UTAH ENERGY CODE

IECC 2021 COMMERCIAL CODE CLASS

Energy Conservation Code Class

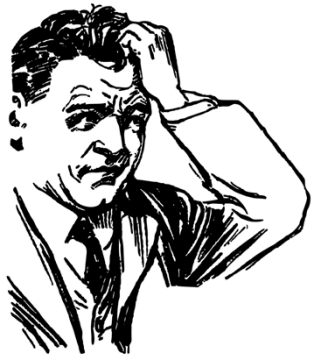
Thursday, March 9th, 2023

Location:
Salt Lake Community College Larry H Miller Campus
Miller Free Enterprise Center (MFEC) 9750 South 300 West Sandy, UT 84070
Time: 9:30 am - 4:00 pm
Presented by: Brent Ursenbach

Supporting Utah Energy Code Training

Significant Updates to the 2021 IECC Commercial Provisions

- Time is limited – Need days to hit all areas in depth.
- Complex Code for everyone
- Extensive Changes in 2021 – possibly the greatest is Additional Efficiency Requirement – 10 Points
- Low Level of Enforcement – Review and Inspection (complexity)
- Larger Buildings generally comply due to Design Professional expertise
- Envelope, Mechanical, and Lighting (Exterior and Interior)
- COMcheck is not mandatory; however, simplest method to show compliance with IECC and ASHRAE 90.1
  - Exception: Performance Compliance options



Why Care About IECC?

- Energy codes and standards set minimum efficiency requirements for new and renovated buildings, assuring reductions in energy use and emissions over the life of the building. Energy codes are a subset of building codes, which establish baseline requirements and govern building construction.

- Code buildings are more comfortable and cost-effective to operate, assuring energy, economic and environmental benefits.

- What will energy cost in 20 years?

EnergyStar Existing Buildings Program: Benchmarking

- Identify underperforming buildings – target improvements
- Best Practices
- Investment Priorities
- Verify Savings
- Report Performance
- E-star Recognition > 75
- May includes water, gas, electricity, waste mgt….
- Implement comprehensive management programs

Degree Days	Estar Score	KBTU/SF Estar
369	96	43.8
247	96	43.8
294	96	43.1
507	97	42.2
567	97	42.2
246	97	41.5
317	97	41.5
670	97	41.1
1083	97	41.1
985	97	40.8
793	97	40.8
620	97	40.3
410	97	40.3
189	97	41.1
464	97	41.1
649	97	41.1
380	97	41.1
248	97	41.1
376	97	41.8
596	97	41.9
902	96	42.4

ELECTRICITY

	Total KWH	On-Peak KWH	Interm KWH	Off-Peak KWH	Delivery Demand	Cost Per KWH	Cost Per Sq.Ft.	KWH Per Sq.Ft.	Total Cost	Service Period Begin	Service Period End
Apr	219,000	120,300		98,700	794	0.103	$ 0.08	0.81	$ 22,663.20	03/18/20	04/16/20
May	177,000	76,200		100,800	683	0.118	$ 0.08	0.66	$ 20,950.58	04/16/20	05/15/20
Jun	213,900	57,600		156,300	606	0.106	$ 0.08	0.79	$ 22,602.56	05/15/20	06/16/20
Jul	232,800	68,100		164,700	725	0.112	$ 0.10	0.86	$ 25,997.30	06/16/20	07/16/20
Aug	264,600	75,900		188,700	699	0.101	$ 0.10	0.98	$ 26,833.14	07/16/20	08/17/20
Sep	237,300	70,200		167,100	669	0.105	$ 0.09	0.88	$ 24,983.18	08/17/20	09/16/20
Oct	195,300	88,500		106,800	613	0.104	$ 0.07	0.72	$ 20,219.30	09/16/20	10/15/20
Nov	242,100	131,100		111,000	918	0.107	$ 0.10	0.90	$ 25,841.87	10/15/20	11/16/20
Dec	306,000	170,400		135,600	879	0.091	$ 0.10	1.13	$ 27,778.56	11/16/20	12/17/20
2020	3,023,700	1,369,500	0	1,654,200		0.099	$ 1.11	11.21	$ 298,468.58		
Jan	345,600	178,800		166,800	891	0.087	$ 0.11	1.28	$ 30,031.44	12/17/20	01/19/21
Feb	291,600	157,500		134,100	842	0.094	$ 0.10	1.08	$ 27,395.30	01/19/21	02/17/21
Mar	280,200	154,200		126,000	910	0.101	$ 0.10	1.04	$ 28,257.85	02/17/21	03/18/21
Apr	239,400	129,000		110,400	771	0.101	$ 0.09	0.89	$ 24,124.37	03/18/21	04/16/21
May	222,600	93,000		129,600	683	0.098	$ 0.08	0.83	$ 21,805.91	04/16/21	05/17/21
Jun	229,800	68,700		161,100	683	0.102	$ 0.09	0.85	$ 23,403.90	05/17/21	06/16/21
Jul	266,400	80,100		186,300	725	0.102	$ 0.10	0.99	$ 27,083.10	06/16/21	07/16/21
Aug	273,300	76,200		197,100	674	0.096	$ 0.10	1.01	$ 26,359.64	07/16/21	08/17/21
Sep	237,600	69,300		168,300	592	0.101	$ 0.09	0.88	$ 24,115.35	08/17/21	09/16/21
Oct	204,000	90,900		113,100	681	0.113	$ 0.09	0.76	$ 23,129.94	09/16/21	10/15/21
Nov	231,600	126,900		104,700	758	0.106	$ 0.09	0.86	$ 24,596.63	10/15/21	11/16/21
Dec	286,500	158,700		127,800	797	0.096	$ 0.10	1.06	$ 27,552.06	11/16/21	12/17/21
2021	3,108,600	1,383,300	0	1,725,300		0.099	$ 1.14	11.53	$ 307,855.49		

Commercial Energy Provisions: Administration & Definitions

Chapters 1 & 2

Scope/Construction Documents
Section C103

- ✓ Documentation shall be prepared by a registered design professional
- ✓ Digital format can be used
- ✓ Information required:
  - ✓ Energy compliance path
  - ✓ Insulation materials and R-values
  - ✓ Fenestration U-factors, SHGC
  - ✓ Area-weighted U-factor and SHGC calculations
  - ✓ Mechanical system design criteria
  - ✓ Mechanical, SWH, equipment types, sizes, and efficiencies
  - ✓ Economizer description
  - ✓ Equipment and system controls
  - ✓ Duct sealing, duct and pipe insulation and location
  - ✓ Lighting fixture schedule with wattage and control narrative
  - ✓ Location of daylight zones
  - ✓ Air barrier and air sealing details, including location

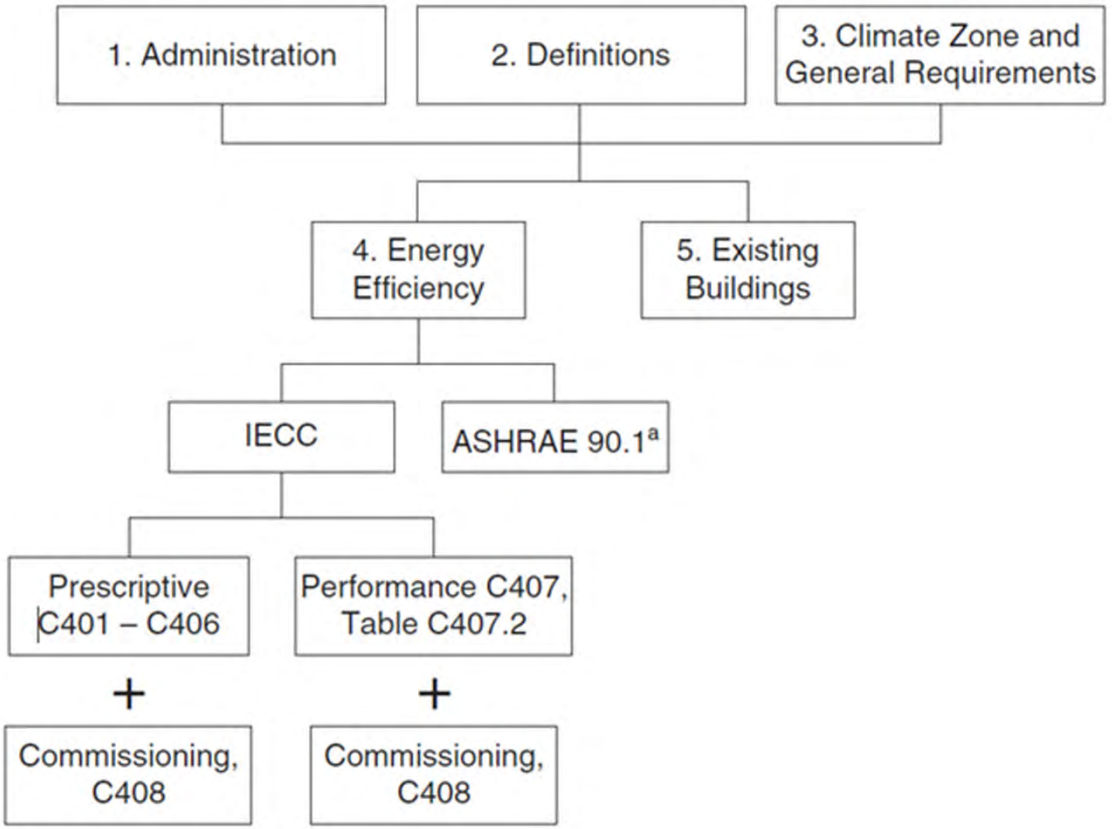
The building thermal envelope shall be represented on the construction drawings

Buried in spec's is not enough

Compliance Path Identified on Plans

- IECC or ASHRAE 90.1
  - No mixing
- Prescriptive include:
  - Tables

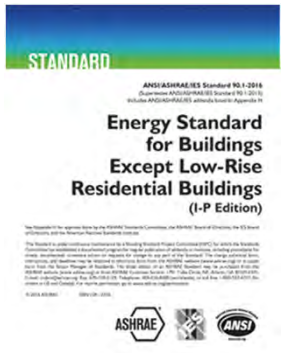
  or
  - Tradeoff – COMcheck
- Commissioning Dependent on Size of HVAC



Commercial Compliance Options LAST CODE CYCLE

1

- ASHRAE 90.1-2016



OR

2 2018 IECC - Prescriptive

- C402 - Envelope
- C403 - Mechanical
- C404 - SWH
- C405 - Lighting

AND

- Pick At Least One C406:

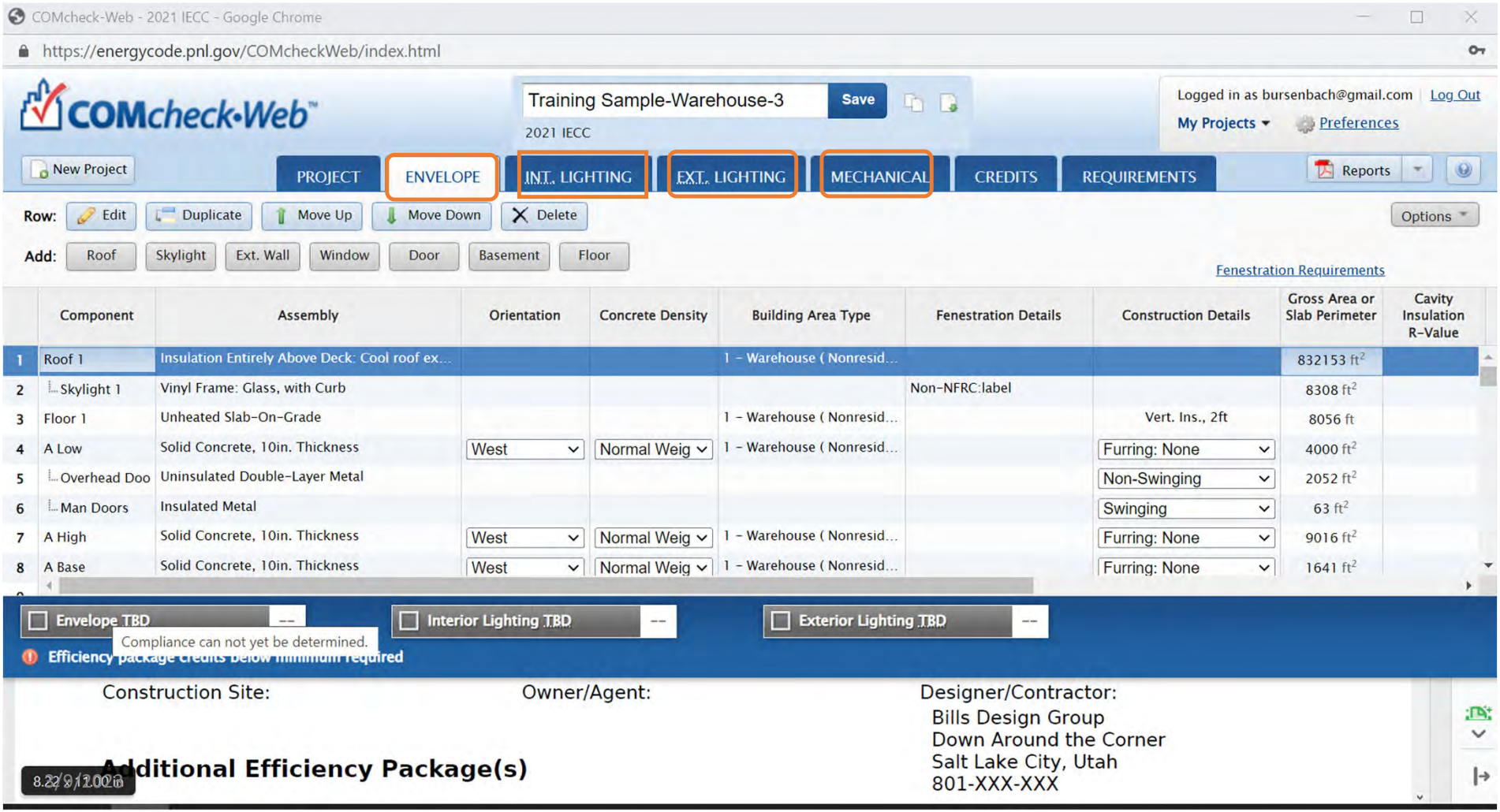
- C406.2 – Eff. HVAC Performance
- C406.3 – Reduced Lighting Power
- C406.4 – Enhanced Lighting Controls
- C406.5 – On-site Supply of Renewable energy
- C406.6 – Dedicated Outdoor Air System
- C406.7 – High Eff. Service Water Heating
- C406.8 – Enhanced Envelope Performance
- C406.9 – Reduced Air Infiltration

OR

3 2018 IECC - Performance

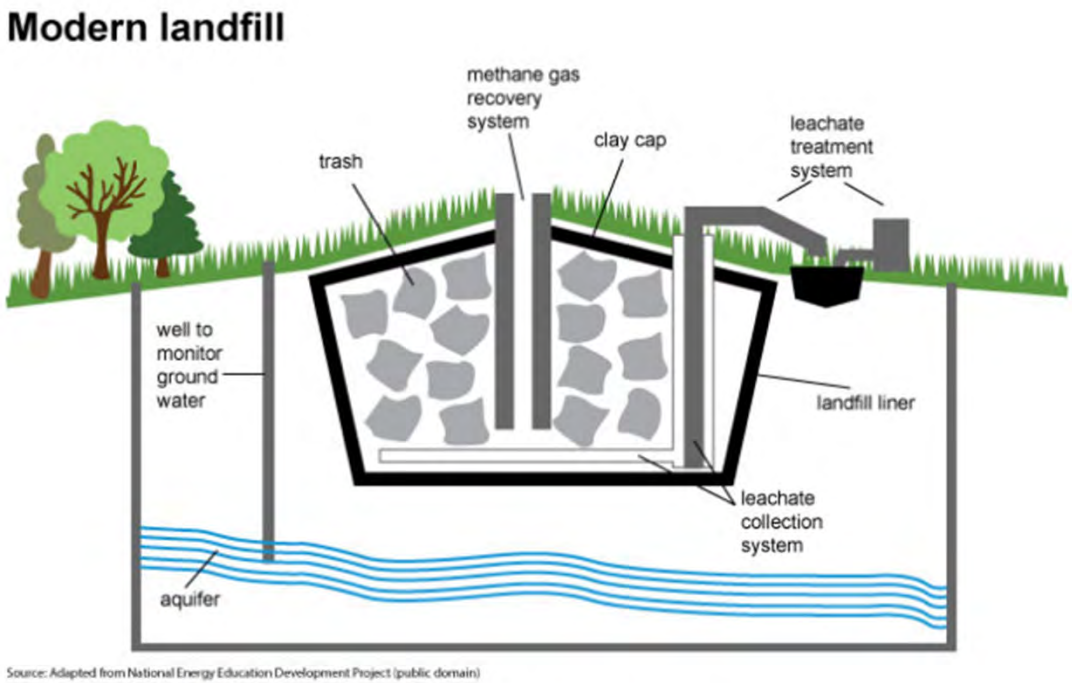
- C407 – Total Building Performance
- C402.5 – Air Leakage
- C403.2 – Provisions applicable to all mechanical systems
- C404 - SWH
- Lighting Mandatory Sections
  - C405.2
  - C405.3
  - C405.4
  - C405.6
- Building energy cost to be ≤ 85% of standard reference design building

2021 COMcheck-Web only – NO download available – 4 reports typically required



2021 Definition - ***Biogas***

A mixture of hydrocarbons that is a gas at 60°F (15.5°C) and 1 atmosphere of pressure that is produced through the anaerobic digestion of organic matter.

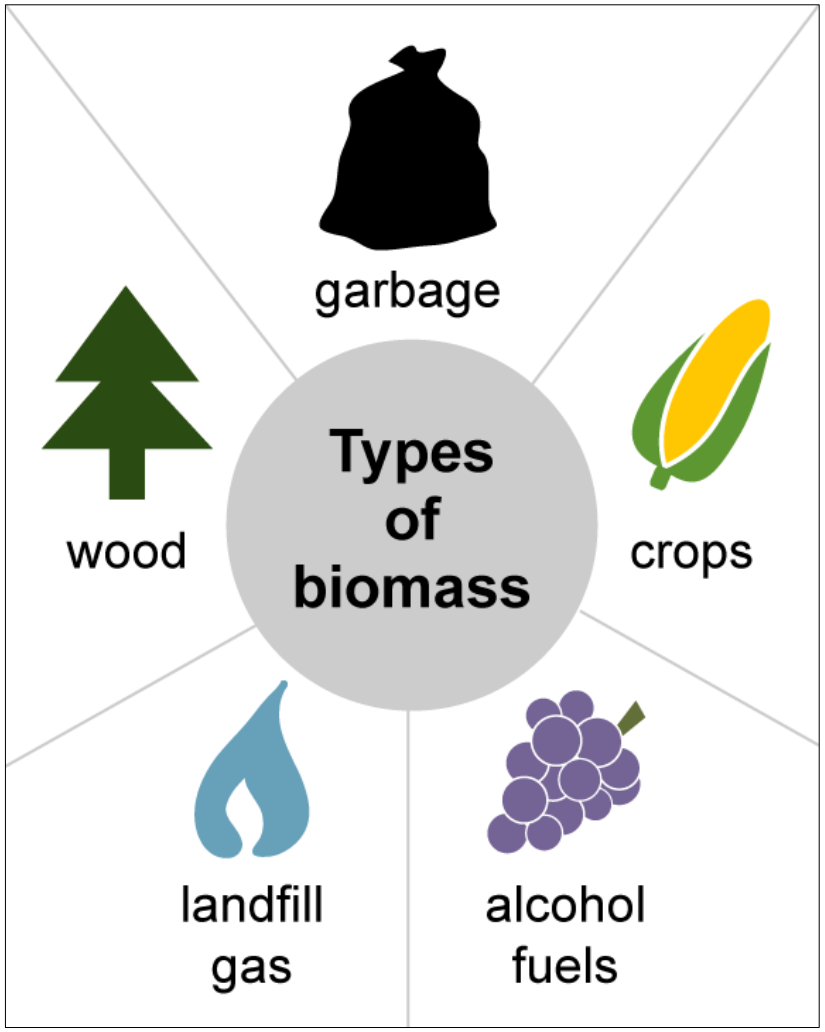


Source: Adapted from National Energy Education Project (public domain)

2021 Definition -

Biomass

Non-fossilized and biodegradable organic material originating from plants, animals and/or micro-organisms, including products, by-products, residues and waste from agriculture, forestry and related industries as well as the non-fossilized and biodegradable organic fractions of industrial and municipal wastes, including gases and liquids recovered from the decomposition of non-fossilized and biodegradable organic material.



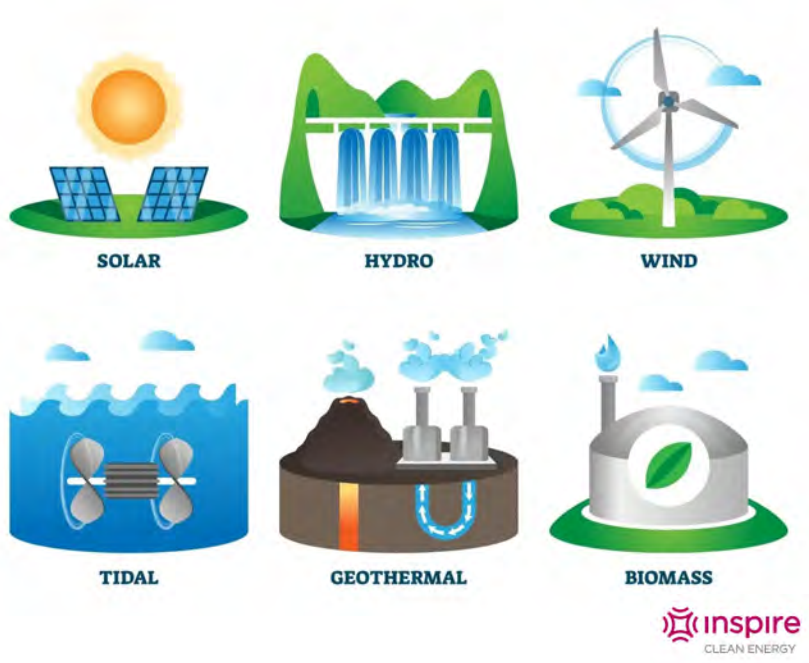
2021 Definition -
On-site Renewable Energy

Energy ~~derived~~ from renewable energy resources harvested at the building project site. ~~solar radiation, wind, waves, tides, landfill gas, biogas, biomass or the internal heat of the earth. The energy system providing onsite renewable energy shall be located on the project site.~~

Expect to see increased use of PV to comply with additional efficiency requirement.

2021 Definition –
Renewable Energy Resources

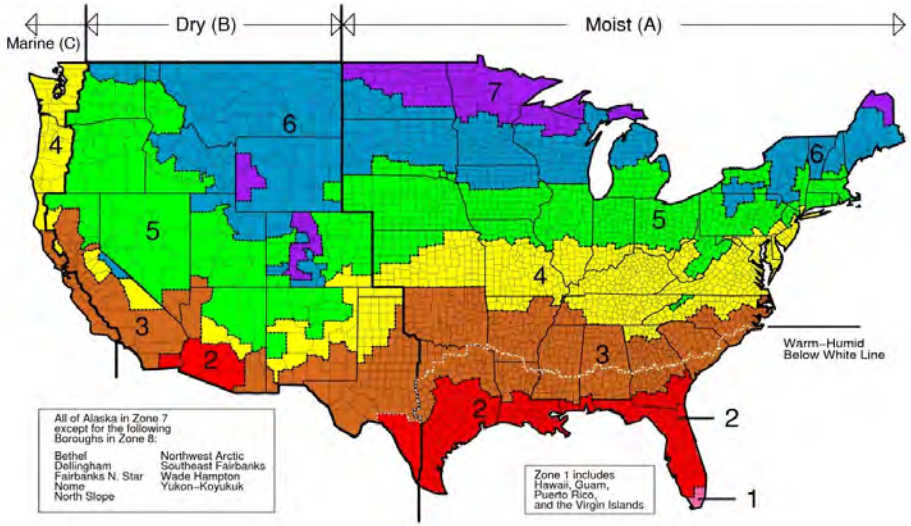
Energy derived from solar radiation, wind, waves, tides, landfill gas, biogas, biomass or extracted from hot fluid or steam heated within the earth.



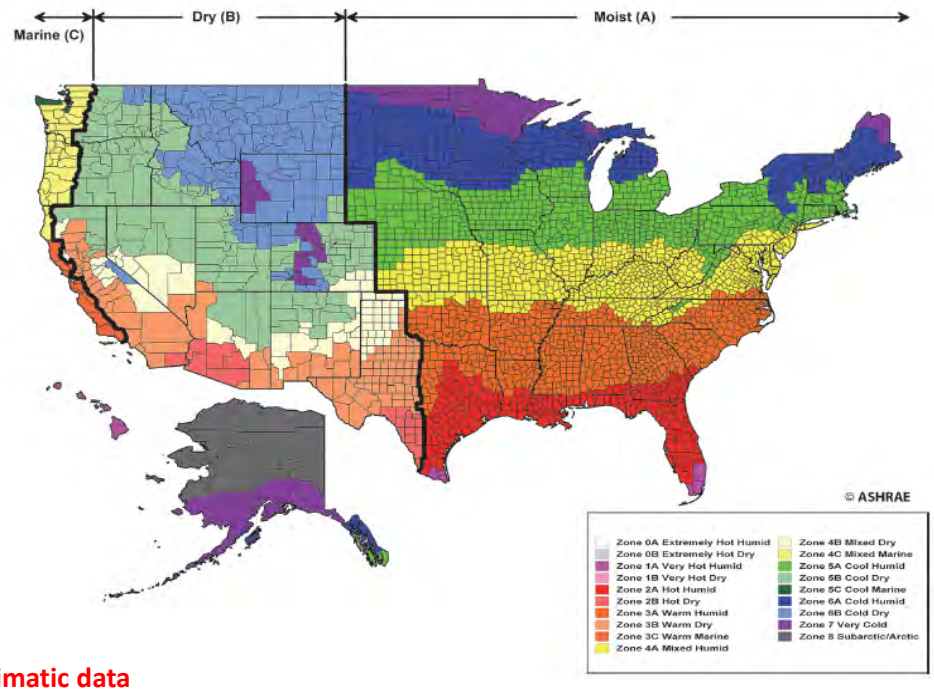
Climate Zones

In Utah: Box Elder, Cache and Carbon – CZ 6 to CZ 5

Climate Zones for 2018 IECC



Climate Zones for 2021 IECC



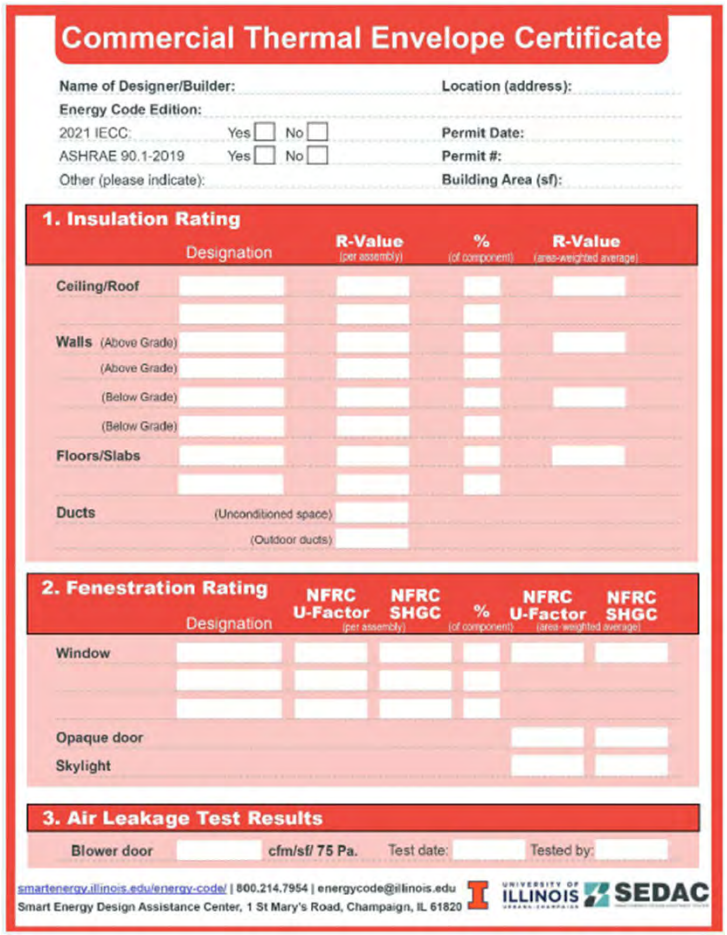
ASHRAE Standard 169-2013 reassigned counties to climate zones based on new climatic data

Thermal Envelope Certificates
Section C401.3

Thermal envelope certificate must include:

1. R-values of insulation installed in opaque envelope assemblies or on ducts
2. U-factors and solar heat gain coefficients (SHGC) of fenestration;
3. Results from any building envelope air leakage testing performed on the building

Where a component has more than one value the certificate shall indicate the area-weighted average



Commercial Thermal Envelope Certificate

Name of Designer/Builder: Location (address):

Energy Code Edition:

2021 IECC: Yes ☐ No ☐ Permit Date:

ASHRAE 90.1-2019 Yes ☐ No ☐ Permit #:

Other (please indicate): Building Area (sf):

1. Insulation Rating

Designation	R-Value (per assembly)	% (of component)	R-Value (area-weighted average)
Ceiling/Roof			
Walls (Above Grade)			
(Above Grade)			
(Below Grade)			
(Below Grade)			
Floors/Slabs			
Ducts (Unconditioned space)			
(Outdoor ducts)			

2. Fenestration Rating

Designation	NFRC U-Factor (per assembly)	NFRC SHGC (per assembly)	% (of component)	NFRC U-Factor (area-weighted average)	NFRC SHGC (area-weighted average)
Window					
Opaque door					
Skylight					

3. Air Leakage Test Results

Blower door cfm/sf/ 75 Pa. Test date: Tested by:

smartenergy.illinois.edu/energy-code/ | 800.214.7954 | energycode@illinois.edu

Smart Energy Design Assistance Center, 1 St Mary's Road, Champaign, IL 61820

UNIVERSITY OF ILLINOIS SEDAC

Courtesy University of Illinois - SEDAC

Low-energy Buildings and Greenhouses

Section C402.1.1

Buildings or portions of buildings that are separated from remainder of building, by building thermal envelope assemblies complying with C402 **are exempt** from the Envelope provisions if:

- Peak design rate of energy < 3.4 Btu/h x ft^2 or 1.0 watt/ft^2 of floor area for space conditioning purposes, **OR**
- Those portions or building that do not contain conditioned space, **OR**

- Greenhouse structures or areas mechanically heated or cooled that comply with the following are exempt from building envelope requirements:
  - Exterior opaque assemblies comply with C402.2 and C402.4.5 (except low energy greenhouses that comply with C402.1.1)
  - Interior partition building envelope assemblies that separate greenhouse from conditioned space comply with C402.2, C402.4.3 and C402.4.5
  - Fenestration assemblies comply with Table C402.1.1.1; skylights = 0.5, vertical fenestration = 0.7. U-factor for roof is roof assembly or roof that includes assembly and internal curtain system (except unconditioned greenhouses)

Equipment Buildings – Cell Towers, Cable, Phone Switching, etc.

Section C402.1.2

Buildings that comply with the following are exempt from the building thermal envelope provisions:

- Separate building with floor area < 1200 ft^2
- Intended to house electronic equipment with installed equipment power totaling > 7 watts/ft^2
- Heating system capacity < 17,000 Btu/hr (5 kW) and a heating thermostat set point that is restricted to < 50ºF
- Average wall and roof U-factor < 0.200 in Climate Zones 1-5 and < 0.120 in Climate Zones 6-8
  - Assembly R-value R-5 CZ 1-5 R-8.3 CZ 6-8
- Comply with the roof solar reflectance and thermal emittance provisions for Climate Zone 1

Building Envelope Requirements

Section C402.1 - General

Building thermal envelope to comply with the following:

- Specific insulation requirements of Section C402.2
- Thermal requirements of either:
  - R-value-based method of Section C402.1.3
  - U-, C-, and F-factor-based method of Section C402.1.4 **OR**
  - Component performance alternative of Section C402.1.5
- Roof solar reflectance and thermal emittance
- Fenestration in building envelope assemblies
- Air Leakage of building envelope assemblies

Where buildings have vertical fenestration area > allowed per C402.4, (30 or 40%) building and building thermal envelope to comply with Item 2 of C401.2.1 (Total Building Performance) or C401.2.2 (ASHRAE 90.1)

The following to comply with C403.11

- Walk-in coolers, walk-in freezers, refrigerated warehouse coolers and refrigerated warehouse freezers

Chapter 4 Prescriptive Approach Compliance

TABLE C402.1.3
OPAQUE THERMAL ENVELOPE INSULATION COMPONENT MINIMUM REQUIREMENTS, R-VALUE METHOD[a, i]

CLIMATE ZONE	1		2		3		4 EXCEPT MARINE		5 AND MARINE 4		6		7		8	
	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R
Roofs																
Insulation entirely above roof deck	R-20ci	R-25ci	R-25ci	R-25ci	R-25ci	R-25ci	R-30ci	R-30ci	R-30ci	R-30ci	R-30ci	R-30ci	R-35ci	R-35ci	R-35ci	R-35ci
Metal buildings[b]	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-25 + R-11 LS	R-25 + R-11 LS	R-30 + R-11 LS	R-30 + R-11 LS	R-30 + R-11 LS	R-30 + R-11 LS
Attic and other	R-38	R-38	R-38	R-38	R-38	R-38	R-38	R-38	R-38	R-49	R-49	R-49	R-49	R-49	R-49	R-49
Walls, above grade																
Mass[g]	R-5.7ci[c]	R-5.7ci[c]	R-5.7ci[c]	R-7.6ci	R-7.6ci	R-9.5ci	R-9.5ci	R-11.4ci	R-11.4ci	R-13.3ci	R-13.3ci	R-15.2ci	R-15.2ci	R-15.2ci	R-25ci	R-25ci
Metal building	R-13+ R-6.5ci	R-13 + R-6.5ci	R13 + R-6.5ci	R-13 + R-13ci	R-13 + R-6.5ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13+ R-19.5ci	R-13 + R-13ci	R-13+ R-19.5ci
Metal framed	R-13 + R-5ci	R-13 + R-5ci	R-13 + R-5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-15.6ci	R-13 + R-7.5ci	R-13+ R17.5ci
Wood framed and other	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R13 + R-15.6ci or R-20 + R-10ci	R13 + R-15.6ci or R-20 + R-10ci
Walls, below grade																
Below-grade wall[d]	NR	NR	NR	NR	NR	NR	R-7.5ci	R-7.5ci	R-7.5ci	R-7.5ci	R-7.5ci	R-7.5ci	R-10ci	R-10ci	R-10ci	R-12.5ci
Floors																
Mass[e]	NR	NR	R-6.3ci	R-8.3ci	R-10ci	R-10ci	R-10ci	R-10.4ci	R-10ci	R-12.5ci	R-12.5ci	R-12.5ci	R-15ci	R-16.7ci	R-15ci	R-16.7ci
Joist/framing	NR	NR	R-30	R-30	R-30	R-30	R-30	R-30	R-30	R-30	R-30	R-30[f]	R-30[f]	R-30[f]	R-30[f]	R-30[f]
Slab-on-grade floors																
Unheated slabs	NR	NR	NR	NR	NR	NR	R-10 for 24" below	R-10 for 24" below	R-10 for 24" below	R-10 for 24" below	R-10 for 24" below	R-15 for 24" below	R-15 for 24" below	R-15 for 24" below	R-15 for 24" below	R-20 for 24" below
Heated slabs[h]	R-7.5 for 12" below + R-5 full slab	R-7.5 for 12" below + R-5 full slab	R-7.5 for 12" below + R-5 full slab	R-7.5 for 12" below + R-5 full slab	R-10 for 24" below + R-5 full slab	R-10 for 24" below + R-5 full slab	R-15 for 24" below + R-5 full slab	R-15 for 24" below + R-5 full slab	R-15 for 36" below + R-5 full slab	R-15 for 36" below + R-5 full slab	R-15 for 36" below + R-5 full slab	R-20 for 48" below + R-5 full slab	R-20 for 48" below + R-5 full slab	R-20 for 48" below + R-5 full slab	R-20 for 48" below + R-5 full slab	R-20 for 48" below + R-5 full slab
Opaque doors																
Nonswinging	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75

For SI: 1 inch = 25.4 mm, 1 pound per square foot = 4.88 kg/m^2, 1 pound per cubic foot = 16 kg/m^3.

ci = Continuous insulation, NR = No Requirement, LS = Liner System.

a. Assembly descriptions can be found in ANSI/ASHRAE/IESNA Appendix A.

b. Where using *R*-value compliance method, a thermal spacer block shall be provided, otherwise use the *U*-factor compliance method in Table C402.1.4.

c. R-5.7ci is allowed to be substituted with concrete block walls complying with ASTM C90, ungrouted or partially grouted at 32 inches or less on center vertically and 48 inches or less on center horizontally, with ungrouted cores filled with materials having a maximum thermal conductivity of 0.44 Btu-in/h-ft^2 °F.

d. Where heated slabs are below grade, below-grade walls shall comply with the exterior insulation requirements for heated slabs.

e. "Mass floors" shall be in accordance with Section C402.2.3.

f. Steel floor joist systems shall be insulated to R-38.

g. "Mass walls" shall be in accordance with Section C402.2.2.

h. The first value is for perimeter insulation and the second value is for slab insulation. Perimeter insulation is not required to extend below the bottom of the slab.

i. Not applicable to garage doors. See Table C402.1.4.

Chapter 4 Prescriptive Approach Compliance

TABLE C402.1.3
OPAQUE THERMAL ENVELOPE INSULATION COMPONENT MINIMUM REQUIREMENTS, R-VALUE METHOD[a, i]

CLIMATE ZONE	1		2		3		4 EXCEPT MARINE		5 AND MARINE 4		6		7		8	
	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R
Roofs																
Insulation entirely above roof deck	R-20ci	R-25ci	R-25ci	R-25ci	R-25ci	R-25ci	R-30ci	R-30ci	R-30ci	R-30ci	R-30ci	R-30ci	R-35ci	R-35ci	R-35ci	R-35ci
Metal buildings[b]	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-25 + R-11 LS	R-25 + R-11 LS	R-30 + R-11 LS	R-30 + R-11 LS	R-30 + R-11 LS	R-30 + R-11 LS
Attic and other	R-38	R-38	R-38	R-38	R-38	R-38	R					R-49	R-49	R-49	R-49	R-49
Wa																
Mass[g]																
Metal building																
Metal framed																
Wood framed and other																
Below-grade wall[h]																
Mass[e]																
Joist/framing																
Unheated slabs																
Heated slabs[h]																
Nonswinging																

ROOFS

CLIMATE ZONE	4 EXCEPT MARINE		5 AND MARINE 4		6		7		8	
	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R
Metal buildings[b]	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-25 + R-11 LS	~~R-25 + R-11 LS~~ R-30 + R-11 LS	R-30 + R-11 LS	R-30 + R-11 LS	~~R-30 + R-11 LS~~ R-25 + R-11 + R-11 LS	~~R-30 + R-11 LS~~ R-25 + R-11 + R-11 LS
Attic and other	~~R-38~~ R-49	~~R-38~~ R-49	~~R-38~~ R-49	R-49	R-49	R-49	~~R-49~~ R-60	~~R-49~~ R-60	~~R-49~~ R-60	~~R-49~~ R-60

For SI: 1 inch = 25
ci = Continuous in
a. Assembly descr
b. Where using *R-*
c. R-5.7ci is allow with ungrouted
d. Where heated sl
e. "Mass floors" shall be in accordance with Section C402.2.3.
f. Steel floor joist systems shall be insulated to R-38.
g. "Mass walls" shall be in accordance with Section C402.2.2.
h. The first value is for perimeter insulation and the second value is for slab insulation. Perimeter insulation is not required to extend below the bottom of the slab.
i. Not applicable to garage doors. See Table C402.1.4.

Chapter 4 Prescriptive Approach Compliance

TABLE C402.1.3
OPAQUE THERMAL ENVELOPE INSULATION COMPONENT MINIMUM REQUIREMENTS, R-VALUE METHOD[a, i]

CLIMATE ZONE	1		2		3		4 EXCEPT MARINE		5 AND MARINE 4		6		7		8	
	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R
Roofs																
Insulation entirely above roof deck	R-20ci	R-25ci	R-25ci	R-25ci	R-25ci	R-25ci	R-30ci	R-30ci	R-30ci	R-30ci	R-30ci	R-30ci	R-35ci	R-35ci	R-35ci	R-35ci
Metal buildings[b]	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-25 + R-11 LS	R-25 + R-11 LS	R-30 + R-11 LS	R-30 + R-11 LS	R-30 + R-11 LS	R-30 + R-11 LS
Attic and other	R-38	R-38	R-38	R-38	R-38	R-38	R-49	R-49	R-49	R-49	R-49	R-49	R-49	R-49	R-49	R-49

WALLS, ABOVE GRADE

CLIMATE ZONE	4 EXCEPT MARINE		5 AND MARINE 4		6		7		8	
	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R
Walls, above grade										
Mass[g]	R-9.5ci	R-11.4ci	R-11.4ci	R-13.3ci	R-13.3ci	R-15.2ci	R-15.2ci	R-15.2ci	R-25ci	R-25ci
Metal building	R-13 + R-13ci	~~R-13 + R-13ci~~ R-13 + R-14ci	~~R-13 + R-13ci~~ R-13 + R-14ci	~~R-13 + R-13ci~~ R-13 + R-14ci	~~R-13 + R-13ci~~ R-13 + R-14ci	~~R-13 + R-13ci~~ R-13 + R-14ci	~~R-13 + R-13ci~~ R-13 + R-17ci	R-13+ R-19.5ci	~~R-13 + R-13ci~~ R-13 + R-19.5ci	R-13+ R-19.5ci
Metal framed	R-13 + R-7.5ci	R-13 + R-7.5ci	~~R-13 + R-7.5ci~~ R-13 + R-10ci	~~R-13 + R-7.5ci~~ R-13 + R-10ci	~~R-13 + R-7.5ci~~ R-13 + R-12.5ci	~~R-13 + R-7.5ci~~ R-13 + R-12.5ci	~~R-13 + R-7.5ci~~ R-13 + R-12.5ci	R-13 + R-15.6ci	~~R-13 + R-7.5ci~~ R-13 + R-18.8ci	~~R-13+ R17.5ci~~ R-13 + R-18.8ci
Wood framed and other	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	~~R-13 + R-3.8ci or R-20~~ R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	~~R13 + R-15.6ci or R-20 + R-10ci~~ R-13 + R-18.8ci	~~R13 + R-15.6ci or R-20 + R-10ci~~ R-13 + R-18.8ci

CLIMATE ZONE	1	2	3	4 EXCEPT MARINE	5 AND MARINE 4	6	7	8
Mass[g]	R-5.7ci[c]							
Metal building	R-13+ R-6.5ci							
Metal framed	R-13 + R-5ci							
Wood framed and other	R-13 + R-3.8ci or R-20							
Below-grade wall[d]	NR							
Mass[e]	NR							
Joist/framing	NR							
Unheated slabs	NR							
Heated slabs[h]	R-7.5 for 12" below + R-5 full slab							
Nonswinging	R-4.75							

	-25ci	R-25ci						
	-13 + -13ci	R-13+ R-19.5ci						
	-13 + -7.5ci	R-13+ R17.5ci						
	13 + 15.6ci	R13 + R-15.6ci or R-20 + R-10ci						
	-10ci	R-12.5ci						
	-15ci	R-16.7ci						
	-30[f]	R-30[f]						
	15 for below	R-20 for 24" below						
	20 for below R-5 ll slab	R-20 for 48" below + R-5 full slab						
	-4.75	R-4.75						

For SI: 1 inch = 25.4 mm, 1 poun
ci = Continuous insulation, NR =
a. Assembly descriptions can be
b. Where using *R*-value compliar
c. R-5.7ci is allowed to be substit with ungrouted cores filled wit
d. Where heated slabs are below
e. "Mass floors" shall be in accor
f. Steel floor joist systems shall b
g. "Mass walls" shall be in accor
h. The first value is for perimeter
i. Not applicable to garage doors.

enter horizontally,

Chapter 4 Prescriptive Approach Compliance

TABLE C402.1.3
OPAQUE THERMAL ENVELOPE INSULATION COMPONENT MINIMUM REQUIREMENTS, R-VALUE METHOD[a, i]

CLIMATE ZONE	1		2		3		4 EXCEPT MARINE		5 AND MARINE 4		6		7		8	
	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R
Roofs																
Insulation entirely above roof deck	R-20ci	R-25ci	R-25ci	R-25ci	R-25ci	R-25ci	R-30ci	R-30ci	R-30ci	R-30ci	R-30ci	R-30ci	R-35ci	R-35ci	R-35ci	R-35ci
Metal buildings[b]	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-25 + R-11 LS	R-25 + R-11 LS	R-30 + R-11 LS	R-30 + R-11 LS	R-30 + R-11 LS	R-30 + R-11 LS
Attic and other	R-38	R-38	R-38	R-38								R-49	R-49	R-49	R-49	R-49
Mass[g]	R-5.7ci[c]	R-5.7ci[c]	R-5.7ci[c]	R-7.6ci								R-15.2ci	R-15.2ci	R-15.2ci	R-25ci	R-25ci

WALLS, BELOW GRADE

TABLE C402.1.3
OPAQUE THERMAL ENVELOPE INSULATION COMPONENT MINIMUM REQUIREMENTS, R-VALUE METHOD[a, i]

CLIMATE ZONE	1		2		3		4 EXCEPT MARINE		5 AND MARINE 4		6		7		8	
	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R
Walls, below grade																
Below-grade wall[d]	NR	NR	NR	NR	NR	NR	R-7.5ci	~~R-7.5ci~~ R-10ci	R-7.5ci	~~R-7.5ci~~ R-10ci	~~R-7.5ci~~ R-10ci	~~R-7.5ci~~ R-15ci	~~R-10ci~~ R-15ci	~~R-10ci~~ R-15ci	~~R-10ci~~ R-15ci	~~R-12.5ci~~ R-15ci

with ungrouted cores filled with materials having a maximum thermal conductivity of 0.44 Btu-in/h-ft² °F.
d. Where heated slabs are below grade, below-grade walls shall comply with the exterior insulation requirements for heated slabs.
e. "Mass floors" shall be in accordance with Section C402.2.3.
f. Steel floor joist systems shall be insulated to R-38.
g. "Mass walls" shall be in accordance with Section C402.2.2.
h. The first value is for perimeter insulation and the second value is for slab insulation. Perimeter insulation is not required to extend below the bottom of the slab.
i. Not applicable to garage doors. See Table C402.1.4.

Chapter 4 Prescriptive Approach Compliance

TABLE C402.1.3
OPAQUE THERMAL ENVELOPE INSULATION COMPONENT MINIMUM REQUIREMENTS, R-VALUE METHOD[a, i]

CLIMATE ZONE	1		2		3		4 EXCEPT MARINE		5 AND MARINE 4		6		7		8	
	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R
Roofs																
Insulation entirely above roof deck	R-20ci	R-25ci	R-25ci	R-25ci	R-25ci	R-25ci	R-30ci	R-30ci	R-30ci	R-30ci	R-30ci	R-30ci	R-35ci	R-35ci	R-35ci	R-35ci
Metal buildings[b]	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-25 + R-11 LS	R-25 + R-11 LS	R-30 + R-11 LS	R-30 + R-11 LS	R-30 + R-11 LS	R-30 + R-11 LS
Attic and other	R-38	R-38	R-38	R-38	R-38	R-38						R-49	R-49	R-49	R-49	R-49
Mass[g]	R-5.7ci[c]	R-5.7ci[c]	R-5.7ci[c]	R-7.6ci	R-7.6ci	R-9.5ci							R-15.2ci	R-15.2ci	R-25ci	R-25ci
Metal building																
Metal framed																
Wood framed a other																
Below-grade w																
Mass[e]																
Joist/framing																
Unheated slabs																
Heated slabs[h]																
Nonswinging																

FLOORS

TABLE C402.1.3
OPAQUE THERMAL ENVELOPE INSULATION COMPONENT MINIMUM REQUIREMENTS, R-VALUE METHOD[a, i]

CLIMATE ZONE	1		2		3		4 EXCEPT MARINE		5 AND MARINE 4		6		7		8	
	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R
Floors																
Mass[e]	NR	NR	R-6.3ci	R-8.3ci	R-10ci	R-10ci	~~R-10ci~~ R-14.6ci	~~R-10.4ci~~ R-16.7ci	~~R-10ci~~ R-14.6ci	~~R-12.5ci~~ R-16.7ci	~~R-12.5ci~~ R-16.7ci	~~R-12.5ci~~ R-16.7ci	~~R-15ci~~ R-20.9ci	~~R-16.7ci~~ R-20.9ci	~~R-15ci~~ R-23ci	~~R-16.7ci~~ R-23ci
Joist/framing	~~NR~~ R-13	~~NR~~ R-13	R-30	R-30	R-30	R-30	R-30	R-30	R-30	R-30	~~R-30~~ R-38	~~R-30[f]~~ R-38	~~R-30[f]~~ R-38	~~R-30[f]~~ R-38	~~R-30[f]~~ R-38	~~R-30[f]~~ R-38

For SI: 1 inch =
ci = Continuous

a. Assembly descriptions can be found in ANSI/ASHRAE/IESNA Appendix A.
b. Where using *R*-value compliance method, a thermal spacer block shall be provided, otherwise use the *U*-factor compliance method in Table C402.1.4.
c. R-5.7ci is allowed to be substituted with concrete block walls complying with ASTM C90, ungrouted or partially grouted at 32 inches or less on center vertically and 48 inches or less on center horizontally, with ungrouted cores filled with materials having a maximum thermal conductivity of 0.44 Btu-in/h-ft² °F.
d. Where heated slabs are below grade, below-grade walls shall comply with the exterior insulation requirements for heated slabs.
e. "Mass floors" shall be in accordance with Section C402.2.3.
f. Steel floor joist systems shall be insulated to R-38.
g. "Mass walls" shall be in accordance with Section C402.2.2.
h. The first value is for perimeter insulation and the second value is for slab insulation. Perimeter insulation is not required to extend below the bottom of the slab.
i. Not applicable to garage doors. See Table C402.1.4.

Chapter 4 Prescriptive Approach Compliance

TABLE C402.1.3
OPAQUE THERMAL ENVELOPE INSULATION COMPONENT MINIMUM REQUIREMENTS, R-VALUE METHOD[a, i]

CLIMATE ZONE	1		2		3		4 EXCEPT MARINE		5 AND MARINE 4		6		7		8	
	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R
Roofs																
Insulation entirely above roof deck	R-20ci	R-25ci	R-25ci	R-25ci	R-25ci	R-25ci	R-30ci	R-30ci	R-30ci	R-30ci	R-30ci	R-30ci	R-35ci	R-35ci	R-35ci	R-35ci
Metal buildings[b]	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-25 + R-11 LS	R-25 + R-11 LS	R-30 + R-11 LS	R-30 + R-11 LS	R-30 + R-11 LS	R-30 + R-11 LS
Attic and other	R-38	R-38	R-38	R-38	R-38	R-38								R-49	R-49	R-49
Mass[g]	R-5.7ci[c]	R-5.7ci[c]	R-5.7ci[c]	R-7.6ci	R-7.6ci	R-9.5ci										
Metal buil																
Metal fram	3		4 EXCEPT MARINE		5 AND MARINE 4		6		7		8					
Wood fram other	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R				
Below-gra	Slab-on-grade floors															
Mass[e]	NR	NR	~~R-10 for 24" below~~	~~R-10 for 24" below~~	~~R-10 for 24" below~~	~~R-10 for 24" below~~	R-10 for 24" below	R-15 for 24" below	~~R-15 for 24" below~~	~~R-15 for 24" below~~	~~R-15 for 24" below~~	~~R-20 for 24" below~~				
Joist/frami																
Unheated s		R-10 for 24" below	R-15 for 24" below	R-15 for 24" below	R-15 for 24" below	R-20 for 24" below	R-20 for 24" below	R-20 for 48" below	R-20 for 48" below	R-20 for 48" below	R-20 for 48" below	R-25 for 48" below				
Heated sla																
Nonswinging																

UNHEATED SLAB-ON GRADE FLOORS

For SI: 1 inch = 25.4 mm, 1 pound per square foot = 4.88 kg/m^2, 1 pound per cubic foot = 16 kg/m^3.

ci = Continuous insulation, NR = No Requirement, LS = Liner System.

a. Assembly descriptions can be found in ANSI/ASHRAE/IESNA Appendix A.

b. Where using *R*-value compliance method, a thermal spacer block shall be provided, otherwise use the *U*-factor compliance method in Table C402.1.4.

c. R-5.7ci is allowed to be substituted with concrete block walls complying with ASTM C90, ungrouted or partially grouted at 32 inches or less on center vertically and 48 inches or less on center horizontally, with ungrouted cores filled with materials having a maximum thermal conductivity of 0.44 Btu-in/h-ft^2 °F.

d. Where heated slabs are below grade, below-grade walls shall comply with the exterior insulation requirements for heated slabs.

e. "Mass floors" shall be in accordance with Section C402.2.3.

f. Steel floor joist systems shall be insulated to R-38.

g. "Mass walls" shall be in accordance with Section C402.2.2.

h. The first value is for perimeter insulation and the second value is for slab insulation. Perimeter insulation is not required to extend below the bottom of the slab.

i. Not applicable to garage doors. See Table C402.1.4.

Chapter 4 Prescriptive Approach Compliance

TABLE C402.1.3
OPAQUE THERMAL ENVELOPE INSULATION COMPONENT MINIMUM REQUIREMENTS, R-VALUE METHOD[a, i]

CLIMATE ZONE	1		2		3		4 EXCEPT MARINE		5 AND MARINE 4		6		7		8	
	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R
Roofs																
Insulation entirely above roof deck	R-20ci	R-25ci	R-25ci	R-25ci	R-25ci	R-25ci	R-30ci	R-30ci	R-30ci	R-30ci	R-30ci	R-30ci	R-35ci	R-35ci	R-35ci	R-35ci
Metal buildings[b]	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-25 + R-11 LS	R-25 + R-11 LS	R-30 + R-11 LS	R-30 + R-11 LS	R-30 + R-11 LS	R-30 + R-11 LS
Attic and other	R-38	R-38	R-38	R-38	R-38	R-38						R-49	R-49	R-49	R-49	R-49
Mass[g]	R-5.7ci[c]	R-5.7ci[c]	R-5.7ci[c]	R-7.6ci	R-7.6ci	R-9.5ci							R-15.2ci	R-15.2ci	R-15.2ci	R-25ci
Metal bu																
Metal fr																
Wood fr other																
Below-g																
Mass[e]																
Joist/fra																
Unheated sla																
Heated slabs																
Nonswinging																

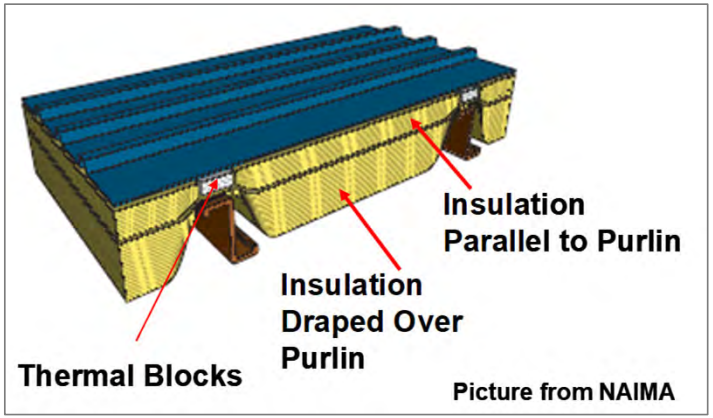
OPAQUE DOORS

TABLE C402.1.4
OPAQUE THERMAL ENVELOPE ASSEMBLY MAXIMUM REQUIREMENTS, *U*-FACTOR METHOD[a, b]

CLIMATE ZONE	1		2		3		4 EXCEPT MARINE		5 AND MARINE 4		6		7	
	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R
Opaque doors														
NonSwinging door	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31
Swinging door	~~U-0.61~~ U-0.37	~~U-0.61~~ U-0.37	~~U-0.61~~ U-0.37	~~U-0.61~~ U-0.37	~~U-0.61~~ U-0.37	~~U-0.61~~ U-0.37	~~U-0.61~~ U-0.37	~~U-0.61~~ U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37
Garage door <14% glazing	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31

For SI: 1 inch
ci = Continuc
a. Assembly
b. Where usi
c. R-5.7ci is
with ungr
d. Where hea
e. "Mass floors" shall be in accordance with Section C402.2.3.
f. Steel floor joist systems shall be insulated to R-38.
g. "Mass walls" shall be in accordance with Section C402.2.2.
h. The first value is for perimeter insulation and the second value is for slab insulation. Perimeter insulation is not required to extend below the bottom of the slab.
i. Not applicable to garage doors. See Table C402.1.4.

Roof R-Value
Metal Buildings



Thermal spacer block required on all metal buildings or must use U-factor Compliance Method

Two layers of insulation required

- ✓CZ 0-5 and marine 4: R-19+R-11 LS
- ✓CZ 6 (all other): R-25+R-11 LS
  CZ 6 (Group R): R-30+R-11 LS
- ✓CZ 7: R-30+R-11 LS
- ✓CZ 8: R-25+R-11+R-11 LS

Liner System includes the following:

- Continuous vapor barrier liner membrane that is installed below the purlins and that is uninterrupted by framing members
- An uncompressed, unfaced insulation resting on top of the liner membrane and located between purlins
- Multilayer installations, the last rated R-value of insulation is for unfaced insulation draped over purlins and compressed when the metal roof panes are attached

Metal Building Roofs Liner Systems

Photos courtesy of MBMA

Minimum Skylight Fenestration Area
Section C402.4.2

- In enclosed spaces > 2,500 ft^2 in floor area directly under a roof with > 75% of ceiling area with ceiling height > 15 ft.
  - total toplit daylight zone to not be < ½ the floor area and provide one of the following
    - Minimum of 3% of skylight area to toplit daylight zone where all skylights have a VT not less than 0.40 or VT_{annual} of not less than 0.26 **OR**
    - Provide a minimum skylight effective aperture of not less than 1% using skylight VT rating or 0.66 percent using Tubular Daylight Device's VT_{annual} rating

Exceptions:

- Climate Zones 6-8
- Spaces with LPDs < 0.5 W/ft^2
- Documented shaded spaces
- Daylight area under rooftop monitors is > 50% of floor area
- Spaces where total area minus area of daylight zones adjacent to vertical fenestration is < 2,500 ft^2 and lighting is controlled per C405.2.3
- Spaces designed as storm shelters complying with ICC 500

Doors

Section C402.4.5

Opaque swinging doors having < 50% glass area and nonswinging doors

Comply with Table C402.1.4

Horizontally hinged opaque non-swinging doors with single row of glazing (garage doors) and glazing area between 14% and 25% to have assembly U-factor

≤ 0.44 in Climates Zones 0-6

≤ 0.36 in Climate Zones 7-8

All other doors to comply with vertical fenestration requirements (Section C402.4.3)

Air Leakage
Section C402.4.5

- ✓ Air barriers
- ✓ Dwelling and sleeping unit enclosure testing
- ✓ Building thermal envelope testing
- ✓ Fenestration air leakage
- ✓ Rooms containing fuel-burning appliances
- ✓ Doors and access openings to shafts, chutes, stairways and elevator lobbies
- ✓ Air intakes, exhaust openings, stairways and shafts
- ✓ Loading dock weather seals
- ✓ Vestibules
- ✓ Recessed lighting
- ✓ Operable openings interlocking

Air Barrier Compliance Options
Section C402.5.1.2

Three ways to comply with air barrier requirements, buildings or portions of buildings:

- ✓ Including Group R and I occupancies, meet Section C402.5.2 (Dwelling and sleeping unit enclosure testing) – 50 Pascals
  - ✓ Except buildings in Climate Zones 2B, 3C and 5C

- ✓ Other than Group R and I occupancies, meet Section C402.5.3 (Building thermal envelope testing), 75 Pascals, except buildings:
  - ✓ In Climate Zones 2B, ***3B***, 3C and 5C
  - ✓ Larger than 5,000 ft^2 in Climate Zones 0B, 1, 2A, 4B and 4C
  - ✓ Between 5,000 ft^2 and 50,000 ft^2 in Climate Zones 0A, 3A and ***5B***

- ✓ That don't complete air barrier testing to meet Section C402.5.1.3 or C402.5.1.4 in addition to Section C402.5.1.5
  - ✓ Materials, Assemblies, Verification

Dwelling and Sleeping Unit Enclosure Testing
Section C402.5.2

- Building thermal envelope tested per ASTM E779, ANSI/RESNET/ICC 380, ASTM E1827 or equivalent method approved by code official
- Measured air leakage not to exceed 0.30 cfm/ft^2 of testing unit enclosure area at 0.2 inch water gauge
- Where multiple dwelling or sleeping units or other occupiable conditioned spaces are contained within one building thermal envelope, each unit to be considered an individual testing unit, and building air leakage to be the weighted average of all testing unit results, weighted by each testing unit's enclosure area
- Units tested separately with unguarded blower door test
  - Where buildings have fewer than 8 testing units, each tested
  - For buildings with *8 or more testing units*, the *greater of 7 units or 20%* of the testing units in the building to be tested, including a top floor unit, ground floor unit, and a unit with the largest testing unite enclosure area. For each tested unit that exceeds max air leakage rate, and additional 2 units to be tested, including a mixture of testing unit types and locations

Building Thermal Envelope Testing
Section C402.5.3

- Tested in accordance with ASTM E 779 at pressure differential of 0.3 inch water gauge (75 pascals) or an equivalent method approved by code official when tested air leakage rate < 0.40 cfm/ft^2
- Alternative approach for portions of building to test and measure air leakage in each portion
  - Weighted area average can't exceed the whole building air leakage limit
  - Portions to be tested:
    - Entire envelope area of all stories that have any spaces directly under a roof
    - Entire envelope area of all stories that have a building entrance, exposed floor, or loading dock, or are below grade
    - Representative above-grade building sections that total at least 25% of wall area enclosing remaining conditioned spec
  - There are exceptions

Building Envelope Performance Verification
Section C402.5.1.5

- Air barrier installation verified by code official, registered design professional, or approved agency per:
  - Review of construction documents and other supporting data
  - Inspection of continuous air barrier components and assemblies during construction while air barrier still accessible for inspection and repair
  - Final commissioning report provided for inspections completed by registered design professional or approved agency
    - To building owner or owner's authorized agent and code official
    - Report to identify deficiencies found during review of construction documents and inspection and details of corrective measures taken

Operable Openings Interlocking
Section C402.5.11

- If operable openings to the outdoors > 40 ft^2 exist, they must be interlocked with the heating and cooling system at the following levels when open
  - Raise cooling setpoint to 90F
  - Lower heating setpoint to 55F
- Exceptions
  - Separately zoned areas for food prep (that have appliances that contribute to HVAC loads of a restaurant or similar)
  - Warehouses where overhead doors are used for function of that occupancy (and approved by code official)
  - First entrance doors of exterior wall that are part of a vestibule

Additional Efficiency Credit Requirements
Section C406

- New buildings need 10 credits from Tables C406.1(1) – (5)
  - Table selected based on use group of the building and credit calculations
  - Where building contains multiple use groups, credits from each use group to be weighted by floor area of each group to determine weighted average building credit
  - Credits from tables or calculation to be achieved where building complies with one ore more of the following
    - More efficient HVAC performance
    - Reduced lighting power
    - Enhanced lighting controls
    - On-site supply of renewable energy
    - Provision of dedicated outdoor air system for certain HVAC equipment
    - High-efficiency service water heating
    - Enhanced envelope performance
    - Reduced air infiltration
    - Where not required by C405.12, include energy monitoring system
    - Where not required by C403.2.3, include fault detection and diagnostics system
    - Efficient kitchen equipment

Energy Credit Table Example

- Most credits table based, some are formulas
- Separate tables:
  - Office (Group B)
  - Multifamily (R) & Institutional (I)
  - Schools (E)
  - Retail (M)
  - Other than above
- Uniform Target
  - 10 credits
- Tenant infill
  - 5 Credits

C406.1

Table C406.1(1) Additional Energy Efficiency Credits for Group B Occupants

Climate Zone:	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
C406.2.1: 5% Heating	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	NA	NA	1	1	NA	1
C406.2.2: 5% Cooling	6	6	5	5	4	4	3	3	3	2	2	2	1	2	2	2	1
C406.2.3: 10% Heating	NA	NA	NA	NA	NA	NA	NA	1	NA	NA	2	1	1	2	2	NA	1
C406.2.4: 10% Cooling	11	12	10	9	7	7	6	5	6	4	4	5	3	4	3	3	3
C406.3.1: 10% LPA	9	8	9	9	9	9	10	8	9	9	7	8	8	6	7	7	6
C406.4:Digital Lt Ctrl	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2	1	1
C406.5: Renewable	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
C406.6: DOAS	4	4	4	4	4	3	2	5	3	2	5	3	2	7	4	5	3
C406.7.1: SWH HR	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
C406.7.2: SWH NG eff	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
C406.7.3: SWH HP	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
C406.8: 85% UA	1	4	2	4	4	3	NA	7	4	5	10	7	6	11	10	14	16

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DOE Residential Codes Field Study: Results and Training Plan

Surprising Data on Residential Building Air Leakage

- Updated October 13, 2022

Project Team

- Project Management
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- Field Team
  - Katy Milliken, Nexant
  - Chris Anjewierden, Nexant
  - Troy Preslar, Building Science West
- Advisory
  - Kevin Emerson, UT Clean Energy
  - Jim Meyers, SWEEP
- Education and Training
  - Brent Ursenbach, West Cost Codes Consultants
- Additional Support
  - Pacific Northwest National Laboratory
  - Department of Energy
  - Rocky Mountain Power
  - Dominion Energy
  - Utah Office of Energy Development

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Goals of the Field Study

- Collect field data to generate baseline compliance rate across two states (Arizona and Utah)

- Develop targeted education programs to address key measures that will result in the largest savings

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Reminder: **Key Measures**

1. **Envelope tightness**
2. Windows (U-factor and SHGC)
3. Wall insulation
4. Ceiling insulation
5. Lighting
6. Foundation insulation
7. Duct tightness

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Location	Count
Herriman, Salt Lake County	7
Lehi, Utah County	3
St. George, Washington County	5
South Jordan, Salt Lake County	3
Eagle Mountain, Utah County	3
Saratoga Springs, Utah County	3
Vineyard town, Utah County	2
Washington, Washington County	2
Bluffdale, Salt Lake County	1
West Jordan, Salt Lake County	3
Hurricane, Washington County	2
~~Cache County Unincorporated Area, Cache County~~	1
Wasatch County Unincorporated Area	
Spanish Fork, Utah County	2
Syracuse, Davis County	1
American Fork, Utah County	2
Orem, Utah County	4
Riverton, Salt Lake County	1
Cedar City, Iron County	1
Heber, Wasatch County	1
Kaysville, Davis County	1
Mapleton, Utah County	1
Ivins, Washington County	1
North Ogden, Weber County	2
Clinton, Davis County	1
~~Plain City, Weber County~~	1
Roy, Weber County	
Pleasant Grove, Utah County	1
Salem, Utah County	1
~~Tremonton, Box Elder County~~	1
Hyrum, Cache County	
Pleasant View, Weber County	1
Hooper, Weber County	1
Ogden, Weber County	1
Park City, Summit County	1
Enoch, Iron County	1
Nibley, Cache County	1
Total	63

Reminder: **Sampling Plan**

- Generated based on stakeholder input to reflect dispersion of construction activity while considering geography, climate, and demographics
- At least 63 total observations per each key item = 126 sites visited
- Construction sites selected randomly using building permit data, and only one visit per site
- No personally identifiable information shared with DOE or PNNL

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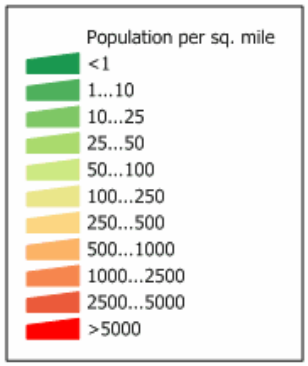
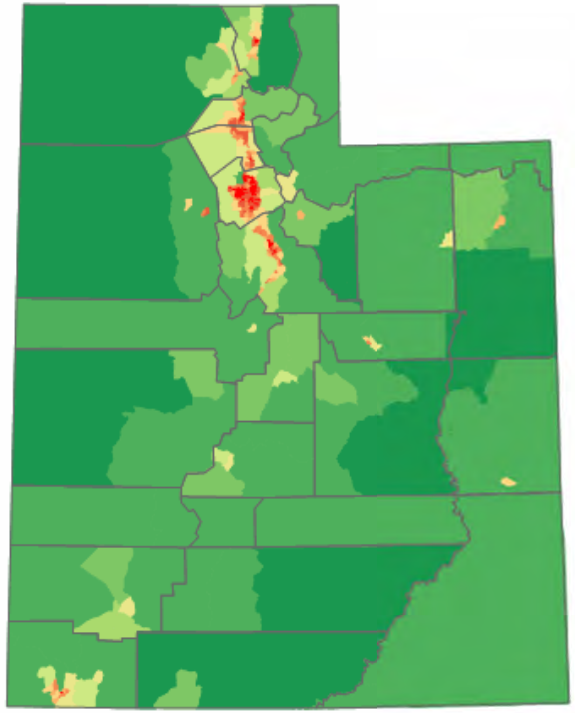
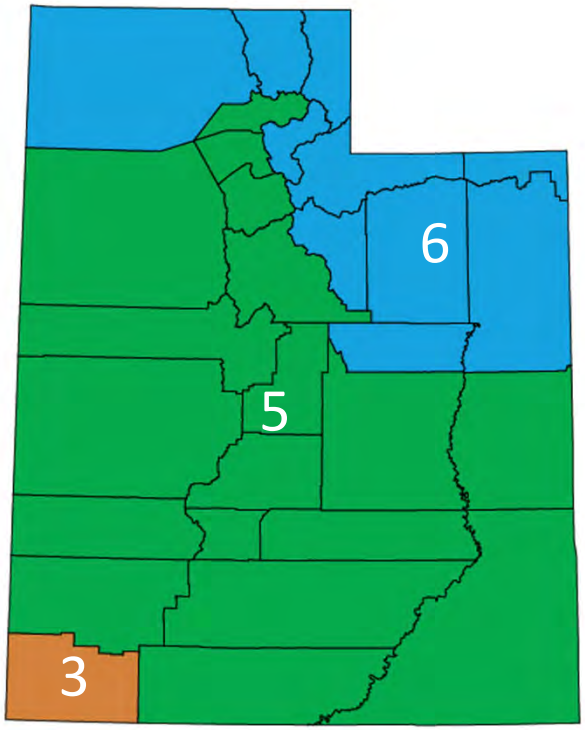
Climate Zones and Population Density



Source: U. S. Census Bureau Census 2000 Summary File 1 population by census tract.





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Statewide Savings Potential of $1.3 Million Annually

Measure	Elec Savings kWh/yr-home	Gas Savings therms/ yr-home	Total Energy Savings (MMBtu)	Total Energy Cost Savings ($)
Exterior Wall Insulation	121	29	59,000	$620,000
Duct Leakage	49	11	23,000	$241,000
Heated Basement Wall Insulation	-62	21	30,000	$164,000
Ceiling Insulation	22	4	9,000	$99,000
Envelope Air Leakage	4	5	9,000	$76,000
Window U-Factor	0	4	6,800	$53,000
Window SHGC	35	0	179	$46,000
High Efficacy Lighting	6	0	219	$10,000

Should this concern us?

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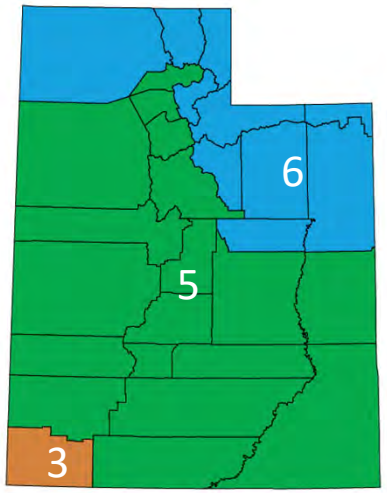
Key takeaways

- Field Study Measures are envelope focused
  - HVAC systems, ventilation efficiency, others, not measured
- Exterior wall insulation and duct leakage are responsible for ~70% total savings potential
- Off the shelf key measures (windows and lighting) are highly compliant, while skilled installation-based measures (wall insulation and duct tightness) have room for improvement.
- Air Leakage is quite low, generally across all Climate Zones
  - **Raises a mechanical ventilation concern**
- Ceiling/Attic insulation generally close to compliant
  - Trade-offs may result in compliance
- Basement wall R-12 average R-value fails to comply (R-15 CI)



Key Measures
1. Envelope tightness
2. Windows U-factor
3. Windows SHGC
4. Wall insulation
5. Ceiling insulation
6. Lighting
7. Foundation insulation
8. Duct tightness

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From the Study:
Increased/Improved Education For:

- **Design Professionals – Architects and Designers**
  - Improve Plans
- **Builders – Production and Custom**
  - Improve Understanding – Identify Benefits
    - Reduce complaints/callbacks
    - Satisfied Customers
- **Sub-Contractors**
  - Framers, Insulation, HVAC, Plumbers & Electricians
- **Code Officials**
  - Plan Review – Ensure documents approved for IECC compliance
  - Inspectors – Typically Checklists are discouraged; however, recently many have requested energy checklist

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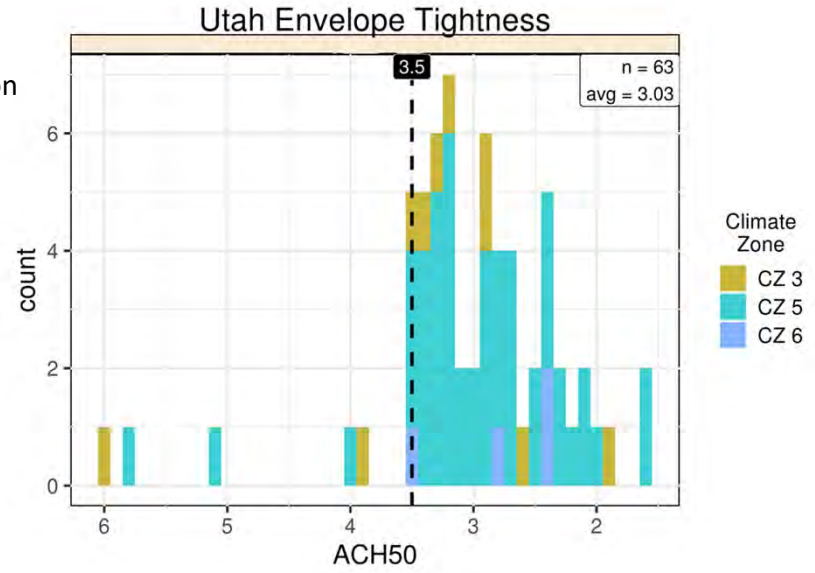
#5. Envelope Air Leakage – Wonderful! Or Is It?

- ***Most Significant Result***
- **Vast Majority ≤ 3.5 ACH@50pa**
- State Amendments
  - Blower Door Test OR
  - Insulation-Air Barrier Inspection Checklist
  - No BD test – no trigger for mechanical ventilation
- Mechanical Ventilation required at this level
- *Most homes do not include MV*
  - Not tested – no trigger
  - Jurisdiction does not enforce, doesn't know or care?
- Poor Air Quality, Moisture Issues, Health Concerns



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IECC COMMERCIAL - MECHANICAL UPDATES

Section C403 Organization

Mechanical sections:

C403.1: General (Loads)

C403.2: System Design

C403.3: Equipment Efficiencies & Specs

C403.4: HVAC Controls

C403.5: Economizers

C403.6: Multi-zone/VAV

C403.7: Vent & Exhaust

C403.8: Fan Eff. & Controls

C403.9: Large-Diameter Ceiling Fans

C403.10: Heat Rejection

C403.11: Refrigeration

C403.12: Construction

C403.13: Outside Bldg.

C403.14: Operable Opening Interlocking Controls

Overview

- ✓ HVAC Load Calculations
- ✓ Equipment and System Sizing
- ✓ HVAC Equipment Performance Requirements
- ✓ HVAC System Controls
- ✓ Guestroom HVAC Controls
- ✓ Hot Water Boiler Outdoor Temp. Set-back Control
- ✓ Ventilation & Vent. Control
- ✓ Energy Recovery Ventilation Systems
- ✓ Kitchen Exhaust Systems
- ✓ Duct and Plenum Insulation and Sealing
- ✓ Piping Insulation
- ✓ HVAC System Commissioning and Completion
- ✓ Air System Design and Control
- ✓ Heating Outside a Building
- ✓ Refrigeration Equipment Performance
- ✓ Walk-in Coolers and Freezers, Refrigerated Warehouse Coolers and Freezers
- ✓ Site-built walk-in Coolers and Walk-in Freezers

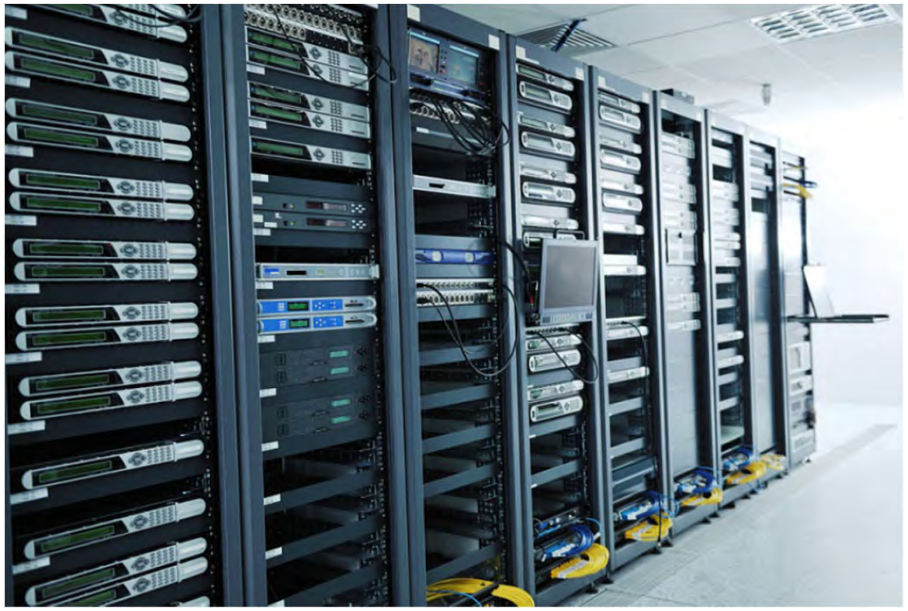
Definition - ***Information Technology Equipment (ITE)***

Items including computers, data storage devices, servers and network and communication equipment

Computers and computing devices from different eras – clockwise from top left:
Early vacuum tube computer (ENIAC)
Mainframe computer (IBM System 360)
Desktop computer (IBM ThinkCentre S50 with monitor)
Supercomputer (IBM Summit)
Video game console (Nintendo GameCube)
Smartphone (LYF Water 2)

2021 Definition – ***Data Center***

A room or series of rooms that share data center systems, whose primary function is to house equipment for the processing and storage of electronic data and that has a design total ITE equipment power density exceeding 20 watts per square foot (20 watts per 0.092 m2) of conditioned area and a total design ITE equipment load greater than 10 kW.



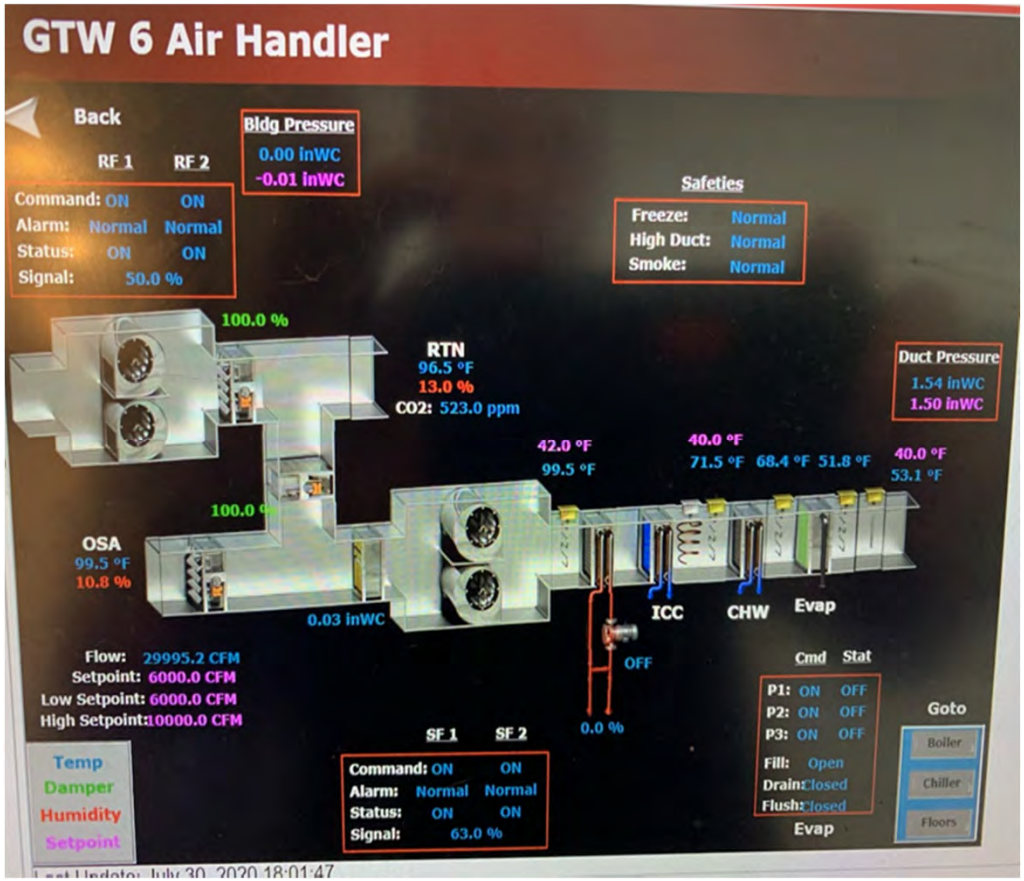
2021 Definition – ***Computer Room***

A room whose primary function is to house equipment for the processing and storage of electronic data which has a design total information technology equipment (ITE) ***equipment power density less than or equal to 20 watts per square foot*** *of conditioned area or* ***a design total ITE equipment load less than or equal to 10 kW***

2021 Definition – ***Direct Digital Control (DDC)***

A type of control where controlled and monitored analog or binary data, such as temperature and contact closures, are converted to digital format for manipulation and calculations by a digital computer or microprocessor, then converted back to analog or binary form to control physical devices.

Typically, a component of the BMS



Definition – ***Fault Detection and Diagnostics (FDD)***

A software platform that utilizes building analytic algorithms to convert data provided by sensors and devices to automatically identify faults in building systems and provide a prioritized list of actionable resolutions to those faults based on cost or energy avoidance, comfort and maintenance impact.

Data Centers

C403.1.2

- Comply with 6 and 8 ASHRAE 90.4 with several changes identified in two new Tables
- Data centers have been given a free pass for years; however, as they continue to become bigger, the power consumption is incredible when coupled with cooling loads.

TABLE C403.1.2(1)
MAXIMUM DESIGN MECHANICAL LOAD COMPONENT (DESIGN MLC)

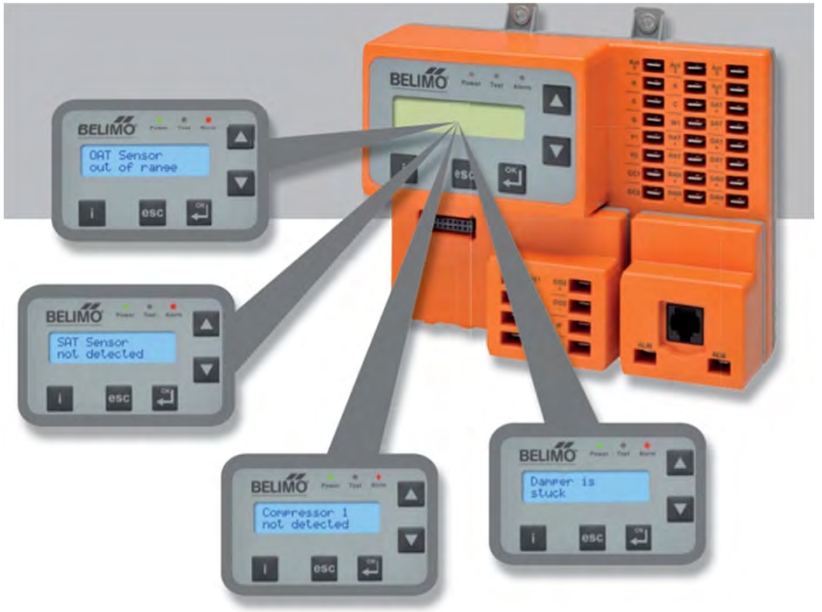
CLIMATE ZONE	DESIGN MLC AT 100% AND AT 50% ITE LOAD
0A	0.24
OB	0.26
1A	0.23
2A	
3A	
4A	
5A	
6A	
1B	
2B	
3B	
4B	
5B	
6B	
3C	

TABLE C403.1.2(2)
MAXIMUM ANNUALIZED MECHANICAL LOAD COMPONENT (ANNUALIZED MLC)

CLIMATE ZONE	HVAC MAXIMUM ANNUALIZED MLC AT 100% AND AT 50% ITE LOAD
0A	0.19
0B	0.20
1A	0.18
2A	0.19
3A	0.18
4A	0.17
5A	0.17
6A	0.17
1B	0.16
2B	0.18
3B	0.18
4B	0.18
5B	0.16
6B	0.17

C403 .2.3 Fault Detection and Diagnostics

- *HVAC control fault detection & diagnostic (FDD)*
- *Required on buildings 100,000 square feet and larger Include permanently installed sensors and devices to monitor the HVAC system's performance;*
- *Sample the HVAC system's performance at least once per 15 minutes;*
- *Automatically identify and report HVAC system faults;*
- *Automatically notify authorized personnel of identified HVAC system faults;*
- *Automatically provide prioritized recommendations for repair of identified faults based on analysis of data collected from the sampling of HVAC system performance; and*
- *Be capable of transmitting the prioritized fault repair recommendations to remotely located authorized personnel.*



HVAC Equipment Efficiency TablesC403.3.2

Each HVAC equipment efficiency updated to match ASHRAE Tables directly

Replaces Tables C403.3.2(1) through C403.3.2(10)

Adding new tables for:

- *DOAS units*
- *Water source heat pumps*
- *Variable refrigerant flow cooling and heat pumps*
- *Heat pump and heat reclaim chiller packages*
- *Ceiling mounted computer room air conditioners*
- *Commercial refrigerators and freezers*

Many table efficiencies are based on Federal appliance manufacturing requirements

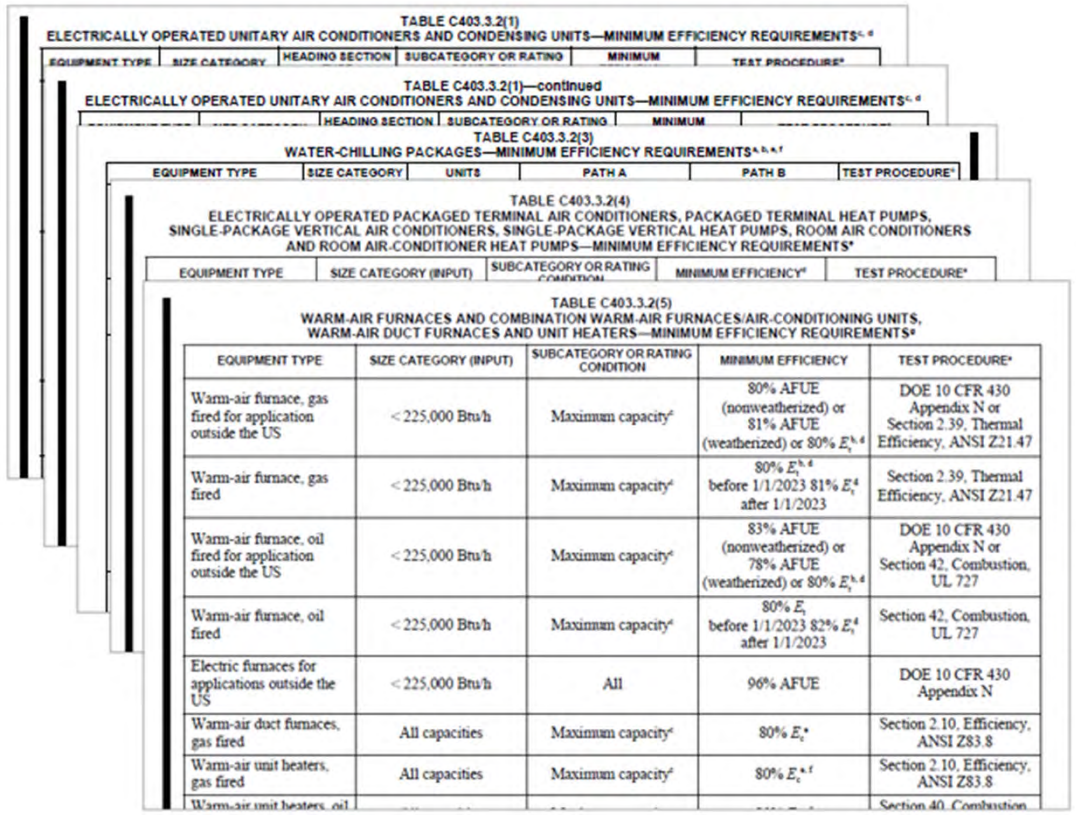


TABLE C403.3.2(1)
ELECTRICALLY OPERATED UNITARY AIR CONDITIONERS AND CONDENSING UNITS—MINIMUM EFFICIENCY REQUIREMENTS[c, d]

EQUIPMENT TYPE	SIZE CATEGORY	HEADING SECTION	SUBCATEGORY OR RATING	MINIMUM	TEST PROCEDURE[a]

TABLE C403.3.2(1)—continued
ELECTRICALLY OPERATED UNITARY AIR CONDITIONERS AND CONDENSING UNITS—MINIMUM EFFICIENCY REQUIREMENTS[c, d]

		HEADING SECTION	SUBCATEGORY OR RATING	MINIMUM	

TABLE C403.3.2(3)
WATER-CHILLING PACKAGES—MINIMUM EFFICIENCY REQUIREMENTS[a, b, e, f]

EQUIPMENT TYPE	SIZE CATEGORY	UNITS	PATH A	PATH B	TEST PROCEDURE[a]

TABLE C403.3.2(4)
ELECTRICALLY OPERATED PACKAGED TERMINAL AIR CONDITIONERS, PACKAGED TERMINAL HEAT PUMPS, SINGLE-PACKAGE VERTICAL AIR CONDITIONERS, SINGLE-PACKAGE VERTICAL HEAT PUMPS, ROOM AIR CONDITIONERS AND ROOM AIR-CONDITIONER HEAT PUMPS—MINIMUM EFFICIENCY REQUIREMENTS[a]

EQUIPMENT TYPE	SIZE CATEGORY (INPUT)	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY[a]	TEST PROCEDURE[a]

TABLE C403.3.2(5)
WARM-AIR FURNACES AND COMBINATION WARM-AIR FURNACES/AIR-CONDITIONING UNITS, WARM-AIR DUCT FURNACES AND UNIT HEATERS—MINIMUM EFFICIENCY REQUIREMENTS[g]

EQUIPMENT TYPE	SIZE CATEGORY (INPUT)	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
Warm-air furnace, gas fired for application outside the US	< 225,000 Btu/h	Maximum capacity[c]	80% AFUE (nonweatherized) or 81% AFUE (weatherized) or 80% E_t[b, d]	DOE 10 CFR 430 Appendix N or Section 2.39, Thermal Efficiency, ANSI Z21.47
Warm-air furnace, gas fired	< 225,000 Btu/h	Maximum capacity[c]	80% E_t[b, d] before 1/1/2023 81% E_t[d] after 1/1/2023	Section 2.39, Thermal Efficiency, ANSI Z21.47
Warm-air furnace, oil fired for application outside the US	< 225,000 Btu/h	Maximum capacity[c]	83% AFUE (nonweatherized) or 78% AFUE (weatherized) or 80% E_t[b, d]	DOE 10 CFR 430 Appendix N or Section 42, Combustion, UL 727
Warm-air furnace, oil fired	< 225,000 Btu/h	Maximum capacity[c]	80% E_t before 1/1/2023 82% E_t[d] after 1/1/2023	Section 42, Combustion, UL 727
Electric furnaces for applications outside the US	< 225,000 Btu/h	All	96% AFUE	DOE 10 CFR 430 Appendix N
Warm-air duct furnaces, gas fired	All capacities	Maximum capacity[c]	80% E_t[e]	Section 2.10, Efficiency, ANSI Z83.8
Warm-air unit heaters, gas fired	All capacities	Maximum capacity[c]	80% E_t[e, f]	Section 2.10, Efficiency, ANSI Z83.8
Warm-air unit heaters, oil				Section 40, Combustion

Table C403.3.2(1)

Electrically Operated Unitary Air Conditioners and Condensing Unit

EQUIPMENT TYPE	SIZE CATEGORY	HEADING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
Air conditioners, air cooled	< 65,000 Btu/h[b]	All	Split system, three phase and applications outside US single phase[b]	13.0 SEER before 1/1/2023 13.4 SEER2 after 1/1/2023	AHRI 210/240—2017 before 1/1/2023 AHRI 210/240—2023 after 1/1/2023
			Single-package, three phase and applications outside US single phase[b]	14.0 SEER before 1/1/2023 13.4 SEER2 after 1/1/2023	
Space constrained, air cooled	≤ 30,000 Btu/h[b]	All	Split system, three phase and applications outside US single phase[b]	12.0 SEER before 1/1/2023 11.7 SEER2 after 1/1/2023	AHRI 210/240—2017 before 1/1/2023 AHRI 210/240—2023 after 1/1/2023
			Single package, three phase and applications outside US single phase[b]	12.0 SEER before 1/1/2023 11.7 SEER2 after 1/1/2023	
Small duct, high velocity, air cooled	< 65,000 Btu/h[b]	All	Split system, three phase and applications outside US single phase[b]	12.0 SEER before 1/1/2023 12.1 SEER2 after 1/1/2023	AHRI 210/240—2017 before 1/1/2023 AHRI 210/240—2023 after 1/1/2023

Inspectors – What is the typical clearance required between two or more condensers?

Table C403.3.2(2)

Electrically Operated Air-cooled Unitary Heat Pumps

EQUIPMENT TYPE	SIZE CATEGORY	HEADING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
Air cooled (cooling mode)	< 66,000 Btu/h	All	Split system, three phase and applications outside US single phase[b]	14.0 SEER before 1/1/2023 14.3 SEER2 after 1/1/2023	AHRI 210/240—2017 before 1/1/2023 AHRI 210/240—2023 after 1/1/2023
			Single package, three phase and applications outside US single phase[b]	14.0 SEER before 1/1/2023 13.4 SEER2 after 1/1/2023	
Space constrained, air cooled (cooling mode)	≤ 30,000 Btu/h	All	Split system, three phase and applications outside US single phase[b]	12.0 SEER before 1/1/2023 11.7 SEER2 after 1/1/2023	AHRI 210/240—2017 before 1/1/2023 AHRI 210/240—2023 after 1/1/2023
			Single package, three phase and applications outside US single phase[b]	12.0 SEER before 1/1/2023 11.7 SEER2 after 1/1/2023	
Single duct, high velocity, air cooled (cooling mode)	< 65,000	All	Split system, three phase and applications outside US single phase[b]	12.0 SEER before 1/1/2023 12.0 SEER2 after 1/1/2023	AHRI 210/240—2017 before 1/1/2023 AHRI 210/240—2023 after 1/1/2023
	≥ 65,000 Btu/h	Electric resistance (or none)		11.0 EER 12.2 IEER before 1/1/2023 14.1 IEER after 1/1/2023	

Table C403.3.2(3)
Water-Chilling Packages

EQUIPMENT TYPE	SIZE CATEGORY	UNITS	PATH A	PATH B	TEST PROCEDURE[c]
Air cooled chillers	< 150 tons	EER (Btu/Wh)	≥ 10.100 FL	≥ 9.700 FL	AHRI 550/590
			≥ 13.700 IPLV.IP	≥ 15.800 IPLV.IP	
	≥ 150 tons		≥ 10.100 FL	≥ 9.700FL	
			≥ 14.000 IPLV.IP	≥ 16.100 IPLV.IP	
Air cooled without condenser, electrically operated	All capacities	EER (Btu/Wh)	Air-cooled chillers without condenser must be rated with matching condensers and comply with air-cooled chiller efficiency requirements		AHRI 550/590
Water cooled, electrically operated positive displacement	< 75 tons	kW/ton	≤ 0.750 FL	≤ 0.780 FL	AHRI 550/590
			≤ 0.600 IPLV.IP	≤ 0.500 IPLV.IP	
	≥ 75 tons and < 150 tons		≤ 0.720 FL	≤ 0.750 FL	
			≤ 0.560 IPLV.IP	≤ 0.490 IPLV.IP	
	≥ 150 tons and < 300 tons		≤ 0.660 FL	≤ 0.680 FL	
			≤ 0.540 IPLV.IP	≤ 0.440 IPLV.IP	
	≥ 300 tons and < 600 tons		≤ 0.610 FL	≤ 0.625 FL	
			≤ 0.520 IPLV.IP	≤ 0.410 IPLV.IP	
	≥ 600 tons		≤ 0.560 FL	≤ 0.585 FL	
			≤ 0.500 IPLV.IP	≤ 0.380 IPLV.IP	
Water cooled, electrically operated centrifugal	< 150 tons	kW/ton	≤ 0.610 FL	≤ 0.695 FL	AHRI 550/590
			≤ 0.550 IPLV.IP	≤ 0.440 IPLV.IP	
			≤ 0.610 FL	≤ 0.635 FL	
			≤ 0.550 IPLV.IP	≤ 0.400 IPLV.IP	
	≥ 300 tons and < 400 tons		≤ 0.560 FL	≤ 0.595 FL	
			≤ 0.520 IPLV.IP	≤ 0.390 IPLV.IP	
	≥ 400 tons and < 600 tons		≤ 0.560 FL	≤ 0.585 FL	

Table C403.3.2(4)

Electrically Operated Packaged Terminal Air Conditioners, Packaged Terminal Heat Pumps, Single-package Vertical Air Conditioners, Single-package Vertical Heat Pumps, Room Air Conditioners and Room Air-conditioner Heat Pumps

EQUIPMENT TYPE	SIZE CATEGORY (INPUT)	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY[d]	TEST PROCEDURE[a]
PTAC (cooling mode) standard size	< 7,000 Btu/h	95°F db/75°F wb outdoor air[c]	11.9 EER	AHRI 310/380
	≥ 7,000 Btu/h and ≤ 15,000 Btu/h		14.0 – (0.300 × Cap/1,000) EER[d]	
	> 15,000 Btu/h		9.5 EER	
PTAC (cooling mode) nonstandard size[a]	< 7,000 Btu/h	95°F db/75°F wb outdoor air[c]	9.4 EER	AHRI 310/380
	≥ 7,000 Btu/h and ≤ 15,000 Btu/h		10.9 – (0.213 × Cap/1,000) EER[d]	
	> 15,000 Btu/h		7.7 EER	
PTHP (cooling mode) standard size	< 7,000 Btu/h	95°F db/75°F wb outdoor air[c]	11.9 EER	AHRI 310/380
	≥ 7,000 Btu/h and ≤ 15,000 Btu/h		14.0 – (0.300 × Cap/1,000) EER[d]	
	> 15,000 Btu/h		9.5 EER	
PTHP (cooling mode) nonstandard size[b]	< 7,000 Btu/h	95°F db/75°F wb outdoor air[c]	9.3 EER	AHRI 310/380
	≥ 7,000 Btu/h and ≤ 15,000 Btu/h		10.8 – (0.213 × Cap/1,000) EER[d]	
	> 15,000 Btu/h		7.6 EER	
PTHP (heating mode) standard size	< 7,000 Btu/h	47°F db/43°F wb outdoor air	3.3 COP_H	AHRI 310/380
	≥ 7,000 Btu/h and ≤ 15,000 Btu/h		3.7 – (0.052 × Cap/1,000) COP_H[d]	
	> 15,000 Btu/h		2.90 COP_H	
PTHP (heating mode) nonstandard size[b]	< 7,000 Btu/h	47°F db/43°F wb outdoor air	2.7 COP_H	AHRI 310/380
	≥ 7,000 Btu/h and ≤ 15,000 Btu/h		2.9 – (0.026 × Cap/1000) COP_H[d]	
	> 15,000 Btu/h		2.5 COP_H	

Table C403.3.2(5)

Warm-air Furnaces And Combination Warm-air Furnaces/Air-conditioning Units, Warm-air Duct Furnaces And Unit Heaters

EQUIPMENT TYPE	SIZE CATEGORY (INPUT)	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
Warm-air furnace, gas fired for application outside the US	< 225,000 Btu/h	Maximum capacity[c]	80% AFUE (nonweatherized) or 81% AFUE (weatherized) or 80% E_t[b,d]	DOE 10 CFR 430 Appendix N or Section 2.39, Thermal Efficiency, ANSI Z21.47
Warm-air furnace, gas fired	< 225,000 Btu/h	Maximum capacity[c]	80% E_t[b,d] before 1/1/2023 81% E_t[d] after 1/1/2023	Section 2.39, Thermal Efficiency, ANSI Z21.47
Warm-air furnace, oil fired for application outside the US	< 225,000 Btu/h	Maximum capacity[c]	83% AFUE (nonweatherized) or 78% AFUE (weatherized) or 80% E_t[b,d]	DOE 10 CFR 430 Appendix N or Section 42, Combustion, UL 727
Warm-air furnace, oil fired	< 225,000 Btu/h	Maximum capacity[c]	80% E_t before 1/1/2023 82% E_t[d] after 1/1/2023	Section 42, Combustion, UL 727
Electric furnaces for applications outside the US	< 225,000 Btu/h	All	96% AFUE	DOE 10 CFR 430 Appendix N
Warm-air duct furnaces, gas fired	All capacities	Maximum capacity[c]	80% E_c[e]	Section 2.10, Efficiency, ANSI Z83.8
Warm-air unit heaters, gas fired	All capacities	Maximum capacity[c]	80% E_c[e,f]	Section 2.10, Efficiency, ANSI Z83.8
Warm-air unit heaters, oil fired	All capacities	Maximum capacity[c]	80% E_c[e,f]	Section 40, Combustion, UL 731

Table C403.3.2(6) Gas- and Oil-Fired Boilers

EQUIPMENT TYPE[b]	SUBCATEGORY OR RATING CONDITION	SIZE CATEGORY (INPUT)	MINIMUM EFFICIENCY	EFFICIENCY AS OF 3/2/2022	TEST PROCEDURE[a]
Boilers, hot water	Gas fired	< 300,000 Btu/h[g,h] for applications outside US	82% AFUE	82% AFUE	DOE 10 CFR 430 Appendix N
		≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h[e]	80% E_t^d	80% E_t^d	DOE 10 CFR 431.86
		> 2,500,000 Btu/h[b]	82% E_c^c	82% E_c^c	
	Oil fired[f]	< 300,000 Btu/h[g,h] for applications outside US	84% AFUE	84% AFUE	DOE 10 CFR 430 Appendix N
		≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h[e]	82% E_t^d	82% E_t^d	DOE 10 CFR 431.86
		> 2,500,000 Btu/h[b]	84% E_c^c	84% E_c^c	
Boilers, steam	Gas fired	< 300,000 Btu/h[g] for applications outside US	80% AFUE	80% AFUE	DOE 10 CFR 430 Appendix N
	Gas fired—all, except natural draft	≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h[e]	79% E_t^d	79% E_t^d	DOE 10 CFR 431.86
		> 2,500,000 Btu/h[b]	79% E_t^d	79% E_t^d	
	Gas fired—natural draft	≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h[e]	77% E_t^d	79% E_t^d	
		> 2,500,000 Btu/h[b]	77% E_t^d	79% E_t^d	
	Oil fired[f]	< 300,000 Btu/h[g] for applications outside US	82% AFUE	82% AFUE	DOE 10 CFR 430 Appendix N
		≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h[e]	81% E_t^d	81% E_t^d	DOE 10 CFR 431.86
		> 2,500,000 Btu/h[b]	81% E_t^d	81% E_t^d	

Table C403.3.2(7)

Performance Requirements for Heat Rejection Equipment

EQUIPMENT TYPE	TOTAL SYSTEM HEAT-REJECTION CAPACITY AT RATED CONDITIONS	SUBCATEGORY OR RATING CONDITION[b]	PERFORMANCE REQUIRED[b, c, d, f, g]	TEST PROCEDURE[a, e]
Propeller or axial fan open-circuit cooling towers	All	95°F entering water 85°F leaving water 75°F entering wb	≥ 40.2 gpm/hp	CTI ATC-105 and CTI STD-201 RS
Centrifugal fan open-circuit cooling towers	All	95°F entering water 85°F leaving water 75°F entering wb	≥ 20.0 gpm/hp	CTI ATC-105 and CTI STD-201 RS
Propeller or axial fan closed-circuit cooling towers	All	102°F entering water 90°F leaving water 75°F entering wb	≥ 16.1 gpm/hp	CTI ATC-105S and CTI STD-201 RS
Centrifugal fan closed-circuit cooling towers	All	102°F entering water 90°F leaving water 75°F entering wb	≥ 7.0 gpm/hp	CTI ATC-105S and CTI STD-201 RS
Propeller or axial fan dry coolers (air-cooled fluid coolers)	All	115°F entering water 105°F leaving water 95°F entering wb	≥ 4.5 gpm/hp	CTI ATC-105DS
Propeller or axial fan evaporative condensers	All	R-448A test fluid 165°F entering gas temperature 105°F condensing temperature 75°F entering wb	≥ 160,000 Btu/h × hp	CTI ATC-106
Propeller or axial fan evaporative condensers	All	Ammonia test fluid 140°F entering gas temperature 96.3°F condensing temperature 75°F entering wb	≥ 134,000 Btu/h × hp	CTI ATC-106

Table C403.3.2(8)

Electrically Operated Variable-Refrigerant-flow Air Conditioners

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
VRF air conditioners, air cooled	< 65,000 Btu/h	All	VRF multisplit system	13.0 SEER	AHRI 1230
	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric resistance (or none)	VRF multisplit system	11.2 EER 13.1 IEER 15.5 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric resistance (or none)	VRF multisplit system	11.0 EER 12.9 IEER 14.9 IEER	
	≥ 240,000 Btu/h	Electric resistance (or none)	VRF multisplit system	10.0 EER 11.6 IEER 13.9 IEER	

Table C403.3.2(9)

Electrically Operated Variable-Refrigerant-Flow and Applied Heat Pumps

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE*
VRF air cooled (cooling mode)	< 65,000 Btu/h	All	VRF multisplit system	13.0 SEER	AHRI 1230
	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric resistance (or none)	VRF multisplit system	11.0 EER 12.9 IEER 14.6 IEER	
			VRF multisplit system with heat recovery	10.8 EER 12.7 IEER 14.4 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h		VRF multisplit system	10.6 EER 12.3 IEER 13.9 IEER	
			VRF multisplit system with heat recovery	10.4 EER 12.1 IEER 13.7 IEER	
	≥ 240,000 Btu/h		VRF multisplit system	9.5 EER 11.0 IEER 12.7 IEER	
			VRF multisplit system with heat recovery	9.3 EER 10.8 IEER 12.5 IEER	
VRF water source (cooling mode)	< 65,000 Btu/h	All	VRF multisplit systems 86°F entering water	12.0 EER 16.0 IEER	AHRI 1230
			VRF multisplit systems with heat recovery 86°F entering water	11.8 EER 15.8 IEER	
	≥ 65,000 Btu/h and < 135,000 Btu/h		VRF multisplit system 86°F entering water	12.0 EER 16.0 IEER	
			VRF multisplit system with heat recovery 86°F entering water	11.8 EER 15.8 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h		VRF multisplit system 86°F entering water	10.0 EER 14.0 IEER	
			VRF multisplit system with heat recovery 86°F entering water	9.8 EER 13.8 IEER	
	≥ 240,000 Btu/h		VRF multisplit system 86°F entering water	10.0 EER 12.0 IEER	
			VRF multisplit system	9.8 EER	

Table C403.3.2(10)

Floor-mounted Air Conditioners and Condensing Units Serving Computer Rooms

EQUIPMENT TYPE	STANDARD MODEL	NET SENSIBLE COOLING CAPACITY	MINIMUM NET SENSIBLE COP	RATING CONDITIONS RETURN AIR (dry bulb/dew point)	TEST PROCEDURE[a]
Air cooled	Downflow	< 80,000 Btu/h	2.70	85°F/52°F (Class 2)	AHRI 1360
		≥ 80,000 Btu/h and < 295,000 Btu/h	2.58		
		≥ 295,000 Btu/h	2.36		
	Upflow—ducted	< 80,000 Btu/h	2.67		
		≥ 80,000 Btu/h and < 295,000 Btu/h	2.55		
		≥ 295,000 Btu/h	2.33		
	Upflow—nonducted	< 65,000 Btu/h	2.16	75°F/52°F (Class 1)	
		≥ 65,000 Btu/h and < 240,000 Btu/h	2.04		
		≥ 240,000 Btu/h	1.89		
	Horizontal	< 65,000 Btu/h	2.65	95°F/52°F (Class 3)	
		≥ 65,000 Btu/h and < 240,000 Btu/h	2.55		
		≥ 240,000 Btu/h	2.47		
Air cooled with fluid economizer	Downflow	< 80,000 Btu/h	2.70	85°F/52°F (Class 1)	AHRI 1360
		≥ 80,000 Btu/h and < 295,000 Btu/h	2.58		
		≥ 295,000 Btu/h	2.36		
	Upflow—ducted	< 80,000 Btu/h	2.67		
		≥ 80,000 Btu/h and < 295,000 Btu/h	2.55		
		≥ 295,000 Btu/h	2.33		
	Upflow—nonducted	< 65,000 Btu/h	2.09	75°F/52°F (Class 1)	
		≥ 65,000 Btu/h and < 240,000 Btu/h	1.99		
		≥ 240,000 Btu/h	1.81		

Table C403.3.2(11)

Vapor-Compression-Based Indoor Pool Dehumidifiers

EQUIPMENT TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
Single package indoor (with or without economizer)	Rating Conditions: A or C	3.5 MRE	AHRI 910
Single package indoor water cooled (with or without economizer)	Rating Conditions: A, B or C	3.5 MRE	
Single package indoor air cooled (with or without economizer)	Rating Conditions: A, B or C	3.5 MRE	
Split system indoor air cooled (with or without economizer)	Rating Conditions: A, B or C	3.5 MRE	

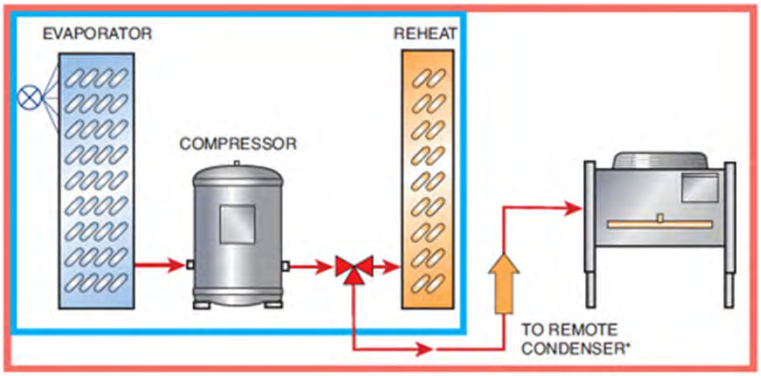


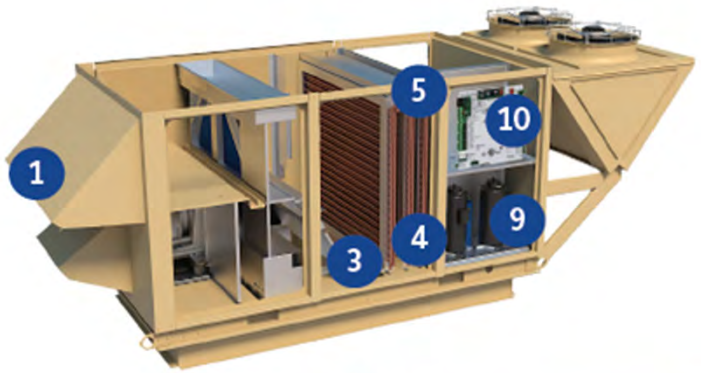
Table C403.3.2(12)

Electrically Operated DX-DOAS Units, Single-package and Remote Condenser, Without Energy Recovery

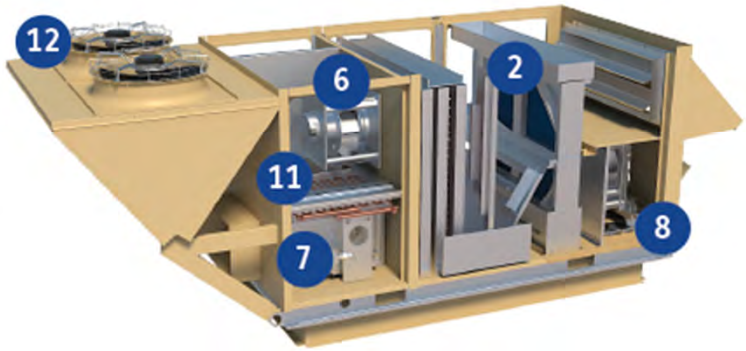
EQUIPMENT TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
Air cooled (dehumidification mode)	—	4.0 ISMRE	AHRI 920
Air-source heat pumps (dehumidification mode)	—	4.0 ISMRE	AHRI 920
Water cooled (dehumidification mode)	Cooling tower condenser water	4.9 ISMRE	AHRI 920
	Chilled water	6.0 ISMRE	
Air-source heat pump (heating mode)	—	2.7 ISCOP	AHRI 920
Water-source heat pump (dehumidification mode)	Ground source, closed loop	4.8 ISMRE	AHRI 920
	Ground-water source	5.0 ISMRE	
	Water source	4.0 ISMRE	
Water-source heat pump (heating mode)	Ground source, closed loop	2.0 ISCOP	AHRI 920
	Ground-water source	3.2 ISCOP	
	Water source	3.5 ISCOP	

Table C403.3.2(13)

Electrically Operated DX-DOAS Units, Single-package and Remote Condenser, with Energy Recovery



EQUIPMENT TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
Air cooled (dehumidification mode)	—	5.2 ISMRE	AHRI 920
Air-source heat pumps (dehumidification mode)	—	5.2 ISMRE	AHRI 920
Water cooled (dehumidification mode)	Cooling tower condenser water	5.3 ISMRE	AHRI 920
	Chilled water	6.6 ISMRE	
Air-source heat pump (heating mode)	—	3.3 ISCOP	AHRI 920
Water-source heat pump (dehumidification mode)	Ground source, closed loop	5.2 ISMRE	AHRI 920
	Ground-water source	5.8 ISMRE	
	Water source	4.8 ISMRE	
Water-source heat pump (heating mode)	Ground source, closed loop	3.8 ISCOP	AHRI 920
	Ground-water source	4.0 ISCOP	
	Water source	4.8 ISCOP	



1. Outside Air Damper
   Provides up to 100% Outside Air
2. Integral Energy Recovery Wheel
3. Fully Intertwined DX Coil
4. Sub-cooling Coil
   Increased Efficiency and Capacity
5. Single or Dual Modulating Reheat Circuits
6. Direct Drive Plenum Fan
7. Heat Section
   Gas or Electric Heat
   Modulating or Staged Control
8. ECM Power Exhaust
9. Energy Efficient Compressors
   Digital and Standard Scroll Options
10. DDC Unit Controller and Multiple Communication Options
11. Double-Wall R-13 Foam Panel Construction
12. Direct Drive Condenser Fans
    ODP and TEFC Motors with Optional ECM VFD Motor Control

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Table C403.3.2(14)

Electrically Operated Water-Source Heat Pumps

EQUIPMENT TYPE	SIZE CATEGORY[b]	HEATING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
Water-to-air, water loop (cooling mode)	< 17,000 Btu/h	All	86°F entering water	12.2 EER	ISO 13256-1
	≥ 17,000 Btu/h and < 65,000 Btu/h			13.0 EER	
	≥ 65,000 Btu/h and < 135,000 Btu/h			13.0 EER	
Water-to-air, ground water (cooling mode)	< 135,000 Btu/h	All	59°F entering water	18.0 EER	ISO 13256-1
Brine-to-air, ground loop (cooling mode)	< 135,000 Btu/h	All	77°F entering water	14.1 EER	ISO 13256-1
Water-to-water, water loop (cooling mode)	< 135,000 Btu/h	All	86°F entering water	10.6 EER	ISO 13256-2
Water-to-water, ground water (cooling mode)	< 135,000 Btu/h	All	59°F entering water	16.3 EER	ISO 13256-2
Brine-to-water, ground loop (cooling mode)	< 135,000 Btu/h	All	77°F entering water	12.1 EER	ISO 13256-2
Water-to-water, water loop (heating mode)	< 135,000 Btu/h (cooling capacity)	—	68°F entering water	4.3 COP_H	ISO 13256-1
Water-to-air, ground water (heating mode)	< 135,000 Btu/h (cooling capacity)	—	50°F entering water	3.7 COP_H	ISO 13256-1
Brine-to-air, ground loop (heating mode)	< 135,000 Btu/h (cooling capacity)	—	32°F entering water	3.2 COP_H	ISO 13256-1

Table C403.3.2(15)

Heat-Pump & Heat Recovery Chiller Packages

HEATING OPERATION													
EQUIPMENT TYPE	SIZE CATEGORY, ton_R	COOLING-ONLY OPERATION COOLING EFFICIENCY[a] AIR-SOURCE EER (FL/IPLV), Btu/W × h WATER-SOURCE POWER INPUT PER CAPACITY (FL/IPLV), kW/ton_R		HEATING SOURCE CONDITIONS (entering/ leaving water) OR OAT (db/wb), °F	HEAT-PUMP HEATING FULL-LOAD EFFICIENCY (COP_H)[b], W/W				HEAT RECOVERY CHILLER FULL-LOAD EFFICIENCY (COP_{HR})[c,d], W/W SIMULTANEOUS COOLING AND HEATING FULL-LOAD EFFICIENCY (COP_{SHC})[c], W/W				Test Procedure[e]
					Leaving Heating Water Temperature				Leaving Heating Water Temperature				
					Low	Medium	High	Boost	Low	Medium	High	Boost	
		Path A	Path B		105°F	120°F	140°F	140°F	105°F	120°F	140°F	140°F	
Air source	All sizes	≥ 9.595 FL ≥ 13.02 IPLV.IP	≥ 9.215 FL ≥ 15.01 IPLV.IP	47 db 43 wb[c]	≥ 3.290	≥ 2.770	≥ 2.310	NA	NA	NA	NA	NA	AHRI 550/590
		≥ 9.595 FL ≥ 13.30 IPLV.IP	≥ 9.215 FL ≥ 15.30 IPLV.IP	17 db 15 wb[c]	≥ 2.230	≥ 1.950	≥ 1.630	NA	NA	NA	NA	NA	
Water-source electrically operated positive displacement	< 75	≤ 0.7885 FL ≤ 0.6316 IPLV.IP	≤ 0.7875 FL ≤ 0.5145 IPLV.IP	54/44[f]	≥ 4.640	≥ 3.680	≥ 2.680	NA	≥ 8.330	≥ 6.410	≥ 4.420	NA	AHRI 550/590
				75/65[f]	NA	NA	NA	≥ 3.550	NA	NA	NA	6.150	
	≥ 75 and < 150	≤ 0.7579 FL ≤ 0.5895 IPLV.IP	≤ 0.7140 FL ≤ 0.4620 IPLV.IP	54/44[f]	≥ 4.640	≥ 3.680	≥ 2.680	NA	≥ 8.330	≥ 6.410	≥ 4.420	NA	
				75/65[f]	NA	NA	NA	≥ 3.550	NA	NA	NA	6.150	
	≥ 150 and < 300	≤ 0.6947 FL ≤ 0.5684 IPLV.IP	≤ 0.7140 FL ≤ 0.4620 IPLV.IP	54/44[f]	≥ 4.640	≥ 3.680	≥ 2.680	NA	≥ 8.330	≥ 6.410	≥ 4.420	NA	
				75/65[f]	NA	NA	NA	≥ 3.550	NA	NA	NA	6.150	
	≥ 300 and < 600	≤ 0.6421 FL ≤ 0.5474 IPLV.IP	≤ 0.6563 FL ≤ 0.4305 IPLV.IP	54/44[f]	≥ 4.930	≥ 3.960	≥ 2.970	NA	≥ 8.900	≥ 6.980	≥ 5.000	NA	
				75/65[f]	NA	NA	NA	≥ 3.900	NA	NA	NA	6.850	
	≥ 600	≤ 0.5895 FL ≤ 0.5263 IPLV.IP	≤ 0.6143 FL ≤ 0.3990 IPLV.IP	54/44[f]	≥ 4.930	≥ 3.960	≥ 2.970	NA	≥ 8.900	≥ 6.980	≥ 5.000	NA	
				75/65[f]	NA	NA	NA	≥ 3.900	NA	NA	NA	6.850	
Water-source electrically operated centrifugal	< 75	≤ 0.6421 FL ≤ 0.5789 IPLV.IP	≤ 0.7316 FL ≤ 0.4632 IPLV.IP	54/44[f]	≥ 4.640	≥ 3.680	≥ 2.680	NA	≥ 8.330	≥ 6.410	≥ 4.420	NA	AHRI 550/590
				75/65[f]	NA	NA	NA	≥ 3.550	NA	NA	NA	≥ 6.150	
	≥ 75 and < 150	≤ 0.5895 FL ≤ 0.5474 IPLV.IP	≤ 0.6684 FL ≤ 0.4211 IPLV.IP	54/44[f]	≥ 4.640	≥ 3.680	≥ 2.680	NA	≥ 8.330	≥ 6.410	≥ 4.420	NA	
				75/65[f]	NA	NA	NA	≥ 3.550	NA	NA	NA	≥ 6.150	
	≥ 150 and < 300	≤ 0.5895 FL ≤ 0.5263 IPLV.IP	≤ 0.6263 FL ≤ 0.4105 IPLV.IP	54/44[f]	≥ 4.640	≥ 3.680	≥ 2.680	NA	≥ 8.330	≥ 6.410	≥ 4.420	NA	
				75/65[f]	NA	NA	NA	≥ 3.550	NA	NA	NA	≥ 6.150	
	≥ 300 and < 600	≤ 0.5895 FL ≤ 0.5263 IPLV.IP	≤ 0.6158 FL ≤ 0.4000 IPLV.IP	54/44[f]	≥ 4.930	≥ 3.960	≥ 2.970	NA	≥ 8.900	≥ 6.980	≥ 5.000	NA	
				75/65[f]	NA	NA	NA	≥ 3.900	NA	NA	NA	≥ 6.850	
	≥ 600	≤ 0.5895 FL ≤ 0.5263 IPLV.IP	≤ 0.6158 FL ≤ 0.4000 IPLV.IP	54/44[f]	≥ 4.930	≥ 3.960	≥ 2.970	NA	≥ 8.900	≥ 6.980	≥ 5.000	NA	
				75/65[f]	NA	NA	NA	≥ 3.900	NA	NA	NA	≥ 6.850	

Table C403.3.2(16)

Ceiling-Mounted Computer-Room Air Conditioners

EQUIPMENT TYPE	STANDARD MODEL	NET SENSIBLE COOLING CAPACITY	MINIMUM NET SENSIBLE COP	RATING CONDITIONS RETURN AIR (dry bulb/dew point)	TEST PROCEDURE[a]
Air cooled with free air discharge condenser	Ducted	< 29,000 Btu/h	2.05	75°F/52°F (Class 1)	AHRI 1360
		≥ 29,000 Btu/h and < 65,000 Btu/h	2.02		
		≥ 65,000 Btu/h	1.92		
	Nonducted	< 29,000 Btu/h	2.08		
		≥ 29,000 Btu/h and < 65,000 Btu/h	2.05		
		≥ 65,000 Btu/h	1.94		
Air cooled with free air discharge condenser with fluid economizer	Ducted	< 29,000 Btu/h	2.01	75°F/52°F (Class 1)	AHRI 1360
		≥ 29,000 Btu/h and < 65,000 Btu/h	1.97		
		≥ 65,000 Btu/h	1.87		
	Nonducted	< 29,000 Btu/h	2.04		
		≥ 29,000 Btu/h and < 65,000 Btu/h	2.00		
		≥ 65,000 Btu/h	1.89		
Air cooled with ducted condenser	Ducted	< 29,000 Btu/h	1.86	75°F/52°F (Class 1)	AHRI 1360
		≥ 29,000 Btu/h and < 65,000 Btu/h	1.83		
		≥ 65,000 Btu/h	1.73		
		< 29,000 Btu/h	1.89		

Heat Pump Supplementary Heat
Section C403.4.1.1

Heat pump systems

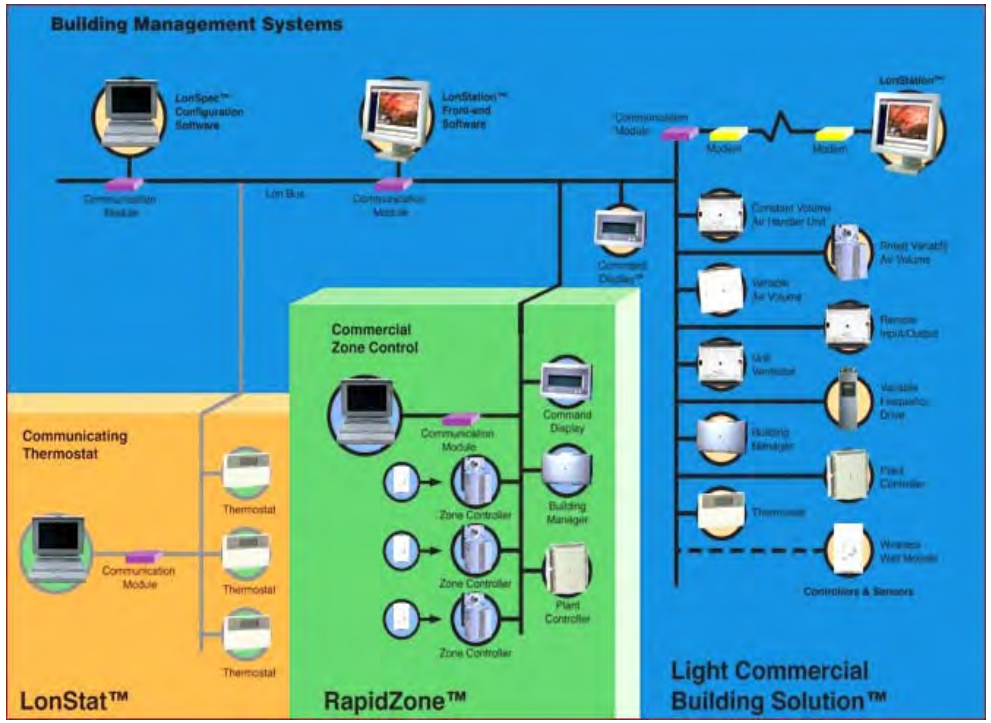
- ✓Controls to limit supplemental heat to only those times of these applies:
  - ✓Vapor compression cycle can't provide necessary heating to satisfy thermostat
  - ✓Heat pump is in defrost mode
  - ✓Vapor compression cycle malfunctions
  - ✓Thermostat malfunctions

HVAC Control Changes C403.4.2.3

Adds optimized stop schedule adjustment

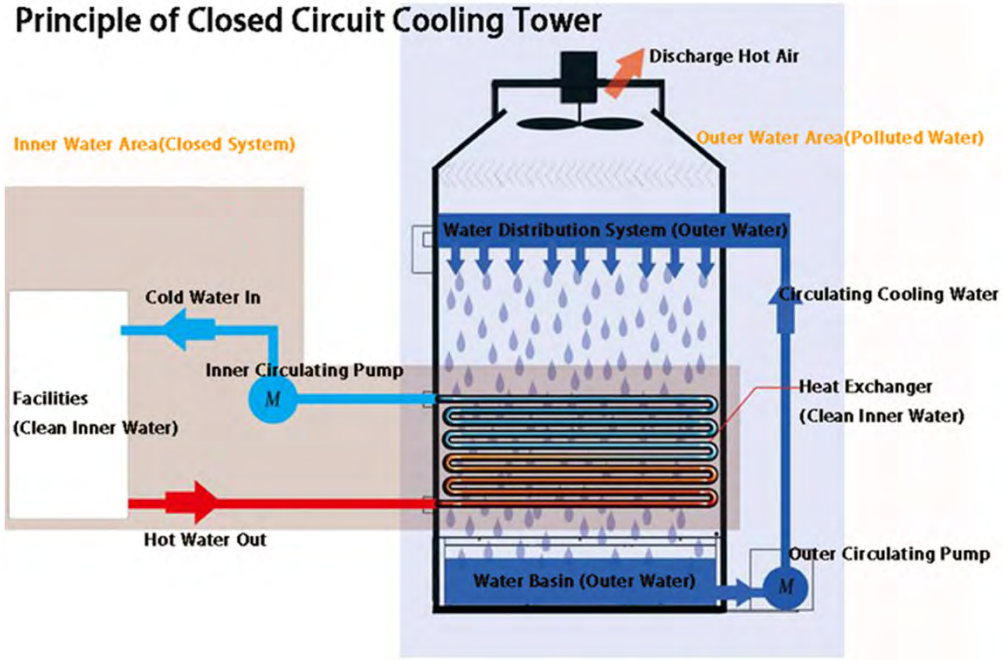
–

End of day system turns off and “coasts” up to temperature shift of +/-2°F



HVAC Control Changes C403.4.3.3.2

Water loop heat pump heat rejection circulation pump shutdown now required on closed-circuit cooling towers



We don't want to reject heat to outside through the tower, when heat is needed inside the building.

HVAC Control Changes C403.5

Variable Refrigerant Flow (VRF) systems no longer require outside air economizers

If DOAS (Dedicated Outdoor Air System) is provided

HVAC Control Changes C403.7.1

Expands Demand Control Ventilation (DCV) requirements from occupant density of *25 down to 15 people/1000 ft2;*

Now includes retail sales areas

Figure 1: CO_2 Duct Sensor

Figure 2: CO_2 Wall Sensor

Demand Controlled Ventilation

Section C403.7.1 – Cont'd

Exceptions:

- ✓Systems with energy recovery per C403.7.4.2
- ✓Multiple zone systems without direct digital control of single zones communicating with central control panel
- ✓Multiple zone systems with design outdoor airflow < 750 cfm
- ✓Spaces where > 75% of space design outdoor airflow is required for makeup air
- ✓Spaces with one or more of the following occupancy classifications per IMC Table 403.3.1.1:
  - ✓Correctional cells
  - ✓Education laboratories
  - ✓Barber
  - ✓Beauty and nail salons
  - ✓Bowling alley seating areas

HVAC Control Changes C403.7.2

Parking garage exhaust reduction controls

Threshold reduced to 8000 CFM (from 22,500 CFM)

Controls sensor specifications consistent with IMC

Similar to DCV, but sensing carbon monoxide and nitrogen dioxide

Energy Recovery Changes C403.7.4

Adds residential (apartment) exhaust energy recovery requirements

Climate zone 3C (marine) exempt

Smaller (<500 ft2) apartments exempt in Climate Zones 0, 1, 2, 3, 4C, 5C

Does NOT to apply in 3B unless ventilation air exceeded 30% of design airflow – very unlikely.

Red – Exhaust From Inside to Outside

White – Fresh air to Inside From Outside

HVAC Control Changes C403.7.6

- *Hotel guest room temperature and ventilation controls*
- *Clarification of operating modes*
- *Reduce occupant sensor shutoff from 30 min to 20 min*

2021 Definition - ***Fan Array***

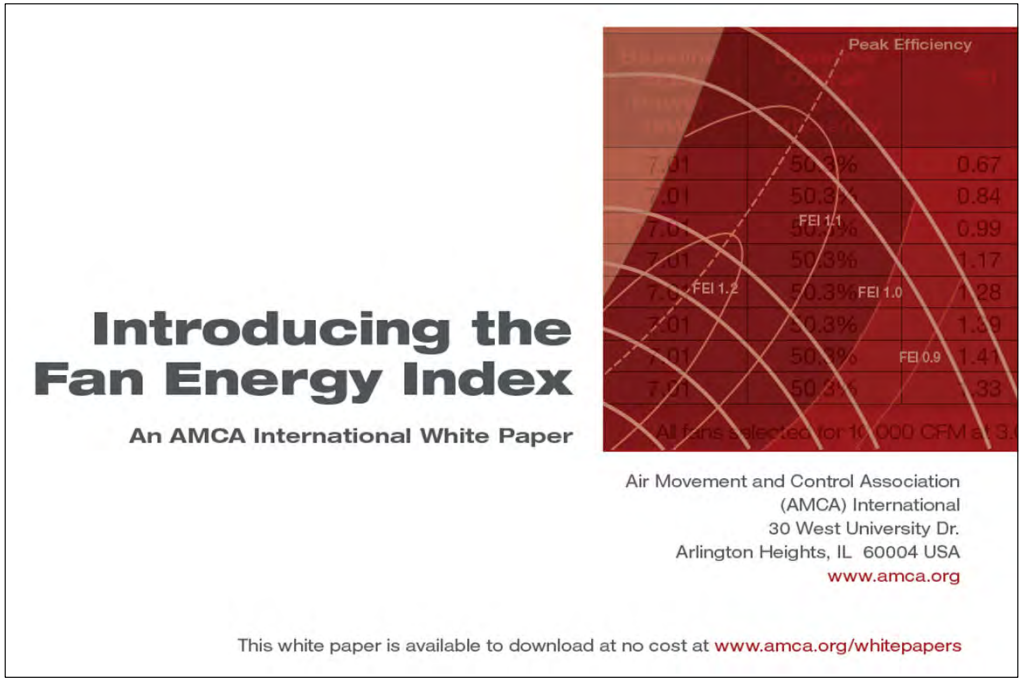
Multiple fans in parallel between two plenum sections in an air distribution system

2021 Definition - ***Fan Embedded***

A fan that is part of a manufactured assembly where the assembly includes functions other than air movement

2021 Definition - ***Fan Energy Index (FEI)***

The ratio of the electric input power of a reference fan to the electric input power of the actual fan as calculated in accordance with AMCA 208



This white paper is available to download at no cost at www.amca.org/whitepapers

2021 Definition – ***Fan Nameplate Electrical Power***

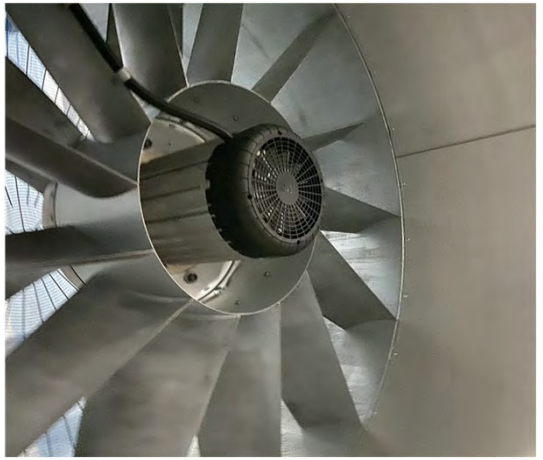
The nominal electrical input power rating stamped on a fan assembly nameplate

Definition – ***Fan System Electrical Input Power***

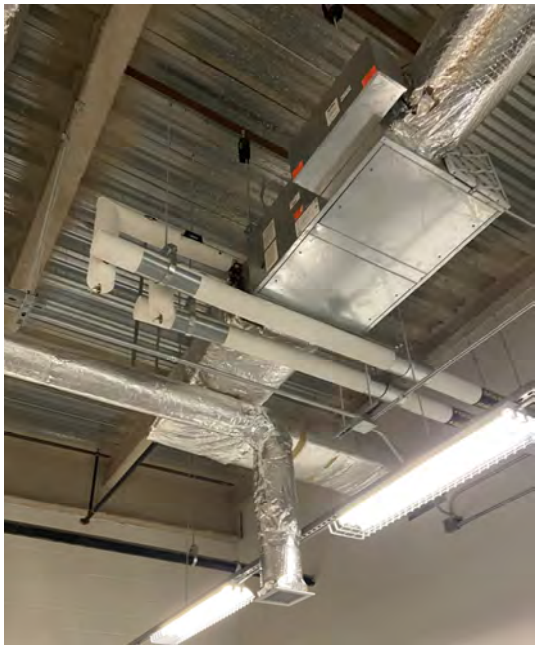
*The sum of the fan electrical power of **all fans** that are required to operate at fan system design conditions to **supply air** from the heating or cooling source **to the conditioned spaces and/or return it to the source or exhaust it to the outdoors.***

C403.8.3 - ***Fan Efficiency***

*Each **fan and fan array** shall have a **fan energy index** not less than **1.00** at the design point of operation*



*Each **variable-air-volume** system fan and fan array used for a shall have an **FEI** of not less than **0.95***



C403.8.3 - ***Fan Efficiency*** *continued*

Exceptions: The following Fans **not** required to have a *fan energy index (FEI):*

1. *Fans not embedded hp < 1.0 hp*
   - *Nameplate power < .89 kW*
2. *Fans embedded with nameplate hp ≤ 5*
   - *Fan system electrical power ≤ 4.1 kw*
3. *Multiple fans, series or parallel, combined hp ≤ 5 hp*
   - *Fan system electrical power ≤ 4.1 kw*
4. *Fans part of equipment per C403.3.2 (Tables C403.3.3.2(1) to C403.3.3.2(16)*
5. *Fans in equipment packages certified for energy performance*
6. *Ceiling fans, non-portable with rotating blades*
7. *Fans moving gases above 425^{0}F*
8. *Fans in explosive atmospheres*
9. *Reversible tunnel ventilation fans*
10. *Fans only intended for emergency conditions*
11. *Fans outside scope of AMCA 208*

C403.8.5 – *Low-Capacity Ventilation Fans*

Mechanical ventilation system fans with motors < 1/12 hp (0.062 kW) in capacity

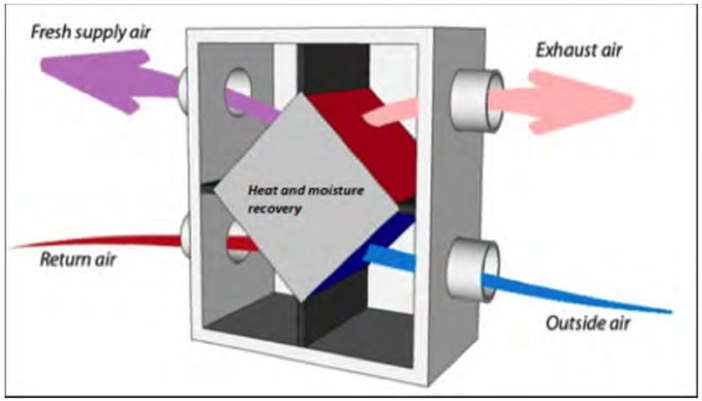
- *meet the efficacy requirements of Table C403.8.5*

Exceptions:

- *Ventilation fan component of heating or cooling appliance*
- *Dryer power ventilator, domestic range hood, range booster, operating intermittently*

TABLE C403.8.5
LOW-CAPACITY VENTILATION FAN EFFICACY[a]

FAN LOCATION	AIRFLOW RATE MINIMUM (CFM)	MINIMUM EFFICACY (CFM/WATT)	AIRFLOW RATE MAXIMUM (CFM)
HRV or ERV	Any	1.2 cfm/watt	Any
In-line fan	Any	3.8 cfm/watt	Any
Bathroom, utility room	10	2.8 cfm/watt	< 90
Bathroom, utility room	90	3.5 cfm/watt	Any



Duct and Plenum Insulation & Sealing

Section C403.12.1

Insulation required for supply and return ducts and plenums

- ✓ Located in unconditioned space:
  - ✓ minimum R-6
- ✓ Duct located outside the building; duct or plenum within building envelope assembly shall be separated from building exterior or unconditioned or exempt spaces:
  - ✓ minimum R-8, Climate Zones 0-4
  - ✓ minimum R-12, Climate Zones 5-8
- ✓ **Underground ducts (beneath buildings) insulated as required by this section or have equivalent *thermal distribution efficiency***
- ✓ **Underground ducts utilizing thermal distribution efficiency method to be listed and labeled with R-value equivalency**

Exceptions:

- ✓ When located within equipment
- ✓ When design temperature difference between interior and exterior of the duct or plenum doesn't exceed 15ºF

Piping Insulation

Section C403.12.3

Exceptions to pipe insulation requirements:

- ✓Piping internal to HVAC equipment *(including fan coil units)* factory installed and tested
- ✓Piping for fluid in temperature range
  60 °F< temp < 105°F
- ✓Piping for fluid not heated or cooled by electricity or fossil fuels
- ✓Strainers, control valves, and balancing valves associated with piping ≤ 1” in diameter
- ✓Direct buried piping for fluids ≤ 60°F
- ✓In radiant heating systems, sections of piping intended by design to radiate heat

Operable Opening Interlocking Controls
Section C403.14

- Heating and cooling systems to have controls that will interlock to the set temperatures of 90F cooling and 55F heating when conditions of C402.5.11 exist (large door – dining)
- Controls configure to shut off systems entirely when outdoor temperatures are below 90F or above 55F

Refrigeration Equipment Performance C403.11

Refrigeration efficiency

Section duplication eliminated

Updated to match federal requirements

Ensure it’s on equipment schedules

C404.2.1 *Large Service Hot Water System Efficiency*

- *Large (≥ 1,000,000 Btu/h) service hot water system efficiency increases from 90% to 92%*

C404.5 Heated Water Supply

New Table C 404.5.2.1 – Water tubing Volumes

TABLE C404.5.2.1
INTERNAL VOLUME OF VARIOUS WATER DISTRIBUTION TUBING

OUNCES OF WATER PER FOOT OF TUBE									
Nominal Size (inches)	Copper Type M	Copper Type L	Copper Type K	CPVC CTS SDR 11	CPVC SCH 40	CPVC SCH 80	PE-RT SDR	Composite ASTM F1281	PEX CTS SDR 9
3/8	1.06	0.97	0.84	N/A	1.17	—	0.64	0.63	0.64
1/2	1.69	1.55	1.45	1.25	1.89	1.46	1.18	1.31	1.18
3/4	3.43	3.22	2.90	2.67	3.38	2.74	2.35	3.39	2.35
1	5.81	5.49	5.17	4.43	5.53	4.57	3.91	5.56	3.91
1 1/4	8.70	8.36	8.09	6.61	9.66	8.24	5.81	8.49	5.81
1 1/2	12.18	11.83	11.45	9.22	13.20	11.38	8.09	13.88	8.09
2	21.08	20.58	20.04	15.79	21.88	19.11	13.86	21.48	13.86

This section is misunderstood, thought to be inconsequential, and brought about disagreements - compliance is low

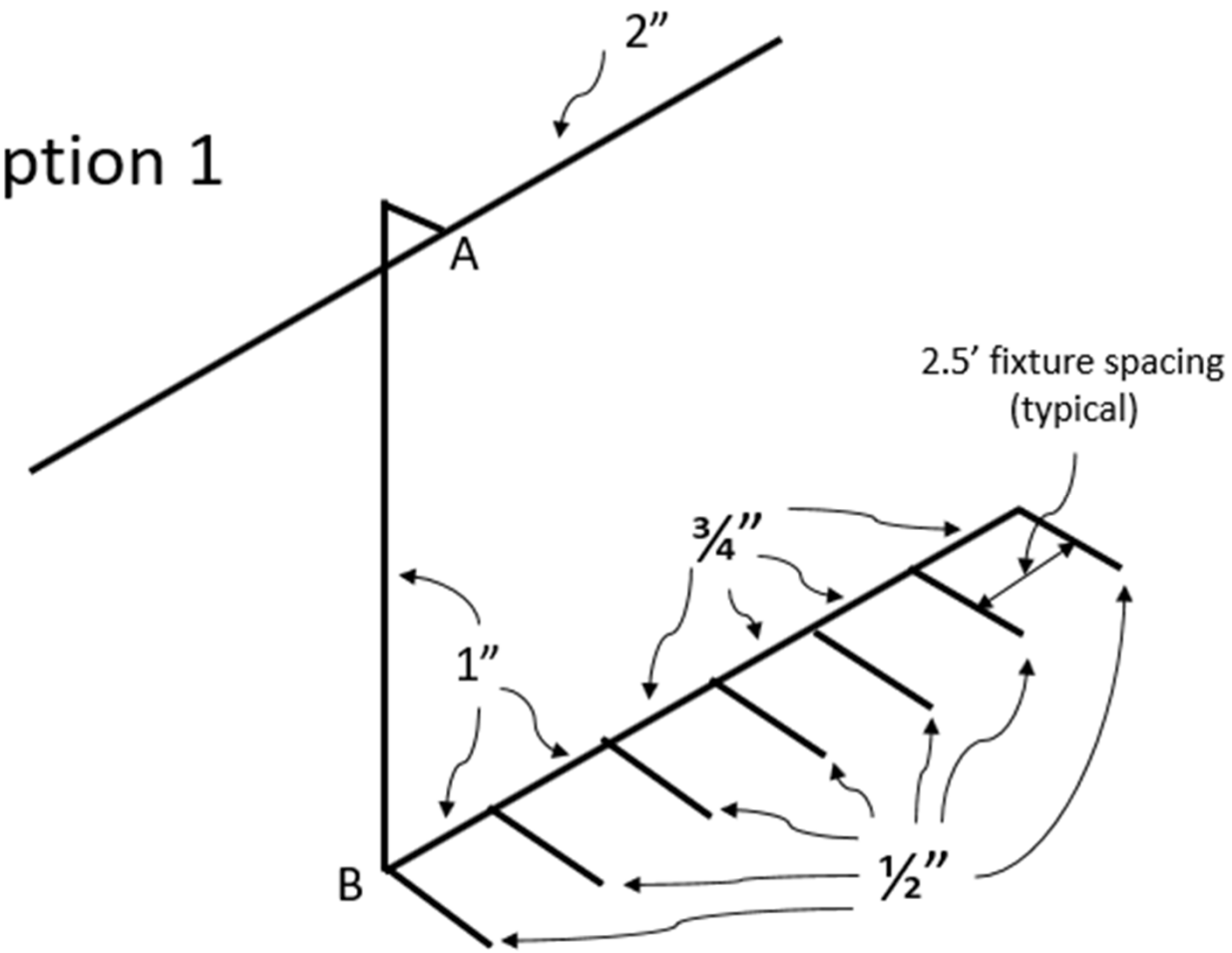
Section C404.5
Discussion: Heated Water Supply Piping (Mandatory)

For piping from the *nearest source of heated water* (from the water heater or from the recirculation or trace heated loop) to fixture requires **either maximum pipe length** (C404.5.1) or **maximum pipe volume** (C404.5.2) and has maximum flow rated by size

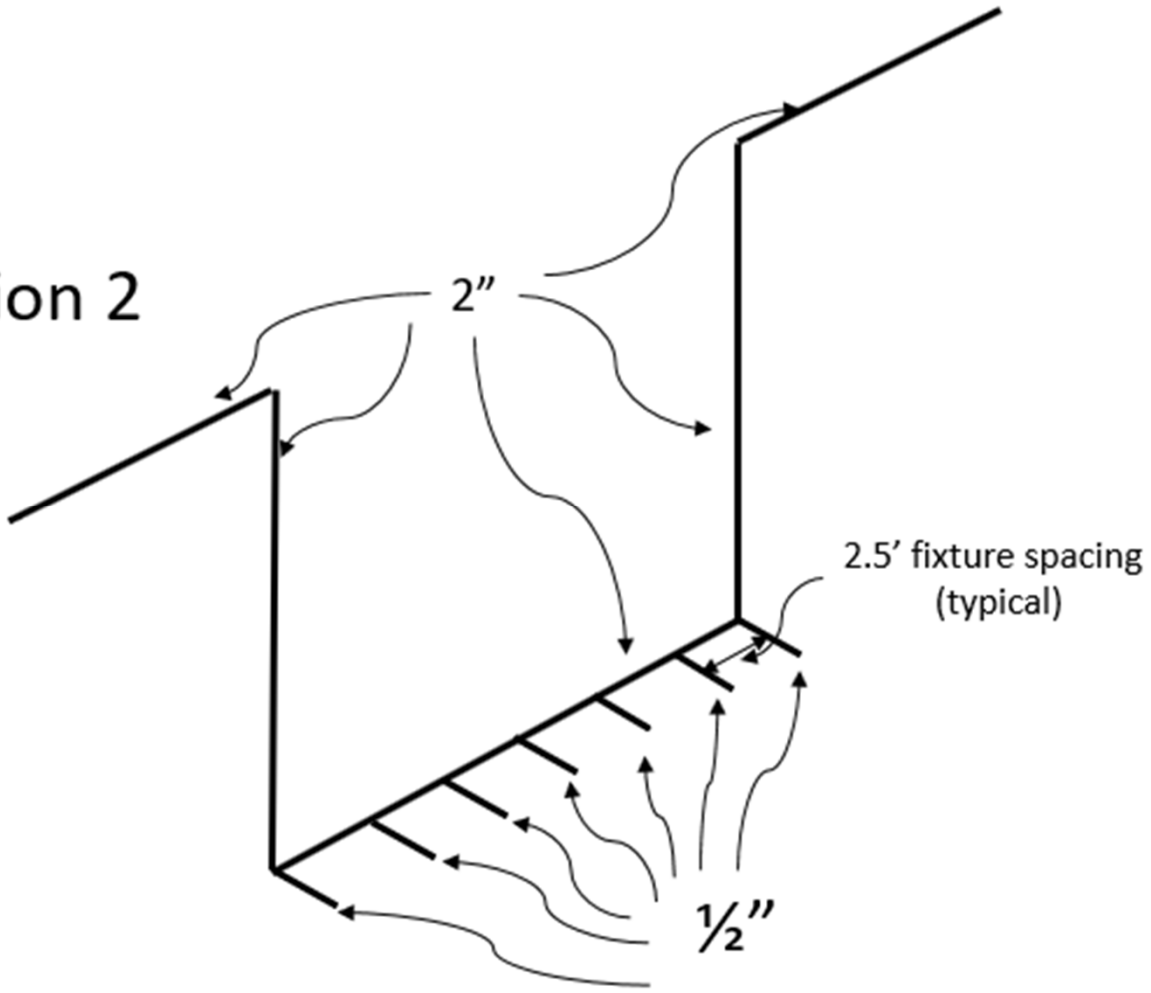
- Flow rate through ¼" piping should be ≤ 0.5 gpm
- Flow rate through 5/16" piping should be ≤ 1.0 gpm
- Flow rate through 3/8" piping should be ≤ 1.5 gpm

Intent is to reduce wasting previously-heated water that has cooled in pipes that do not require insulation

Option 1



Option 2



Hot Water Volume & Length Table

TABLE C404.5.1
PIPING VOLUME AND MAXIMUM PIPING LENGTHS

NOMINAL PIPE SIZE (inches)	VOLUME (liquid ounces per foot length)	MAXIMUM PIPING LENGTH (feet)	
		Public lavatory faucets	Other fixtures and appliances
1/4	0.33	6	50
5/16	0.5	4	50
3/8	0.75	3	50
1/2	1.5	2	43
5/8	2	1	32
3/4	3	0.5	21
7/8	4	0.5	16
1	5	0.5	13
1 1/4	8	0.5	8
1 1/2	11	0.5	6
2 or larger	18	0.5	4

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 liquid ounce = 0.030 L, 1 gallon = 128 ounces.

A quick calculation will identify the inefficiency in the Option 1 design when used in a public restroom.

Length A-B = 10’

Length between each fixture branch = 2.5’

Length each branch to fixture = 1.5’

Total length and volume to furthest fixture:

1” pipe: 10’ + 2.5 + 2.5’ = 15’	Volume/ft: 5 fluid oz.	15 X 5 = 75.0 fluid oz.
¾” pipe: 2.5’ X 3 = 7.5’	Volume/ft: 3 fluid oz.	7.5 X 3 = 22.5 fluid oz.
½” pipe: 2.5’ + 1.5’ = 4’	Volume/ft: 1.5 fluid oz.	4 X 1.5 = 6.0 fluid oz.
Total Volume to furthest fixture:		103.5 fluid oz.

128 fluid oz. per gallon; volume in gallons = 103.5 ÷ 128 = 0.81 gallons

TABLE 604.4
MAXIMUM FLOW RATES AND CONSUMPTION FOR PLUMBING FIXTURES AND FIXTURE FITTINGS

PLUMBING FIXTURE OR FIXTURE FITTING	MAXIMUM FLOW RATE OR QUANTITY[b]
Lavatory, private	2.2 gpm at 60 psi
Lavatory, public (metering)	0.25 gallon per metering cycle
Lavatory, public (other than metering)	0.5 gpm at 60 psi
Shower head[a]	2.5 gpm at 80 psi
Sink faucet	2.2 gpm at 60 psi
Urinal	1.0 gallon per flushing cycle
Water closet	1.6 gallons per flushing cycle

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Considering a public lavatory with a maximum flow rate of 0.5 gpm, and the calculated 0.81 gallons of water which must clear the line to obtain hot water at the far fixture:

0.81 gallons ÷ 0.5 gpm = 1.62 minutes, or 97 seconds

Additional Efficiency Credit Requirements
Section C406

- New buildings need 10 credits from Tables C406.1(1) – (5)
  - Table selected based on use group of the building and credit calculations
  - Where building contains multiple use groups, credits from each use group to be weighted by floor area of each group to determine weighted average building credit
  - Credits from tables or calculation to be achieved where building complies with one ore more of the following
    - More efficient HVAC performance
    - Reduced lighting power
    - Enhanced lighting controls
    - On-site supply of renewable energy
    - Provision of dedicated outdoor air system for certain HVAC equipment
    - High-efficiency service water heating
    - Enhanced envelope performance
    - Reduced air infiltration
    - Where not required by C405.12, include energy monitoring system
    - Where not required by C403.2.3, include fault detection and diagnostics system
    - Efficient kitchen equipment

C406 *Additional Efficiency Requirements*

Why are we revisiting this???

*New buildings shall achieve a total of **10 credits from Tables C406.1(1) through C406.1(5)** where the **table is selected based on the use group** of the building and from credit calculations as specified in relevant subsections of Section C406*

Tenant Spaces shall achieve 5 points

- Achieving all 10 points within the envelope is very difficult.
- 3 COMchecks
- This will require cooperation/teamwork between the different design professionals

1. More efficient HVAC performance in accordance with Section C406.2.
2. Reduced lighting power in accordance with Section C406.3.
3. Enhanced lighting controls in accordance with Section C406.4.
4. On-site supply of renewable energy in accordance with Section C406.5.
5. Provision of a dedicated outdoor air system for certain HVAC equipment in accordance with Section C406.6.
6. High-efficiency service water heating in accordance with Section C406.7.
7. Enhanced envelope performance in accordance with Section C406.8.
8. Reduced air infiltration in accordance with Section C406.9
9. *Where not required by Section C405.12, include an energy monitoring system in accordance with C406.10.*
10. *Where not required by Section C403.2.3, include a fault detection and diagnostics (FDD) system in accordance with Section C406.11.*
11. *Efficient kitchen equipment in accordance with Section C406.12.*

Occupancy Tables

Based on Climate Zone and Occupancy – Substantial Credits for:

Table C406.1(1) - B Occupancy: Lighting

Table C406.1(2) - R & I Occupancy: Hot Water

Table C406.1(3) - E Occupancy: Lighting

Table C406.1(4) - M Occupancy: **Lighting**

Table C406.1(5) – All Others Occupancy: Lighting

Warm Climates – greater credit for cooling efficiency

Cold Climates – greater credits for heating efficiency

Energy Credit Table Example

- Most credits table based, some are formulas
- Separate tables:
  - Office (Group B)
  - Multifamily (R) & Institutional (I)
  - Schools (E)
  - Retail (M)
  - Other than above
- Uniform Target
  - 10 credits
- Tenant infill
  - 5 Credits

C406.1

Table C406.1(1) Additional Energy Efficiency Credits for Group B Occupants

Climate Zone:	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
C406.2.1: 5% Heating	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	NA	NA	1	1	NA	1
C406.2.2: 5% Cooling	6	6	5	5	4	4	3	3	3	2	2	2	1	2	2	2	1
C406.2.3: 10% Heating	NA	NA	NA	NA	NA	NA	NA	1	NA	NA	2	1	1	2	2	NA	1
C406.2.4: 10% Cooling	11	12	10	9	7	7	6	5	6	4	4	5	3	4	3	3	3
C406.3.1: 10% LPA	9	8	9	9	9	9	10	8	9	9	7	8	8	6	7	7	6
C406.4:Digital Lt Ctrl	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2	1	1
C406.5: Renewable	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
C406.6: DOAS	4	4	4	4	4	3	2	5	3	2	5	3	2	7	4	5	3
C406.7.1: SWH HR	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
C406.7.2: SWH NG eff	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
C406.7.3: SWH HP	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
C406.8: 85% UA	1	4	2	4	4	3	NA	7	4	5	10	7	6	11	10	14	16

Tables expand previous 'pick one" with added credit options

Mechanical

TABLE C406.1(1)
ADDITIONAL ENERGY EFFICIENCY CREDITS FOR GROUP B OCCUPANCIES

SECTION	CLIMATE ZONE																
	0A & 1A	0B & 1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
C406.2.1: 5% heating efficiency improvement	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	NA	NA	1	1	NA	1
C406.2.2: 5% cooling efficiency improvement	6	6	5	5	4	4	3	3	3	2	2	2	1	2	2	2	1
C406.2.3: 10% heating efficiency improvement	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2	1	1	2	2	NA	1
C406.2.4: 10% cooling efficiency improvement	11	12	10	9	7	7	6	5	6	4	4	5	3	4	3	3	3
C406.3: Reduced lighting power	9	8	9	9	9	9	10	8	9	9	7	8	8	6	7	7	6
C406.4: Enhanced digital lighting controls	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2	1	1
C406.5: On-site renewable energy	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
C406.6: Dedicated outdoor air	4	4	4	4	4	3	2	5	3	2	5	3	2	7	4	5	3
C406.7.2: Recovered or renewable water heating	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
C406.7.3: Efficient fossil fuel water heater	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
C406.7.4: Heat pump water heater	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
C406.8: Enhanced envelope performance	1	4	2	4	4	3	NA	7	4	5	10	7	6	11	10	14	16
C406.9: Reduced air infiltration	2	1	1	2	4	1	NA	8	2	3	11	4	1	15	8	11	6
C406.10: Energy monitoring	4	4	4	4	3	3	3	3	3	3	2	3	2	2	2	2	2
C406.11: Fault detection and diagnostics system	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1

NA = Not Applicable.

TABLE C406.1(2)
ADDITIONAL ENERGY EFFICIENCY CREDITS FOR GROUP R AND I OCCUPANCIES

SECTION	CLIMATE ZONE																
	0A & 1A	0B & 1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
C406.2.1: 5% heating efficiency improvement	NA	NA	NA	NA	1	NA	NA	1	NA	1	1	1	1	2	1	2	2
C406.2.2: 5% cooling efficiency improvement	3	3	2	2	1	1	1	1	1	NA	1	1	NA	1	1	1	NA
C406.2.3: 10% heating efficiency improvement	NA	NA	NA	NA	1	NA	NA	1	1	1	2	2	1	3	2	3	4
C406.2.4: 10% cooling efficiency improvement	5	5	4	3	2	3	1	2	2	1	1	1	1	1	1	1	1
C406.3: Reduced lighting power	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
C406.4: Enhanced digital lighting controls	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
C406.5: On-site renewable energy	8	8	8	8	7	8	8	7	7	7	7	7	7	7	7	7	7
C406.6: Dedicated outdoor air system	3	4	3	3	4	2	NA	6	3	4	8	5	5	10	7	11	12
C406.7.2: Recovered or renewable water heating	10	9	11	10	13	12	15	14	14	15	14	14	16	14	15	15	15
C406.7.3: Efficient fossil fuel water heater	5	5	6	6	8	7	8	8	8	9	9	9	10	10	9	10	11
C406.7.4: Heat pump water heater	6	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
C406.8: Enhanced envelope performance	3	6	3	5	4	4	1	4	3	3	4	5	3	5	4	6	6
C406.9: Reduced air infiltration	6	5	3	11	6	4	NA	7	3	3	9	5	1	13	6	8	3
C406.10: Energy monitoring	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
C406.11: Fault detection and diagnostics system	1	1	1	1	1	1	NA	1	1	NA	1	1	NA	1	1	1	1

NA = Not Applicable.

Mechanical Systems Commissioning and Completion Requirements

Section C408.2 Exceptions

✓These systems are exempt from commissioning requirements

- In buildings where total mechanical equipment capacity is < 480,000 Btu/h (40 tons) cooling capacity **and** < 600,000 Btu/h combined service water heating and space-heating capacity
- Included in Section C403.3 that serve individual dwelling units and sleeping units

Included for Informational Purposes – not a change in 2021 IECC – in the code for several code cycles

Lighting

Image courtesy Panasonic

High-Efficacy Lamps - Definition

- ✓Compact fluorescent lamps, LED lamps, T8 or smaller diameter linear fluorescent lamps, or other lamps with efficacy not less than 65 lumens/watt or luminaires with an efficacy of not less than 45 lumens/watt

General
Section C405.1

Sleeping units

A minimum of 90 percent of the lamps in permanently installed lighting fixtures serving dwelling units (excluding kitchen appliance lighting) to be provided by lamps

- Efficacy of not less than 65 lm/W OR
- Luminaires with an efficacy not less than 45 lm/W OR
- Comply with C405.2.4 and C405.3
  - Daylight controls and Lighting Power Allowance Tables

Lighting Controls
Section C405.2

Lighting systems required to be provided with controls as specified for:

- Occupant sensor controls – C405.2.1
- Time-switch controls – C405.2.2
- Light-reduction controls – C405.2.3
- Daylight-responsive controls – C405.2.4
- Specific application controls – C405.2.5

Generally, tightened up wattage allowance in exceptions

Occupant Sensor Controls
Sections C405.2.1

Occupancy sensors are required in:

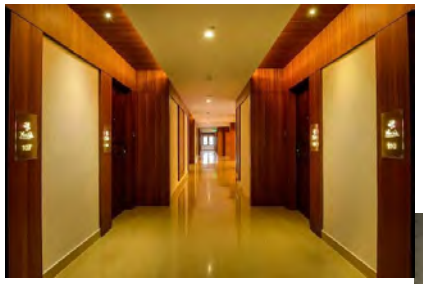
- ✓Classrooms/lecture/training rooms
- ✓Conference/meeting/multipurpose rooms
- ✓Copy/print rooms
- ✓Lounges/breakrooms
- ✓Enclosed offices
- ✓Open plan office areas
- ✓Restrooms
- ✓Storage rooms
- ✓Locker rooms
- ✓Corridors
- ✓Other spaces ≤ 300 ft^2 enclosed by floor-to-ceiling height partitions
- ✓Warehouse storage areas

Occupant Sensor Controls - *C405.2.1.1 Exemptions*

Exemptions:

Full auto-on controls allowed in

- ✓Public corridors
- ✓Stairways
- ✓Restrooms
- ✓Primary building entrance areas and lobbies
- ✓Areas where manual-on operation would endanger safety or security of room or occupants



Occupant Sensor Controls
Sections C405.2.1.1

Occupancy sensor function (other than for warehouses – C405.2.1.2 and open plan office areas – C405.2.1.4):

- ✓ Automatically turn lights off within 20 minutes after occupants have left space
- ✓ Either manual-on or controlled to automatically turn on lighting to not more than 50% power
- ✓ Incorporate a manual control to allow occupants to turn off lights

Exemptions:

Full auto-on controls with no manual controls allowed in

- ✓ Corridors
- ✓ Interior parking areas
- ✓ Stairways
- ✓ Restrooms
- ✓ Locker rooms
- ✓ Lobbies
- ✓ Library stacks
- ✓ Areas where manual-on operation would endanger safety or security of room or occupants

Occupant Sensor Controls

Section C405.2.1.2 – Warehouse Storage Areas

- Aisleways and open areas
  - Automatically reduce lighting power by ≤ 50% within 20 minutes of areas becoming unoccupied
  - Control lighting in each aisleway independently
  - Lights not turned off by occupant sensors to be turned off by time-switch control per C405.2.2.1
  - Provide manual control to allow occupants to turn off lights

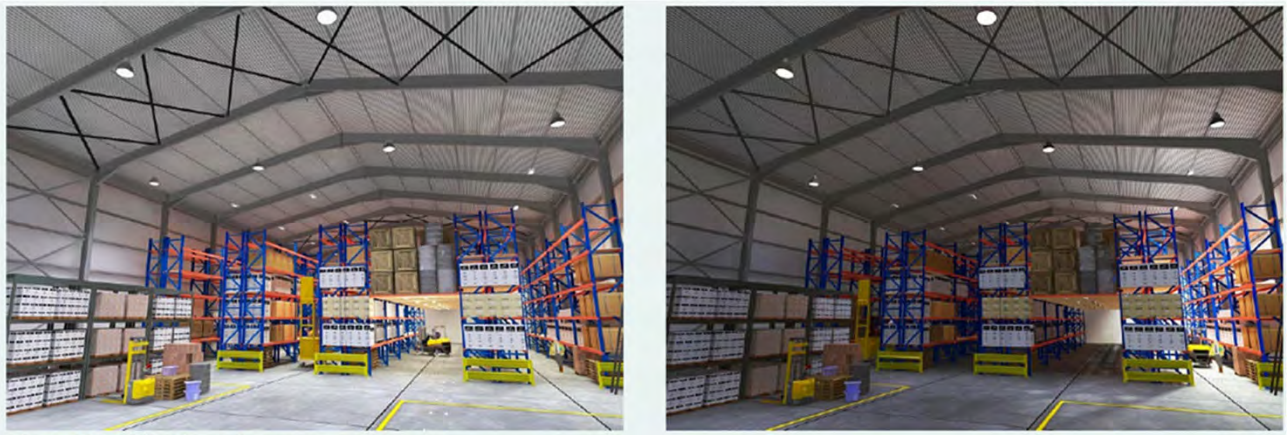


Image from http://luxreview.com

Occupant Sensor Controls

Section C405.2.1.4 – Corridors

- Occupant sensor controls in corridors to uniformly reduce lighting power to not more than 50% of full power within 20 minutes of all occupants leaving the space
- Exception
  - Corridors with less than 2 footcandles of illumination on the floor at the darkest point with all lights on. (Reducing more will result in too dark)

Time-switch Controls
Section C405.2.2

Each area of the building that is NOT provided with occupant sensor control must have a time-switch control to turn lights off automatically

<u>Exceptions</u> where a manual control can provide the light reduction and time-switch control is not required:

- Luminaires required to have specific application controls per C405.2.4
  - Daylight-responsive controls
- Spaces where patient care is directly provided
- Spaces where an automatic shutoff would endanger occupant safety or security
- Lighting intended for continuous operation
- Shop and laboratory classrooms

Time-switch Control Functions
Section C405.2.2.1

Must include an override switching device with the following:

- Automatically turn off lights when space scheduled to be unoccupied
- Minimum 7-day clock
- Capable of being set for 7 different day types/week
- Incorporate holiday “shutoff” feature to turn all controlled lighting loads for ≥ 24 hours and resume to normally scheduled operations
- Program backup capabilities to prevent loss of program and time setting for ≥ 10 hours if power is interrupted
- Override switch should include:
  - Manual control
  - Control lighting to remain on for ≤ 2 hours
  - Control lighting for an area ≤ 5,000 ft^2

Light-reduction Controls
Section C405.2.3.1

Light Reduction Controls must allow the occupant to reduce connected lighting load

- ✓By not less than 50%
- ✓In a reasonably uniform illumination pattern with intermediate step in addition to full on or off, or with continuous dimming control

Light-reduction Control Options

- ✓Continuous dimming of all luminaires from full output to < 20% full power
- ✓Switching all luminaires to reduced output of not less than 30% and not more than 70% of full power
- ✓Switching alternate luminaires or alternate rows of luminaires to achieve reduced output of not less than 30% and not more than 70% of full power

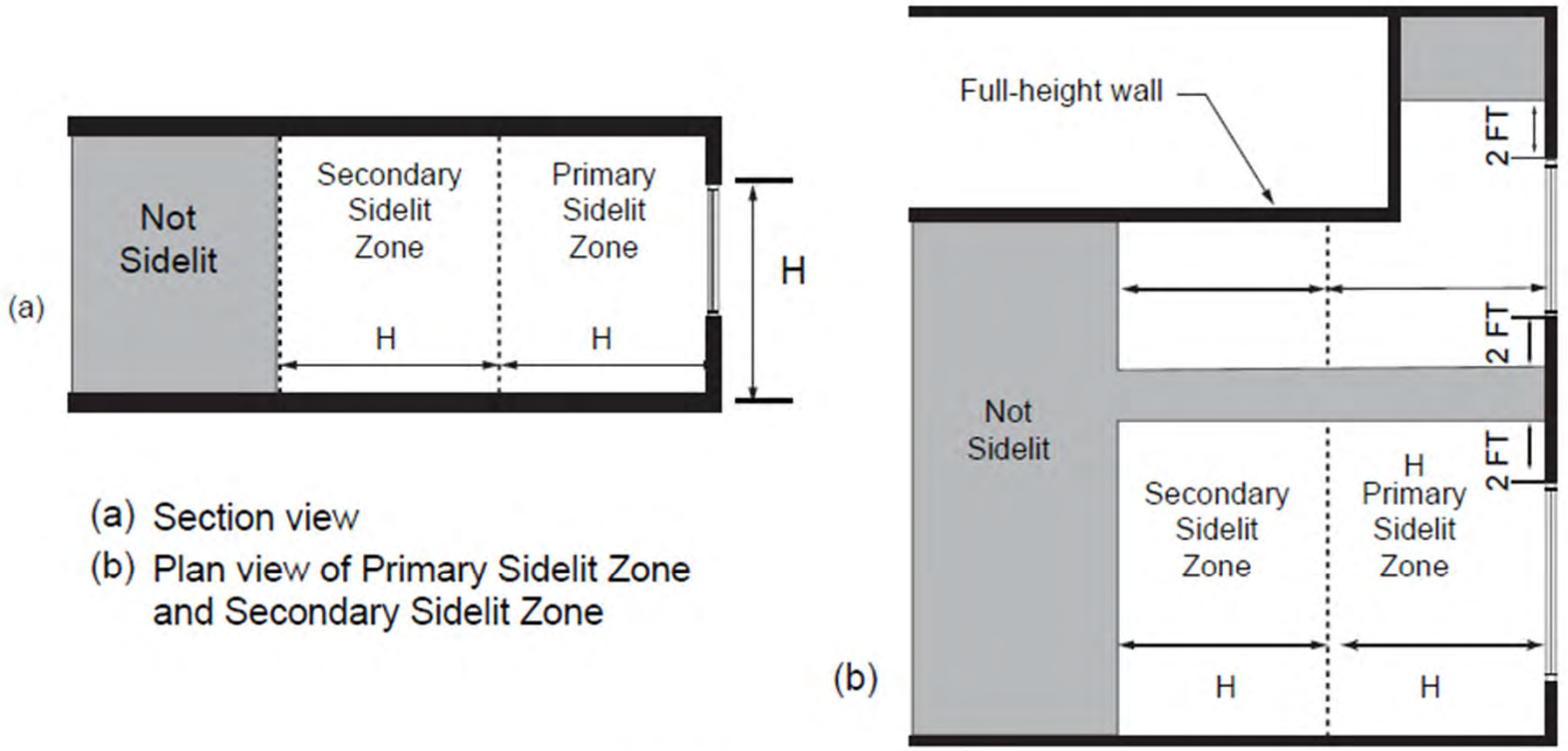


FIGURE C405.2.4.2(1)
PRIMARY AND SECONDARY SIDELIT DAYLIGHT ZONES

Courtesy International Code Council®

Daylight-responsive Control Functions

Section C405.2.4.1

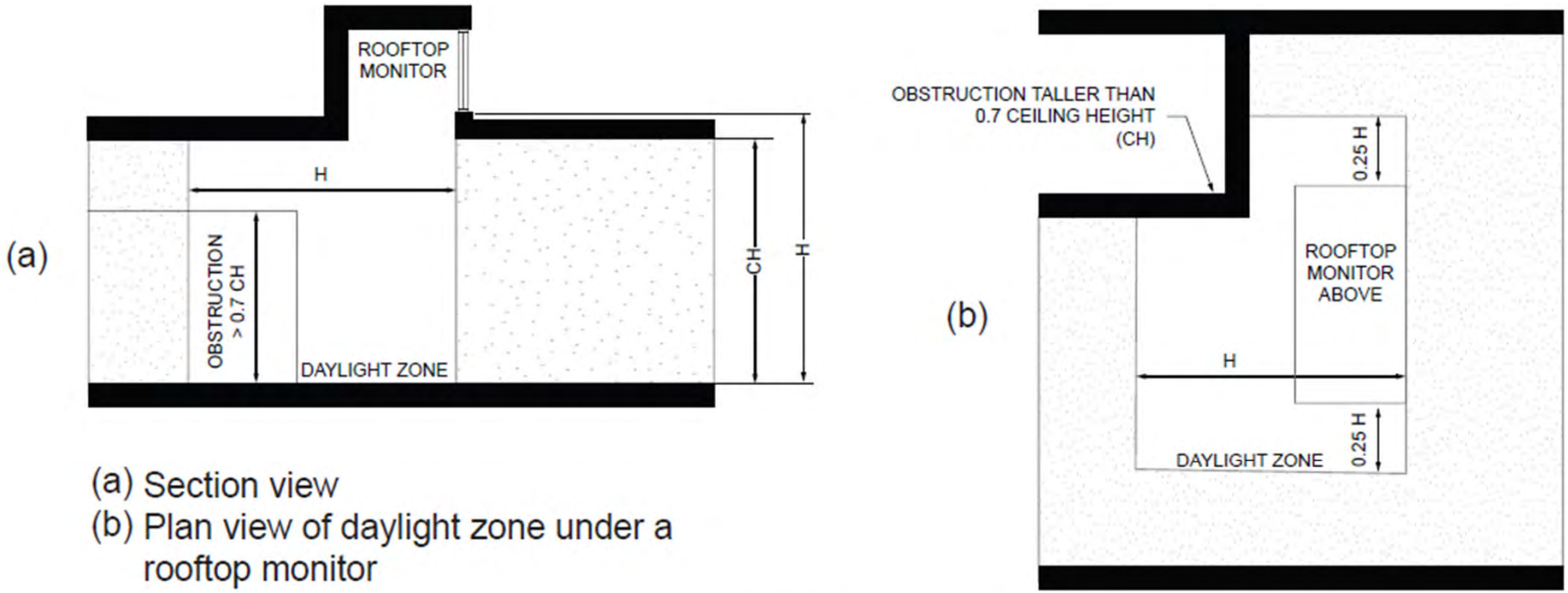
- Toplit zones shall be controlled independently of lights in sidelit zones
- Lights in primary sidelit daylight zones to be controlled independently of those in secondary sidelit daylight zone
- Controls shall be configured so that they can be calibrated from within the space by authorized personnel
- Calibration mechanisms shall be in a location with ready access
- Dim lights continuously from full light output to 15% of full light output or lower
- Controls configured to completely shut off all controlled lights
- When occupant sensor controls have reduced lighting to unoccupied setpoint, controls to continue to adjust electric light levels in response to available daylight, but configured to not increase the lighting power above specified unoccupied setpoint
- Sidelit zones facing different cardinal orientations (within 45 degrees of due north, east, south, west) controlled independently of each other

Daylight-responsive Control Functions

Section C405.2.4.1 – Cont'd.

Exceptions:

- < 150 watts in each space within primary sidelit daylight zone is permitted to be controlled together with lighting in a primary daylight zone facing a different cardinal orientation
- < 150 watts in each space within secondary sidelit daylight zone is permitted to be controlled together with lighting in a secondary daylight zone facing a different cardinal orientation



(a) Section view
(b) Plan view of daylight zone under a rooftop monitor

FIGURE C405.2.4.2(2)
DAYLIGHT ZONE UNDER A ROOFTOP MONITOR

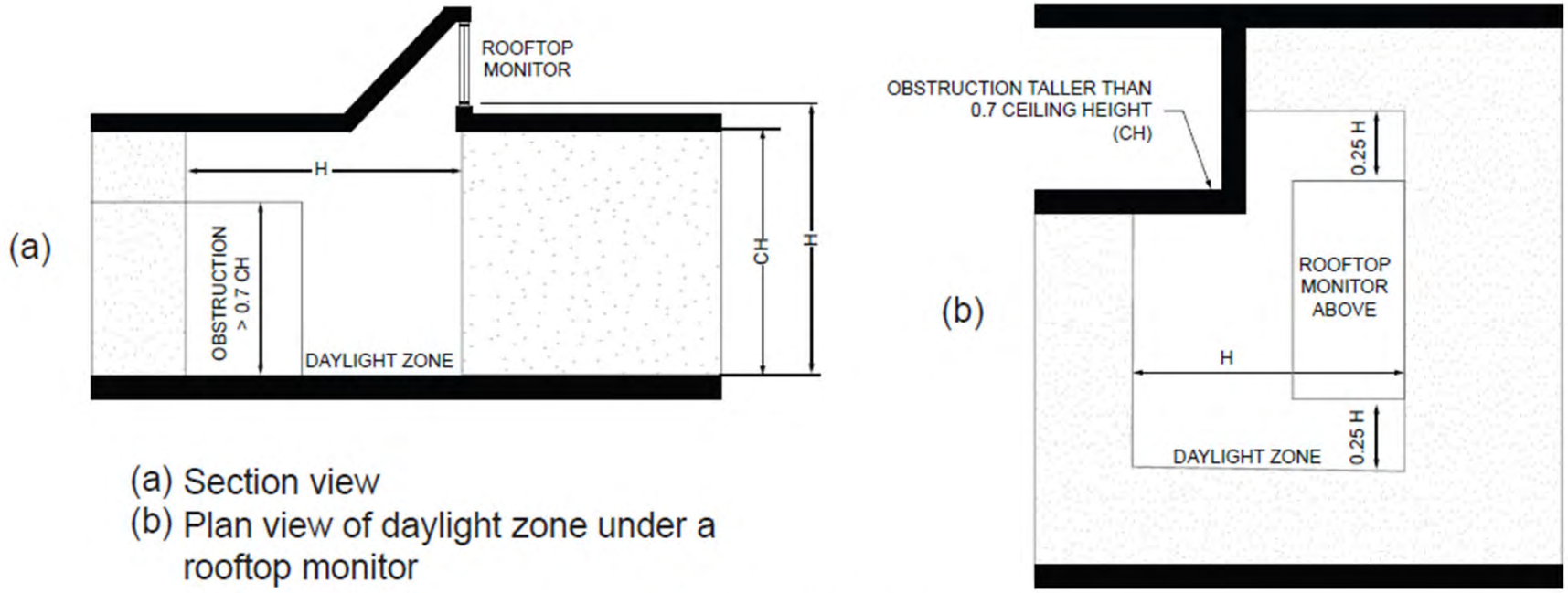
Courtesy International Code Council®

Sidelit Daylight Zone

Section C405.2.4.2

Definition: floor area adjacent to vertical fenestration that complies with all of the following:

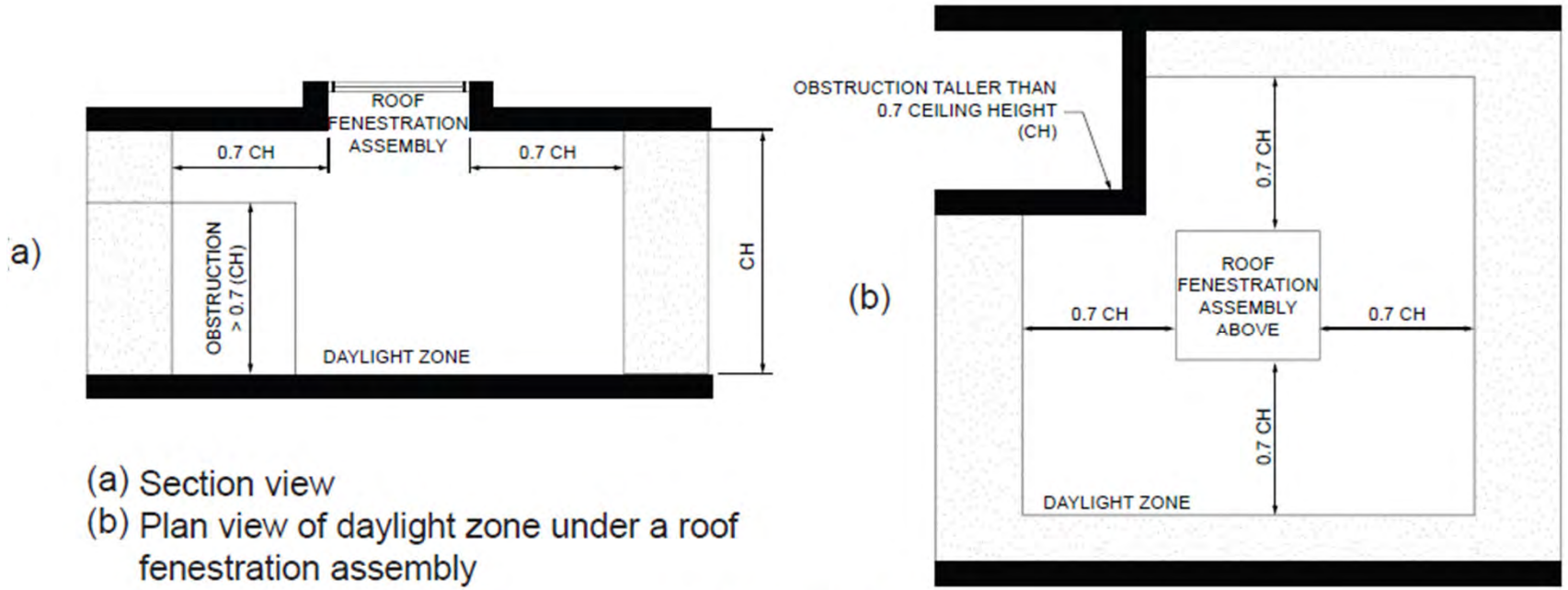
- Fenestration located in a wall:
  - Sidelit daylight zone shall extend laterally to the nearest full-height wall OR
  - < 1.0 x height from the floor to the top of the fenestration, and longitudinally from the edge of the fenestration to the nearest full-height wall, or up to 0.5 times the height from the floor to the top of the fenestration, whichever is less
- Fenestration located in a rooftop monitor:
  - Sidelit daylight zone to extend laterally to the nearest obstruction that is taller than 0.7 times the ceiling height, or up to 1.0 times the height from the floor to the bottom of the fenestration, whichever is less, and longitudinally from edge of the fenestration to the nearest obstruction that is taller than 0.7 times the ceiling height, or up to 0.25 times the height from the floor to the bottom of the fenestration, whichever is less
- Secondary sidelit daylight zone is directly adjacent to the primary sidelit daylight zone
  - Extend laterally to 2.0 times the height from the floor to the top of the fenestration or to the nearest full height wall, whichever is less, and longitudinally from the edge of the fenestration to the nearest full height wall, or up to 2 ft, whichever is less. The area of secondary sidelit zones to not be considered in the calculation of the daylight zones.



(a) Section view
(b) Plan view of daylight zone under a rooftop monitor

FIGURE C405.2.4.2(3)
DAYLIGHT ZONE UNDER A SLOPED ROOFTOP MONITOR

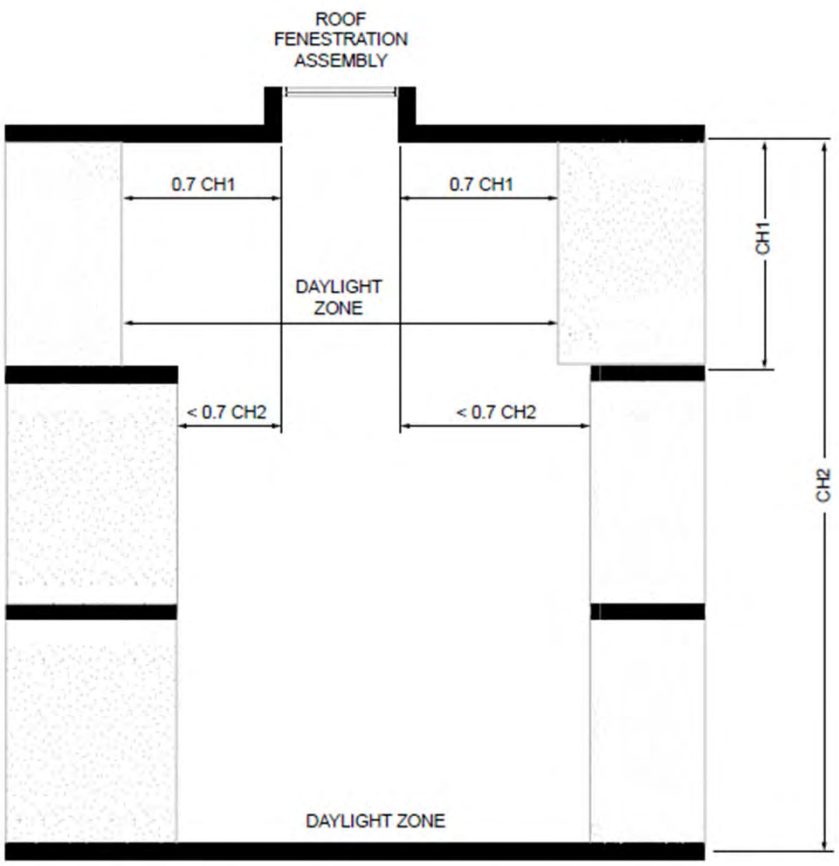
Courtesy International Code Council®



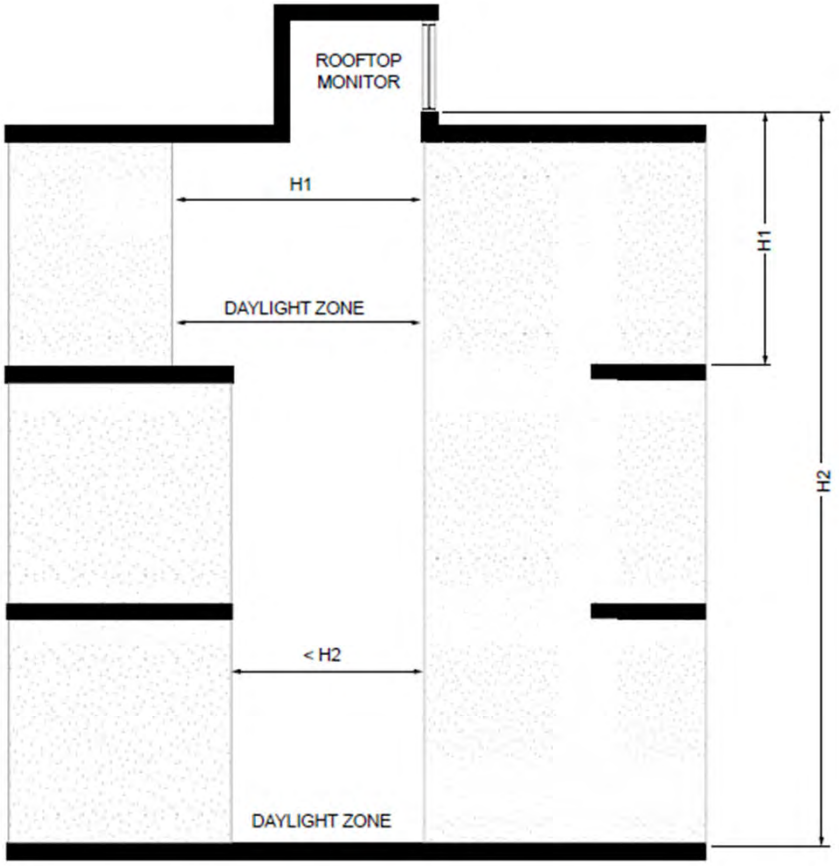
(a) Section view
(b) Plan view of daylight zone under a roof fenestration assembly

FIGURE C405.2.4.3
TOPLIT DAYLIGHT ZONE

Courtesy International Code Council®



(a) Section view of roof fenestration assembly at atrium



(b) Section view of roof monitor at atrium

C405.2.4.4
DAYLIGHT ZONES AT A MULTISTORY ATRIUM

Courtesy International Code Council®

Atriums

Section C405.2.4.4

- Daylight zones in atrium spaces
  - At top floor surrounding atrium space and floor of atrium space (not on intermediate floors)

Sidelit Daylight Zone

Section C405.2.4.2 – Cont'd.

- Area of fenestration $\geq$ 24 ft^2
- Distance from fenestration to any building or geological information that would block access to daylight is > than one half height from bottom of fenestration to top of building or geologic information
- The visible transmittance of fenestration $\geq$ 0.20
- Projection factor for any overhanging shaded projection is not greater than
  - 1.0 for fenestration oriented 45 degrees or less from true north
  - 1.5 for all other orientations

Toplit Daylight Zone

Section C405.2.4.3

Definition: the floor area underneath a roof fenestration assembly that complies with all of the following:

- Zone shall extend laterally and longitudinally beyond the edge of the roof fenestration assembly to the nearest obstruction that is (taller) > 0.7 x the ceiling height, > 0.7 x the ceiling height, whichever is less
- Where located in rooftop monitor, toplit zone to extend laterally to nearest obstruction taller than 0.7 x the ceiling height, or up to 1.0 times the height from floor to bottom of fenestration, whichever is less, and longitudinally from the edge of the fenestration to the nearest obstruction taller than 0.7 x ceiling height, or up to 0.25 times the height from the floor to bottom of fenestration, whichever is less
- No building or geological formation blocks different sunlight from hitting the roof fenestration assembly at the peak solar angle on the summer solstice
- Where located in existing buildings, visible transmittance of the roof fenestration assembly times the area of the rough opening of the roof fenestration assembly divided by area of daylight zone $\geq$ 0.008

Specific Application Controls
Section C405.2.5

- ✓ These types to be controlled by occupant sensor or time-switch control, and a manual control provided to control separately from general lighting
  - Luminaires for which additional lighting power is claimed per C405.3.2.2.1
  - Display and accent lighting
  - Display case lighting
  - Supplemental task lighting, including permanently installed under-shelf or under-cabinet lighting
  - Equipment for sale or educational demonstrations
  - Display lighting for exhibits in galleries, museums and monuments – in addition to general lighting
- ✓ Sleeping units
  - Master control device capable of automatically switching off all installed luminaires and switched receptacles within 20 minutes of occupants leaving the room
  - **Exceptions**: lighting and switch receptacles controlled by captive key systems and spaces where patient care is provided
- ✓ Permanently installed luminaires within dwelling units to have controls complying with C405.2.1.1 or C405.2.3.1
- ✓ Nonvisual applications, plant growth and food warming shall be controlled via time-switch control
- ✓ Task lighting for medical and dental purposes in addition to general lighting to be provided a manual control

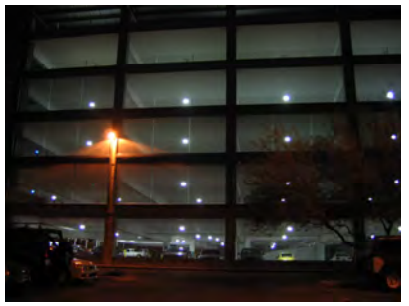
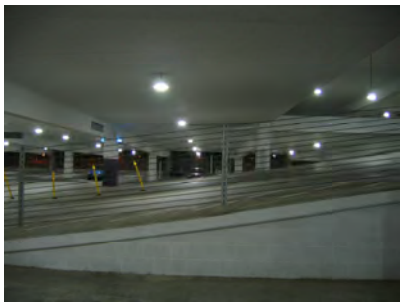
Lighting Setback
Section C405.2.7.3

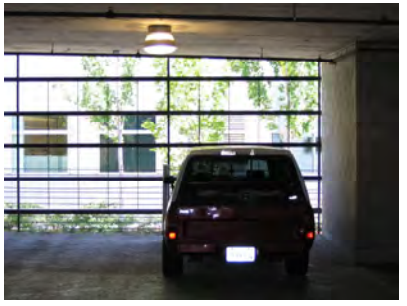
- ✓Building façade or landscape NOT covered in Section C405.2.7.2 shall have controls configured to automatically reduce connected lighting power ≥ 50%
  - ✓no later than midnight to not earlier than 6 am
  - ✓from not later than 1 hour after business closing to not earlier than 1 hour before opening
  - ✓any period where activity has not been detected for at least 15 minutes
- ✓Outdoor parking areas with rated input wattage of > 78 W and mounting height of 24 feet or less above ground
  - ✓Controlled so lighting is reduced by at least 50% after 15 minutes of inactivity
    - ✓Not more than 1500 W to be controlled together

Parking Garage Lighting Control
Section C405.2.8

Multiple control requirements required for parking garage lighting

- Automatic time-switch
- Automatically reduce lighting by 30% when no activity in a lighting zone for 20 minutes, zone must be < 3600 ft^2
- In daylight transition zone at entrances and exits, lighting to be separately controlled that reduces lighting at night
- Lighting within 30 ft of perimeter opening or fenestration to reduce in response to daylight by at least 50%



Exemptions to Proposed Interior Lighting Power Calculation

Section C405.3.1

- ✓ Television broadcast lighting for playing areas in sports arenas
- ✓ Emergency lighting automatically off during normal business operation
- ✓ Lighting for occupants with special needs (visual impairment and other medical and age-related issues)
- ✓ Casino gaming areas
- ✓ Mirror lighting in dressing rooms
- ✓ Task lighting for medical and dental purposes (in addition to general lighting and controlled independently)
- ✓ Display lighting for exhibits in galleries, museums and monuments (in addition to general lighting and controlled independently)
- ✓ Theatrical, stage, film, and video production
- ✓ Used for photographic processes
- ✓ Integral to equipment or instrumentation installed by manufacturer
- ✓ Plant growth or maintenance
- ✓ Advertising or directional signage
- ✓ Food warming
- ✓ Lighting equipment that is for sale
- ✓ Lighting demonstration equipment in lighting education facilities
- ✓ Approved because of safety considerations
- ✓ In retail display windows when the display is enclosed by ceiling-height partitions
- ✓ Furniture-mounted supplemental task lighting controlled by automatic shutoff
- ✓ Exit signs
- ✓ Antimicrobial lighting used for sole purpose of disinfecting a space

Interior Lighting Power Allowance
Section C405.3.2

Two methods to determine entire building allowance:

- ✓ Building Area Method
  - Floor area for each building area type x value for the area
  - Each building area type to be treated as a separate area
- ✓ Space-by-Space Method
  - Floor area of each space x value for the area
  - Then sum the allowances for all the spaces
  - Tradeoffs among spaces are allowed
  - If unfinished spaces, LPA for them is total connected power for those spaces or 0.2 W/ft^2, whichever is less
- If only portions of a building – must use Space-by-Space
- If buildings with unfinished spaces – must use Space-by-Space

Interior Lighting Power Allowance
Section C405.3.2

Two methods to determine allowance:

- ✓ Building Area Method
  - Floor area for each building area type x value for the area
  - "area" defined as all contiguous spaces that accommodate or are associated with a single building area type as per the table
  - When used for an entire building, each building area type to be treated as a separate area
- ✓ Space-by-Space Method
  - Floor area of each space x value for the area
  - Then sum the allowances for all the spaces
  - Tradeoffs among spaces are allowed

Building Area Method *Table C405.3.2(1)*

Building Area Type	LPD (w/ft^2)
Automotive facility	0.75
Convention center	0.64
Courthouse	0.79
Dining: bar lounge/leisure	0.80
Dining: cafeteria/fast food	0.76
Dining: family	0.71
Dormitory	0.53
Exercise center	0.72
Fire station	0.56
Gymnasium	0.76

(partial table)

Space-By-Space Method *Table C405.3.2(2)*

Space Type	LPD (w/ft^2)
Food Preparation Area	1.09
Guestroom	0.41
Laboratory	
In or as a classroom	1.11
Otherwise	1.33
Laundry / washing area	0.53
Loading dock, interior	0.88
Lobby	
For an elevator	0.65
Visually impaired facility	1.69
In a hotel	0.51

(partial table)

Additional Interior Lighting Power
Section C405.3.2.2.1

2018 & 2021 – no change - informational

Additional Interior Lighting Power Allowance =

1000 watts +

(Retail Area 1 x 0.45 W/ft^2) +

(Retail Area 2 x 0.45 W/ft^2) +

(Retail Area 3 x 1.05 W/ft^2) +

(Retail Area 4 x 1.87 W/ft^2),

Where:

- ✓ **Retail Area 1 = the floor area for all products not listed in Retail Area 2, 3 or 4.**
- ✓ **Retail Area 2 = the floor area used for the sale of vehicles, sporting goods and small electronics.**
- ✓ **Retail Area 3 = the floor area used for the sale of furniture, clothing, cosmetics and artwork.**
- ✓ **Retail Area 4 = the floor area used for the sale of jewelry, crystal, and china.**

Lighting for plant growth and maintenance C405.4

Not less than 95 percent of the permanently installed luminaires used for plant growth and maintenance shall have a photon efficiency of not less than 1.6 µmol/J as defined in accordance with ANSI/ASABE S640.

Image courtesy of DOE

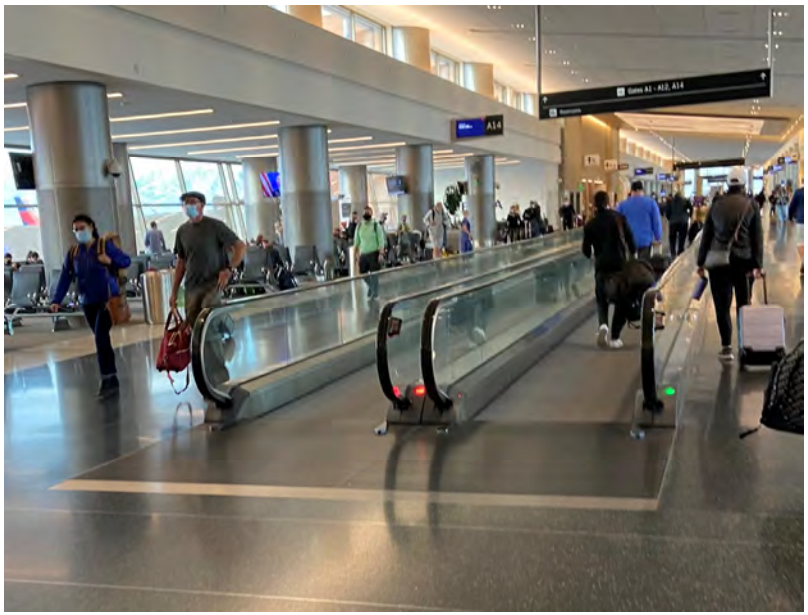
Additional Efficiency Credit Requirements
Section C406

- Tenant Spaces
  - Comply with sufficient options from Tables C406.1(1)-(5) to achieve a minimum number of 5 credits (selected from C406.2, C406.3, C406.6, C406.7 or C406.10)
  - Where the entire building complies using credits from C406.5, C406.8 or C406.9, tenant spaces are deemed to comply
  - Exception
    - Previously occupied tenant spaces that comply with this code per C501

General system modifications C405.9.2

Escalator or moving walk speed controls based on traffic analysis per ASME A17.1/CSA B44

Sensors detect approaching passengers



Escalator Energy Recovery C405.9.2.1

Power recovery language clarified and tied to traffic analysis

Like regenerative brakes

- Includes escalators moving both up and down
  - Consider the mass and momentum change when many people either step on or off

Automatic Receptacle Control C405.11

The following shall have automatic receptacle control complying with Section C405.11.1:

1. At least 50 percent of all 125V, 15- and 20-amp receptacles installed in enclosed offices, conference rooms, rooms used primarily for copy or print functions, breakrooms, classrooms and individual workstations, including those installed in modular partitions and module office workstation systems.

2. At least 25 percent of branch circuit feeders installed for modular furniture not shown on the construction documents.

C405.11.1 Automatic receptacle control function.

See the IECC – many options and exceptions

Image by Leviton

C405.12

Energy Monitoring

New Building ≥ 25,000 ft² equipped to measure, monitor, record, and report energy consumption

Exception: R-2 occupancies < 5000 ft² and individual spaces with its own utility service

- **Total HVAC System** - Heating, cooling and ventilation
- **Interior Lighting** - Lighting w/in the building
- **Exterior Lighting** - Lighting NOT w/in the building
- **Plug Loads** - Devices, appliances, and equipment connected to receptacle outlets
- **Process Loads** - Any load that exceeds 5% of peak connected load – data centers, manufacturing equipment, and commercial kitchens
- **Building Operations & Misc. Loads** - Remaining loads NOT already covered – elevators, escalators, motorized shading, ornamental fountains, fireplaces, swimming pools, spas and snow melt

QUESTIONS OR COMMENTS?

Thank you for your participation!

Please Send Your Brilliant Ideas or Suggestions to:

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