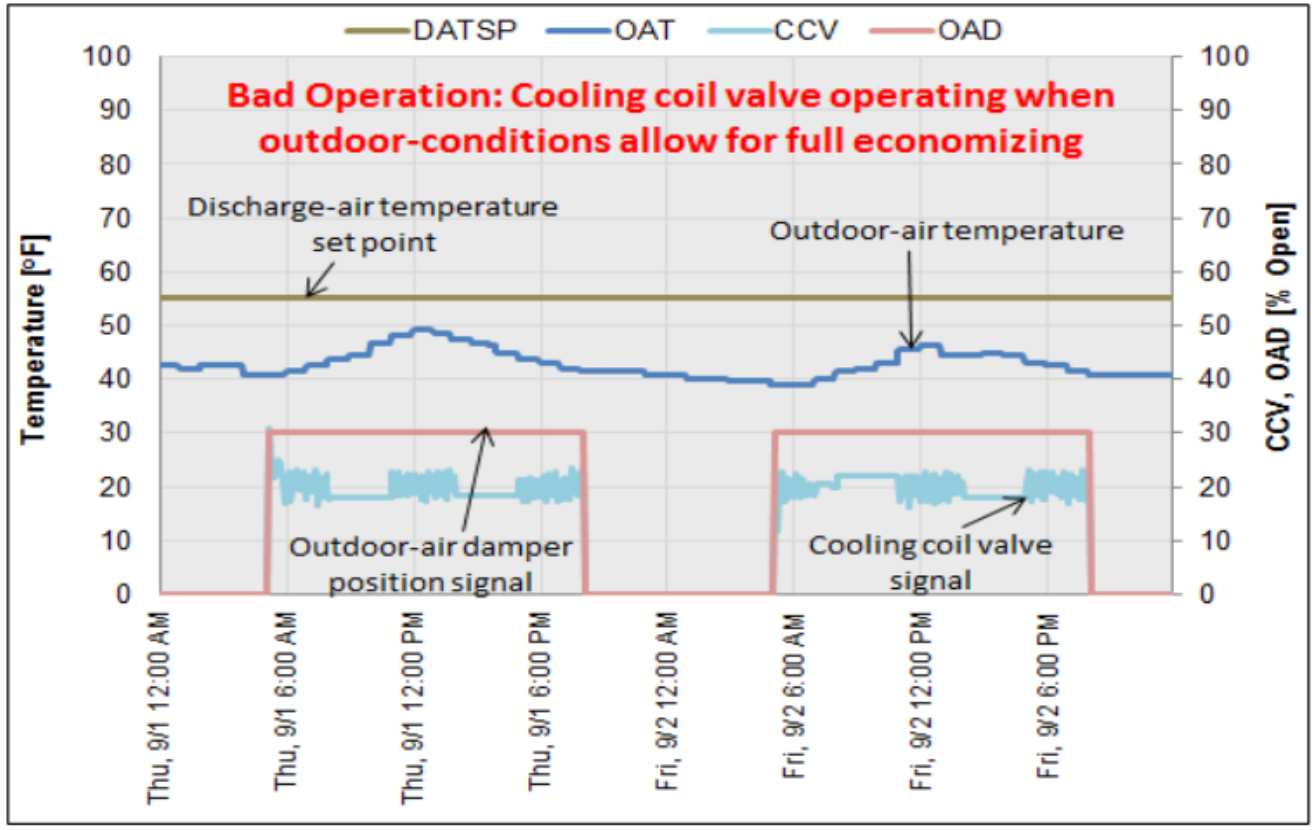

Figure 7: Cooling coil valve opening when outdoor conditions allow for full economizing, wasting cooling energy.

Trending and BAS automated alarming

Thermostat/System Displays

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#24. C408 Maintenance Information and System Commissioning

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C408 Maintenance Information and System Commissioning

- 2018 IECC controls shall be *configured* with:
  - Thermostat deadbands
  - Unoccupied setback and optimized start/stop
  - Equipment modulation to match loads (fan speed, pressure, & temperature resets, etc…)
  - Economizers and energy recovery
  - Demand control ventilation
  - And More!

Many missed without early commissioning

Commissioning often cut from construction budgets as other line-items exceed projected costs, or delays occur.

Often leads to long-term energy costs and occupant complaints

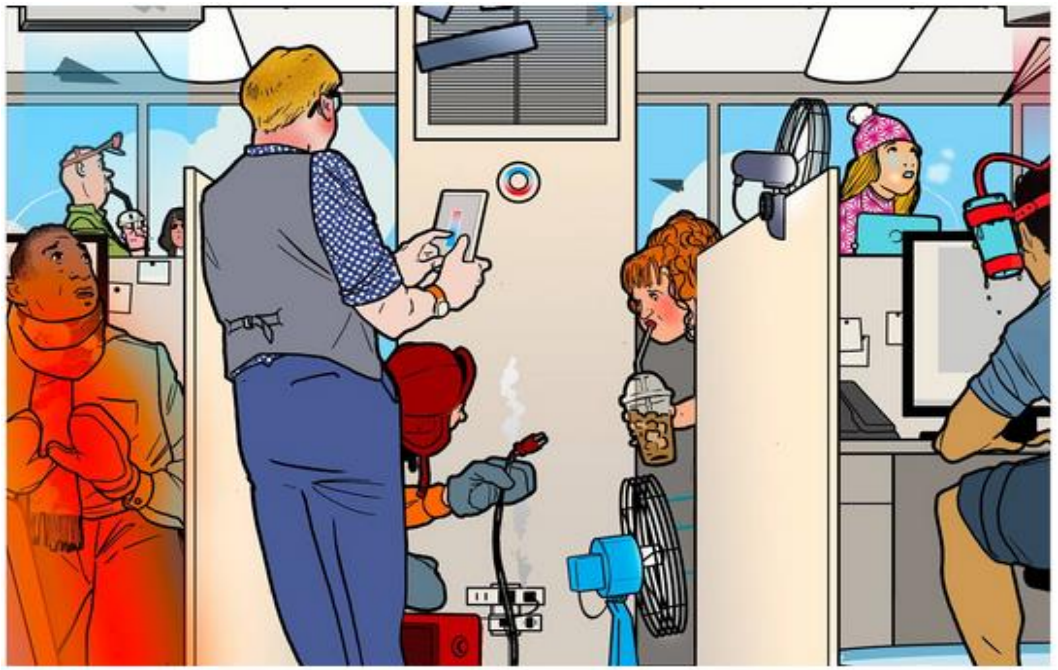

ILLUSTRATION: JASON SCHNEIDER WSJ - Let the Thermostat Wars Begin

C408 Maintenance Information and System Commissioning

- Commissioning costs range from $0.25 to $1.25 per sf (aceee.org)
- LBL report found that commissioning new construction reduced energy $0.18/sf-yr at a cost of $1.16/sf
- Also improves building durability, prolongs service life, reduces comfort complaints from occupants.

Example from field experience:

HVAC fans turned off on schedule, but back on at midnight instead of morning start-up.

Image courtesy WBDG.org

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C408 Commissioning Documentation For Compliance

OWNER'S NOTIFICATION OF COMMISSIONING

To be filled in and signed by Owner before a building permit is issued.

The International Energy Conservation Code requires a registered design professional or approved agency to ensure buildings are designed, constructed and commissioned in accordance with the approved plans, specifications and commissioning plan.

I, as owner/legal agent, do hereby certify that I have retained _____ to be responsible for building commissioning services in accordance with this certificate.

Signed : _____ Print name: _____
(signature of owner or legal representative)

Relation to Project (owner/legal agent): _____ Date: _____

COMMISSIONING RESPONSIBILITY

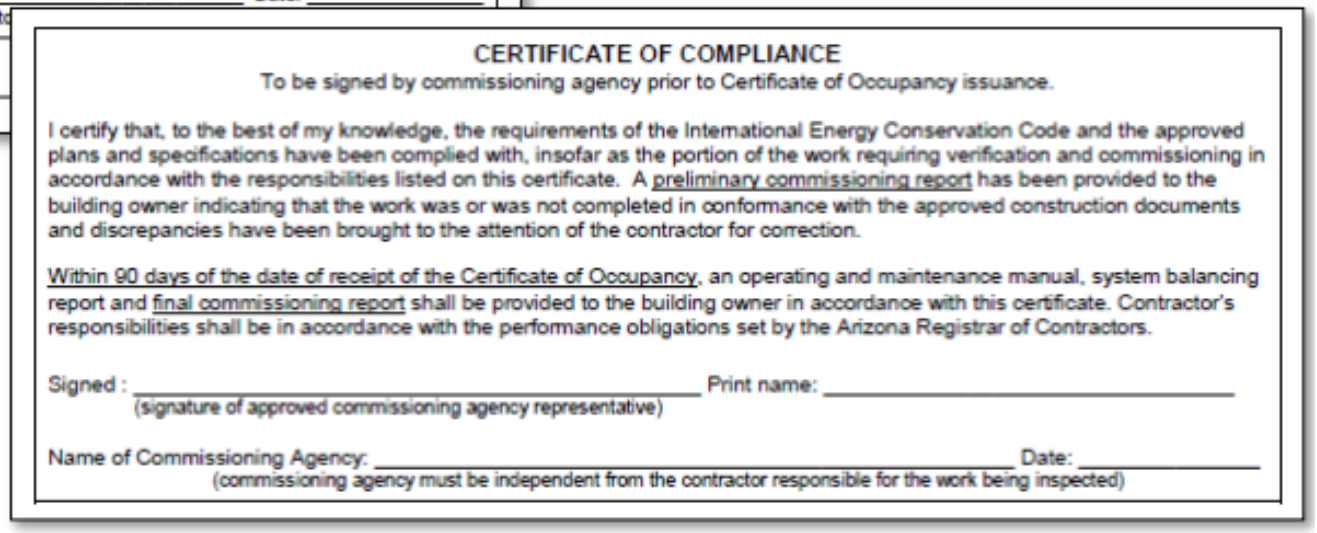
To be filled in and signed by the registered design professional or approved agency before a building permit is issued.

As the commissioning agency for the above named project, I certify that I am familiar with the design of the project and hereby assume full responsibility for carrying out the required commissioning responsibilities in accordance with this certificate.

Signed : _____ Print name: _____
(signature of commissioning agency representative)

Name of Commissioning Agency: _____ Date: _____
(commissioning agency must be independent from the contracto

Processed by _____
City Plans Examiner



CERTIFICATE OF COMPLIANCE

To be signed by commissioning agency prior to Certificate of Occupancy issuance.

I certify that, to the best of my knowledge, the requirements of the International Energy Conservation Code and the approved plans and specifications have been complied with, insofar as the portion of the work requiring verification and commissioning in accordance with the responsibilities listed on this certificate. A preliminary commissioning report has been provided to the building owner indicating that the work was or was not completed in conformance with the approved construction documents and discrepancies have been brought to the attention of the contractor for correction.

Within 90 days of the date of receipt of the Certificate of Occupancy, an operating and maintenance manual, system balancing report and final commissioning report shall be provided to the building owner in accordance with this certificate. Contractor's responsibilities shall be in accordance with the performance obligations set by the Arizona Registrar of Contractors.

Signed : _____ Print name: _____
(signature of approved commissioning agency representative)

Name of Commissioning Agency: _____ Date: _____
(commissioning agency must be independent from the contractor responsible for the work being inspected)

Examples from Texas of compliance forms for commissioning.

C408.2.4.1 – Preliminary Commissioning Report to be provided before final inspection can be performed

- Initial list of deficiencies to be corrected

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#25. C403.7.7 Shut-off Dampers

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C403.7.7 Shut-off Dampers

- Outdoor air intake and exhaust openings and stairway and shaft vents shall be provided with Class 1 motorized dampers [with] an air leakage rate of ≤4cfm/sf of damper surface area at 1” w.g. and shall be labeled by an approved agency when tested in accordance with AMCA 500D for this purpose.

This section is for pressurization/ventilation dampers.

- Fire dampers are covered in the fire code.

Commonly find these dampers are not sealed, and leak more than code requirements.

Low-rise buildings can have non-motorized gravity dampers with leakage rates

<20 cfm/sf if >24” in either dimension or
<40 cfm/sf if <24” in either dimension

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Maintaining Damper Closure

TORQUE DATA
Torque values are given in in.-lbs. and (Nm)

Damper Height in. and (mm)	FACE VELOCITY TORQUE Damper Width in. and (mm)				PRESSURE TORQUE Damper Width in. and (mm)				SEALING TORQUE Damper Width in. and (mm)			
	12" (305)	24" (610)	36" (914)	48" (1219)	12" (305)	24" (610)	36" (914)	48" (1219)	12" (305)	24" (610)	36" (914)	48" (1219)
12" (305)	1 (1)	1 (1)	2 (1)	3 (1)	1 (1)	3 (1)	4 (1)	5 (1)	21 (3)	31 (4)	41 (5)	52 (6)
18" (457)	1 (1)	3 (1)	4 (1)	6 (1)	2 (1)	4 (1)	5 (1)	7 (1)	30 (4)	44 (5)	58 (7)	71 (9)
24" (610)	1 (1)	2 (1)	5 (1)	6 (1)	2 (1)	5 (1)	8 (1)	11 (2)	38 (5)	56 (7)	73 (9)	90 (11)
30" (762)	2 (1)	4 (1)	6 (1)	8 (1)	3 (1)	7 (1)	10 (2)	14 (2)	47 (6)	68 (8)	89 (11)	109 (13)
36" (914)	2 (1)	4 (1)	7 (1)	9 (2)	4 (1)	8 (1)	12 (2)	16 (2)	56 (7)	80 (10)	104 (12)	129 (15)
42" (1067)	2 (1)	5 (1)	8 (1)	11 (2)	4 (1)	9 (2)	14 (2)	19 (3)	65 (8)	93 (11)	120 (14)	148 (17)
48" (1219)	3 (1)	6 (1)	9 (2)	13 (2)	5 (1)	10 (2)	16 (2)	22 (3)	74 (9)	105 (12)	136 (16)	167 (19)
54" (1372)	4 (1)	10 (2)	15 (2)	20 (3)	6 (1)	12 (2)	19 (3)	26 (3)	85 (10)	122 (14)	159 (19)	197 (23)
60" (1524)	4 (1)	10 (2)	15 (2)	20 (3)	6 (1)	12 (2)	19 (3)	26 (3)	91 (11)	128 (15)	165 (19)	203 (23)
66" (1676)	5 (1)	11 (2)	17 (2)	23 (3)	6 (1)	14 (2)	22 (3)	29 (4)	101 (12)	143 (17)	185 (21)	226 (26)
72" (1829)	6 (1)	12 (2)	19 (3)	26 (3)	7 (1)	16 (2)	25 (3)	33 (4)	111 (13)	157 (18)	204 (24)	250 (29)

Above values based on 1000 fpm (5 m/s) face velocity. Use multipliers below for other face velocities.

Above values based on differential pressure of 1 in. wg. (250 Pa). Use multipliers below for other differential pressures.

Above values based on the use of dual durometer vinyl seals on the blade and metallic compression seals at the jambs.

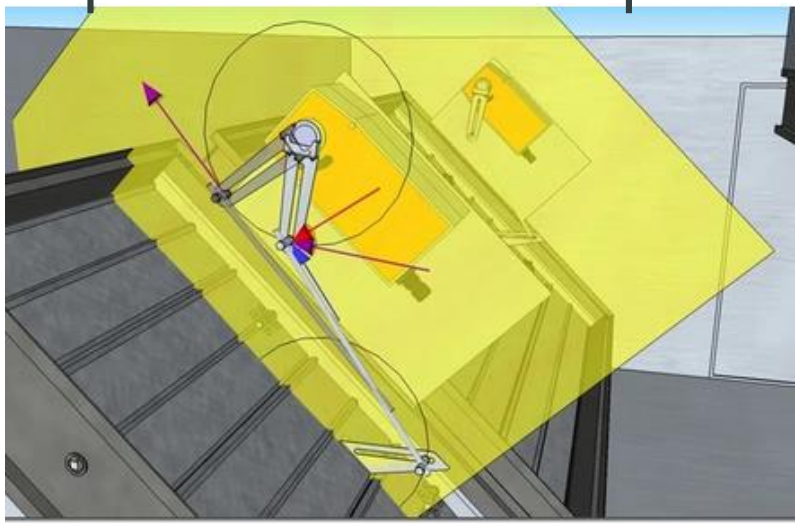
Face Velocity fpm (m/s)	Multiplier	Diff. Pressure in. wg (Pa)	Multiplier
1500 (8)	2.25	1 (250)	1
2000 (10)	4.00	2 (500)	2
2500 (13)	6.25	3 (750)	3
3000 (15)	9.00	4 (1000)	4

See page 6 for multi-panel jackshafting arrangements.

Mesteksa.com

Common Shut-off damper/economizer problem that linkage geometry is incorrect to maintain closure seal or provide full range of motion.

Some RTUs only have gravity closure dampers, which don't always stay sealed on a pressurized RTU plenum or in breeze.



Economizers–The Physics of Linkage Systems-David Sellers, Facility Dynamics Engineering

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#26. C403.11.1 Duct and Plenum Sealing and Insulation

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C403.11.1 Duct and Plenum Insulation and Sealing

Supply and return dusts and plenums shall be insulated with not less than R-6 insulation where located in unconditioned spaces and where located outside the building with not less than…R-12 insulation…Ducts, air handlers and filter boxes shall be sealed.

- Residential testing commonplace, not for commercial, though.
- Particularly bad for unducted returns above ceilings where return depressurizes surrounding space, amplifying supply leakage.
- Duct joints often covered by insulation and left unsealed, or sealant applied over insulation, which still allows leakage and condensation risk as well.

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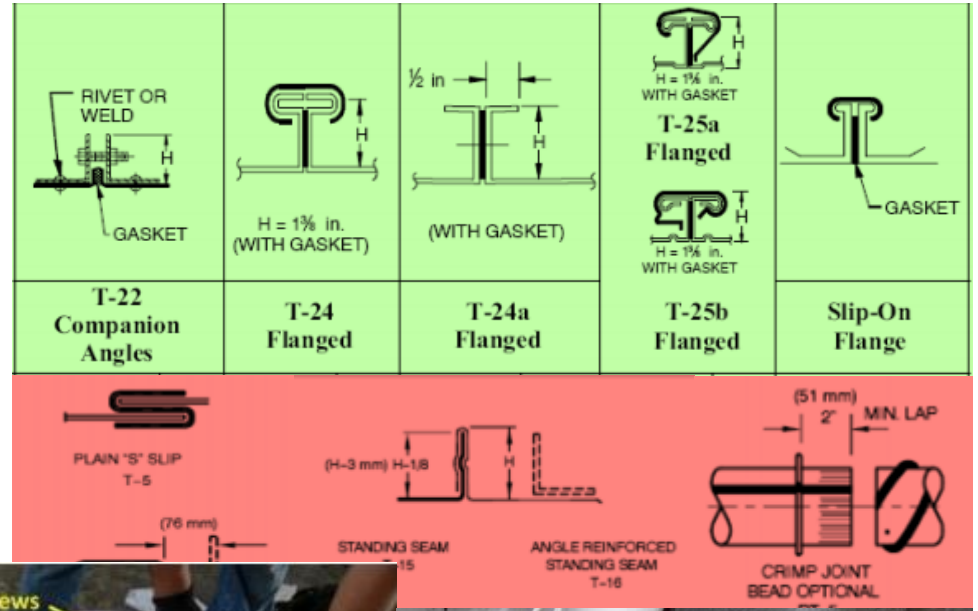
C403.11.1 Duct and Plenum Insulation and Sealing

- Gasketed joints are ideal, but not always used or properly applied.
- Ungasketed joints should be sealed with UL-181 mastic or tape.
- Gasketed joints should be applied to duct surface, not insulation wrap.
- Transitions between duct materials often failure point.

DON’T USE DUCK TAPE



#27. C403.7.1 Demand Control Ventilation

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C403.7.1 Demand Control Ventilation

DCV shall be provided for spaces larger than 500 sf and with an average occupant load of 25 people or greater per 1,000 sf of floor area…and served by systems with (1.) air-side economizer, (2.) automatic modulating control of OA damper, and/or (3.) design OA of >3,000cfm.

Exceptions:

1. Systems with energy recovery complying with C403.7.4
2. Multiple-zone systems without direct digital control of individual zones communicating with a central control panel
3. Systems with a design outdoor airflow less than 1,200 cfm
4. Spaces where the supply airflow rate minus any makeup or outgoing transfer air requirements is less than 1,200 cfm
5. Ventilation provided only for process loads.

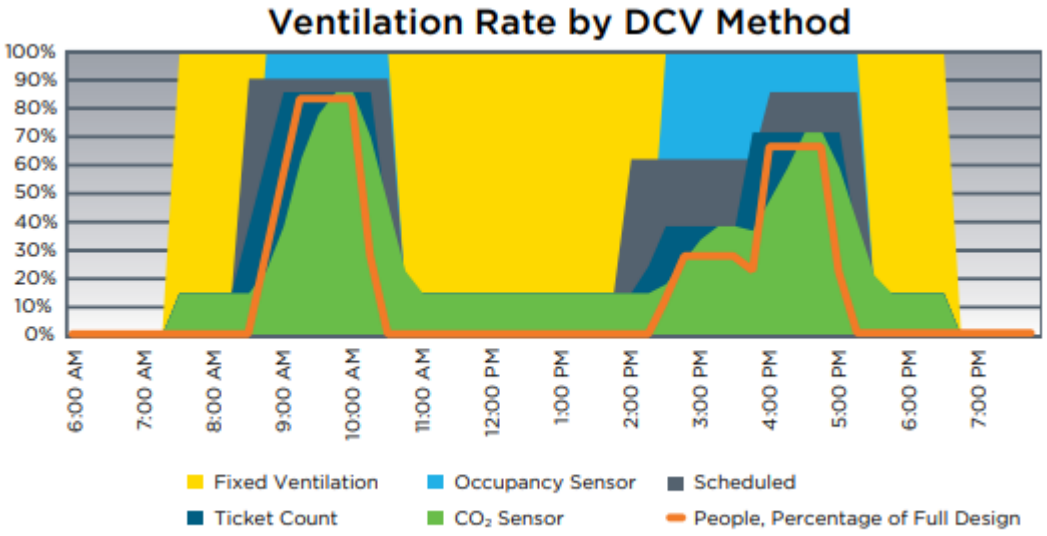

Figure 1. Ventilation rates provided with fixed ventilation and DCV alternatives

Chart courtesy Energycodes.gov: Note that all methods of DCV reduce airflow over a fixed ventilation rate.

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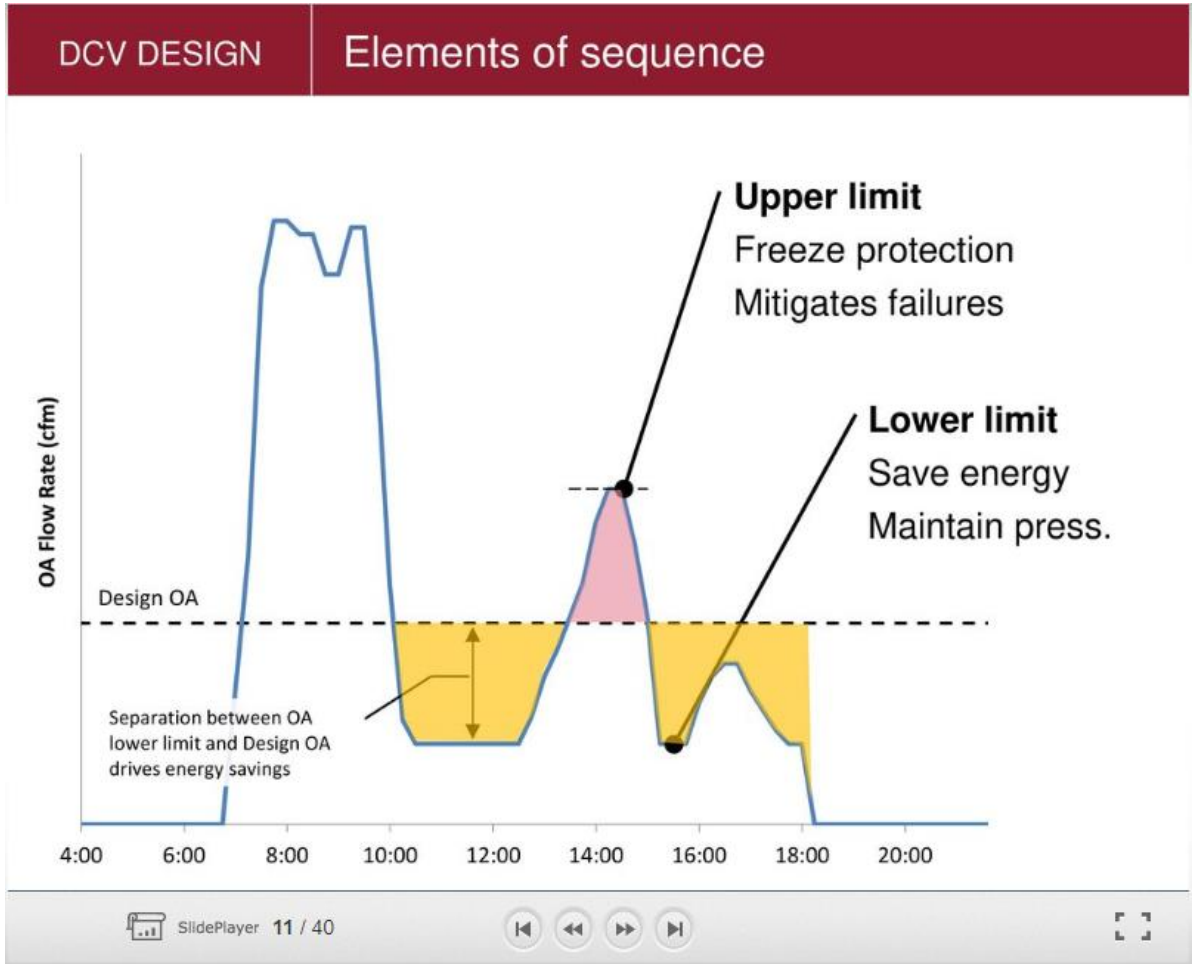
Common Demand Control Ventilation Issues

Common issues:

- Economizer not set-up to override DCV, resulting in loss of economizing ability
- Confusion on CO_2 sensor set points (too low/high) depending on set point type (differential or total CO_2)
- Minimum area ventilation and maximum occupant ventilation limits are not set at the AHUs controls, resulting in incorrect ventilation levels.



DCV presentation MN Energy Expo, Scott Hackel, Senior Energy Engineer

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#28. C403.11.3.1 Protection of Piping Insulation

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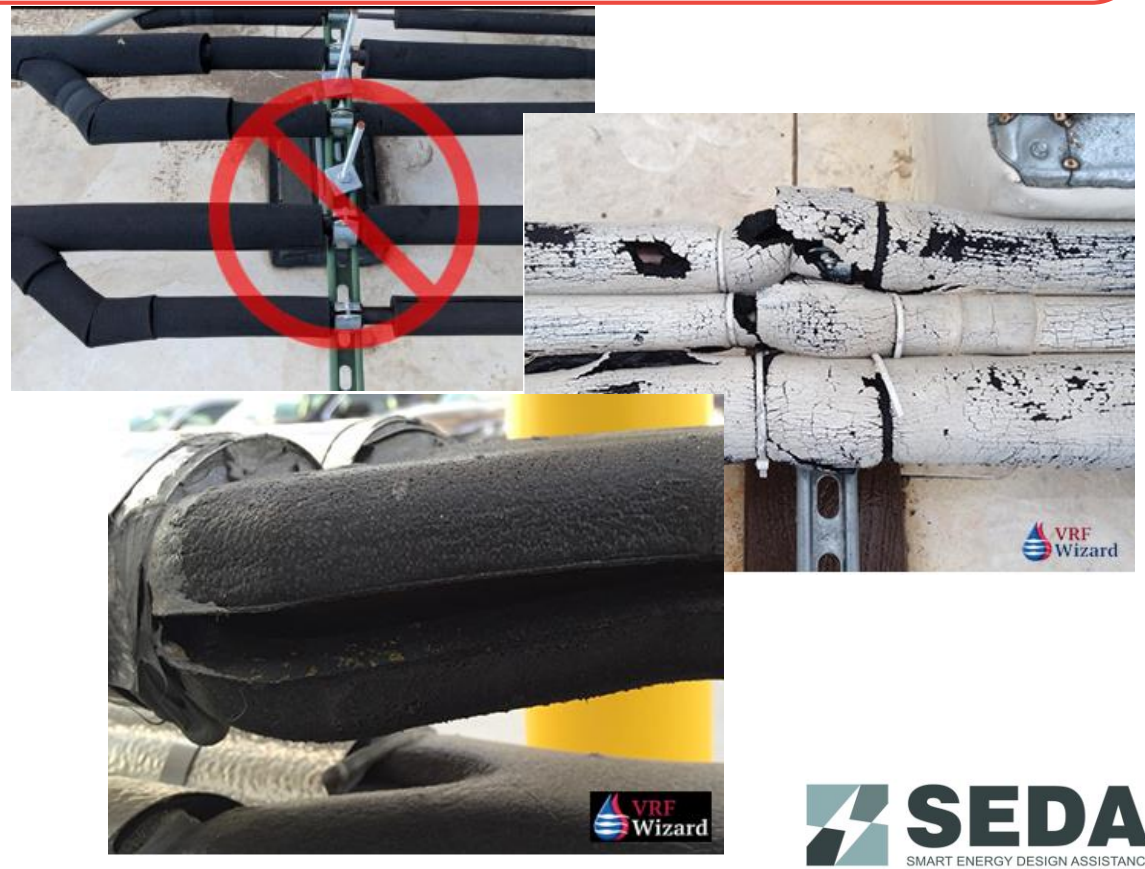
C403.11.3.1 Protection of Piping Insulation

Piping insulation exposed to the weather shall be protected from damage, including that caused by sunlight, moisture, equipment maintenance and wind, and shall provide shielding from solar radiation that can cause degradation of the material. Adhesive tape shall not be permitted.

Commonly an issue with small refrigeration units (residential-style DX, small diameter pipes)

- Wrapped with foam pipe wrap, and nothing else
- UV-degradation turns insulation to dust after a few years
- Crimped by zip-ties
- Gaps/incomplete insulation



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C403.11.3.1 Protection of Piping Insulation

Mitered joints to prevent compression/stretching.

Hangers & supports enclose insulation – no compression

UV protective wraps for insulation.

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Impact of Failed Piping Insulation

- Failed insulation significantly increases parasitic loads on refrigeration systems (DX, VRF, CHW, etc…) On heat pumps, also impacts heating capacity.
- Failed insulation also exposes underlying pipe to corrosion damage

Results for Piping @ +20°F

Properly Maintained Insulation Estimate

Pipe Size [in]	Insulation Thickness [in]	Annual Heat Gain [ton-hrs per 100 ft]	Annual Cost per 100 ft
8"	**3"**	540	$36
4"	**3"**	224	$22
2"	**2.5"**	165	$16

Assumptions

- Madison, WI
- 0.9 HP/ton
- $0.10/kWh

Failed Insulation Estimate†

Pipe Size [in]	Insulation Thickness [in]	Annual Heat Gain [ton-hrs per 100 ft]	Annual Cost per 100 ft
8"	**3"**	1,826	$120

† Factor of 2 loss of insulation thermal conductivity on top factor of 6 on the bottom

www.irc.wisc.edu – Presentation by Todd Jekel, Ph.D., P.E. Back to Basics: Pipe Insulation

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#29. C404.6.1 Circulation Systems & C404.7 Demand Recirculation Controls

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C404.6.1 Circulation Systems & C404.7 Demand Recirculation

C404.6.1: “Controls…shall start the pump based on the identification of a demand for hot water within the occupancy. The controls shall automatically turn off the pump when the water in the circulation loop is at the desired temperature and when there is not a demand for hot water.”

C404.7: “The controls shall start the pump upon receiving a signal from the action of a user of a fixture or appliance…The controls shall limit the temperature of the water entering the cold-water piping to ≤ 104 °F.”

Both code sections essentially have a demand-based component to circulation pump “ON” command. The shut-off method is the difference between the two.

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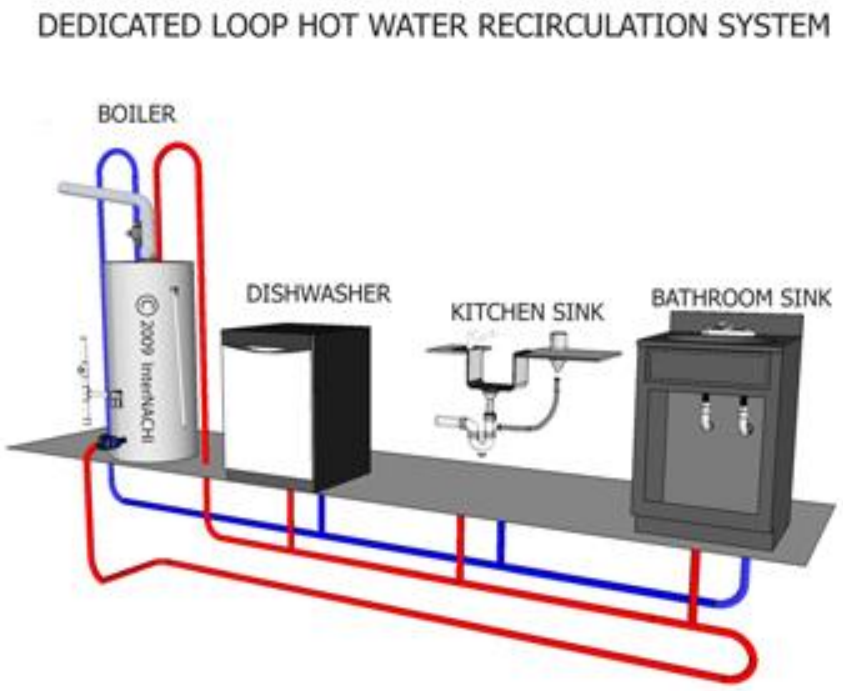
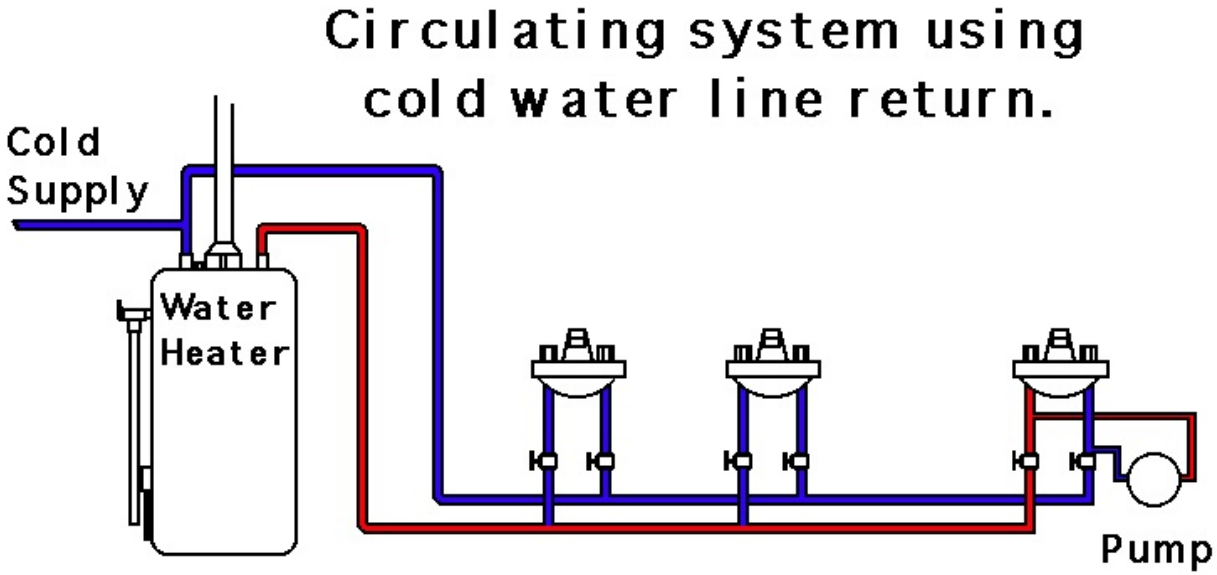
C404.6.1 Circulation Systems & C404.7 Demand Recirculation

Commonly find circulation systems that circulate water continuously to ensure entire loop is always hot. Should cycle to maintain loop temperature.



https://www.nachi.org/hot-water-recirculation-systems.htm



http://hotwaterrecirculatingpump.com/

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#30. C403.12.3 Freeze Protection System Controls

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C403.12.3 Freeze Protection System Controls

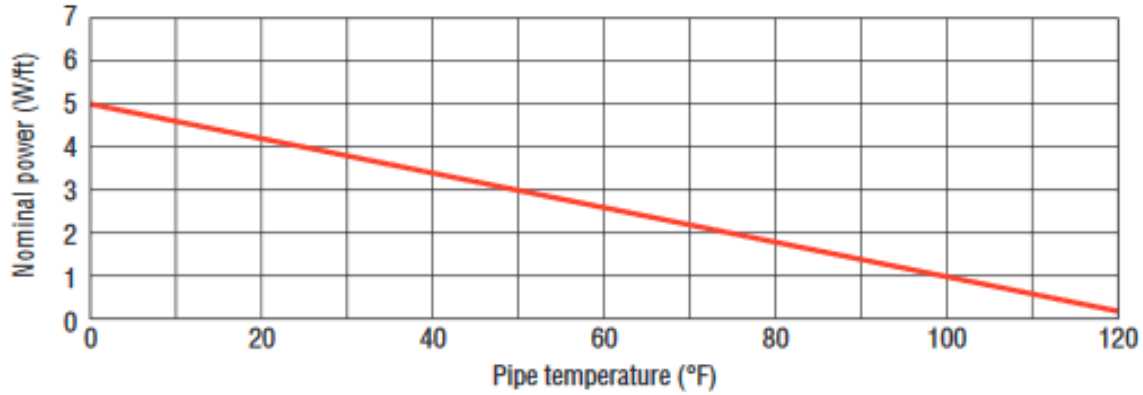
Freeze protection systems, such as heat tracing or outdoor piping and heat exchangers… shall include automatic controls configured to shut off the systems when outdoor air temperatures are >40 °F or when the conditions of the protected fluid will prevent freezing.

Common for heat-trace to be active year-round

Self regulating heat trace uses continuous power, does not automatically shut off when no freeze potential.

Graph 1 Nominal power output rating

This graph shows the self-regulating characteristics of Frostex heating cable. The conductive polymer core automatically adjusts its heat output as depicted in the graph at each point along the pipe, with no need for thermostats.



Source: Frostex® freeze protection system

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Common Freeze Protection System Control Oversights

- Freeze protection pumps on CHW coils for AHUs running year-round is common
  - Pumps are in parallel with system supply loop, allowing pump to circulate flow in coil alone for freeze protection
  - Often confused with series booster pumps, which are in series with system loop to maintain turbulent coil flow.
- Cooling tower sumps often set to 45 °F, wasting heating energy for sump freeze protection in milder weather (WB>32 °F).
  - Sumps are often electric heat, but can also include HW heat exchangers.

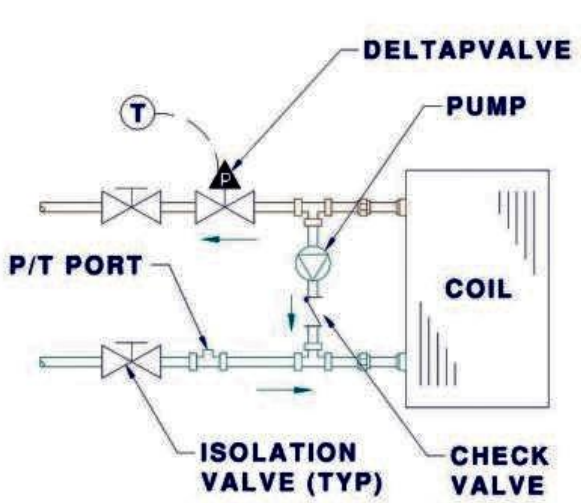
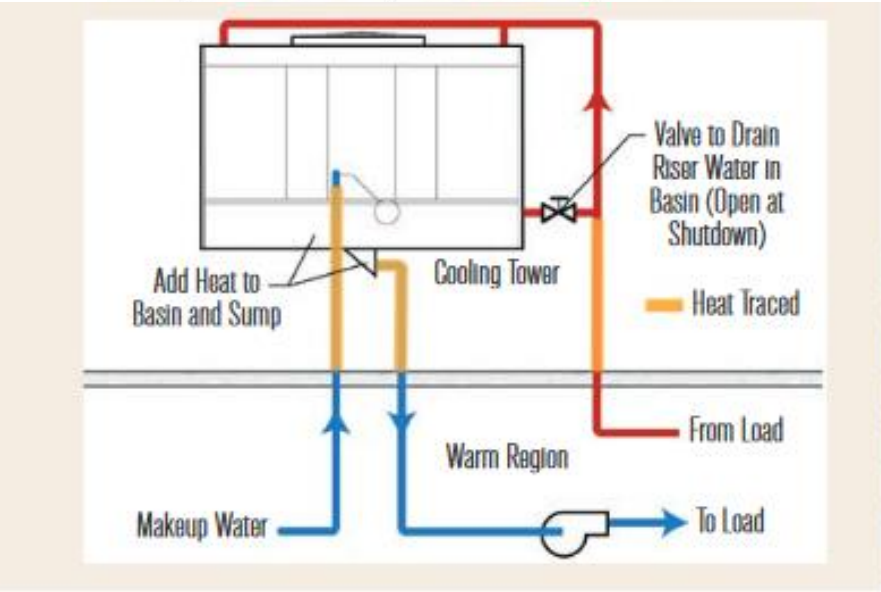
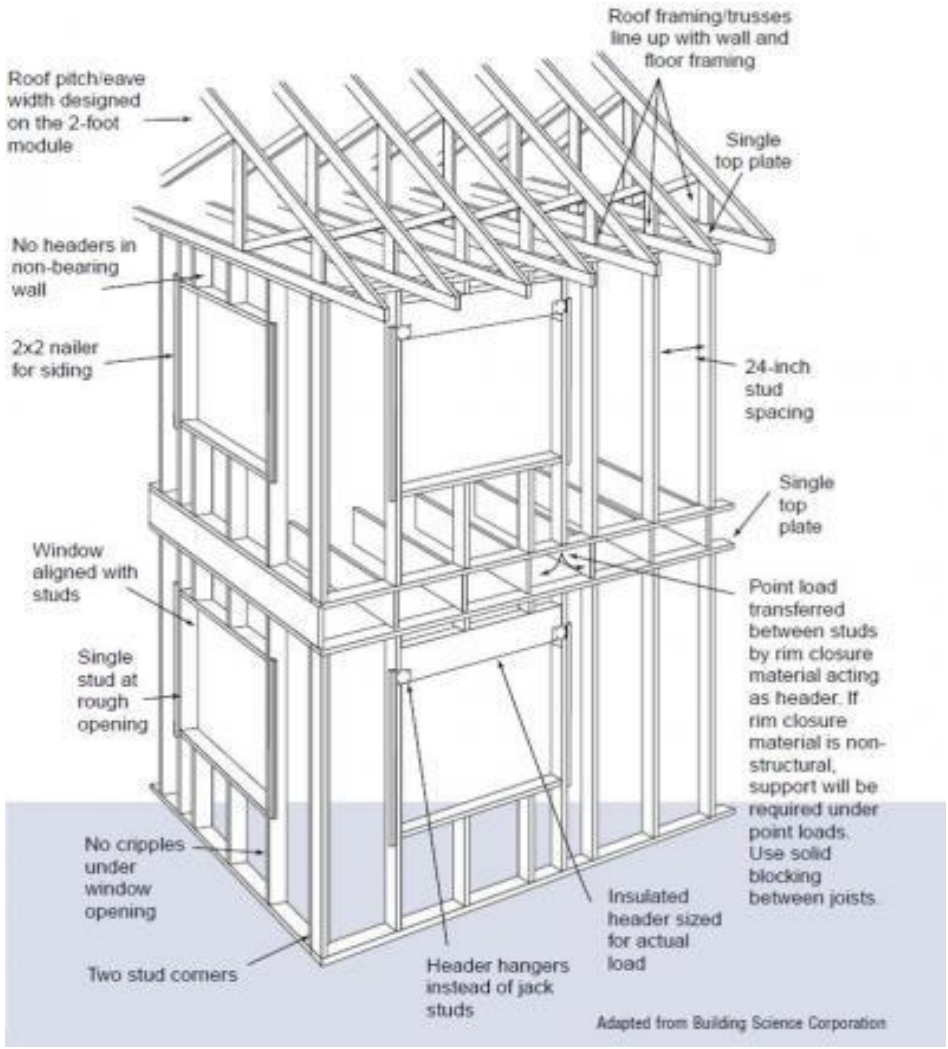


Figure 10: Pumped Coil Schematic
Pump 25% of coil design flow for freeze protection.



Top 40 Requirements (Part 2): 2018 IECC Residential Provisions

31. Energy Certificate [R401.3]
32. Insulation [R402.1, R402.2]
33. Envelope Sealing [R402.4]
34. Blower Door Testing [R402.4.1.2]
35. Duct Insulation, Sealing & Testing [R403.3]
36. Pipe Insulation [R403.4, R403.5.3]
37. HVAC Load & Sizing [R403.7]
38. Ventilation [R403.6]
39. Lighting [R404.1, R402.4.5]
40. Additions / Alterations [R502, R503]



https://basc.pnnl.gov/images

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#31. R401.3 Certificate (Mandatory)

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R401.3 Certificate (Mandatory)

Permanently posted on a wall in the space where the furnace is located, a utility room or an *approved* location inside the building

Don’t cover or obstruct the visibility of other required labels

Includes the following:

- R-values of insulation installed for the thermal building envelope, including ducts outside conditioned spaces
- U-factors and SHGC for fenestration
- Results from any required duct system and building envelope air leakage testing
- Types and efficiencies of heating, cooling and service water heating equipment

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IECC Sample Energy Efficiency Certificate

Energy Efficiency Certificate

Insulation Rating		R-Value		R-Value
Ceiling /Roof	Attic	R- 38	Vaulted	R- 30
Walls	Frame	R- 20	Mass	R- N/A
	Basement	R- 10	Crawl space	R- 10
Floors	Over unconditioned space	R- 19	Slab edge	R- 10
Ducts	Attic	R- 8	Other	R- N/A

Air Leakage Test Results				
Blower door	3.0	ACH/50 Pa.	Duct testing	4.0 Cfm/100 ft²

Fenestration Rating	NFRC U-Factor	NFRC SHGC
Window	U- 0.32	0.40
Opaque door	U- 0.32	N/A
Skylight	U- 0.55	0.40

Equipment Performance	Type	Efficiency	
Heating system	Gas forced-air	90%	AFUE
Cooling system	Central AC	15	SEER
Water heater	Gas (Storage-type)	0.57	EF

Indicate if the following have been installed (an efficiency shall not be listed)

☐ electric furnace ☐ gas-fire unvented room heater ☐ baseboard electric heater

Designer/builder

Code edition 2012 IRC Date 01/2/2013

https://shop.iccsafe.org/media/wysiwyg/material/0726S2-sample.pdf

TABLE 401.9
ENERGY EFFICIENCY CERTIFICATE

Builder, Permit Holder or Registered Design Professional
Print Name:

Signature:

Property Address:

Date:

Insulation Rating – List the value covering largest area to all that apply	R - Value
Ceiling/roof:	R -
Wall:	R -
Floor:	R -
Closed Crawl Space Wall:	R -
Closed Crawl Space Floor:	R -
Slab:	R -
Basement Wall:	R -
Fenestration:	
U-Factor	
Solar Heat Gain Coefficient (SHGC)	
Building Air Leakage	
☐ Visually inspected according to 402.4.2.1 OR	
☐ Building Air Leakage Test Results (Sec. 402.4.2.2) ACH50 [Target: 5.0] or CFM50/SFSA [Target: 0.30]	
Name of Tester/Company:	
Date: Phone:	
Ducts:	
Insulation	R -
Total Duct Leakage Test Result (Sect. 403.2.2) (CFM25 Total/100SF) [Target: 6]	
Name of Tester/Company:	
Date: Phone:	
Certificate to be displayed permanently	

https://www.pdffiller.com/

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#32. R402.1 & R402.2 Insulation (Prescriptive)

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R402.1.2 Insulation and Fenestration Criteria

TABLE R402.1.2
INSULATION AND FENESTRATION REQUIREMENTS BY COMPONENT[a]

CLIMATE ZONE	FENESTRATION *U*-FACTOR[b]	SKYLIGHT[b] *U*-FACTOR	GLAZED FENESTRATION SHGC[b,e]	CEILING *R*-VALUE	WOOD FRAME WALL *R*-VALUE	MASS WALL *R*-VALUE[i]	FLOOR *R*-VALUE	BASEMENT[c] WALL *R*-VALUE	SLAB[d] *R*-VALUE & DEPTH	CRAWL SPACE[c] WALL *R*-
1	NR	0.75	0.25	30	13	3/4	13	0	0	0
2	0.40	0.65	0.25	38	13	4/6	13	0	0	0
3	0.32	0.55	0.25	38	20 or 13+5[h]	8/13	19	5/13[f]	0	5/13
4 except Marine	0.32	0.55	0.40	49	20 or 13+5[h]	8/13	19	10/13	10, 2 ft	10/13
5 and Marine 4	0.30	0.55	NR	49	20 or 13+5[h]	13/17	30[g]	~~15/19~~10/13	10, 2 ft	15/19
6	0.30	0.55	NR	49	20+5 or 13+10[h]	15/20	30[g]	15/19	10, 4 ft	15/19
7 and 8	0.30	0.55	NR	49	20+5 or 13+10[h]	19/21	38[g]	15/19	10, 4 ft	15/19

R-5 Insulation under the full slab area of a heated slab in addition to required slab edge insulation R-value for slabs

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Table R402.4.1.1

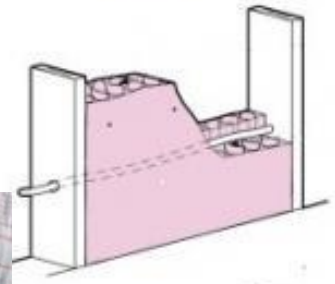
TABLE R402.4.1.1
AIR BARRIER AND INSULATION INSTALLATION[a]

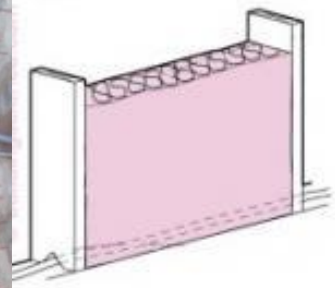
COMPONENT	AIR BARRIER CRITERIA	INSULATION INSTALLATION CRITERIA
General requirements	A continuous air barrier shall be installed in the building envelope. The exterior thermal envelope contains a continuous air barrier. Breaks or joints in the air barrier shall be sealed.	Air-permeable insulation shall not be used as a sealing material.
Ceiling/attic	The air barrier in any dropped ceiling or soffit shall be aligned with the insulation and any gaps in the air barrier shall be sealed. Access openings, drop down stairs or knee wall doors to unconditioned attic spaces shall be sealed.	The insulation in any dropped ceiling/soffit shall be aligned with the air barrier.
Walls	The junction of the foundation and sill plate shall be sealed. The junction of the top plate and the top of exterior walls shall be sealed. Knee walls shall be sealed.	Cavities within corners and headers of frame walls shall be insulated by completely filling the cavity with a material having a thermal resistance, *R*-value, of not less than R-3 per inch. Exterior thermal envelope insulation for framed walls shall be installed in substantial contact and continuous alignment with the air barrier.
Windows, skylights and doors	The space between framing and skylights, and the jambs of windows and doors, shall be sealed.	—

Insulation Installation Quality

The R-value of the insulation in all the insulated building assemblies (walls, ceilings, floors) can have a big effect on the results.

HERS raters put a grade on the installation quality, it helps the rater develop a more accurate energy model of the home. When a rater goes in and looks at the insulation, they've got to record each assembly as having a Grade I, Grade II, or Grade III insulation installation quality.





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3 Grades of Insulation Installation

Grade I is the best. This means that the insulation is installed according to the manufacturer's instructions. It completely fills the cavity in the case of air-permeable insulation and also is encapsulated on six sides (with an exception for IECC climate zones 1-3). It's cut around electrical junction boxes, split around wires and pipes, and generally not compressed.

Grade II is second best. There's some allowance for imperfections in the installation but overall, it's still not too bad. The HERS Standards say a Grade II installation can have "moderate to frequent installation defects: gaps around wiring, electrical outlets, plumbing and other intrusions; rounded edges or “shoulders”; or incomplete fill..."

Grade III is the lowest grade. It has "substantial gaps and voids."

The energy rating software models these three grades differently. When the rater enters Grade I, the software calculates according 100% of the cavity insulation having the R-value entered. When the rater enters Grade II, the software models the cavities as having 98% of their area insulated to the given R-value and 2% uninsulated. For Grade III, 95% of the cavity area is calculated with the given R-value and 5% is treated as uninsulated. (The reason for these particular numbers should become clear to you below.)

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2 Parameters for Assigning a Grade to Installation

1. **Missing insulation.** When a cavity in a building assembly has insulation installed in a way that leaves gaps, that affects the amount of heat that flows across the building envelope. More heat will pass through assemblies that have gaps. The more gaps there are, the worse the grade it gets.

2. **Compression and incomplete fill.** Compression is a common problem with fiberglass batt insulation because the batts are often not cut to the proper size for the cavity.

Insulation Critical Details

Good & Bad Insulation Installation

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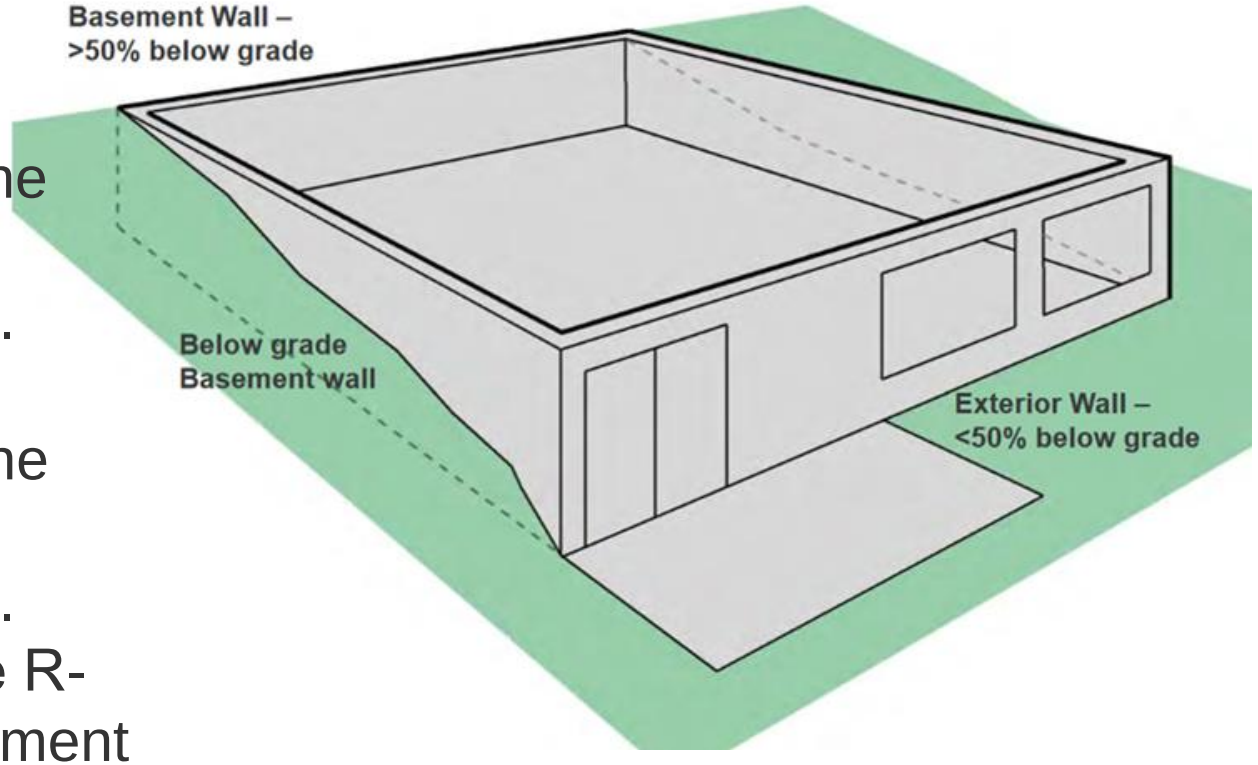
R402.2.9 Basement Walls

IECC Definition of a *Basement Wall*:
A wall 50 percent or more below grade and enclosing *conditioned space.*

Basement wall insulation requirements:
IL: 10/13

10/13 means R-10 continuous insulation on the interior or exterior of the home or R-13 cavity insulation on the interior of the basement wall.

15/19 means R-15 continuous insulation on the interior or exterior of the home or R-19 cavity insulation on the interior of the basement wall. Alternatively, compliance with “15/19” shall be R-13 cavity insulation on the interior of the basement walls plus R-5 continuous insulation on the interior or exterior of the home.



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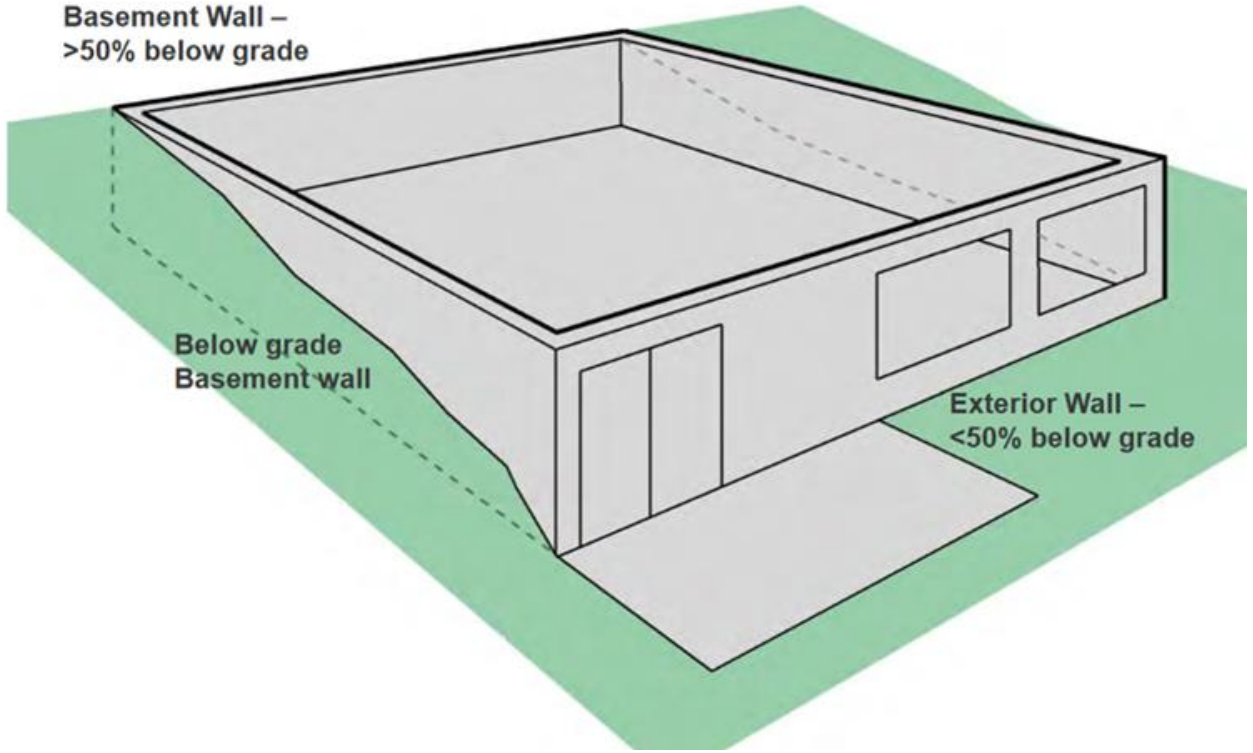
R402.2.9 Basement Walls

Insulate to within 6” of the basement floor (or closer)

Walls associated with conditioned basements may be insulated from the top of the basement wall down to 4’ below grade when the Basement R-value is at least 15/19

15/19 means R-15 continuous insulation on the interior or exterior of the home or R-19 cavity insulation on the interior of the basement wall. Alternatively, compliance with “15/19” shall be R-13 cavity insulation on the interior of the basement walls plus R-5 continuous insulation on the interior or exterior of the home.



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#33. R402.4 Air Leakage (Mandatory)

Envelope Sealing

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Is Air Sealing a Big Deal? …… Yes!

Primary Energy Consumption attributed to building envelope components in 2010 (in quads)

Building Component	Residential	
	Heating	Cooling
Roofs	1.00	0.49
Walls	1.54	0.34
Foundation	1.17	-0.22
Infiltration	2.26	0.59
Windows (Conduction)	2.06	0.03
Windows (Solar Heat Gain)	-0.66	1.14

Source: Windows and Building Envelope Research and Development: Roadmap for Emerging Technologies, DOE BTO, 2014
https://www.energy.gov/sites/prod/files/2014/02/f8/BTO_windows_and_envelope_report_3.pdf

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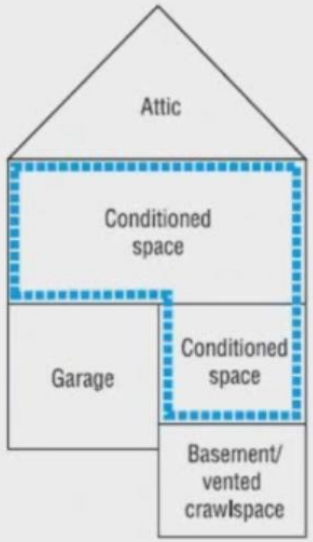
First Need to Identify Where Thermal Envelope Is

Building Thermal Envelope

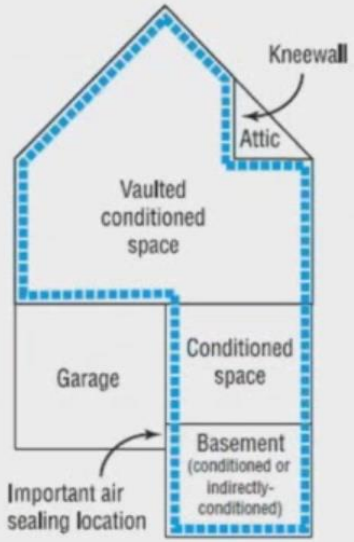
Southface

The *building thermal envelope* is the barrier that separates the conditioned space from the outside or unconditioned spaces. The building envelope consists of two parts - an air barrier and a thermal barrier that must be both continuous and contiguous (touching each other). In a typical residence, the building envelope consists of the roof, walls, windows, doors, and foundation. Examples of unconditioned spaces include attics, vented crawlspaces, garages, and basements with ceiling insulation and no HVAC supply registers.

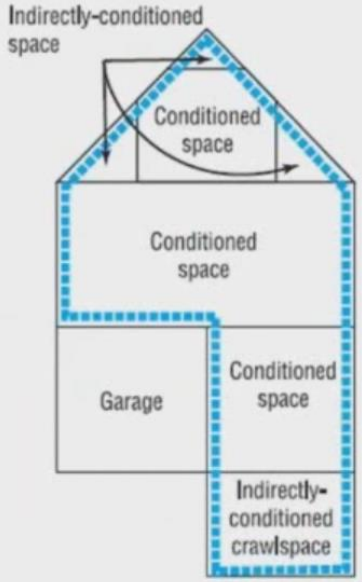
Example 1



Example 2



Example 3



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Critical Areas for Air Sealing

Ceiling Plane (vented attics)

- Top plates
- Access panel
- Penetrations – bath fans, duct boots, electrical
- Framed cavities – above kitchen cabinets, soffits, & chases

Walls [1c]

- Bottom plate at deck/slab
- Penetrations
- Sheathing
- Windows & doors
- Garage-side drywall
- Knee-wall air barriers
- Behind tubs & stairs
- Framed cavities – within chases & bulkheads

Fireplaces

- Behind pre-fabricated fireplaces
- Around dampers & vents

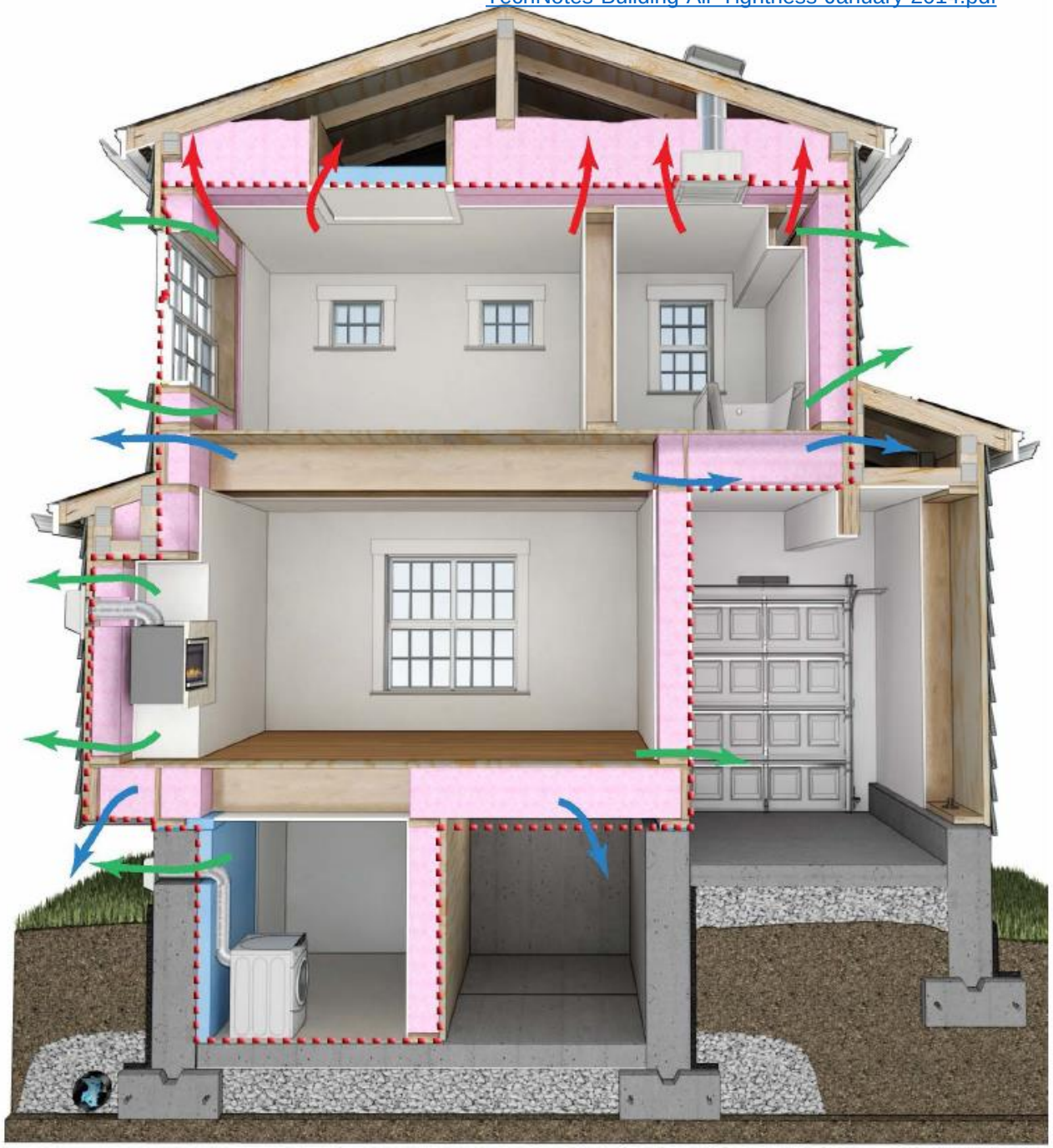
Rim Joist Areas

- Rim board – joist cavity
- Sill plate at foundation
- Draft stops at garage & knee walls

Floors

- Cantilevered
- Above garages, vented crawl spaces, & unconditioned basements

https://www.homeinnovation.com/~/media/Files/Reports/TechNotes-Building-Air-Tightness-January-2014.pdf



The red dashed line represents an example continuous air barrier.

R402.4 Air Leakage (Mandatory 2 Step Process)

R402.4.1.1 Installation

The components of the building thermal envelope as listed in Table R402.4.1.1 shall be installed in accordance with the manufacturer's instructions and the criteria listed in the Table

Where required by the code official, an approved third party shall inspect all components and verify compliance

R402.4.1.2 Testing

The building shall be tested and verified as having an air leakage rate of:

4 ACH50 in Illinois

Requirement of a written report

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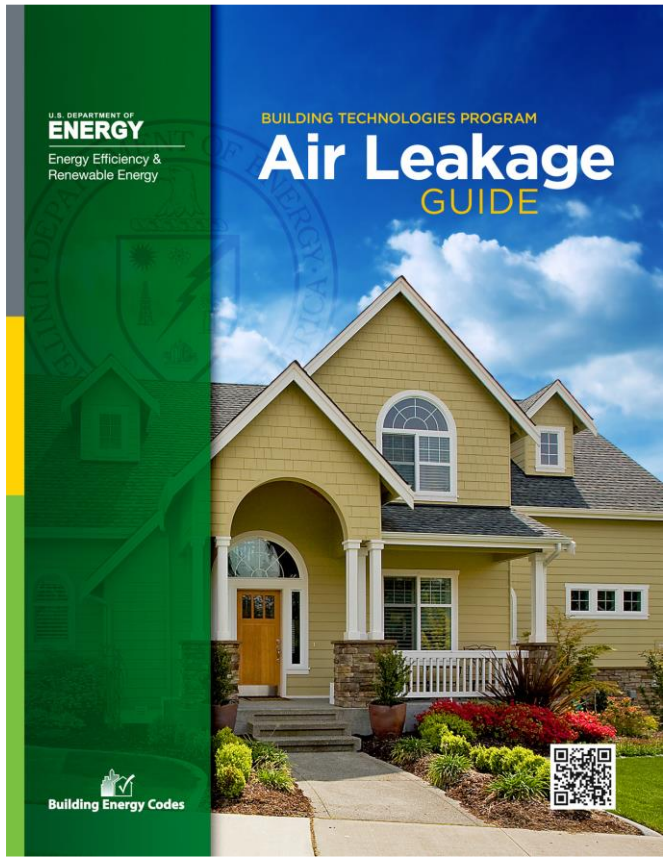
Table R402.4.1.1

TABLE R402.4.1.1
AIR BARRIER AND INSULATION INSTALLATION[a]

COMPONENT	AIR BARRIER CRITERIA	INSULATION INSTALLATION CRITERIA
General requirements	A continuous air barrier shall be installed in the building envelope. The exterior thermal envelope contains a continuous air barrier. Breaks or joints in the air barrier shall be sealed.	Air-permeable insulation shall not be used as a sealing material.
Ceiling/attic	The air barrier in any dropped ceiling or soffit shall be aligned with the insulation and any gaps in the air barrier shall be sealed. Access openings, drop down stairs or knee wall doors to unconditioned attic spaces shall be sealed.	The insulation in any dropped ceiling/soffit shall be aligned with the air barrier.
Walls	The junction of the foundation and sill plate shall be sealed. The junction of the top plate and the top of exterior walls shall be sealed. Knee walls shall be sealed.	Cavities within corners and headers of frame walls shall be insulated by completely filling the cavity with a material having a thermal resistance, *R*-value, of not less than R-3 per inch. Exterior thermal envelope insulation for framed walls shall be installed in substantial contact and continuous alignment with the air barrier.
Windows, skylights and doors	The space between framing and skylights, and the jambs of windows and doors, shall be sealed.	—

Air Leakage Guide



https://www.energycodes.gov/sites/default/files/documents/BECP_Buidling%20Energy%20Code%20Resource%20Guide%20Air%20Leakage%20Guide_Sept2011_v00_lores.pdf

A tight house will:

Have lower heating bills due to less heat loss

Have fewer drafts and be more comfortable

Reduce the chance of mold and rot because moisture is less likely to enter and become trapped in cavities

Have a better performing ventilation system

Potentially require smaller heating and cooling equipment capacities.

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Sealing Air Leaks

Use weather-stripping to seal drafty windows & doors

Add a door sweep to help seal exterior doors

Use silicone caulk for gaps between window/door trim & the walls

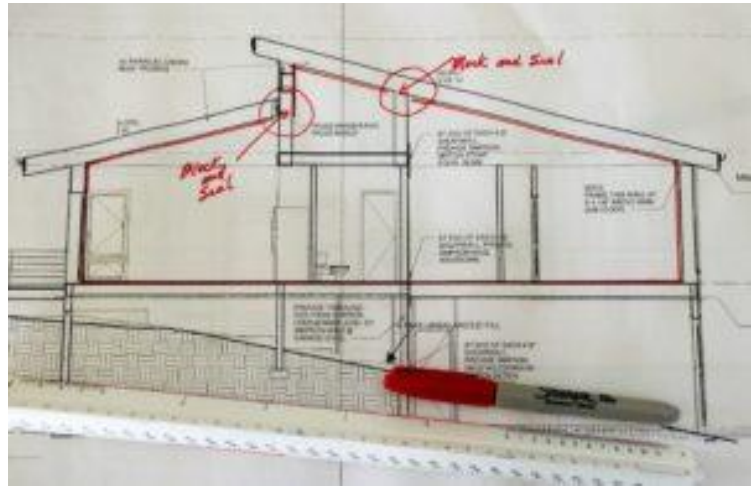
Use caulk to seal around small pipe/wire openings in the attic and exterior walls

Use cans of spay foam for larger openings

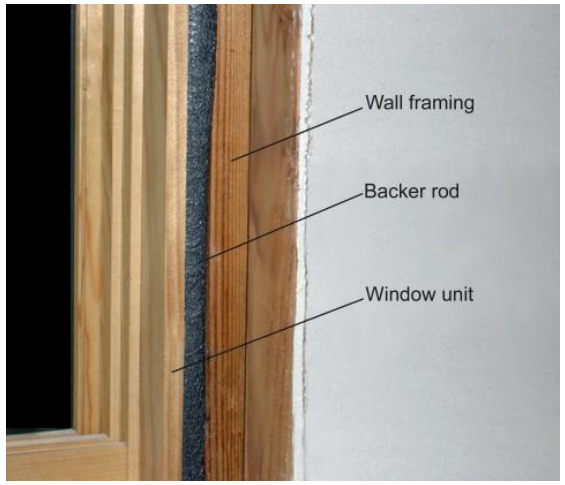
Repair damaged siding/roofing, and seal small gaps with caulk

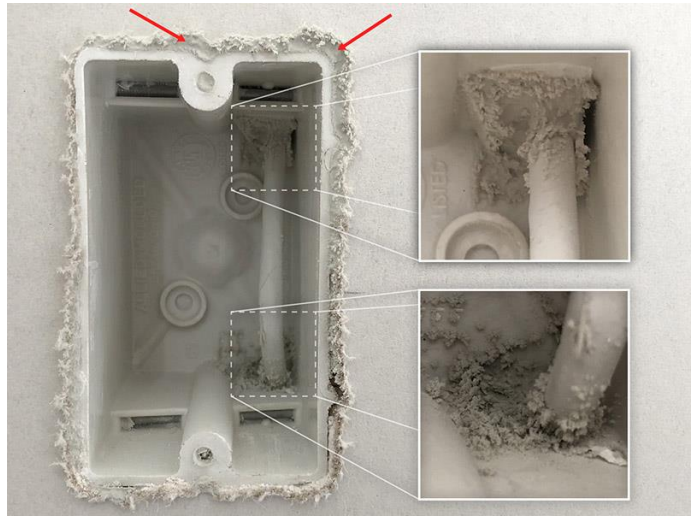
Seal foundation cracks or sill plates with a bead of caulk

Add foam gaskets behind outlet or switch plates



Examples of Air Sealing





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Common Air Leak Locations

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Other Air Leak Locations

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#34. R402.4 Air Leakage (Mandatory)

Blower door testing

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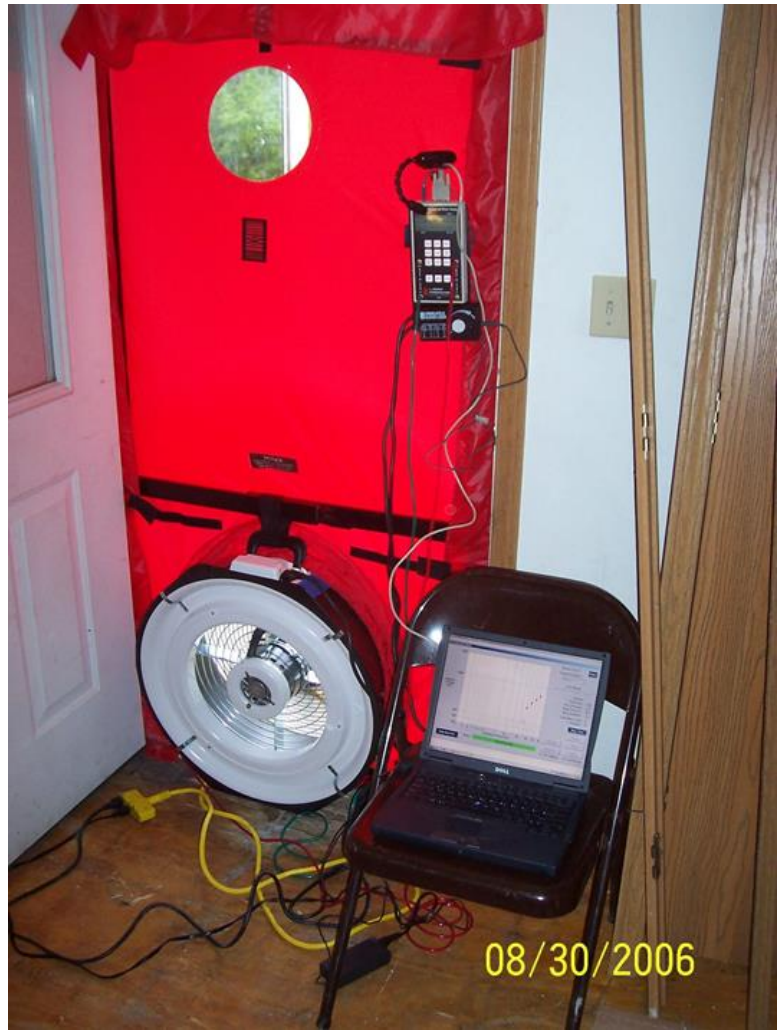
R402.4.1.2 Blower Door Testing

Mandatory for residential construction

Residential air leakage rate not to exceed 4 air changes per hour @ 50 pascals

Where required by code official, testing shall be conducted by an approved third party.

Testing performed after creation of all penetrations of the building thermal envelope



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R402.4.1.2 Blower Door Testing Procedure

During testing:

1. Exterior windows, doors, fireplace & stove doors to be closed, but not sealed.
2. Dampers to be closed, but not sealed.
3. Interior doors, where installed at the time of the test, to be opened.
4. Exterior or interior termination for continuous ventilation systems to be sealed.
5. Heating & cooling systems, where installed at the time of the test to be turned off.
6. Supply & return registers, where installed at the time of the test to be fully open.

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Bloor Door Testing for Multifamily Housing

Low-rise multifamily

Air leakage not exceeding 0.25 cubic feet per minute of enclosure area (all six sides) at 50 Pascal.

Sampling methodology available for buildings >7 units

https://www.mncee.org/blog/may-2019/research-sidesteps-obstacles-measuring-air-tightne/

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#35. R403.3 Duct Insulation, Sealing & Testing

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R403.3.1 Duct Insulation (Prescriptive)

Supply and return ducts in attics:

- Min. R-8 for ducts ≥ 3 inches. Min. R-6 for ducts < 3 inches in dia.

Supply and return ducts in other areas:

- Min. R-6 for ducts ≥ 3 inches. Min. R-4.2 for ducts < 3 inches in dia.

Exception: Ducts located completely inside the building thermal envelope

Location	Duct Dia ≥3” or <3”
Attic	R-8 or R-6
Conditioned Space	NR
Vented Crawlspace	R-6 or R-4.2
Conditioned Crawlspace	NR
Basement - Conditioned	NR
Basement - Unconditioned	R-6 or R-4.2
Exterior Walls	R-6 or R-4.2

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R403.3.2 Duct Sealing (Mandatory)

Ducts, air handlers and filter boxes shall be sealed.

Joints and seams shall comply with either the International Mechanical Code (IMC) or International Residential Code (IRC), as applicable.

Why is duct sealing important?

About 20 – 30% of the air that moves through the duct system is lost due to leaks, holes, and poorly connected ducts.

https://www.energystar.gov/campaign/heating_cooling/duct_sealing

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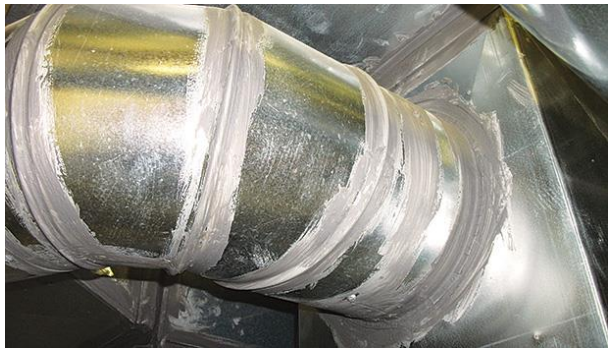
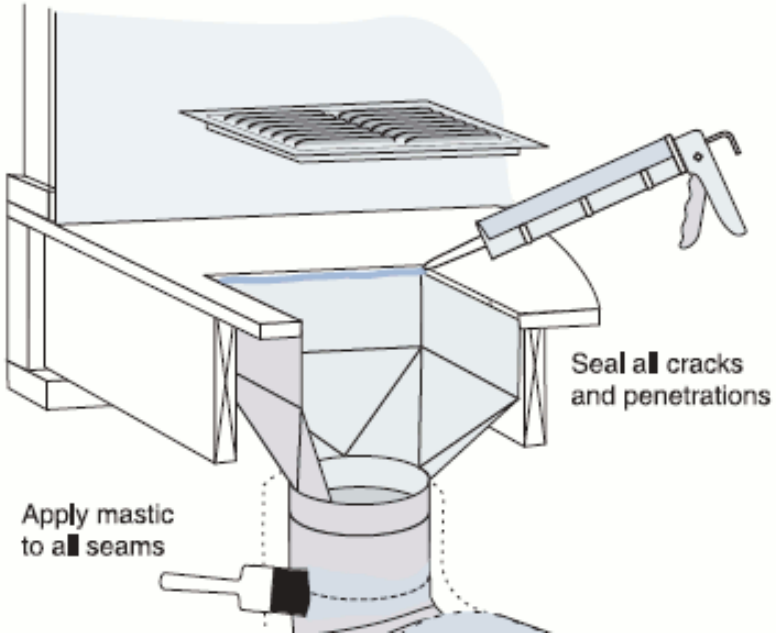
Examples of Duct Sealing





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R403.3.3 Duct Testing (Mandatory)

Ducts shall be pressure tested to determine air leakage by one of the following methods:

1. Rough-in test: Total leakage shall be measured with a pressure differential of 0.1 inch w.g. (25 Pa) across the system, including the manufacturers air handler enclosure if installed at the time of the test. Registers shall be taped or otherwise sealed during the test.

2. Postconstruction test: Total leakage shall be measured with a pressure differential of 0.1 inch w.g. (25 Pa) across the entire system, including the manufacturer's air handler enclosure. Registers shall be taped or otherwise sealed during the test.

Exceptions

1. A duct air-leakage test shall not be required where the ducts and air-handlers are located entirely within the building thermal envelope.

2. A duct air-leakage test shall not be required for ducts serving heat or energy recovery ventilators that are not integrated with ducts serving heating or cooling systems.

A written report of the results of the test shall be signed by the party conducting the test and provided to the Code Official.

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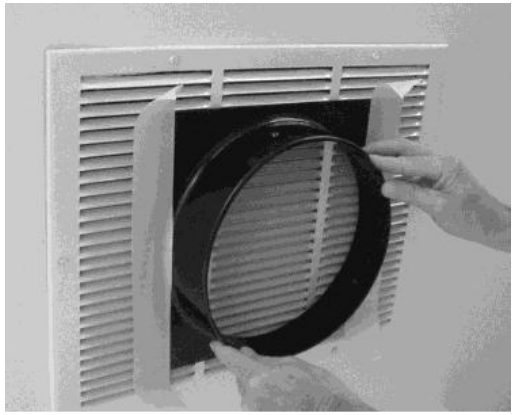
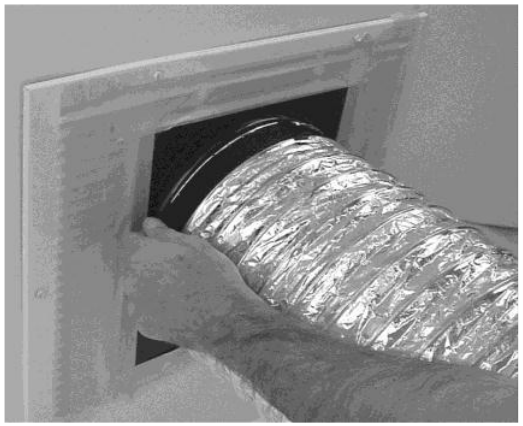
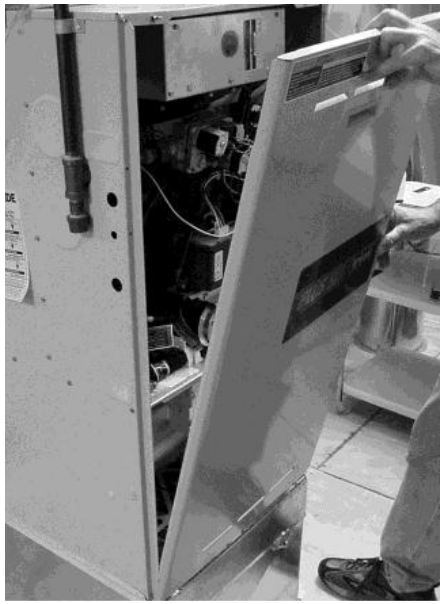
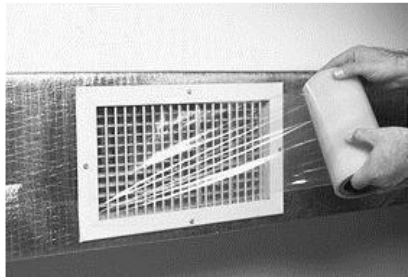
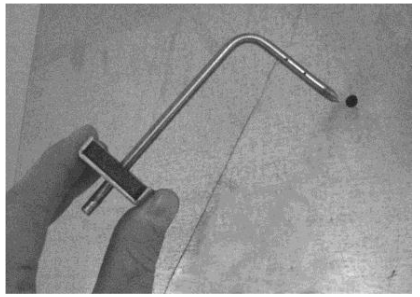
Duct Testing

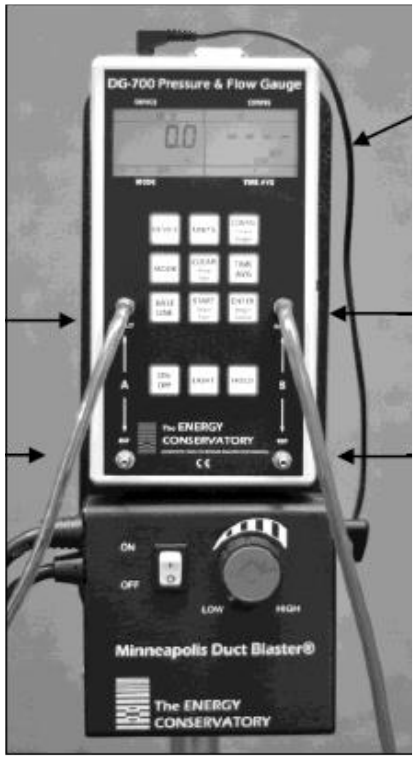












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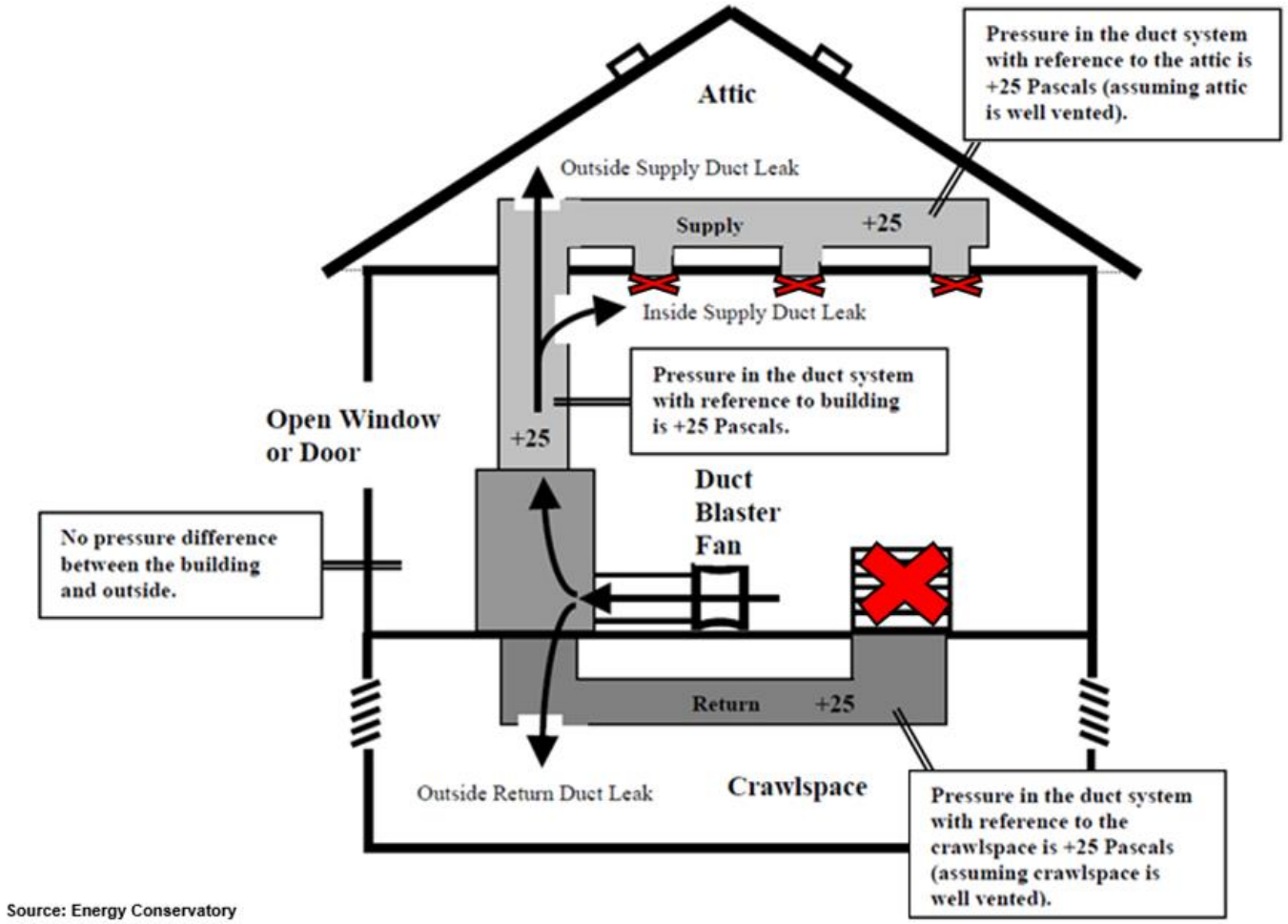
Duct Testing



Source: Energy Conservatory

https://paenergycode.com/duct_testing/default.html

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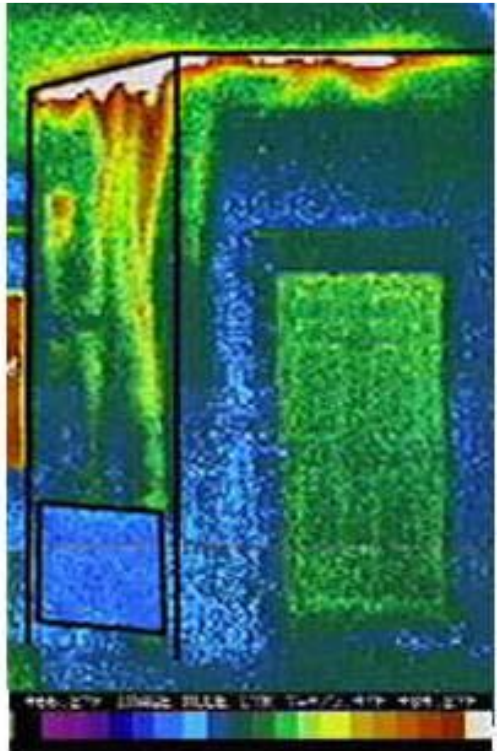
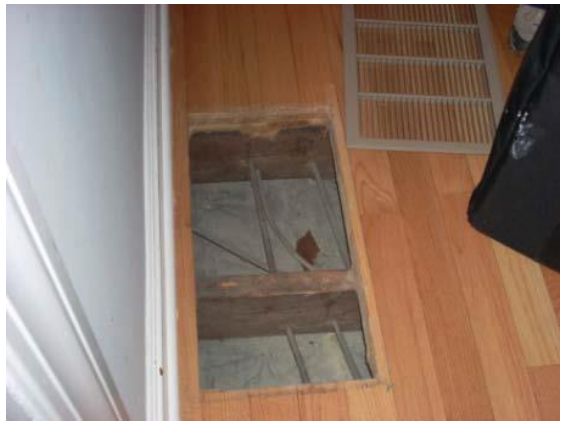
Old Practices Now Forbidden

R403.2.3 Building cavities (Mandatory).

Building framing cavities shall not be used as ducts or plenums.





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#36. R403.4 & R403.5.3 Pipe Insulation

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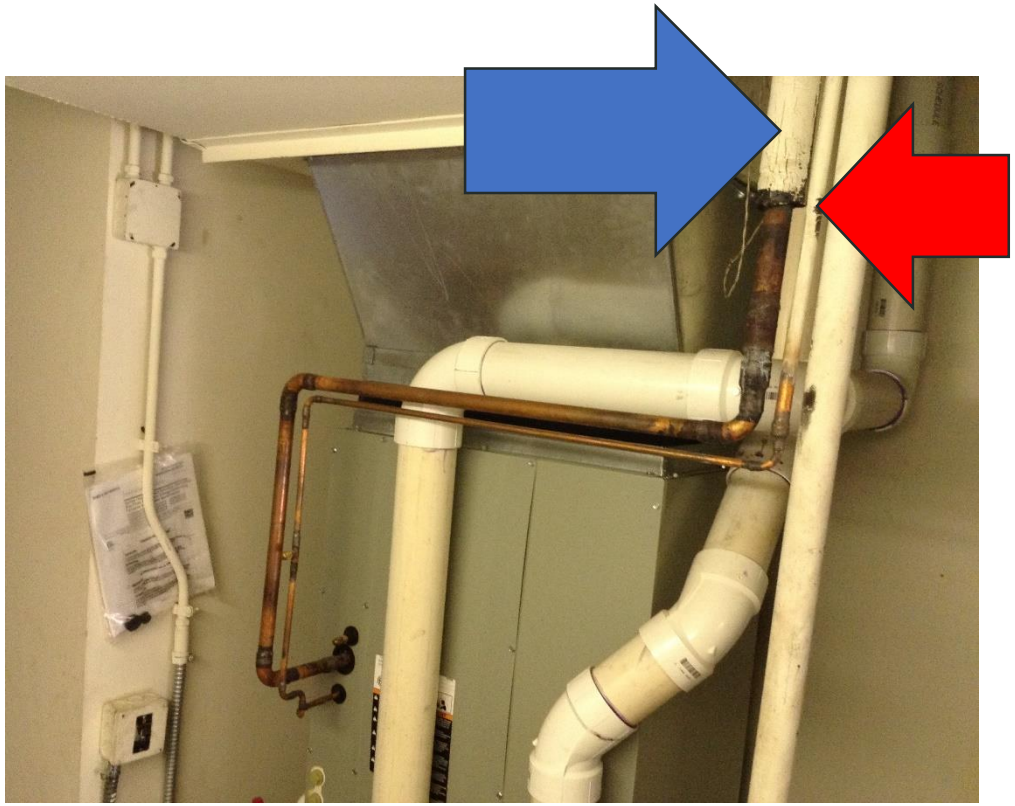
R403.4 Mechanical System Piping Insulation (Mandatory)

Mechanical system piping capable of carrying fluids greater than 105F or less than 55F shall be insulated to an R-value of not less than R-3

Piping insulation exposed to weather shall be protected from damage including sunlight, moisture, equipment maintenance and wind. Adhesive tapes shall be prohibited.



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R403.5.3 Hot Water Pipe Insulation (Prescriptive)

Insulation for hot water piping with a thermal resistance , R-value, of not less than R-3 shall be applied to the following

1. Piping ¾ inch and larger in nominal diameter.
2. Piping serving more than one dwelling unit.
3. Piping located outside the conditioned space.
4. Piping from the water heater to a distribution manifold.
5. Piping located under a floor slab.
6. Buried piping.
7. Supply and return piping in recirculating systems other than demand recirculating systems.

https://basc.pnnl.gov/images/hot-water-heating-pipes-insulated-1-inch-jacketed-fiberglass

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#37. R403.7 HVAC Equipment Load & Sizing (Mandatory)

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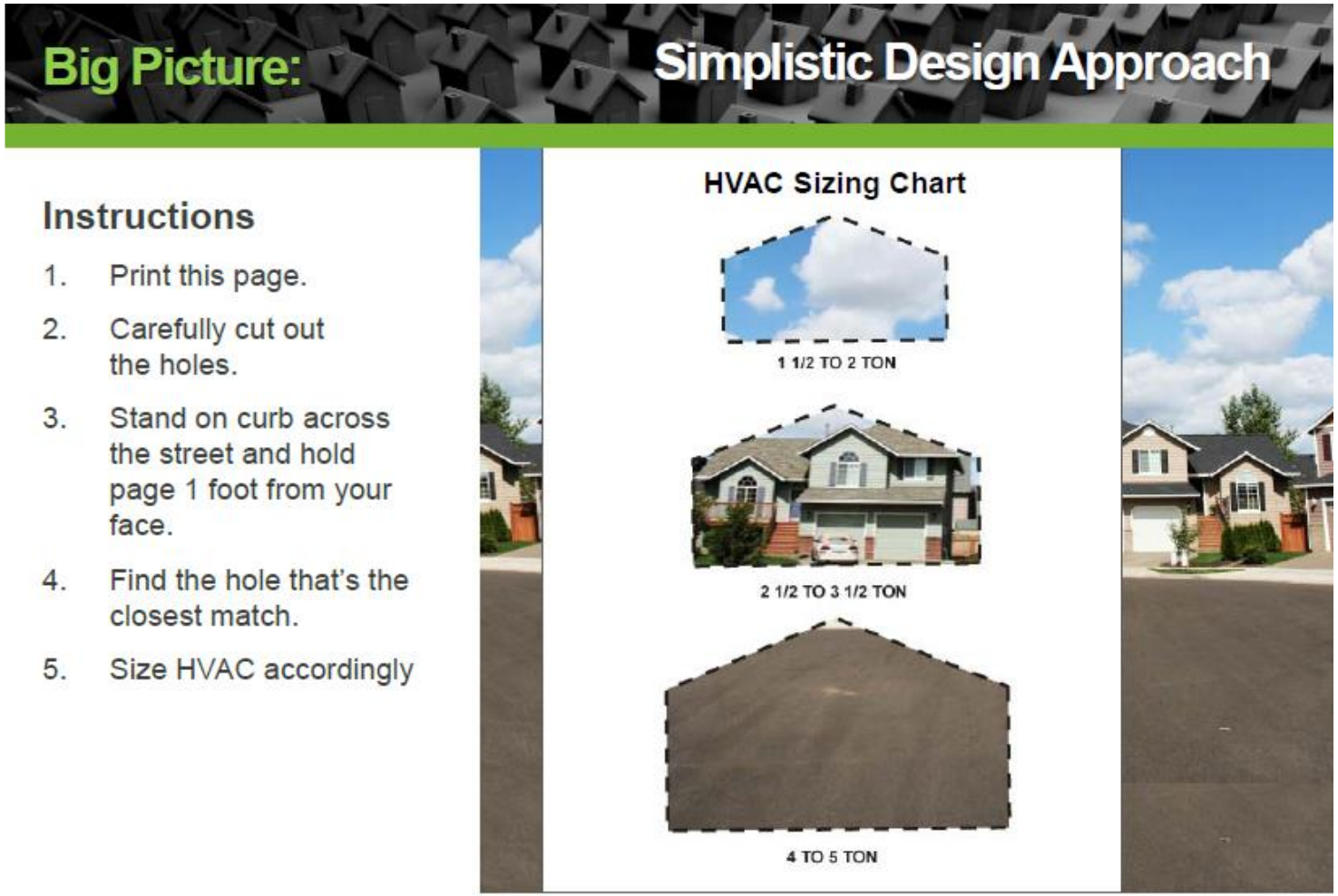
Before Codes, How HVAC Systems Used to be Sized



IBACOS | Alliance

https://www.energy.gov/sites/prod/files/2013/12/f5/webinar_hvac_calculatingloads_20110428.pdf

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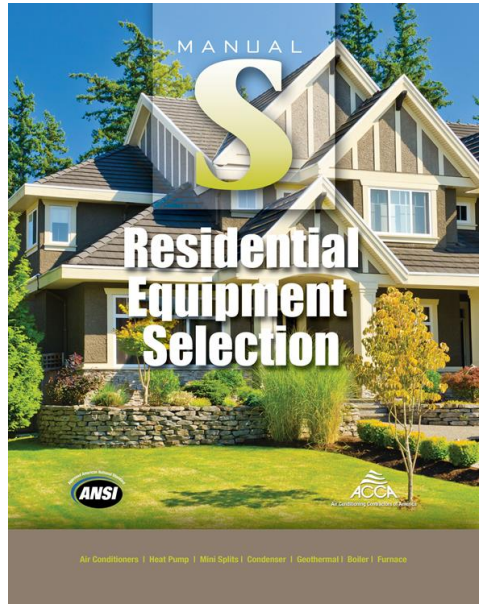
R403.7 Equipment Sizing & Efficiency Rating (Mandatory)

Heating and cooling equipment shall be sized in accordance with ACCA Manual S based on *building* loads calculated in accordance with ACCA Manual J or other *approved* heating and cooling calculation methodologies.

New or replacement heating and cooling equipment shall have an efficiency rating equal to or greater than the minimum required by federal law for the geographic locations where the equipment is installed.



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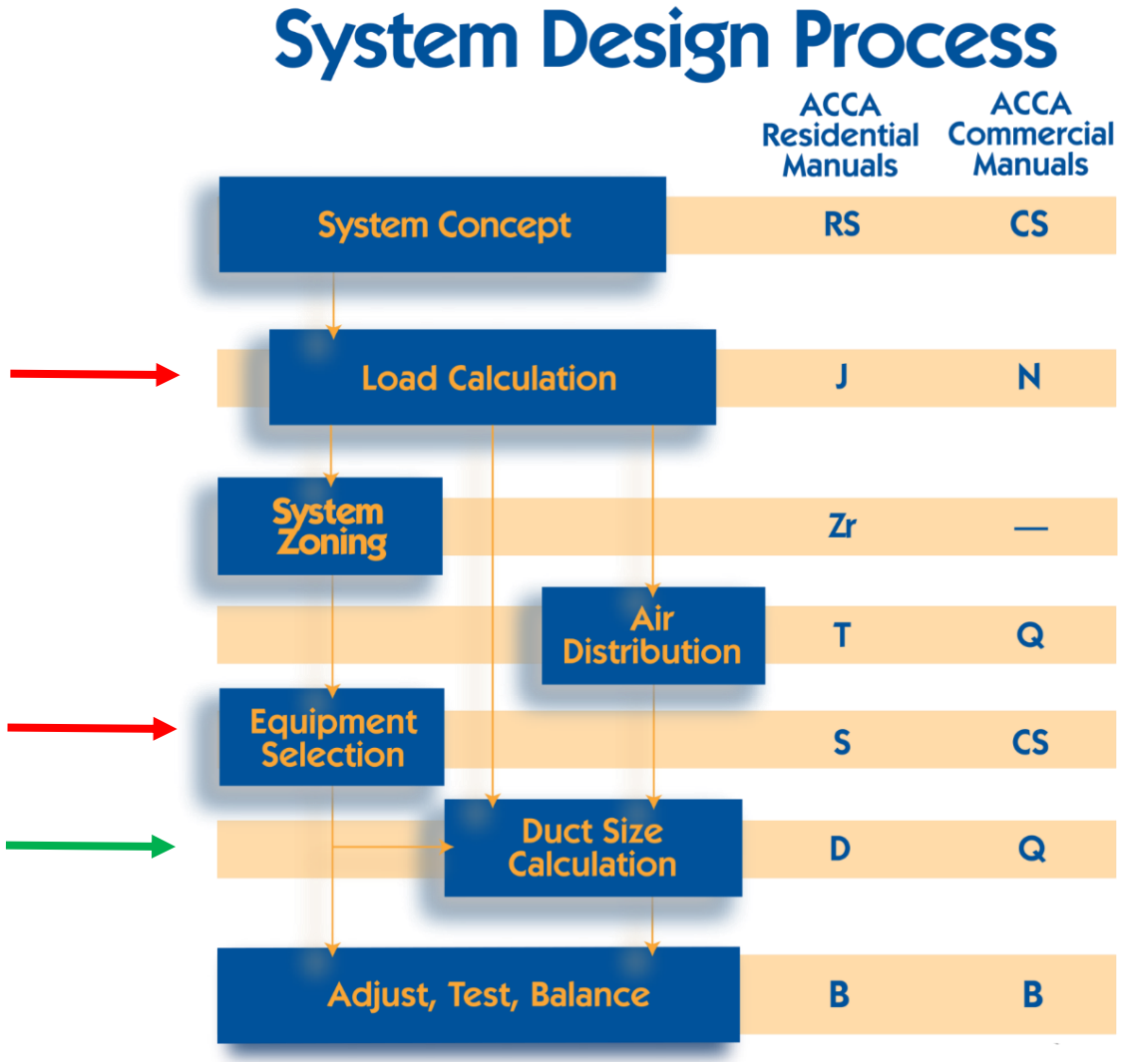
Mechanical System Design Process



https://www.acca.org/standards/technical-manuals

ACCA Technical manuals cover design, installation and maintenance for residential and light commercial HVAC systems.

HVAC Design Impacts

- 1st construction costs
- Comfort
- Indoor air quality
- Building durability
- Energy efficiency
- Higher customer satisfaction/ lower call backs

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Why the Emphasis on Sizing Equipment?

What has changed?

- Thermal envelopes have improved substantially
- Air tightness is now an important part of envelope construction
- Natural ventilation greatly reduced
- Rooms have much lower loads (Lighting)
- More moisture is retained

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Manual J Outdoor Design Conditions

Location	Elevation	Latitude	Winter	Summer					
	Feet	Degrees North	Heating 99% Dry Bulb	Cooling 1% Dry Bulb	Coincident Wet Bulb	Design Grains 55% RH	Design Grains 50% RH	Design Grains 45% RH	Daily Range (DR)
Pocatello AP	4454	43	0	90	60	-41	-34	-28	H
Twin Falls AP	4150	42	2	95	61	-44	-37	-31	H
Illinois									
Aurora	706	41	-1	91	76	42	49	55	M
Belleville, Scott AFB	453	38	10	93	77	46	53	59	M
Bloomington	875	40	-2	90	74	31	38	44	M
Carbondale	411	37	7	93	77	46	53	59	M
Champaign/Urbana	754	40	2	92	74	28	35	41	M
Chicago, Meigs Field	593	41	3	89	73	27	34	40	M
Chicago, Midway AP	620	41	0	91	73	24	31	37	M
Chicago, O'Hare AP	668	42	-1	88	73	29	36	42	M
Chicago CO	647	41	2	91	74	30	37	43	L
Danville	696	40	1	90	74	31	38	44	M
Decatur	682	39	3	91	75	36	43	49	M
Dixon	785	41	2	90	74	31	38	43	M

https://farm-energy.extension.org/wp-content/uploads/2019/04/7.-Outdoor_Design_Conditions_508.pdf

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#38. R403.6 Mechanical Ventilation (Mandatory)

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R403.6 Mechanical Ventilation

- Building to have ventilation meeting IRC or IMC or with other approved means
- Outdoor air intakes and exhausts shall have automatic or gravity dampers that close when the ventilation system is not operating

R403.6.1 Whole-house mechanical ventilation system fans to meet efficacy in Table R403.6.1

Exception

- When fans are integral to tested and listed HVAC equipment, powered by electronically commutated motor

Table R403.6.1
Whole-house mechanical ventilation system fan efficacy

Fan Location	Air flow rate (CFM)	Minimum Efficacy CFM/Watt)	Air Flow rate maximum (CFM)
HRV or ERV	Any	1.2 CFM/watt	Any
Range hoods	Any	2.8 CFM/watt	Any
in-line fan	Any	2.8 CFM/watt	Any
Bathroom, utility room	10	1.4 CFM/watt	<90
Bathroom, utility room	90	2.8 CFM/watt	Any

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Ventilation Types (Negative, Positive, Balanced)

Mechanical ventilation system designs typically fall into one of three categories:

1. Exhaust Only
2. Supply Only
3. Balanced Supply/Exhaust

The 2018 IRC/IECC requires a continuously operating mechanical ventilation system to remove stale air and add fresh air to each dwelling. The required system flow rates are specified in Section M1507 of the 2015 IRC:

Table M1505.4.3(1)
Continuous Whole-House Mechanical Ventilation System Airflow Rate Requirements

Dwelling Unit Floor Area (square feet)	Number of Bedrooms				
	0-1	2-3	4-5	6-7	> 7
	AIRFLOW IN CFM				
< 1,500	30	45	60	75	90
1,501—3,000	45	60	75	90	105
3,001—4,500	60	75	90	105	120
4,501—6,000	75	90	105	120	135
6,001—7,500	90	105	120	135	150
> 7,500	105	120	135	150	165

"Continuous operation" requires the system to either run at all times or cycle on at least once every four hours at a rate adequate to provide an overall average rate that meets the minimum flow requirement in the table.

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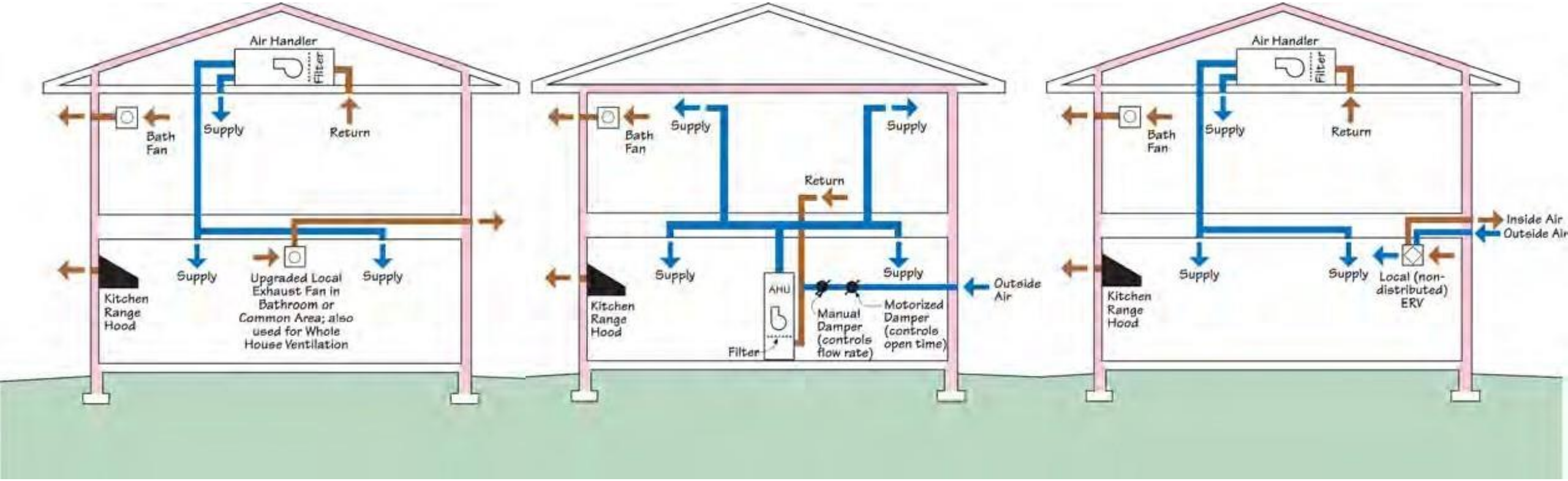
Ventilation Types (Negative, Positive, Balanced)



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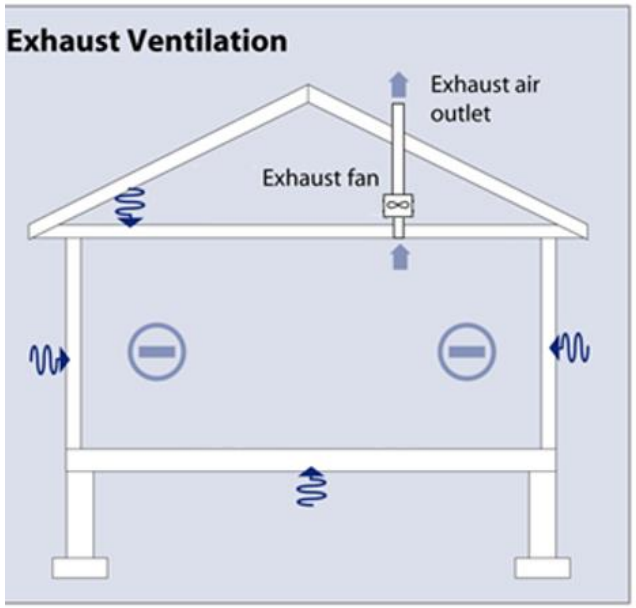
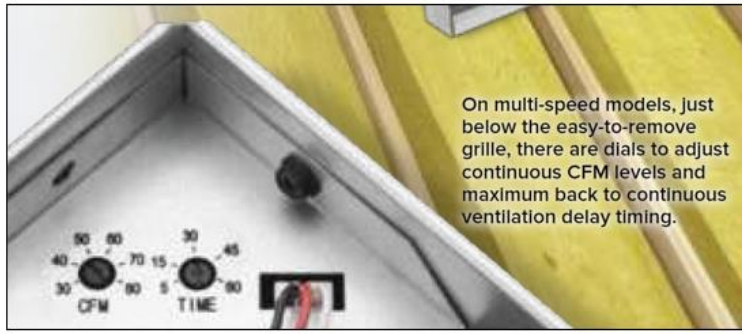
Exhaust Only Ventilation (Negative Ventilation)

Exhaust only systems use one or more fans to remove stale air. This depressurizes the building, so fresh air enters through leaks in the envelope.

Exhaust only ventilation systems are the most common design. This strategy is usually accomplished with a bath fan, which then serves as both local exhaust and whole-building ventilation.

This ventilation method is the most affordable option, but it has a few drawbacks.





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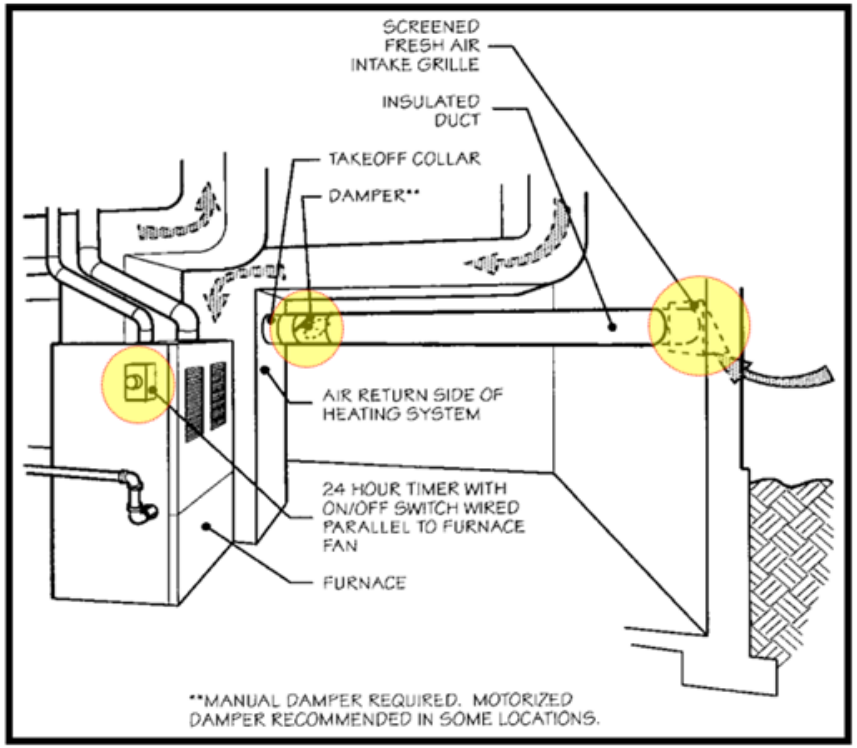
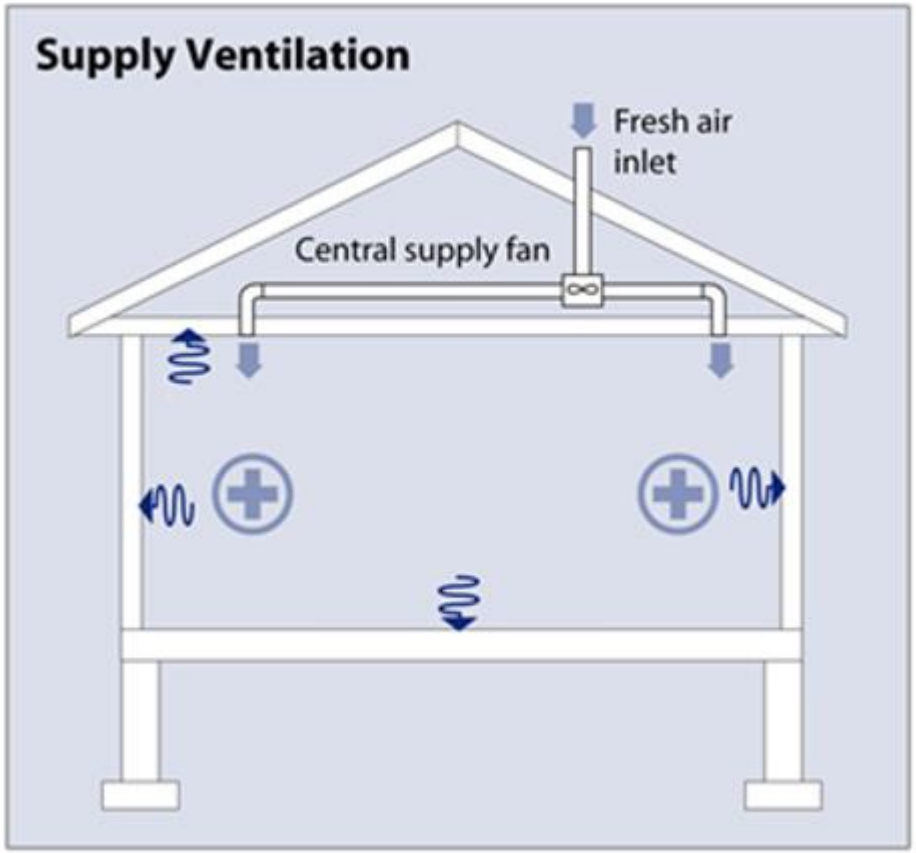
Supply Only Ventilation Types (Positive Ventilation)

Supply only systems use one or more fans to push fresh air into the building. They pressurize the building so stale air is pushed out through leaks in the envelope.

A commonly used approach to supply-only ventilation is the addition of an outdoor air intake to the return stream of a ducted system.





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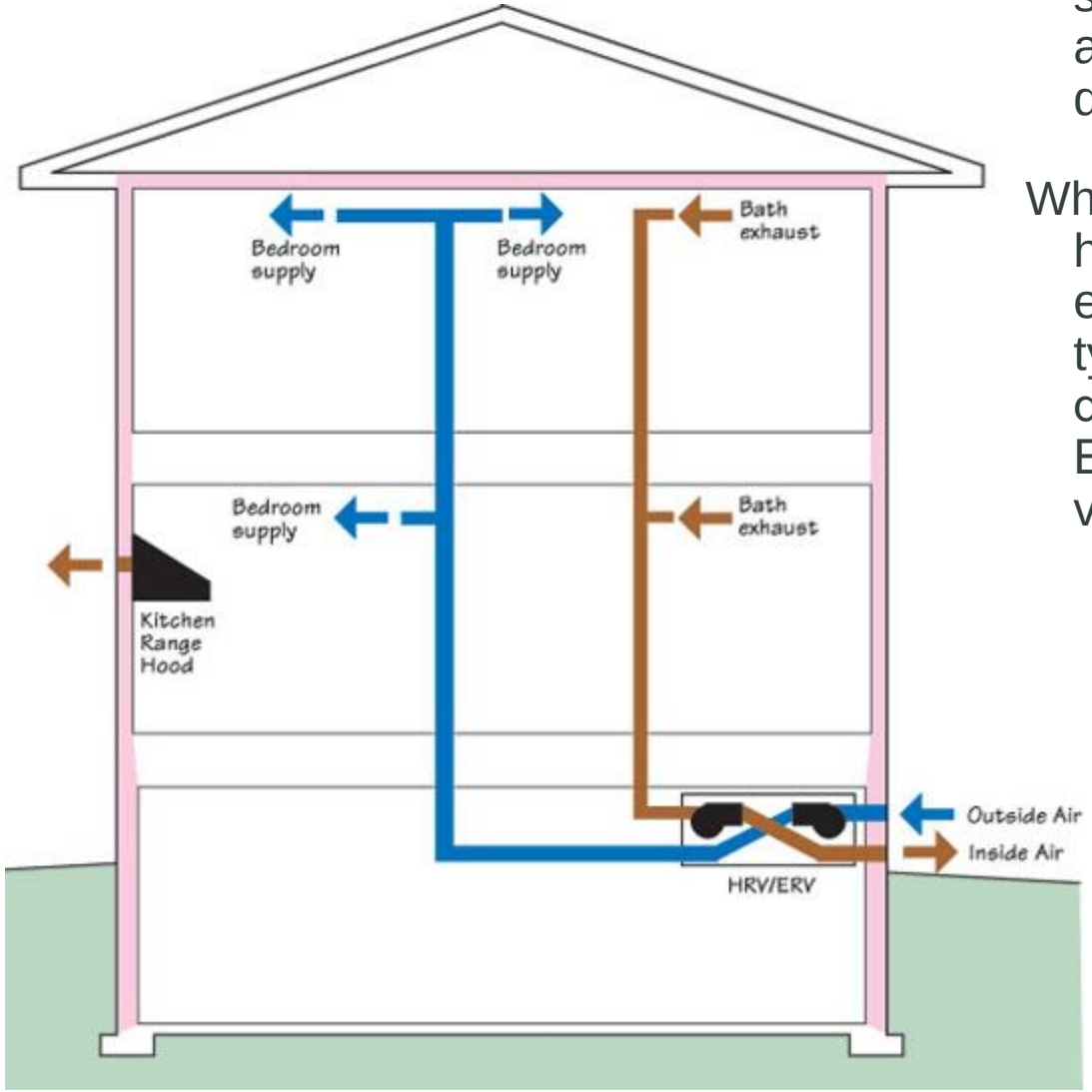
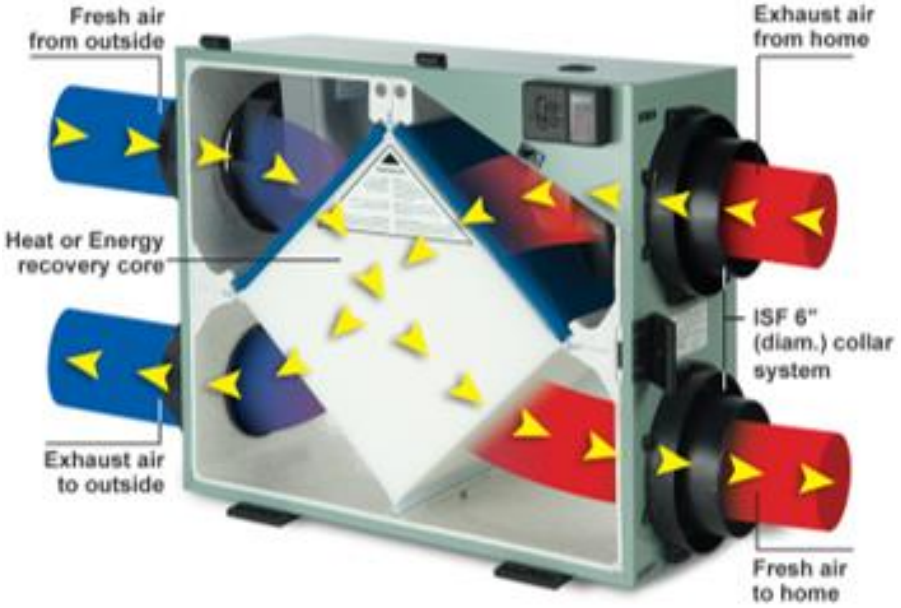
Balanced Ventilation



Balanced systems use a balanced combination of fan-driven supply and exhaust air. The supply fans bring in the same amount of air that the exhaust fans pull out, so no pressures differences are created in the house by them.

When there are two air streams, the opportunity exists to move heat and moisture from one stream into the other, improving energy use and comfort. Therefore, balanced ventilation is typically done with a pre-designed, all-in-one, system. This diagram shows how it works. We call the devices HRV's and ERV's: heat recovery ventilators and energy recovery ventilators.



Balanced ventilation is the most preferable option, but it is also the most expensive and complicated to install

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Illinois Amendments Not Included in 2018 IECC

R403.6.2 Recirculation of air. (2018 IRC M1505.2)

R403.6.3 Exhaust equipment. (2018 IRC M1505.3)

R403.6.4 Whole-house mechanical ventilation system. (2018 IRC M1505.4)

- R403.6.4.1 System Design (2018 IRC M1505.4.1)
- R403.6.4.2 System Controls. (2018 IRC M1505.4.2)

R403.6.6 Mechanical Ventilation Rate. (2018 IRC M1505.4.3)

R403.6.4.3.1 Different Occupant Density.

R403.6.4.3.2 Airflow Measurement

R403.6.4.4 Local Exhaust Rates (2018 IRC M1505.4.4)

Illinois Amendments: https://www2.illinois.gov/cdb/business/codes/Pages/IllinoisEnergyConservationCode.aspx

Link to 2018 IRC: https://codes.iccsafe.org/content/IRC2018

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#39. R404.1, R402.4.5 Lighting (Mandatory)

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R404.1 Lighting Equipment (Mandatory)

Illinois Amendments Definitions

High-Efficacy Lamps. Compact fluorescent lamps, light-emitting diode (LED) lamps, T-8 or smaller diameter linear fluorescent lamps, or other lamps with an efficacy of not less than 65 lumens per watt or light fixtures of not less than 55 lumens per watt.

Not less than 90 percent of the permanently installed fixtures shall contain only high-efficacy lamps

Low voltage exception removed for 2018 IECC

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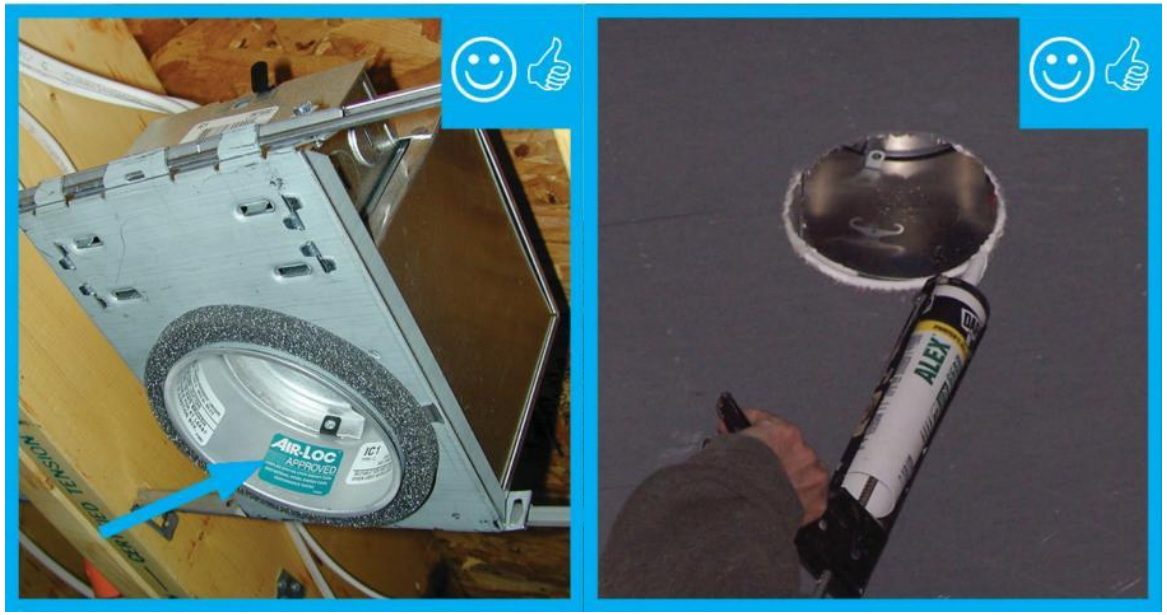
R402.4.5 Recessed Lighting

Recessed luminaires installed in the building thermal envelope shall be sealed to limit air leakage between conditioned and unconditioned spaces. Recessed luminaires shall be IC-rated and labeled as having an air-leakage rate of not greater than 2.0 cfm when tested in accordance with ASTM E283 at a pressure differential of 1.57 psf (75 PA). Recessed luminaires shall be sealed with a gasket or caulked between the housing and interior wall or ceiling covering.



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#40. R502, R503 Additions / Alterations

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R503.1 Alterations

Alterations to any building or structure shall comply with the requirements of the code for new construction. Alterations shall be such that the existing building or structure is not less conforming to the provisions of this code than the existing building or structure was prior to the alteration.

Alterations to an existing building, building system or portion thereof shall conform to the provisions of this code as they relate to new construction without requiring the unaltered portions of the existing building or building system to comply with this code.

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R503.1 Alterations Exception

The following are not required to comply provided the energy use of the building is not increased:

1. Storm windows over existing fenestration
2. Existing ceiling, wall or floor cavities exposed during construction provided that these cavities are filled with insulation
3. Construction where the existing roof, wall or floor cavity is not exposed
4. Roof recover (See definition)
5. Roofs w/o insulation in the cavity and where the sheathing or insulation is exposed during the reroofing shall be insulated either above or below the sheathing
6. Surface applied window film installed on existing single pane fenestration to reduce solar heat gain provided that the code does not require the glazing or fenestration to be replaced

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R503.1 Alterations Exception

R503.1.1 Roof Membrane Peel & Replacement

*This provision is narrow and not likely to apply as flat roofs are rarely replaced before there is a leak which would require work to be carried out on the roof insulation, eliminating the ability to use the provision.

Roof membrane peel and replacement – Where an existing weather resisting roof membrane alone is removed, exposing insulation or sheathing and only a new weather resisting roof membrane is installed.

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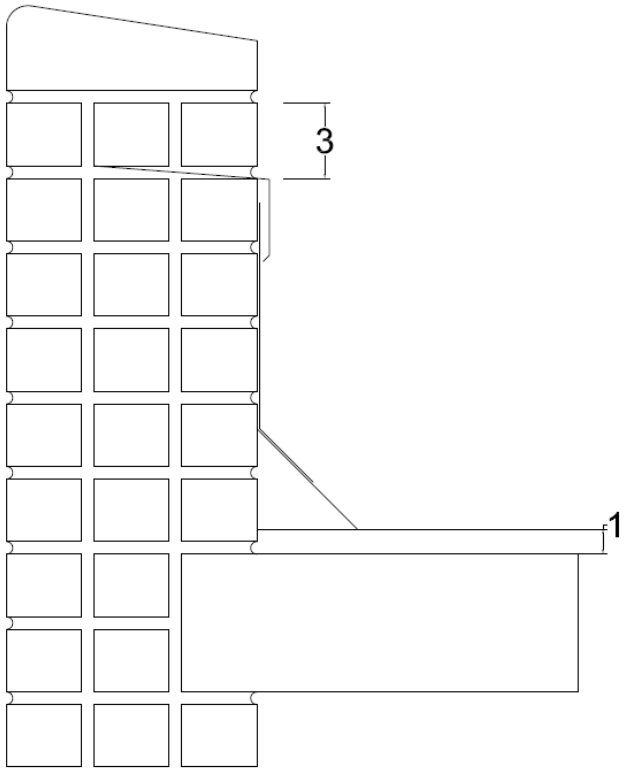
R503.1 Alterations

Alterations to an existing building, building system or portion thereof shall conform to the provisions of this code as they relate to new construction without requiring the unaltered portions of the existing building or building system to comply with this code.

Alterations shall not create an unsafe or hazardous condition or overload existing systems.



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Questions?

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