2015 WSEC Survival Guide

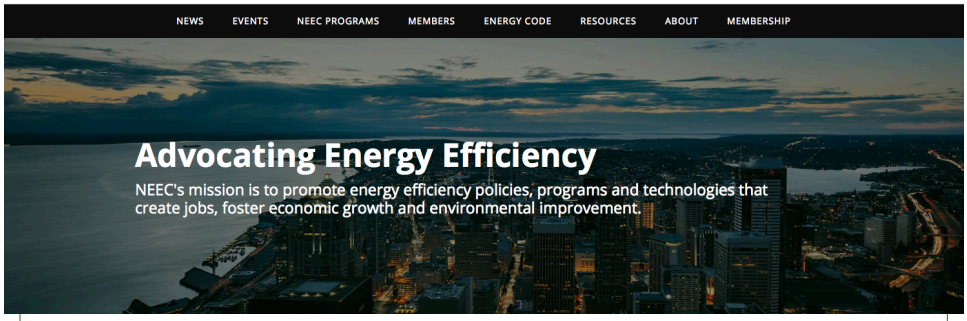
WSEC COMMERCIAL UPDATE

LISA ROSENOW
LISA.ROSENOW@NEEC.NET
(206) 624-0283

NEEC Northwest Energy Efficiency Council

ICC PREFERRED EDUCATION PROVIDER

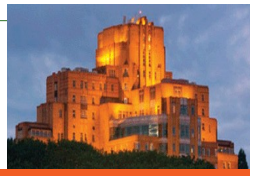
SMART BUILDINGS CENTER A project of NEEC



- NEEC provides technical support to the design and construction industry for the WSEC Commercial Provisions.
- *Services we provide:*
  - Advocate for code language clarity
  - Inform industry about Code updates
  - Fact sheets on key topics
  - Compliance documentation forms
  - **Training, training, training!**
  - On-call technical support
    - **NEW Email - wsec@neec.net**
    - Lisa Rosenow, WSEC Tech Support Service Manager
      (206) 624-0283

NEEC Northwest Energy Efficiency Council

SMART BUILDINGS CENTER A project of NEEC

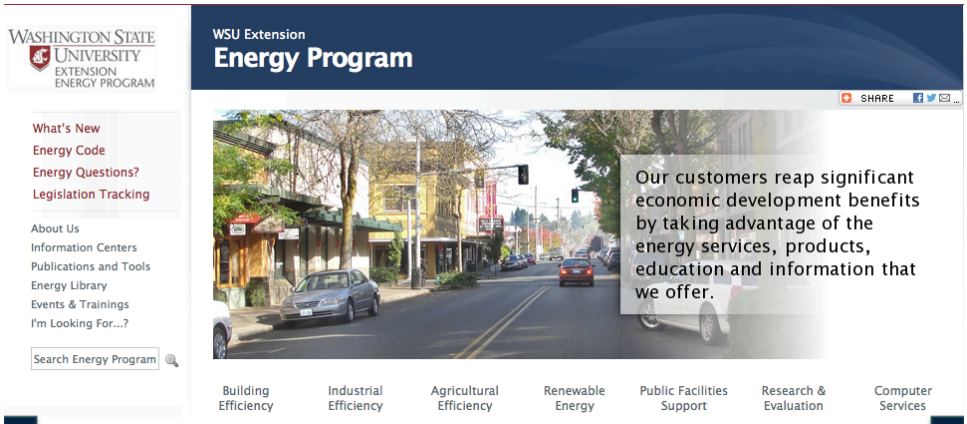


WELCOME TO OUR NEW HOME!

NEEC is now located within the SBC

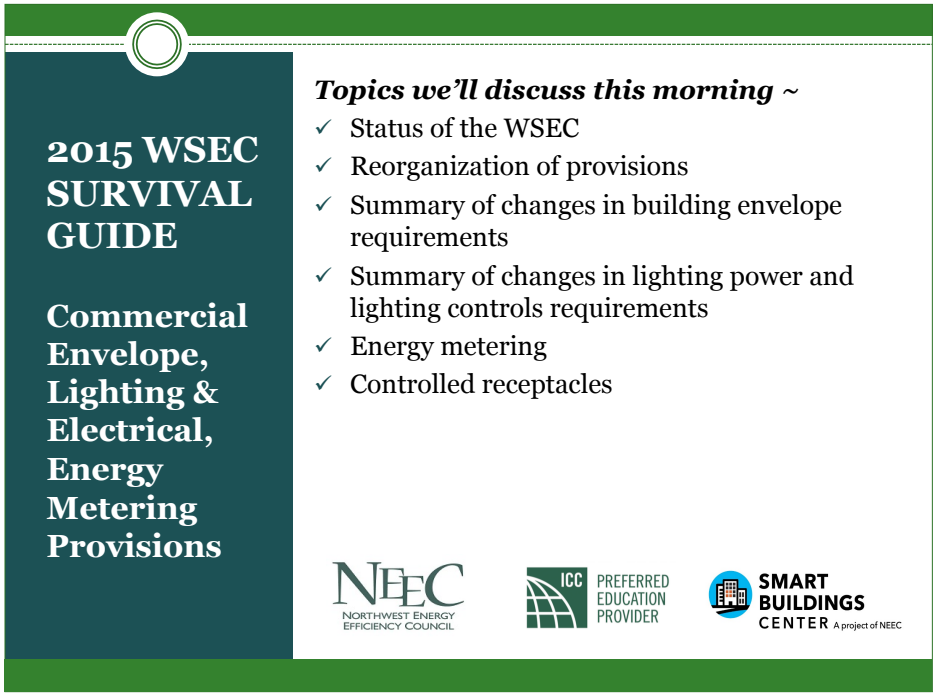
Smart Buildings Center
1200 12th Ave. S., Suite 110
Seattle, WA 98144

http://www.smartbuildingscenter.org



- WSU Energy Extension offers training, technical support and educational resources to homeowners and the design and construction industry for the WSEC Residential Provisions.
- On-call Technical Support:
  - energycode@energy.wsu.edu
  - (360) 956-2042
  - WSU EEP Website - www.energy.wsu.edu/code


neea
Home | Subscribe | Careers | Calendar
About NEEA
Initiatives
Resource Center
NEEA Newsroom
Get Involved
Home » Initiatives » Codes & Standards
Related Resources
Washington Residential Energy Code Compliance
Idaho Residential Code Compliance
2011 Residential Codes Energy Use Savings
Conduit Spotlight
Energy Codes and Standards
WSEC technical support services are made possible thanks to the generous support of the Northwest Energy Efficiency Alliance
Codes & Standards
Instituting long-term energy savings
More stringent codes and standards play an important role in helping the Northwest secure long-term energy savings. The Northwest Power and Conservation Council's 6th Power Plan estimates that over 40 percent of Northwest energy efficiency savings between now and 2030 will come from increased codes and standards.
Through aggregating and synthesizing knowledge, then convening and collaborating with our partners, NEEA gains an independent perspective. This helps us advance building energy codes and helped us provide training to more than 2000 building officials and trade allies around the region in 2011.
Through the following codes and standards initiatives, NEEA helps the region secure energy savings to help the Northwest meet its growing energy needs.
www.neea.org
Codes
Helping to create new and more stringent building codes and providing technical support and training after adoption.
Standards
Serving as a technical expert during U.S. Department of Energy rulemaking process to encourage the adoption of optimal efficiency federal appliance and equipment standards.
Join the conversation »
Success Story
NEEA Builds Market Capacity Enabling More Energy-Efficient Codes


2015 WSEC SURVIVAL GUIDE
Commercial Envelope, Lighting & Electrical, Energy Metering Provisions
Topics we'll discuss this morning ~
✓ Status of the WSEC
✓ Reorganization of provisions
✓ Summary of changes in building envelope requirements
✓ Summary of changes in lighting power and lighting controls requirements
✓ Energy metering
✓ Controlled receptacles
NEEC
NORTHWEST ENERGY EFFICIENCY COUNCIL
ICC PREFERRED EDUCATION PROVIDER
SMART BUILDINGS CENTER A project of NEEC

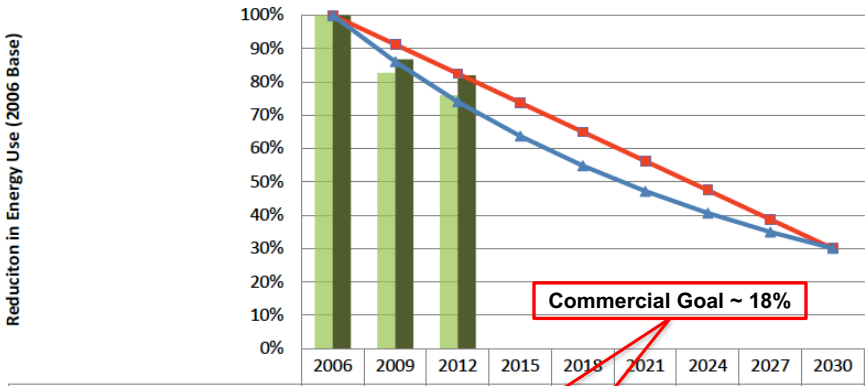
2015 Washington State Energy Code

- Interpretation
  - This presentation represents Ecotope's and the Northwest Energy Efficiency Council's "***unofficial***" interpretation of the Code intent.
  - "***Official***" interpretations of WSEC provisions are made only by the SBCC in response to questions submitted by building officials.
  - Official interpretations are published on the SBCC website and are deemed "advisory" information.

Washington State Energy Efficiency Target

- **2009 – RCW 19-27-160 Energy Code Act Amended**
  - Requires **70%** reduction in residential and commercial building energy consumption by 2031. The 2006 WSEC is the baseline.
  - Energy efficiency achieved through increased stringency, new technology and new scope.
  - New provisions predicted to achieve the most savings for commercial in the 2015 WSEC:
    - C406 Additional efficiency package options
    - C403.6 Dedicated outside air systems (DOAS)

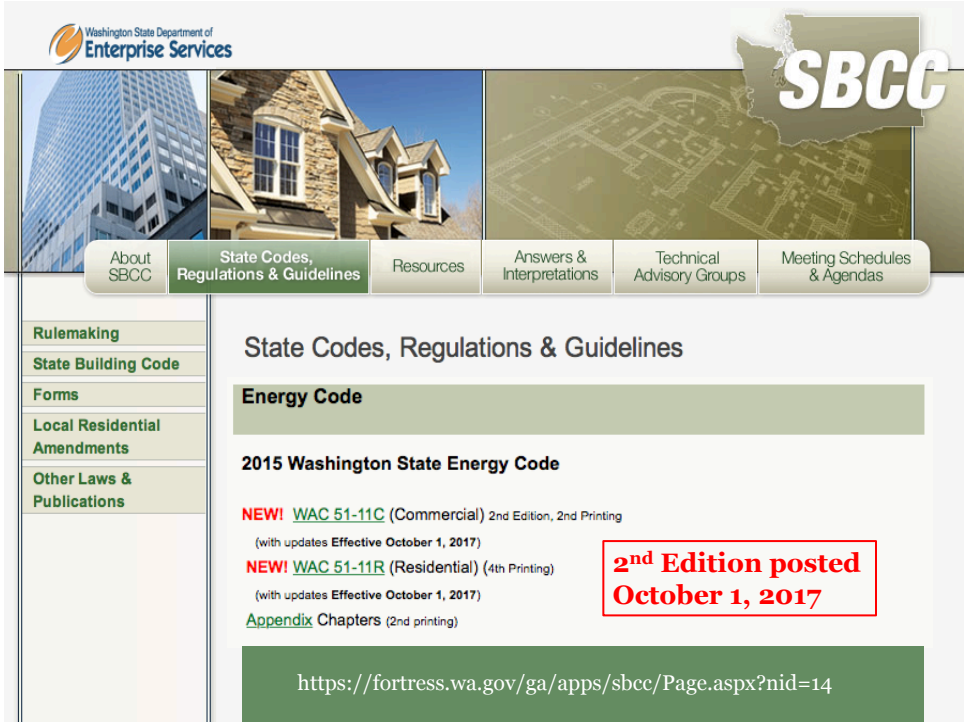
Incremental Improvement Compared to Targets



	2006	2009	2012	2015	2018	2021	2024	2027	2030
Residential	100%	82.7%	76.1%						
Commercial	100%	86.8%	82.0%						
Target: 8.75 % savings compared to the 2006 WSEC	100%	91%	83%	74%	65%	56%	48%	39%	30%
Target: 14% savings compared to each previous code	100%	86%	74%	64%	55%	47%	41%	35%	30%

Code Development Process - Stakeholders

- Washington State Building Code Council (SBCC)
  - Advises state legislature on all building code related issues.
  - 16 members, appointed by the Governor
- Energy Code Technical Advisory Group (TAG)
  - 24 members representing all applicable industry sectors.
  - Tasked with reviewing and voting on proposed changes to the WSEC.
- Design & Construction Industry
  - General public is encouraged to participate in the WSEC development process.
  - SBCC and TAG meetings are open to the public and opportunity is provided for public comment, which is an important part of the process.
- ***2018 WSEC development process is underway…***



Reorganization of Provisions

- Chapter 1 – Scope and Administration
- Chapter 2 – Definitions
- Chapter 3 – General Requirements
- Chapter 4 – Commercial Energy Efficiency
- **NEW! Chapter 5 – Existing Buildings**
- Chapter 6 – Reference Standards
- Appendix Chapters

Chapter 5 Existing Buildings

- All provisions related to existing buildings have been consolidated
  - Additions
  - Alterations
  - Repairs
  - Change in space conditioning
  - Change of occupancy or use
  - Historic buildings

Start here for all projects associated with an existing building

Chapter 4 Commercial Energy Efficiency

- Discipline specific provisions
  - C401 – Compliance Options
  - C402 – Building envelope
  - C403 – Mechanical systems
  - C404 – Service water heating systems
  - C405 – Electrical power and lighting
  - **NEW!** C406 – Additional efficiency package options
  - C407 – Total building performance
  - C408 – Commissioning
  - C409 – Energy metering
  - **NEW!** C410 – Refrigerated spaces

Compliance Options

C401.2

- There are two compliance options ~
  1. Option 1 – All Applicable Provisions Includes all applicable provisions in Sections C402, C403, C404, C405, C406, C408, C409 and C410.
  2. Option 2 – Total Building Performance Whole building energy model per C407, plus all mandatory provisions.

Mandatory vs. Prescriptive

- Mandatory – "Must Do's"
  - All applicable mandatory provisions shall be met.
  - Cannot use the Total Building Performance compliance path to avoid a mandatory provision.
- Prescriptive – "Can model out of…"
  - If it can be demonstrated with a whole building energy model that an alternate design without a prescriptive provision uses less energy than the WSEC Standard Reference Design, then it may be deemed to comply. (C407 - Total Building Performance Compliance Path)

Whole Building Energy Model

- C407 Total Building Performance Path (TBP)
  - Requires a whole building energy model per Section C407 and compliance with all applicable mandatory provisions:
    - C402.5 – Air leakage
    - C403.2 – Mandatory mechanical
    - C404 – Service water systems
    - C405.2 – Interior lighting controls
    - *C405.5* – Exterior lighting power
    - C405.3 – Exit signs
    - C405.6 – Transformers
    - C408 – Commissioning
    - C409 + C405.7 – Metering
    - C410 – Refrigerated spaces
  - C407.3 - Building energy consumption shall be better than the Standard Reference Design (SRD) by:
    - 13% with no additional efficiency options (87% of SRD).
    - 10% if project complies with one additional efficiency option.
    - 7% if project compliance with two additional efficiency options.

NEW!
Section C406

Additional Efficiency Package Options

B = Building-level
S = System-level

- Buildings shall comply with no less than ***two*** of the following options:
  - Enhanced envelope performance - B
  - Reduced air infiltration - B
  - More efficient HVAC performance - S
  - Dedicated outside air system (DOAS) - S
  - High efficiency service water heating - S
  - Reduced lighting power density - S
  - Enhanced lighting controls - S
  - On-site renewable energy – B

NEW! Section C406

Additional Efficiency Package Options

- **When are options required?**

  SBCC official interpretation 17-02 & 17-03 ~
  - New construction, including shell & core
  - First occupancy build-out = Tenant spaces
  - Building additions
  - Change in space conditioning or occupancy
  - Applies to all levels of space conditioning – low energy, semi-heated, conditioned, refrigerated coolers and freezers

NEW! Section C406

Additional Efficiency Package Options

- Shell & Core + Tenant Space Projects

  SBCC official interpretation 17-03 ~
  - In general, tenant spaces are only required to comply with 1 option.
  - S&C complies with 1 of the building-level options, or 2 system-level options that serve the entire building.

    ✔ No options required for tenant spaces
  - S&C complies with 1 system level option but system only serves utility/common areas.

    ✔ Tenant spaces shall comply with 1 option
  - S&C completed prior to 2015 WSEC.

    ✔ Tenant spaces shall comply with 1 option
  - In buildings with multiple tenant spaces, it is acceptable to mix & match system-level options.

Additional Efficiency Package Options In Existing Buildings

- Retrofits requiring full compliance
  - C503.2 Change in space conditioning
    - Space converted from unconditioned to semi-heated or conditioned space.
    - Space converted from semi-heated to conditioned space.
  - C505 Change in occupancy or use
    - Space converted from F, S or U occupancy to something other than F, S or U.
    - Space converted to Group R from another use or occupancy.
    - Group R dwelling unit converted to commercial use or occupancy if dwelling unit was permitted prior to July 1, 2002.

Space Conditioning Categories

- C402.1.1 Low energy buildings and spaces
  - Low energy spaces are exempt from all envelope provisions ***only***. All other applicable provisions apply for mechanical, lighting, service water heating, etc.

Low energy spaces include:

1) Unconditioned spaces
2) Spaces that are heated and/or cooled and the installed peak output space conditioning capacity (heating or cooling, whichever is greater) is less than 3.4 Btu/h per SF (1 watt/SF).
3) ***Greenhouses cooled with only ventilation air or evaporative cooling system. Space conditioning system does not include a condensing unit.***
4) Unstaffed equipment shelters for wireless service facilities.

- **GREENHOUSE**
  - A permanent structure that maintains a ***specialized sunlit environment*** that is used exclusively for, and is essential to, the cultivation, protection or maintenance of plants. Greenhouses are spaces erected for 180 days or more.
- **TEMPORARY GROWING STRUCTURE**
  - A structure erected for less than 180 days with sides and roof covered with polyethylene, polyvinyl or similar flexible synthetic material. Provides plants with either frost protection or increased heat retention.
  - C101.2 Exception to WSEC - If used solely for commercial production of horticultural plants, and all mechanical equipment and lighting fixtures are portable.

Image source – Inhabitat & WeatherPort

Equipment Buildings

- C402.1.2 Equipment buildings are exempt from all envelope provisions if all of the following apply:
  1) Separate building no larger than 500 sf.
  2) Houses electronic equipment with installed equipment power of 7 watts/sf or more.
  3) Heating system capacity does not exceed 17,000 Btu/h and t-stat limit is restricted to 50°F or less.
  4) U-factors of the roof and walls are less than U-0.20 (R-5 or greater).
- *Un-official* interpretation – Cooling capacity is allowed, capacity threshold not defined.

Space Conditioning Categories

- C402.1.1.1 Semi-heated buildings and spaces
  - Installed peak output heating capacity is between 3.4 and 8 Btu/h per SF and there is ***no*** mechanical cooling installed.
  - May take exemption for ***wall insulation*** if space is not heated with an electric resistance system. However, wall shall be calculated as code compliant for component performance and TBP calculations.

Space Conditioning Categories

- C410 Refrigerated warehouse & walk-in coolers/freezers
  - **Cooler** – Maintains temp greater than 32°F but less than 55°F
  - **Freezer** – Maintains temp at or below 32°F
  - Envelope shall comply with C410.2 ***and all applicable provisions in C402***. *SBCC Permanent Rule - WSR 16-24-070*
    - Requirements per **C410.2**
      - Roof, wall, door insulation
      - Windows in doors & transparent reach-in doors
      - Freezer floor insulation
      - Door closures and method of infiltration management when door is open
    - Requirements per **C402**
      - Vertical fenestration
      - Slab edge and floors over unconditioned space insulation
      - Air barrier and air leakage testing

Building Envelope

Roof and Wall Assemblies

Table C402.1.3 - R-Value Method

CLIMATE ZONE	5 AND MARINE 4	
	All Other	Group R
Roofs		
Insulation entirely above deck	~~R-30ci~~ **R-38ci**	R-38ci
Metal buildings	R-25 + R-11 LS	R-25 + R-11 LS
Attic and other	R-49	R-49
Walls, Above Grade		
Mass	R-9.5ci	R-13.3ci
Metal buildings	~~R-13 + R-13ci~~ **R-19ci**	~~R-13 + R-13ci~~ **R-19ci**
Steel framed	R-13 + R-10ci	R-19 + R-8.5ci
Wood framed and other	R-21 int	R-21 int
Walls, Below grade		
Below grade walls	Same as above grade	Same as above grade

Table C402.1.4 - U-Factor Method

CLIMATE ZONE	5 AND MARINE 4	
	All Other	Group R
Roofs		
Insulation entirely above deck	~~U-0.034~~ **U-0.027**	~~U-0.031~~ **U-0.027**
Metal buildings	U-0.031	U-0.031
Attic and other	U-0.021	U-0.021
NEW - Joist or single rafter	**U-0.027**	**U-0.027**
Walls, Above Grade		
Mass	U-0.104	U-0.078
NEW – Mass transfer deck slab edge	**U-0.20**	**U-0.20**
Metal buildings	U-0.052	U-0.052
Steel framed	U-0.055	U-0.055
Wood framed and other	U-0.054	U-0.054
Walls, Below grade		
Below grade walls	Same as above grade	Same as above grade

Above-Grade Wall Framing Types

- A103.2 Framing descriptions
  - Refer to A103.2 for Weighting Factors
  - Standard – 16" OC framing; 3-stud corners; air space between header & sheathing; interior partition/exterior wall intersection uses 2-studs in exterior wall
  - ***Intermediate*** –16" OC framing; 2-stud corners or other means to insulate corners; headers insulated with R-10 minimum; interior partition/exterior wall intersection fully insulated in exterior wall
  - Advanced – Same as Intermediate Framing with 24" OC framing

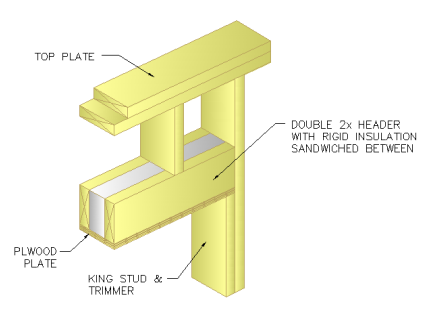


Image Sources – www.ToolBase.org

Floors and Opaque Doors

Table C402.1.3 - R-Value Method

CLIMATE ZONE	5 AND MARINE 4	
	All Other	Group R
Floors		
Mass	R-30ci	R-30ci
Joist/Framing	R-30	R-30
Steel floor joist system	R-38 + R-10ci	R-38 + R-10ci
Slab-on--Grade Floors		
Unheated slabs	R-10 for 24" below	R-10 for 24" below
Heated slabs	R-10 perimeter & under entire slab	R-10 perimeter & under entire slab
Opaque Doors		
Nonswinging (Formerly Roll-up/sliding)	R-4.75	R-4.75

Table C402.1.4 - U-Factor Method

CLIMATE ZONE	5 AND MARINE 4	
	All Other	Group R
Floors		
Mass	U-0.031	U-0.031
Joist/Framing	U-0.029	U-0.029
Slab-on--Grade Floors		
Unheated slabs	F-0.54	F-0.54
Heated slabs	F-0.55	F-0.55
Opaque Doors		
Swinging	U-0.37	U-0.37
NEW - Nonswinging	**U-0.34**	**U-0.34**

Thermal Bridging

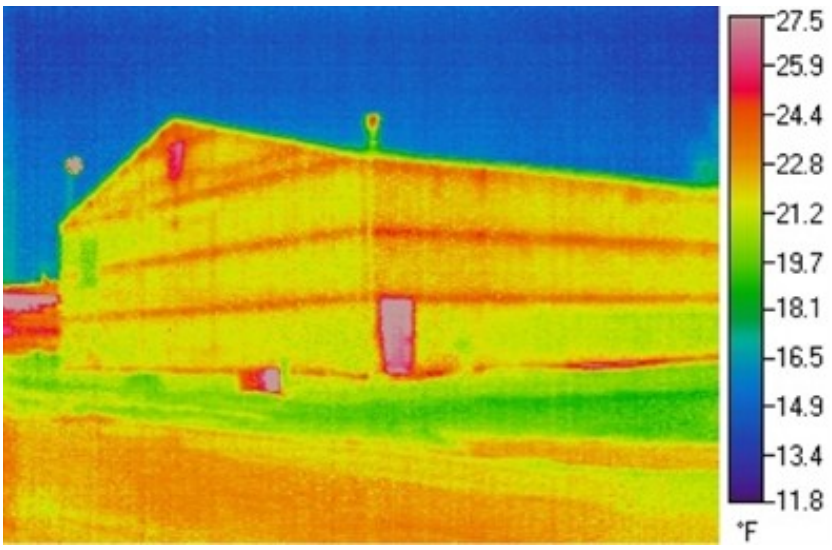


TABLE C402.1.4.1
EFFECTIVE *R*-VALUES FOR STEEL STUD WALL ASSEMBLIES

NOMINAL STUD DEPTH (inches)	SPACING OF FRAMING (inches)	CAVITY *R*-VALUE (insulation)	CORRECTION FACTOR (F_c)	EFFECTIVE *R*-VALUE (ER) (Cavity *R*-Value × F_c)
3 1/2	16	13	0.46	5.98
		15	0.43	6.45
3 1/2	24	13	0.55	7.15
		15	0.52	7.80
6	16	19	0.37	7.03
		21	0.35	7.35
6	24	19	0.45	8.55
		21	0.43	9.03
8	16	25	0.31	7.75
		24	25	0.38	9.50

That's a 65% loss in performance!

- Demonstrates the effect of thermal bridging through metal structural members from the interior to the exterior of the wall.

Continuous Insulation

- **CONTINUOUS INSULATION (C.I.).**
  - Insulating material that is continuous across all structural members without thermal bridges other than fasteners and service openings.
  - To be continuous, penetrations in the insulation cannot exceed ***0.04%*** of the cross-sectional area of the opaque surface.
  - It can be installed on the interior, exterior or integral to the assembly.
  - No continuous metal elements (e.g. metal studs, z-girts, z-channels, shelf angles) penetrate the otherwise continuous portion of the insulation.
  - Metal penetrations that are isolated or discontinuous:
    - Brick ties or other discontinuous metal attachments.
    - Offset brackets supporting shelf angles that allow insulation to go between shelf angle and the primary portions of the wall structure.

Metal Stud Walls with Insulation Supported by Z-Furring

Metal Framing	R-Value of Foam Board Insulation	Z-furring Attachment	Cavity Insulation					
			R-0	R-11	R-13	R-15	R-19	R-21
16" o.c.	R-0 (none)	Horizontal	0.352	0.132	0.124	0.118	0.109	0.106
	R-5	Horizontal	0.155	0.089	0.086	0.083	0.078	0.077
	R-7.5	Horizontal	0.128	0.080	0.077	0.074	0.071	0.069
	R-10	Horizontal	0.110	0.072	0.070	0.068	0.065	0.064
	R-12.5	Horizontal	0.099	0.068	0.065	0.064	0.061	0.060
R-13.9	R-15	Horizontal	0.091	0.064	0.062	0.060	0.058	0.057
	R-17.5	Horizontal	0.084	0.060	0.058	0.057	0.055	0.054
	R-20	Horizontal	0.078	0.057	0.056	0.054	0.052	0.052
	R-22.5	Horizontal	0.074	0.055	0.054	0.052	0.051	0.050
	R-25	Horizontal	0.071	0.053	0.052	0.051	0.049	0.048
	R-0 (none)	Vertical	0.352	0.132	0.124	0.118	0.109	0.106
	R-5	Vertical	0.165	0.093	0.089	0.086	0.081	0.079
	R-7.5	Vertical	0.142	0.085	0.081	0.079	0.075	0.073
	R-10	Vertical	0.126	0.079	0.076	0.074	0.070	0.069
	R-12.5	Vertical	0.115	0.074	0.072	0.070	0.066	0.065
R-12.6	R-15	Vertical	0.107	0.071	0.069	0.067	0.064	0.063
	R-17.5	Vertical	0.100	0.068	0.065	0.064	0.061	0.060
	R-20	Vertical	0.094	0.065	0.063	0.061	0.059	0.058
	R-22.5	Vertical	0.090	0.063	0.061	0.060	0.057	0.056
	R-25	Vertical	0.086	0.061	0.059	0.058	0.056	0.055

Table A103.3.6.1(2) -- Overall Assembly U-factors for Metal Stud Walls

Metal Stud Walls with Effective Continuous Insulation

Metal Framing	R-Value of Continuous Foam Board Insulation	Cavity Insulation					
		R-0	R-11	R-13	R-15	R-19	R-21
16" o.c.	R-0 (none)	0.352	0.132	0.124	0.118	0.109	0.106
	R-1	0.260	0.117	0.111	0.106	0.099	0.096
	R-2	0.207	0.105	0.100	0.096	0.090	0.087
	R-3	0.171	0.095	0.091	0.087	0.082	0.080
	R-4	0.146	0.087	0.083	0.080	0.076	0.074
	R-5	0.128	0.080	0.077	0.074	0.071	0.069
	R-6	0.113	0.074	0.071	0.069	0.066	0.065
	R-7	0.102	0.069	0.066	0.065	0.062	0.061
	R-8	0.092	0.064	0.062	0.061	0.058	0.057
	R-9	0.084	0.060	0.059	0.057	0.055	0.054
	R-10	0.078	0.057	0.055	0.054	0.052	0.051
	R-11	0.072	0.054	0.052	0.051	0.050	0.049
	R-12	0.067	0.051	0.050	0.049	0.047	0.047
	R-13	0.063	0.049	0.048	0.047	0.045	0.045
	R-14	0.059	0.046	0.045	0.045	0.043	0.043
	R-15	0.056	0.044	0.043	0.043	0.041	0.041
	R-20	0.044	0.036	0.036	0.035	0.034	0.034

Much better performance of insulation!

R-18.2

Table A103.3.6.1(1) -- Overall Assembly U-factors for Metal Stud Walls

Table C402.1.3 Alternate Prescriptive R-value Table

Assemblies with continuous insulation (see definition)	Alternate option for assemblies with metal penetrations, greater than 0.04% but less than 0.08%	Alternate option for assemblies with metal penetrations, greater than or equal to 0.08% but less than 0.12%
R-9.5ci	R-11.9ci	R-13ci
R-11.4ci	R-14.3ci	R-15.7ci
R-13.3ci	R-16.6ci	R-18.3ci
R-15.2ci	R-19.0ci	R-21ci
R-30ci	R-38ci	R-42ci
R-38ci	R-48ci	R-53ci
R-13 + R-7.5ci	R-13 + R-9.4ci	R-13 + R-10.3ci
R-13 + R-10ci	R-13 + R-12.5ci	R-13 + R-13.8ci
R-13 + R-12.5ci	R-13 + R-15.6ci	R-13 + R-17.2ci
R-13 + R-13ci	R-13 + R-16.3ci	R-13 + R-17.9ci
R-19 + R-8.5ci	R-19 + R-10.6ci	R-19 + R-11.7ci
R-19 + R-14ci	R-19 + R-17.5ci	R-19 + R-19.2ci
R-19 + R-16ci	R-19 + R-20ci	R-19 + R-22ci
R-20 + R-3.8ci	R-20 + R-4.8ci	R-20 .+ R-5.3ci
R-21 + R-5ci	R-21 + R-6.3ci	R-21 + R-6.9ci

Prescriptive Steel-Framed Wall

Prescriptive Mix 'n Match

- Prescriptive Compliance Path
  - A project may comply by providing a combination of the two types of prescriptive values for opaque building envelope assemblies:
    - Prescriptive insulation R-values
    - Prescriptive assembly U-factors

Prescriptive Opaque U-factors

- C402.1.4 Eligible U-factors
  - The U-factors for typical construction assemblies are included in Appendix A. These values shall be used for all calculations.
  - If an assembly is not available in Appendix A, U-factors shall be calculated per ASHRAE *Handbook—Fundamentals* using framing factors listed in Appendix A. Calculated U-factors shall include the thermal bridging effects of framing materials.
- C402.1.4.1 Thermal resistance of cold-formed steel walls
  - U-factors of walls with cold-formed steel studs may be determined per Equation 4-1:

$$U = 1/[Rs + (ER)]$$

Rs = The cumulative *R*-value of the wall components along the path of heat transfer, excluding the cavity insulation and steel studs.

ER = The effective *R*-value of cavity insulation per Table C402.1.4.1.

Vertical Fenestration and Skylights

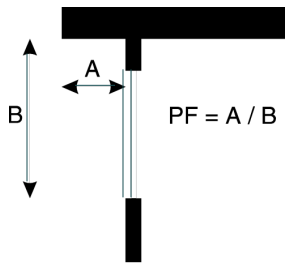
Table C402.4 - U-Factor & SHGC

CLIMATE ZONE	5 AND MARINE 4	
Vertical Fenestration		
U-Factor		
Non-metal framing (all)	U-0.30	
Metal framing (fixed)	U-0.38	
Metal framing (operable)	U-0.40	
Metal framing (entrance doors)	U-0.60	
SHGC		
Orientation	SEW	N
PF < 0.2	0.4	0.53
0.2 =< PF < 0.5	0.48	0.58
PF >= 0.5	0.64	0.64
Skylights		
U-factor	0.5	
SHGC	0.35	

- SHGC multipliers have been pre-applied.
- Area-weighting of fenestration U-Factors between ***like*** fenestration categories is allowed.

Projection Factor Calculation

- **A** = Distance measured horizontally from the furthest continuous extremity of any overhang, eave, or permanently attached shading device to the vertical surface of the glazing.
- **B** = Distance measured vertically from the bottom of the glazing to the underside of the overhang, eave, or permanently attached shading device.



Projection Factor Equation

Vertical Fenestration Area Limit & Alternates

- C402.4.1 - Prescriptive maximum area
  - ***Area Limit = 30%***
  - Calculated per gross above-grade wall area.
  - Fenestration area limit does not include opaque doors or opaque spandrel.
- Three alternates available that increase the area limit to ***40%***
  1. Substantial daylit zone area
  2. High performance fenestration
  3. NEW - High performance DOAS system
- Fenestration alternates allowed for Component Performance but not Total Building Performance.

Fenestration Alternate #1

- C402.4.1.1 With daylight responsive controls
  - In buildings not greater than ***2 stories*** above grade, no less than ***50%*** of the conditioned floor area is within the daylight zone.
  - In buildings ***3 or more stories*** above grade, no less than ***25%*** of the **net** floor area is within the daylight zone.
  - Daylight responsive controls are provided in all daylit areas.
  - Fenestration visible light transmittance meets: (VT) ≥ (SHGC)*(1.1)

Photo Source: Energy Design Resources

Fenestration Alternate #2

- C402.4.1.3 – High performance fenestration
- Maximum U-factors required
  - All non-metal framing = ~~U-0.30~~ **U-0.28**
  - Fixed metal framing = ~~U-0.38~~ **U-0.34**
  - Operable metal framing = ~~U-0.40~~ **U-0.36**
  - Metal-framed entrance doors = U-0.60
- Maximum SHGC required
  - All fenestration = ~~SHGC-0.4~~ **SHGC-0.35**
  - May be adjusted for permanent shading devices.
- Area-weighted averaging is allowed under this alternate for ***like*** fenestration product categories.

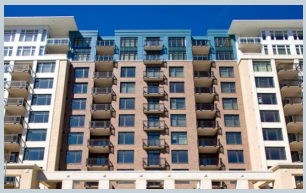
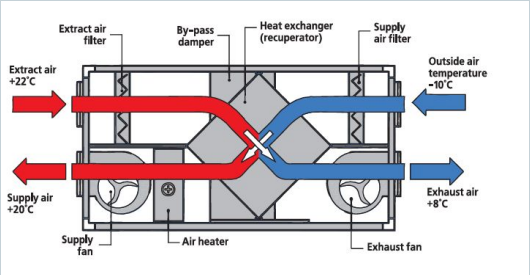


Photo Source: Mirabella Assisted Living, Seattle – www.Innotech-Windows.com

Fenestration Alternate #3

- NEW - C402.4.1.4 High performance mechanical system
  - Mechanical systems comply with all applicable requirements per C403.6 Dedicated outside air systems.
  - May not utilize any of the exceptions to C403.6



Component Performance – The Basics

- C402.1.5 Component performance UA calculation
  - U-factor * Area Trade-off Path
  - Allows one or more envelope elements that are better than Code to make up the difference for other envelope elements that do not meet Code.
  - When the percentage of fenestration exceeds the maximum allowed, the Code Target UA is adjusted to make up for the extra fenestration. (Target area adjustment)
  - Compliance forms include: ENV-UA and ENV-SHGC

Minimum skylight area for open spaces

- C402.4.2 Minimum skylight fenestration area
  - Total daylight zone under skylights shall be no less than 50% of the floor area, AND
  - Shall meet one of the two options for minimum skylight area to daylight zone area.
- Exceptions
  - Total floor area minus sidelight daylight zone area is < 2,500 sf.
  - Daylight zone under rooftop monitors is > 50% of space.
  - General area LPD is < 0.5 W/sf
  - Existing structures or natural objects impede daylight.

- Applies to spaces that meet all of the following:
  - Single story building
  - Enclosed space > ~~10,000 sf~~ ***2,500 sf***
  - Space located directly under a roof where ***at least 75%*** of the ceiling area is > 15 ft AFF
  - Required in all space types listed in Section C402.4.2.
- Skylight material haze factor must be >90% per ASTM D 1003.
- Haze factor not required for skylights with fixed or automated baffles.

Building Air Leakage

Why the emphasis on building air leakage?

- Studies have shown envelope leakage can be responsible for up ***40%*** of the ***building heating loss.***
- 2005 ASHRAE Study – Persily/Grot
  - Data from 203 US commercial and institutional buildings.
  - Findings - Overall average airtightness of ***1.55 cfm/sf*** at 0.3" w.g., similar to a typical house.
- Primary contributor of ***condensation problems*** in building envelope assemblies.
- ***Mechanical engineer's dilemma*** - When the envelope leakage rate is unknown, it is difficult to predict what HVAC system capacity is needed.


NEEC

Air Barrier Management

Fact Sheet

Funding for this Publication provided by The American Recovery and Reinvestments Act of 2009, U.S. Department of Energy
Administered by Battelle Memorial Institute, Pacific Northwest National Laboratory

OCTOBER 2011 • VOLUME 1, ISSUE 2

WHAT IS THE PURPOSE OF THIS REQUIREMENT?

Infiltration/exfiltration is uncontrolled air leakage through the building envelope. Air leakage increases building energy usage in two ways:

- ***Infiltration of cold outside air*** – This lowers the temperature within the space, causing the heating coil at the air terminal to have to produce higher temperature supply air and/or a greater volume of supply air to meet the desired space temperature. The result is an increase in heating energy.
- ***Exfiltration of conditioned indoor air*** – The loss of building air (warm or cool) has to be made up by the air handler by increasing the volume of outside air beyond what would normally be needed for ventilation. In addition, the volume of supply air needed to condition the space and maintain positive pressurization is greater. The result is an increase in fan, heating and cooling energy.

In cold climates, it has been estimated that air leakage is responsible for 45% of heating loads in office buildings.[1] Using whole-building computer simulation and benchmark models of commercial office buildings from the U.S. Department of Energy, a 12-story office building in the Seattle area could reduce its annual heating energy by 33% by scaling the building envelope to the new WSEC requirements.[2] Air leakage is also the main contributor to condensation problems in building envelope assemblies and it is also linked to increased wind-driven rain penetration problems. Since 2008 the US Army Corps of Engineers has been requiring air leakage testing on new facilities and a maximum air leakage rate of 0.25 cfm/sq ft tested at 0.3 in. wg. Since then, several buildings have been built with air leakage rates between 0.16 and 0.25 cfm/sq ft. The requirement has been achieved on multiple projects using traditionally available air barrier systems.

Figure 1.

WHAT DOES THE WSEC REQUIRE?

The air barrier is defined as material(s) that are assembled and joined together to provide a barrier to air leakage through the building envelope.

All Commercial and Multifamily Residential Buildings

The following is a list of key areas of the building envelope that shall be sealed, caulked, gasketed or weather-stripped to minimize air leakage:

- *Joints around manufactured and site-built fenestration and door frames;*
- *Junctions between walls and foundations, between walls at building corners, between walls and structural floors or roofs, and between walls and roof or roof panels;*
- *Openings at penetrations of utility services through the roofs, walls and floors;*
- *Building assemblies used as ducts or plenums;*
- *Joints, seams and penetrations of vapor retarders;*
- *Recessed lighting fixtures;*

In a sample of 203 commercial buildings, the average measured air leakage was 1.55 cfm per square foot of above grade envelope area when tested at 0.3 inch w.g. (1.57 psf, 75 Pa) pressure difference.

2009 Washington State Energy Code (WSEC)

Air Leakage Provisions in the WSEC

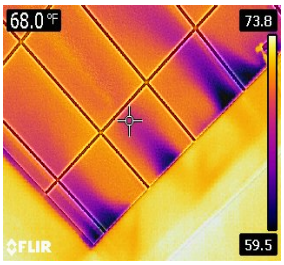
- ***Continuous air barrier*** Prevents passage of air through the envelope
- Building entrance ***vestibules***
- Low leakage ***motorized dampers*** on outdoor air supply inlets, exhaust openings, relief outlets, return openings & stairway/shaft vents
- Sealed ***recessed lighting***
- ***Building air leakage test***

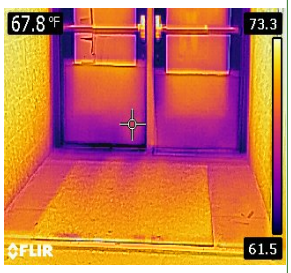
"Passionate air barrier installer!"

Photo Source & Quote – Spray-Tech

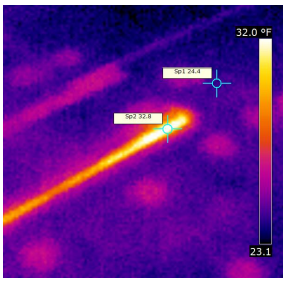
Air Leakage Testing

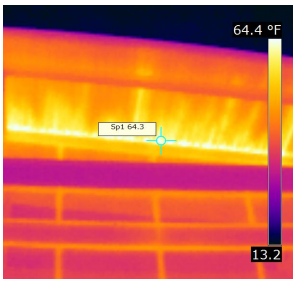
- C402.5.1.2 Building test
  - ***Required for all commercial buildings regardless of size***
  - Target - Air leakage rate of ***0.4 cfm/SF*** at 0.3 w.g.
  - Testing method - ASTM E 779 Includes method for using HVAC systems to perform test.
  - Inspection - ***The building may fail the test.*** Requires inspection of all air barrier elements, measures taken to seal leaks as practicable, and a follow-up report.

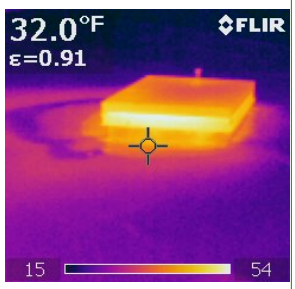




Air Barrier Leaks Under 0.3" Negative & Positive Pressure







Photos courtesy of TestComm

Responsibilities of Team Members

- Architect
  - The architect specifies the air barrier material for each assembly, details all transitions, and defines the air barrier enclosure.
- Mechanical Engineer
  - Specifies low leakage motorized dampers where required.
  - If air barrier testing will be performed with HVAC system fan pressurization, engineer designs system to accommodate.
- General Contractor
  - Air barrier testing may occur anytime during the construction schedule when the air barrier enclosure is complete. Include sufficient time in the schedule for testing and diagnostics.
- Sub-Contractors
  - Inform ***all*** subs that any unsealed penetration through the air barrier can impact building air leakage performance.

NEW! Section C406

Additional Efficiency Package Options

- Buildings shall comply with no less than ***two*** of the following options:
  - **Enhanced envelope performance**
  - **Reduced air infiltration**
  - More efficient HVAC equipment efficiency
  - Dedicated outside air system (DOAS)
  - High efficiency service water heating
  - Reduced lighting power density
  - Enhanced lighting controls
  - On-site renewable energy

Enhanced envelope performance

Reduced air infiltration

- C406.8 Enhanced envelope
  - The total U-factor * Area (UA) of the building thermal envelope shall be 15% lower than the maximum allowed UA based on Code target U-factors.
- C406.9 Reduced air infiltration
  - The measured air leakage rate of the building envelope ***does not exceed 0.25 cfm/SF***.
  - Testing shall be performed by an independent third party.
  - The air leakage report shall be provided to the Code official and the building owner.

Lighting Systems

Lighting power allowance

- C405.4.1 Interior lighting power
  - Lighting power allowances have been lowered ***20-25%*** across the board. This includes:
    - Table C405.4.2(1) Building Area Method Allowances
    - Table C405.4.2(2) Space-By-Space Method Allowances
  - Also includes additional wattage allowances for retail spaces.
- C405.5.2 Exterior building lighting power
  - Lighting power allowances for *Uncovered Parking Areas* and *Building Facades* have been lowered. All others unchanged.
  - C405.5.1 Exterior building grounds lighting greater than 100 watts
    - Minimum efficacy requirement has been increased to *80 lumens per watt* unless fixture is controlled by a motion sensor.

NEW! Section C406

Additional Efficiency Package Options

- Buildings shall comply with no less than ***two*** of the following options:
  - Enhanced envelope performance
  - Reduced air infiltration
  - More efficient HVAC performance
  - Dedicated outside air system (DOAS)
  - High efficiency service water heating
  - **Reduced lighting power density**
  - Enhanced lighting controls
  - On-site renewable energy

Lighting power density

- C406.3 Reduced lighting power density
  - There are two required elements to complete this option:
    1. Total interior lighting power of the building is equal to or less than 75% of the LPAs under Building Area Method or Space-By-Space Method.
    2. No less than 95% of permanently installed fixtures in dwelling units and sleeping units have an efficacy of at least 60 lumens per watt.

Promoting New Technology

- Luminaire Level Lighting Controls (LLLC)
  - **Definition** - A lighting system consisting of one or more luminaire(s) each with embedded lighting control logic, occupancy and ambient light sensors, local or central wireless networking capabilities, and local override switching capability.
  - They offer 40-60% savings compared with non-controlled fixtures.
  - Embedding lighting controls into luminaires reduces costs and simplifies installation and commissioning compared with traditional controls that are separate from the luminaires.
  - LLLC allows each luminaire to function independently – provides individual controllability and the potential for increased energy savings.

Promoting New Technology

- C405.2 Lighting controls, New exception
  - LLLC can be used in lieu of all other required lighting controls provide they have:
    - Occupancy sensor capability.
    - Ambient light monitoring capability (both electric and daylight) that lightens or dims lighting to the desired light level.
    - Configured for control of all required performance parameters at each individual fixture.

Photo Source – Energy Trust of Oregon

Occupancy Sensors

- C405.2.1 Occupancy sensor controls
  - The list of spaces requiring occupancy sensors has been expanded.
  - C405.2.1.1 Occupant sensor control function has not changed.
    - Classrooms, ***lecture & training rooms***
    - Conference, meeting ***& multipurpose rooms***
    - Copy/print rooms
    - ***Lounges***
    - Employee lunch and break rooms
    - Private offices
    - Storage rooms
    - Janitorial closets
    - Restrooms
    - ***Locker rooms***
    - Warehouse spaces
    - Other enclosed spaces 300 sf or less

Photo Source – Leviton

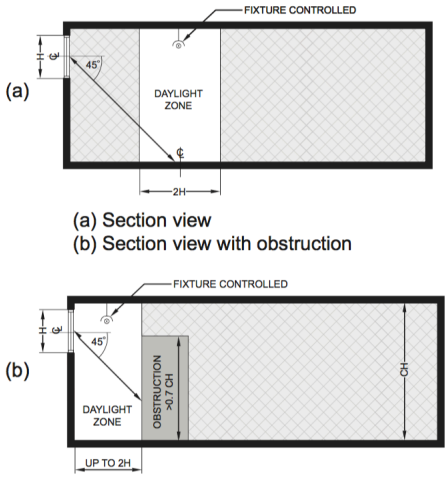
Occupancy sensors

- C405.2.1.2 Occupant sensor control function in warehouses
  - Lighting in aisleways and open areas shall be controlled with occupancy sensors that automatically reduce lighting power by not less than 50% when these spaces are unoccupied.

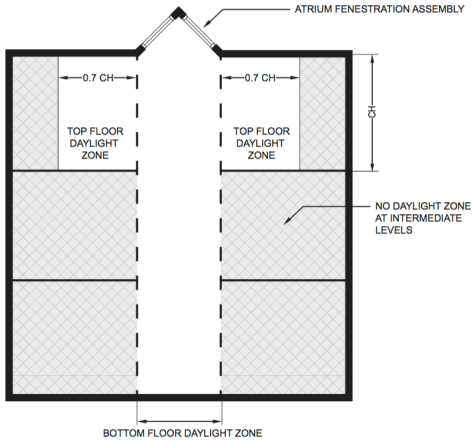
Daylight zones

- Daylight zone diagrams have been moved from Chapter 2 to Section C405. Several diagrams have been revised.
  - Figure C405.2.4.2(1) Adjacent to fenestration in a wall
  - Figure C405.2.4.2(2) Under a rooftop monitor
  - Figure C405.2.4.2(3) Under a sloped rooftop monitor
  - Figure C405.2.4.2(4) Adjacent to clerestory fenestration in a wall
  - Figure C405.2.4.3(1) Under a rooftop fenestration assembly
  - Figure C405.2.4.3(2) Under atrium fenestration

Daylight zone adjacent to clerestory fenestration



Daylight zone under atrium fenestration



Daylight responsive controls

- Areas where daylight responsive controls are required:
  - Sidelight daylight zones and toplight daylight zones that have two or more fixtures within the primary and secondary daylight zones.
  - Exceptions
    - Health care facilities where patient care is ***directly*** provided.
    - Dwelling unit and sleeping units
    - Lighting required to have specific application controls per Section C405.2.5.
    - Sidelight daylight zones on the first floor above grade in Group A-2 and Group M occupancies.
    - Daylight zones where the total proposed LPD is ***less than 35%*** of the LPA. Benefits LED lighting systems.

Daylight responsive controls

- C405.2.4.1.1 Dimming
  - Controls shall automatically reduce the power of lighting in the space while maintaining *uniform illumination*.
  - **UNIFORM ILLUMINATION.** A quality of illumination delivered by a lighting system typically comprised of similar fixtures mounted at a regular spacing interval. This lighting system provides a uniform contrast ratio of no greater that 5:1 maximum-to-minimum ratio throughout the entire area served, including task areas.
  - Dimming options:
    - Continuous dimming using dimming ballasts/dimming drivers and daylight sensing automatic controls.
    - Stepped dimming using multi-level switching and daylight sensing controls.
  - Continuous dimming is required in ***offices, classrooms, laboratories and library reading rooms***.

NEW! Section C406

Additional Efficiency Package Options

- Buildings shall comply with no less than ***two*** of the following options:
  - Enhanced envelope performance
  - Reduced air infiltration
  - More efficient HVAC performance
  - Dedicated outside air system (DOAS)
  - High efficiency service water heating
  - Reduced lighting power density
  - **Enhanced digital lighting controls**
  - On-site renewable energy

Digital lighting controls

- C406.4 Enhanced digital lighting controls
  - No less than 90% of all installed lighting power shall have the following enhanced control functions:
    1. Luminaires are configured for continuous dimming.
    2. Each luminaire is individually addressed.

Compliance Forms

2015 WSEC Commercial Provisions – Compliance Forms

Projects that are permitted on or after July 1, 2016 shall use the 2015 WSEC Commercial Provisions Compliance Forms to document compliance with this Code. The 2015 WSEC compliance forms are available for free to download.

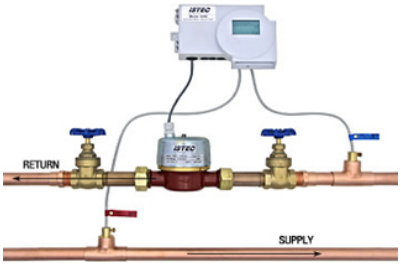
Announcement – ***New and expanded 2015 WSEC Envelope and Lighting Compliance forms are now available!*** Envelope workbook updates include a new section in PROJ-SUM to document C406 additional efficiency package options, and new methods in the ENV forms to document projects with multiple space conditioning categories and to calculate total building WWR and SRR for additions and existing building retrofits. In addition, ENV forms now support compliance documentation for refrigerated spaces. Lighting workbook improvements support exterior lighting systems and lighting retrofit projects.

- Building Envelope (**MS Excel** 435k, Updated 10-18-17)
- Lighting (**MS Excel** 264k, Updated 11-9-17)
- Mechanical (**MS Excel** 407k, Updated 1-10-17)

NOTE – New documentation procedure requires that a PROJ-SUM form accompany all compliance form submittals. This includes Lighting and Mechanical compliance forms submitted independently from the Building Envelope compliance forms. Refer to Building Envelope Excel workbook for the PROJ-SUM form.

Energy Metering

Energy Metering



Benefits of Energy Metering & Monitoring

- *"What do a building's energy meters and an automobile's gages for speed, gas, oil, water and engine temperature have in common? They control nothing, but provide vital information to help a design engineer or operator maximize equipment operations."*
- Recommended resource – Plourde, Jim. *"Making the Case for Energy Metering"* ASHRAE Journal, April 2011

Energy metering

- C409 - Buildings shall be equipped to ***measure, monitor, record and display*** energy consumption data for each energy source and end use category defined in C409.
- ***All the necessary elements for effective energy management.***
- Metering categories:
  - C409.2 Energy source
  - C409.3 Energy end-use
- Required for all new buildings and additions with a gross conditioned floor area greater than **50,000 SF**.
- Exceptions:
  - Tenant spaces less than 50,000 SF if the tenant space has its own utility service and meters.
  - Buildings where the largest gross conditioned floor area is 25,000 SF or less, including common areas.

Energy metering in existing buildings

C409.5 - When do energy metering provision apply to existing building upgrades and system retrofits?

- Alterations, renovations or repairs
  - All new or replacement systems and equipment if energy metering was required by the WSEC when the building was constructed.
- Additions in small buildings
  - Small buildings originally exempt from the metering provisions when constructed that undergo an addition that adds at least **25,000 SF**.

Energy source metering

- C409.2 Energy sources:
  - Electrical energy
  - Natural gas and liquid fuels
  - District energy
  - Site generated renewable
- Exceptions:
  - If end use metering accounts for all usage of that energy type
  - Solid fuels are not metered.
- Collect data for the whole building or each separately metered portion of the building.
- C405.7 – Individual dwelling units in Group R-2 shall have a separate electric meter.

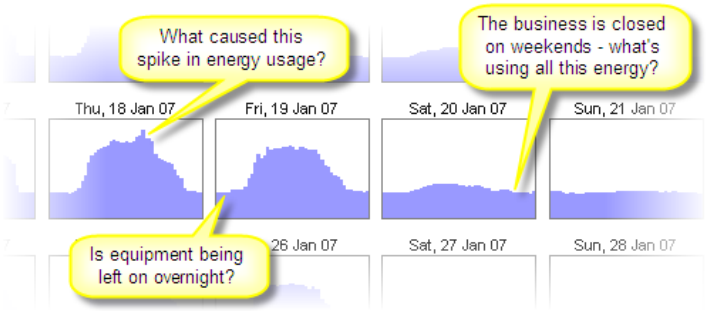
- ***Electrical energy*** - Supplied to the building and its site. Includes site lighting, parking, recreational facilities, and other areas that serve the building.
- ***Liquid fuels*** – Includes diesel, fuel oil and propane.
- ***District energy*** – Net energy from district steam systems, chilled water loops, hot water systems, or other energy sources serving multiple buildings.
- ***Renewable energy*** – Net energy generated from on-site solar, wind, geothermal, tidal or other natural sources.

Energy end-use metering

- C409.3 Energy end-use
  - All HVAC equipment that provide space heating and cooling, dehumidification and ventilation.
  - All service hot water heating systems if system capacity is greater than 50 kW (170 MBH).
  - Collect data for the whole building or each separately metered portion of the building.
- C404.9 - Group R-2 spaces with a central service hot water system shall meter domestic hot water usage of each individual dwelling unit.

- Energy end-use metering not required for:
  - Lighting systems or plug loads
  - Energy used for process loads
  - 120 volt equipment and 208/120 volt equipment where the main service is 480/277.
  - HVAC and service water heating equipment serving individual dwelling & sleeping units.
- Multiple meters may be used for an end-use category, provided that the data acquisition system totals all of the energy used by that category.

Energy Consumption Management



Sample energy metering data output – Source: BizEE Energy Lens

Energy consumption management

- C409.4 Measurement devices, data acquisition system and energy display
- Meters:
  - Shall have local display or capability to automatically communicate data to acquisition system.
  - Provides at least hourly data.
  - Current sensors or flow meters are allowed for end-use metering.
  - Source meters shall be digital.
- Data acquisition:
  - Shall provide real-time energy consumption data.
  - Shall store required data for a minimum of 36 months.
- Energy display shall be:
  - A readily accessible and visible on-site display, OR
  - A web page, OR
  - An electronic source accessible directly to building management, OR
  - Accessible to a third party service who then makes the information readily accessible to building O&M personnel.

Controlled Receptacles

Plug load management

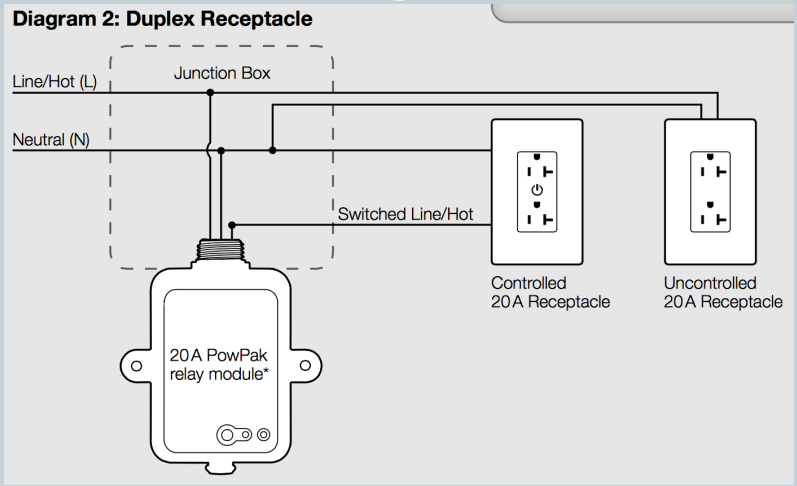


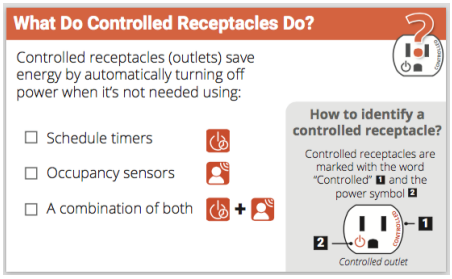
Diagram Source – Leviton Controlled Receptacles

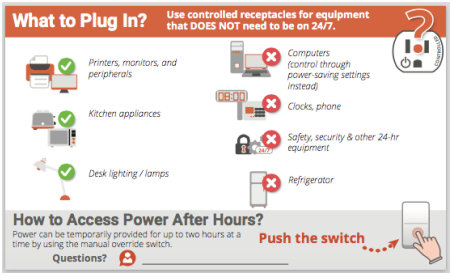
Plug load management

- C405.10 Controlled receptacles
  - At least 50% of all 120 volt 15- and 20-ampere receptacles shall be controlled receptacles.
  - Products available include duplex and split receptacles.
  - Required in private and open offices, conference rooms, print/copy rooms, break rooms, individual workstations and classrooms.
  - Controlled receptacles shall be located within 72-inches of an uncontrolled receptacle and shall be visibly differentiated.
  - Acceptable control options:
    - Occupancy sensor turns off receptacle when no occupants have been detected for 20 minutes.
    - Time of day control device that turns off receptacle at programmed times.

Educational Resources

The City of Seattle has controlled receptacle guides available for Occupants, Designers and Building Operators





2015 WSEC Survival Guide

WSEC COMMERCIAL UPDATE

LISA ROSENOW
LISA.ROSENOW@NEEC.NET
(206) 624-0283

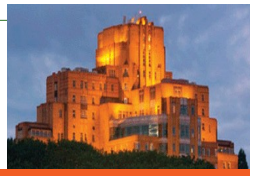
NEEC Northwest Energy Efficiency Council

ICC PREFERRED EDUCATION PROVIDER

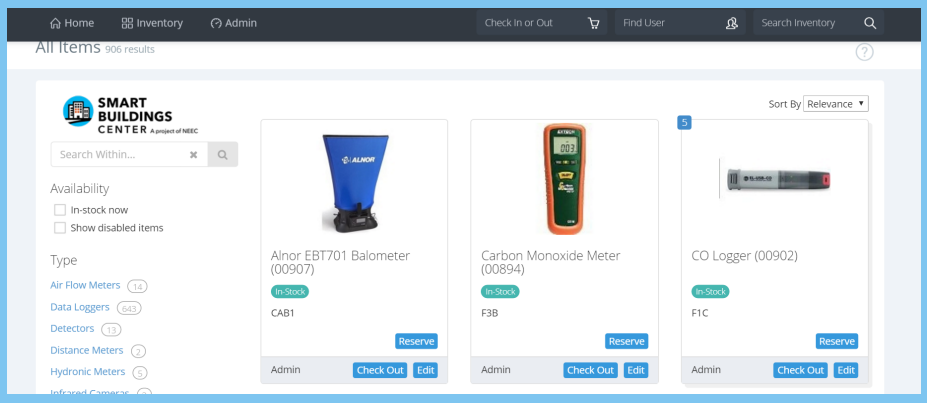
SMART BUILDINGS CENTER A project of NEEC

SMART BUILDINGS CENTER A project of NEEC

Smart Buildings Center
1200 12th Ave. S., Suite 110
Seattle, WA 98144



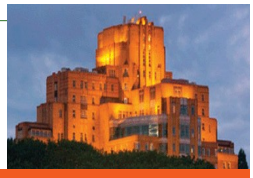
TOOL LENDING LIBRARY



HTTP://WWW.SMARTBUILDINGSCENTER.ORG/TOOL-LIBRARY/

SMART BUILDINGS CENTER A project of NEEC

Smart Buildings Center
1200 12th Ave. S., Suite 110
Seattle, WA 98144



TOOL LENDING LIBRARY

Tool Lending Library at the SBC

FREE!!

- 85 tool types
- Online reservation system
- Loan period up to 4 weeks
- Local pickup or shipped
- Open Tuesday-Thursday 9am to 4pm

CONTACT:
- **Duane Lewellen, Project Director**
- 206-538-0856
- duane.lewellen@smartbuildingscenter.org

2015 WSEC SURVIVAL GUIDE

Commercial Mechanical & Service Water Heating Provisions

Topics we'll discuss this afternoon ~

- ✓ Dedicated Outside Air Systems (DOAS)
- ✓ Variable Air Volume (VAV) Systems
- ✓ Economizer Requirements & Exceptions
- ✓ Efficient Fan Systems
- ✓ Objectives of Mechanical Controls
- ✓ Refrigerated Spaces and Systems
- ✓ Service Water Heating & Distribution
- ✓ Commissioning
- ✓ Additional Efficiency Package Options

NEEC Northwest Energy Efficiency Council

ICC Preferred Education Provider

SMART BUILDINGS CENTER A project of NEEC

Mechanical Systems

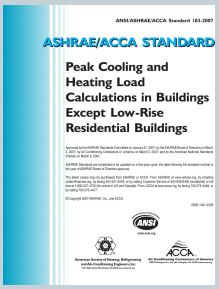
- C403.1 – Mechanical scope
- C403.2 – Mandatory "*must do*" provisions applicable to all mechanical systems
  - Load calculations & right sizing
  - Equipment efficiencies
  - Required system elements & controls
  - Ductwork & piping insulation
- Prescriptive "*can model out of*" provisions
  - C403.3 – Economizers
  - C403.4 – Hydronic and multiple-zone HVAC controls and equipment
  - C403.5 – Energy recovery
  - C403.6 – Dedicated outside air systems
  - C403.7 – High-performance VAV

Change in terminology

- In most instances in the 2015 WSEC, the term "*capable of*" has been changed to "*configured to*"
  - **Interpretation of "capable of"** – A WSEC required element only needs to have the capability of operating in a particular way or performing at a particular level.
  - **Interpretation of "configured to"** –***Element shall operate or perform as the WSEC requires.*** Significant increase in stringency depending on the provision.

Design Loads and Right Sizing

- C403.2.1 Heating & cooling load calcs
  - Design loads associated with heating, ventilating and air conditioning.
  - ASHRAE Standard 183 or approved equivalent method
  - Adjust to account for load reduction via energy recovery systems.



- C403.2.2 Equipment & system sizing
  - ***Heating & cooling output capacity shall be no greater than the smallest available equipment size that exceeds the calculated loads.***
  - Packaged equipment that provides both heating and cooling can meet the right sizing criteria for the peak operating condition, either heating or cooling, does not have to meet both.

Efficient Fan System Provisions

- There are five provisions associated with efficient fan operation ~
  1) C403.2.11.1 Allowable fan motor horsepower
  2) C403.2.11.2 Motor nameplate horsepower
  3) **NEW** C403.2.11.3 Fan efficiency
  4) **NEW** C403.2.11.4 Group R occupancy exhaust fan efficacy
  5) **REVISED** C403.2.11.5 Fan airflow control

Fan Power

- C403.2.11.1 Allowable fan motor horsepower
  - Promotes good design of air distribution system to minimize system static losses and associated pressure drop.
  - Applies to systems where total nameplate hp of all fans required for the delivery and removal of conditioned air is ***greater than 5 hp***.
  - Two compliance methods - Motor nameplate hp or fan system bhp
  - Refer to Table C403.2.11.1(1) and C403.2.11.1(2) for calculations and pressure drop adjustments
- C403.2.11.2 Motor nameplate horsepower
  - Fan motor nameplate hp shall be no larger than the first available motor size greater than the design bhp.
  - Exception – May use next nameplate motor size up if:
    - Fan < 6 hp and first available size is within 50% of bhp
    - Fan ≥ 6 hp and first available size is within 30% of bhp

MECH-FANSYS Compliance Form

Mechanical Fan System Power Allowance — **MECH-FANSYS**

2015 Washington State Energy Code Compliance Forms for Commercial Buildings including R2 & R3 over 3 stories and all R1 — Revised Feb 2017

Project Title:	Fill this line out on MECH-SUM	Date	1/1/15
A separate MECH-FANSYS form must be completed for every HVAC system that exceeds the 5 hp threshold.		For Building Dept. Use	
Fan System ID	**AHU-1**		
System Supply Fan Speed Control	**VAV**	*Constant Volume (CV), Variable Air Volume (VAV), or Hospital/Lab CV system that qualifies for VAV budget per C403.2.11.1, Exception 1*	
Compliance Option	**Brake HP**	*Compliance is based upon either the fan motor nameplate horse power (Option 1), the fan brake horsepower (Option 2), or C403.7 high efficiency VAV fan brake horsepower (10% less than Option 2). The bhp calculation provides adjustments for special equipment per Table C403.2.11.1(2).*	
Fan System Supply CFM Total	**10,000**	*in Fan Equipment Schedule below, provide maximum design supply airflow rate (CFM) of all supply fans serving the conditioned space in Fan Equipment Schedule below. Fan System CFM Total is the supply airflow of the central air handler at peak design conditions. Additional volumetric air flow provided at zone fan terminals, booster fans, or through induction is not included in the supply CFM total. However, the fan power of this equipment is included in the HP and BHP calculations.* ***Fan System Supply CFM Total is automatically calculated by the form.***	

Fan Equipment Schedule

Fan ID and Location	Fan Type	Quantity of Fan Type	Total CFM (Note 1)	Total Nameplate HP (Note 2)	Total BHP (Note 3)
AHU-1 Supply	**Supply**	**1**	**10,000**	**7.5**	**6.2**
AHU-1 Return	**Return**	**1**	**7,500**	**5**	**3.8**
EF-1 Kitchen Exhaust	**Exhaust**	**1**	**2,500**	**1.5**	**1**

Note 1 - Total CFM is the maximum CFM of the listed fan(s) when operating at peak design operating conditions.
Note 2 - Total nameplate hp of the listed fan(s).
Note 3 - Total brake horsepower (bhp) of the listed fan(s) at peak design operating conditions. Not required if Nameplate HP compliance option chosen.

Total Proposed:	**14.0**	**11.0**
Total Allowance:	**15.0**	**13.0**
Compliance Message:	**COMPLIES**	

Brake Horsepower Allowance Adjustments

Device Type	Description and Location	CFM thorough this device (CFMD)	Assigned Pressure Drop, PD in w.c. (Note 6)	Calculated Pressure Drop, PD in w.c. (Note 7)	Adjustment, A in bhp (Note 8)

Total Adjustment (bhp): 0.00

Note 4 - Bhp allowance for energy recovery devices and run around coil loops includes both air streams, so the CFMD is the sum of the supply CFM and exhaust CFM if both go through the device.
Note 5 - Energy recovery effectiveness is defined as change in the enthalpy of the outdoor air supply divided by the enthalpy difference between the outdoor air and return air at design conditions.
Note 6 - Assigned pressure drop (PD) adjustment per Table C403.2.11.1(2).
Note 7 - Pressure drop (PD) adjustment shall be calculated per the applicable method defined in Table C403.2.11.1(2) based on specific system conditions.
*Note 8 - A = PD * CFMD/4131 where A is the allowed system brake horse power adjustment, PD is pressure drop allowance, and CFMD is the cfm through the device.*

Add Fan System Form

Fan Efficiency

- C403.2.11.3 Fan efficiency
  - **FAN EFFICIENCY GRADE (FEG).** A numerical rating identifying the fan's aerodynamic ability to convert shaft power, or impeller power in the case of a direct-driven fan, to air power.
  - **Fan Rating** – Fans shall have an FEG rating of 67 or higher based on manufacturer's data per AMCA 205.
  - **Fan Selection** – Fan efficiency at design operation shall be within 15% of the FEG rating of the fan.
  - Exceptions include: Single fans 5 hp or less; multiple fans in series or parallel that combined total 5 hp or less; and fans integral to package equipment.
- C405.8 Fractional hp fan motors (1/12 – 1 hp)
  - Requires ECM motors or minimum 70% motor efficiency, unless covered under efficiency Tables C405.8(3) or C405.8(4) for small fan motors.

Exhaust fan efficacy

- C403.2.11.4 Group R occupancy exhaust fan efficacy
  - Group R fans that have capacity of 400 cfm or less shall meet the efficacy requirements in Table C403.2.11.4.
  - Exceptions
    - Energy recovery ventilators
    - Domestic clothes dryer booster and range hood fans.
    - Whole house fans integrated with forced-air systems, however they shall have ECM motors if required by C405.8.

TABLE C403.2.4.11.4
MECHANICAL VENTILATION SYSTEM FAN EFFICACY

Fan location	Air Flow Rate Minimum (cfm)	Minimum Efficacy (cfm/watt)	Air Flow Rate Minimum (cfm)
Exhaust fan: Bathroom, utility room, whole house	10	1.4 cfm/watt	< 90
Exhaust fan: Bathroom, utility room, whole house	90	2.8 cfm/watt	Any

Variable fan flow control

- C403.2.11.5 Fan airflow control – Vary as a function of the load
  - Required for the following cooling systems:
    - DX cooling systems greater than or equal to 65,000 Btu/h
    - Evaporative cooling systems greater than or equal to 5 hp
  - Cooling units that control capacity based on space temperature:
    - Shall have at least 2 stages of fan control.
    - Minimum speed setting shall be 66% or less than full speed, and shall draw not more than 40% of full speed fan power.
  - Cooling units that control space temperature by adjusting airflow:
    - Shall have modulating fan control.
    - Minimum speed setting shall be 50% or less than full speed, and shall draw not more than 30% of full speed fan power.
  - Exceptions – May increase min speed to that required for ventilation.

Kitchen Hoods

Kitchen Hoods

- *Substantive Change* - C403.2.7.1 Kitchen Hoods
  - Replacement air introduced directly at the hood cavity is limited to no more than 10% of the exhaust airflow rate.
  - Conditioned supply air delivered to the space shall not exceed:
    - Ventilation rate to meet heating and cooling load, OR
    - Exhaust hood airflow minus available transfer air
  - Kitchens with total exhaust hood airflow greater than 2,000 cfm
    - Equipment listed per UL 710 AND max exhaust rate per Table C403.2.7.1
    - AND, Provide one of the following:
      - Utilize not less than 50% transfer air that would otherwise be exhausted.
      - Demand controlled ventilation system designed to provide 50% reduction in exhaust and replacement system cfm.
      - Energy recovery system with min. 40% sensible effectiveness.

Kitchen Hoods

- One hood over multiple kitchen appliances
  - Maximum allowed exhaust airflow rate is based on the highest appliance duty rating, unless the hood:
    - Utilizes not less than 75% transfer air that would otherwise be exhausted, OR
    - Is a "certified grease extractor hood" with maximum face velocity no greater than 60 fpm

Refrigeration Equipment

- Refrigerated display cases and storage cabinets
  - C410.1.1 (Prefabricated) refrigeration equipment performance
    - Shall be tested and listed to meet AHRI Standard 1200
    - Typo - ~~Table C410.2(1) & C410.2(2)~~ Table C410.1.1(1) & C410.1.1.(2)
  - C410.2.2 Site-assembled or site-constructed refrigeration equipment
    - Lighting, defrost cycle and anti-sweat heater controls requirements

Refrigeration Equipment

- Equipment serving refrigerated spaces
  - C410.2 Walk-in and warehouse cooler and freezer requirements
    - Controls and maximum allowed power draw for anti-sweat heaters
    - Requirements for evaporator and condenser fan motors less than 1 hp
  - C410.3 Refrigeration systems with remote compressors or condensers
    - Condenser design temperature and fan control requirements
    - Compressor system controls requirements
    - Typo – ~~Section C410.4.1 & C410.4.2~~ Section C410.3.1 & C410.3.2

NEW! Section C406 Additional Efficiency Package Options

- **Buildings shall comply with no less than *two* additional efficiency package options**
- **When are options required?**

  SBCC official interpretation 17-02 & 17-03 ~
  - New construction, including shell & core
  - First occupancy build-out = Tenant spaces
  - Building additions
  - Change in space conditioning or occupancy
  - Applies to all levels of space conditioning – low energy, semi-heated, conditioned, refrigerated coolers and freezers

NEW! Section C406 Additional Efficiency Package Options

- Buildings shall comply with no less than ***two*** of the following options:
  - Enhanced envelope performance
  - Reduced air infiltration
  - **More efficient HVAC performance**
  - Dedicated outside air system (DOAS)
  - High efficiency service water heating
  - Reduced lighting power density
  - Enhanced lighting controls
  - On-site renewable energy

More efficient HVAC system performance

- Three elements to complete this option ~
  1. C406.2.1 HVAC system selection
     - At least 90% of the total HVAC capacity serving the building is provided by equipment governed by the WSEC.
  2. C406.2.2 Minimum equipment efficiency
     - All equipment shall exceed all efficiency requirements by 15%. Includes cooling and heating efficiencies.
  3. C406.2.3 Minimum fan efficiency
     - Applies to all stand-alone supply, return and exhaust fans 1 hp and up.
     - Fan efficiency classification no less than FEG 71.
     - Total fan efficiency at design conditions shall be within 10% of either the maximum total efficiency of the fan or the static efficiency of the fan.

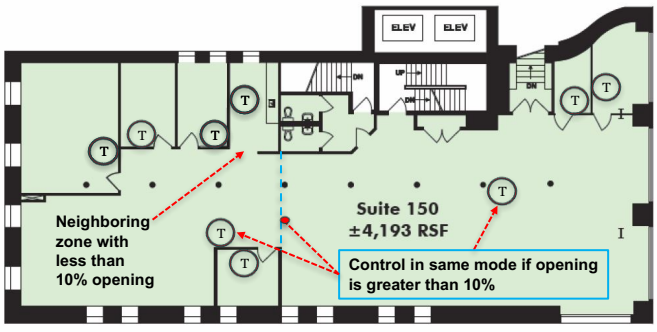
Objectives for Mechanical Controls

- **Design for off**
  - Equipment operation is based on demand
    - Zone-level call for heating and cooling
    - Occupancy and ventilation requirements
  - Methods
    - Part load - variable flow control
    - Occupancy sensors and CO2 sensors
    - Shut-off and zone isolation dampers and valves
    - Thermostatic controls that maintain a temperature deadband and prevents simultaneous heating/cooling
    - Automatic temperature reset controls based on loads, outdoor conditions, supply-to-return temperature difference

Thermostatic Zone Controls

- **REVISED** - C403.2.4.1 Thermostatic controls
  - Systems serving the same zone or neighboring zones shall be controlled to keep all systems in the same mode, either heating or cooling.
  - Avoids neighboring zones fighting each other by simultaneously being in heating and cooling mode.
  - Definition of a "neighboring zone" – Zones connected by openings larger than 10% of the floor area of either zone.
  - Exception - Where an interior zone is open to a neighboring perimeter zone, cooling may occur in the interior zone while the perimeter zone is in heating if the interior zone temperature is at least 5°F higher than the perimeter zone.

- Thermostatic Zone Controls
  - Intent is to control all zones in the same mode unless physically separated from each other by walls or doors.
  - Enclosed spaces have individual controls.
  - Multiple systems serving open areas are all controlled in the same mode of operation (heating or cooling).

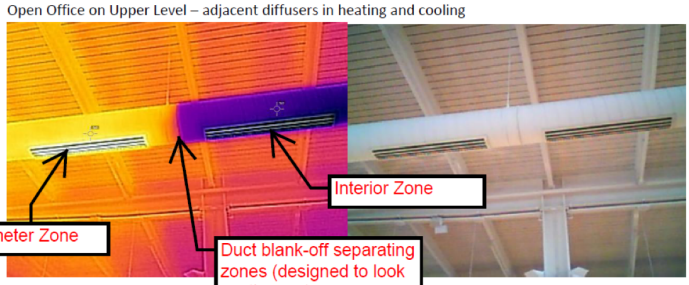


Field Audit Discovery

Example of Neighboring Zones In Opposing Conditioning Modes

Open Office on Upper Level – VAV's serving same open area operating in both heating/cooling

Open Office on Upper Level – adjacent diffusers in heating and cooling



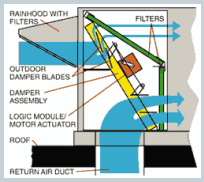
Thermal images courtesy of Hargis Engineers

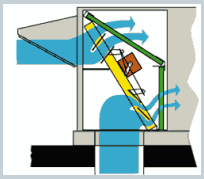
Economizer

- Prescriptive baseline – Economizer is required for all cooling systems regardless of capacity
  - Requires capability to utilize up to 100% outside air for free cooling.
  - Provisions include integrated economizer operation, fault detection and diagnostics, and high limit shut-off requirements.
- Alternatives to complying with air economizer provisions:
  - Exceptions
    - C403.3 – New construction
    - C503.4 & Table C503.4 - System replacement or alteration
  - C407 Total building performance path

Economizer Operation Monitoring

- C403.2.4.7 Economizer fault detection & diagnostics (FDD)
  - An FDD system is required for air-cooled unitary DX equipment with capacity equal to or greater than 54,000 Btu/h
  - Increases likelihood of intended operational performance over time
  - FDD system shall include:
    - Temperature monitoring sensors on all airstreams, and refrigerant pressure sensors
    - Manual initiation capability for each operating mode so all components can be tested.
    - System status of operational variables
    - Fault reporting application accessible to building operations and service personnel





Economizer Exceptions – New Construction

- **NEW** – Systems complying with C403.6 DOAS that serve spaces with internal loads for lighting and equipment < 5 watts/sf.
- **REVISED** – VRF system exception no longer limited to buildings 60,000 sf or less.
- **NEW** – Cooling equipment for spaces with year-round cooling loads > 5 watts/sf that include energy recovery system that uses waste heat for space heating or service water heating. Requires prior approval by the Code Official.
- **NEW** – Unitary or packaged systems serving a single zone that complies with efficiency requirements in Table C403.3.

TABLE C403.3
EQUIPMENT EFFICIENCY PERFORMANCE EXCEPTION FOR ECONOMIZERS

Climate Zone	Efficiency Improvement[a]
4C	64%
5B	59%

- **NEW** – Equipment used to cool Controlled Plant Growth Environments that have SEER, EER or IEER ratings that are 20% better than WSEC minimum efficiency.

- **CONTROLLED PLANT GROWTH ENVIRONMENT** – Group F and U spaces specifically controlled to facilitate and enhance plant growth and production by manipulating various indoor environmental conditions. Includes electric lighting, temperature, air quality, humidity and carbon dioxide.

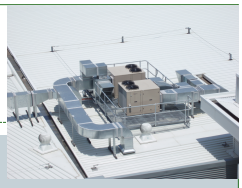
Image sources – Grow Pod Solutions & Farmed Here Indoor Farm

Economizer Exceptions – Alterations

- **NEW** - Alternate designs
  - Systems not in full compliance may be approved if code official determines existing building constraints make full compliance impractical.
  - Must be accompanied by alternate energy saving strategies that achieve a comparable level of energy efficiency as economizer.
- Exceptions designated as not eligible for shell and core, initial tenant space build-out, or C407
  - Small qualifying equipment
  - Chilled water terminal units
- Table C503.4 – Economizer options for mechanical alterations
  - Based on system type and scope of alteration
    - New or replacement equipment
    - Replacement unit is same type with same output capacity
    - Replacement unit is same type and larger output capacity
    - New equipment added to existing systems
    - Replacement unit of different type
  - Some cases less stringent than new construction exceptions
  - Section references corrected

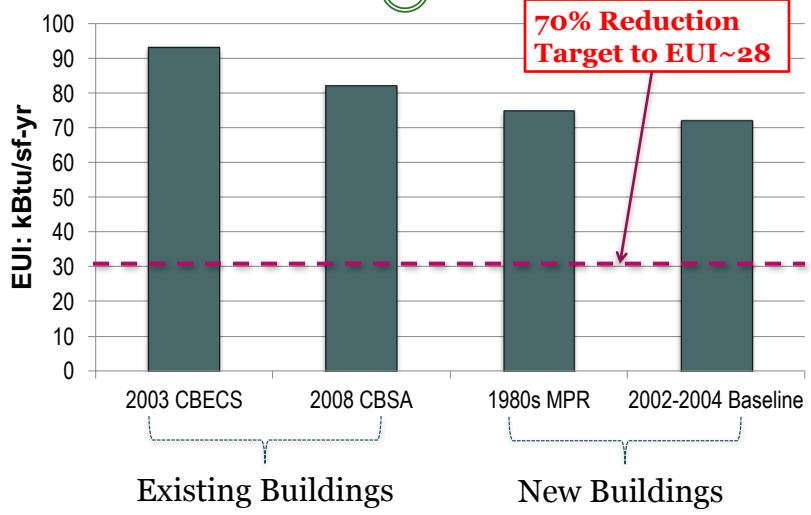
Dedicated Outside Air Systems

Traditional HVAC Systems

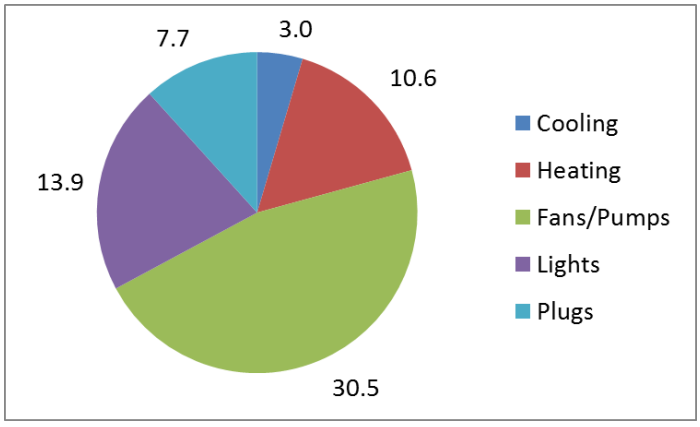


- All-in-One System
  - System sized for annual peak design heating and cooling loads, frequently operating outside optimal range.
  - Fans are on during all occupied hours to meet minimum ventilation requirements, even when there is no call for heating or cooling.
  - Zone with highest ventilation requirement drives system percentage of OSA, potentially over-ventilating other areas of the building.
- Variable-Air-Volume
  - Serves multiple temperature zones with a single central system and terminal units that vary primary supply air to each zone.
  - Offers a means of providing simultaneous heating and cooling to meet diverse space conditioning demands of multiple zones.
  - Zone with highest cooling demand drives central supply air temperature, often requiring substantial reheat for all other zones.

Office Buildings - EUI



Typical Medium Office Building



HVAC is 2/3 of energy use. Fan energy and heating energy are key.

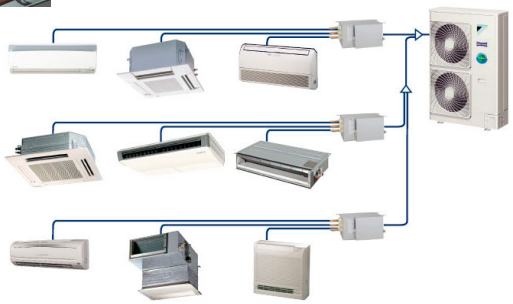
NEW Design Provisions in the WSEC

- Incremental savings approach
  - The WSEC has historically been focused on incremental improvements to equipment efficiency, controls, etc.
- Design approach
  - Mandates the type of equipment and systems that can be applied based on occupancy.
  - Promotes whole system-level efficiency improvements.
  - Includes:
    - Dedicated outdoor air systems
    - High efficiency VAV systems

NEW Design Provision - DOAS

- C403.6 Dedicated outdoor air systems
  - **Decoupled system** - A ventilation system which delivers 100% of required ventilation air directly to an occupied space independently from the heating and cooling system.
  - **Design for off** - Heating & cooling fans, circulation pumps and terminal unit fans shut-off when there is no call for heating or cooling.
  - DOAS can be effectively paired with common zonal systems such as ductless heat pumps, VRF and 4-pipe fan coils. Also combines well with radiant or chilled beam systems.

Zonal Systems



Where is DOAS required?

- **Office, retail, education, libraries, fire stations**

  SBCC official interpretation 17-09 ~

  - Applies to areas within buildings that are for office, retail and educational use.
  - Applies to *all* occupied areas within a library or fire station that are not naturally ventilated.
  - Does not apply to these types of areas if they are accessory to a building designated as a different primary use.
  - What is an accessory occupancy?

    IBC 508.2 – Occupancies that are ancillary to the main occupancy of the building or portion thereof.

    IBC 508.2.3 – Aggregate accessory occupancies shall not occupy more than 10% of the floor area of the story in which they are located.

Where is DOAS required?

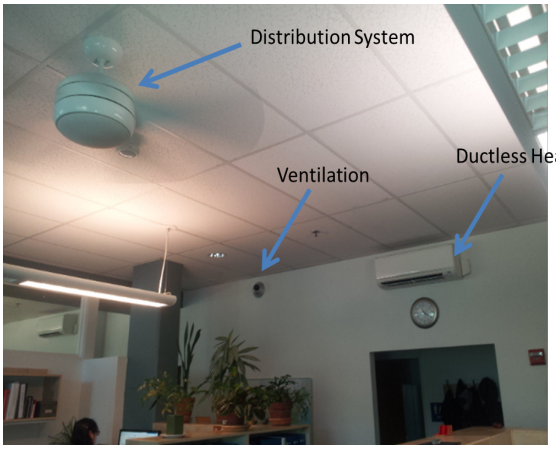
- **Office, retail, education, libraries, fire stations**

  SBCC official interpretation 17-09 ~
  - "Education" refers to classrooms and lecture use areas. Not daycare facilities or non-classroom vocational training areas.
  - "Retail" refers to areas utilized for the purpose of display and sales of goods. Does not apply to these types of areas that are accessory to the primary building use.
  - Does not apply to medical office buildings.

Question – Ventilation air mixing in zone

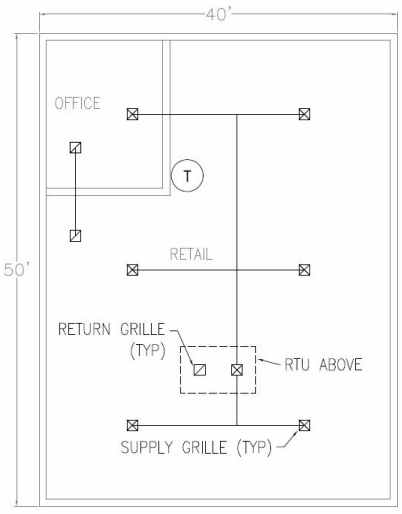
- *How do I ensure adequate mixing of ventilation air in the zone?*
  - Displacement diffusers, supply air nozzles
  - Displacement via delivery of ventilation air at the building perimeter, return exhaust air in the building core.
  - High volume, low velocity (HVLV) ceiling fans
  - C403.6.2 Exception allows heating and cooling fans to be used for destratification and mixing when system is in setpoint deadband if energy used by the fan is less than ***0.12 watts/cfm***.

Dedicated Outdoor Air System

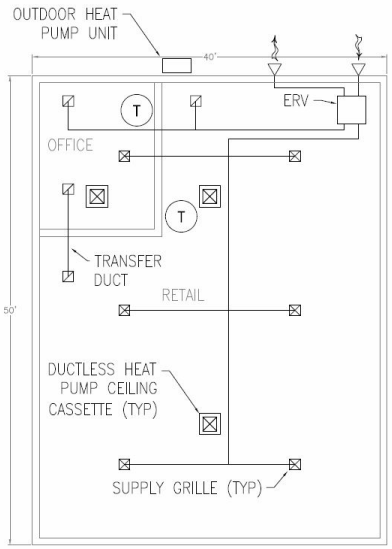


Energy and Cost Savings Potential

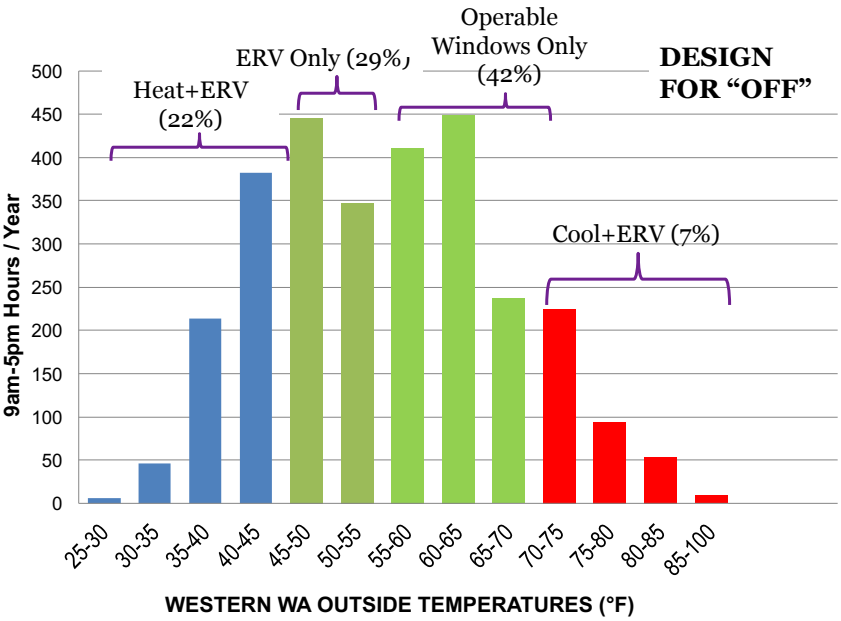
- Only Energy or Heat Recovery Ventilator (ERV/HRV) is on during all occupied hours.
- Zonal heating and cooling system turns off when there is no call for heating or cooling.



Typical Rooftop Unit System



DOAS Equivalent

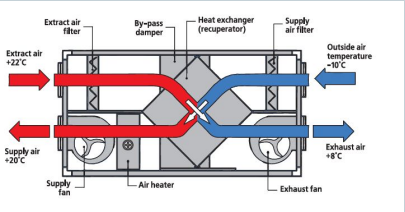


DOAS Energy Recovery

- C403.6.1 Energy recovery ventilation with DOAS
  - Energy recovery is required for all DOAS systems unless eligible for an exception. (Disregard "either" in the provision language - typo.)
  - Minimum required ER effectiveness is ***50% change of enthalpy*** between outdoor air and return air per C403.5.1.
  - Exception for systems that solely provide make-up air for systems exhausting toxic, flammable, paint, corrosive fumes, dust, dryer exhaust or commercial kitchen hoods.
  - ENERGY RECOVERY VENTILATION SYSTEM. *Systems that employ air-to-air heat exchangers to recover energy from exhaust air for the purpose of preheating, precooling, humidifying or dehumidifying outdoor ventilation air prior to supplying the air to a space, either directly or as part of an HVAC system.*

DOAS Energy Recovery

- Various system options
  - Typical occupancy spaces can comply with this provision with energy recovery (sensible + latent) or heat recovery (sensible only) ventilators, provided they meet the required ER effectiveness
  - A run-around loop between OSA intake and exhaust fans, or (refrigerant-based) heat pipe systems may also comply with this provision, provided they meet the required ER effectiveness



Exception for DOAS Energy Recovery

- C403.6.1 Exception for high occupancy spaces
  - Can utilize a demand controlled ventilation system in lieu of energy recovery if occupant density > 25 people per 1,000 sf, **AND**
  - System is under the thresholds where C403.5 Energy Recovery Ventilation Systems would normally be required.
    - Minimum ventilation is 5,000 cfm or less, OR
    - Design ventilation and supply airflow rates not per Tables ☛

TABLE C403.5.1(1)
ENERGY RECOVERY REQUIREMENT
(VENTILATION SYSTEMS OPERATING LESS THAN 8,000 HOURS PER YEAR)

CLIMATE ZONE	PERCENT (%) OUTDOOR AIR AT FULL DESIGN AIRFLOW RATE							
	≥ 10% and < 20%	≥ 20% and < 30%	≥ 30% and < 40%	≥ 40% and < 50%	≥ 50% and < 60%	≥ 60% and < 70%	≥70% and < 80%	≥ 80%
	DESIGN SUPPLY FAN AIRFLOW RATE (cfm)							
4C, 5B	NR	NR	NR	NR	NR	NR	≥5000	≥ 5000

NR = not required

TABLE C403.5.1(2)
ENERGY RECOVERY REQUIREMENT
(VENTILATION SYSTEMS OPERATING NOT LESS 8,000 HOURS PER YEAR)

CLIMATE ZONE	PERCENT (%) OUTDOOR AIR AT FULL DESIGN AIRFLOW RATE							
	≥ 10% and < 20%	≥ 20% and < 30%	≥ 30% and < 40%	≥ 40% and < 50%	≥ 50% and < 60%	≥ 60% and < 70%	≥70% and < 80%	≥ 80%
	DESIGN SUPPLY FAN AIRFLOW RATE (cfm)							
4C	NR	≥ 19500	≥ 9000	≥ 5000	≥ 4000	≥ 3000	≥ 1500	≥ 0
5B	≥ 2500	≥ 2000	≥ 1000	≥ 500	≥ 0	≥ 0	≥ 0	≥ 0

DCV and Occupancy Sensors

- C403.2.6.2 Demand controlled ventilation
  - Required in spaces > 500 sf, with occupant density > 25 people per 1,000 sf, that is also served by systems with one or more of following:
    - Airside economizer
    - Automatic modulating control of outdoor air damper
    - Design outdoor airflow > 3,000 cfm
  - Several exceptions including ***systems with energy recovery per C403.5.1***.
- C403.2.6.3 Occupancy sensors
  - Required in classrooms, gyms, auditoriums and conf rooms > 500 sf
  - Closes outside air damper or turns off serving equipment when space is unoccupied.

Question – Controls in a classroom

- *DCV is not required if DOAS has heat recovery. However, occupancy sensors are still required to close off ventilation air when the space is not occupied. In a classroom building, this can lead to a lot of control dampers and complications with building pressurization. If DOAS has energy recovery can the DCV exception also apply to the occupancy sensor requirement?*
- **No.** Occupancy sensors are required.
- ***Simplifying controls option*** – Serve each classroom with it's own ERV so when the classroom is unoccupied the ERV can shut-off, versus having to vary the speed of a central system.

Economizer Exception for DOAS

- **NEW** – Systems complying with C403.6 DOAS that serve spaces with internal loads for lighting and equipment < 5 watts/sf.
- *Question – What system(s) does this exception apply to?*
  - The original intent was to apply this exception to both the heating & cooling system and the DOAS serving the space.
  - Official interpretation inquiry on it's way…
- Other inter-related exceptions:
  - **REVISED** – VRF system exception no longer limited to buildings 60,000 sf or less.
  - **NEW** – Unitary or packaged systems serving a single zone that complies with efficiency requirements Table C403.3.

TABLE C403.3
EQUIPMENT EFFICIENCY PERFORMANCE EXCEPTION FOR ECONOMIZERS

Climate Zone	Efficiency Improvement[a]
4C	64%
5B	59%

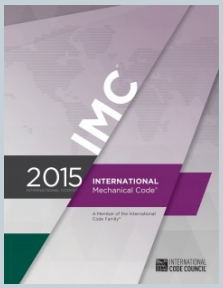
(i.e. Ductless heat pumps)

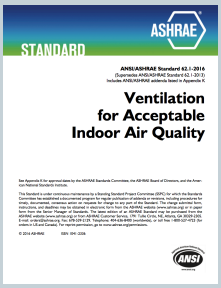
Energy Recovery Bypass

- C403.6.1 Energy recovery ventilation with DOAS
  - Requires DOAS to have energy recovery bypass, "*where applicable,*" per C403.5.1.
- C403.5.1 Energy recovery ventilation systems
  - *"Where air economizer is required, the ER system shall include a bypass that permits operation of economizer per C403.3."*
  - ***Unofficial interpretation*** – Only systems where the economizer exception is not taken, and the design OSA exceeds the thresholds of C403.5.1 *Energy recovery ventilation,* have to comply with this requirement.
  - Realistically, energy recovery bypass is only available in larger DOAS equipment where there is the highest potential for quasi-economizer savings.

Ventilation

- C403.2.6 Ventilation
  - 2015 IMC Section C403.2 minimum ventilation rates
    - IMC Table 403.3 Minimum Ventilation Rates
    - WA State Amendment allows ASHRAE 62.1 as an alternate method
    - Requires ventilation calculations





- Systems shall be ***configured*** *to* provide no greater than ***150%*** of the required min ventilation rate to the area that the system serves per 2015 IMC or other applicable code (OSHA, WAC), whichever is greater.
- Exception – ***Systems that comply with C403.5.1 Energy recovery***

Questions – Ventilation air sizing & tempering

- *Can ventilation air from a DOAS be heated or cooled before delivering it to the zone?*
  - Code does not prohibit DOAS with integral heating and/or cooling capacity sized to adequately temper outside air.
  - ***Strategy:*** Oversize the heat exchanger in ERV/HRV to achieve high thermal effectiveness to accomplish near neutral temperature ventilation air.
- *If a DOAS serving multiple zones has energy recovery, can the ventilation capacity of this system be over-sized?*
  - **Yes.** Per C403.2.6 Ventilation Exception 4 the 150% rule does not apply in this case.
  - However, an over-sized DOAS with heating & cooling capacity that serves multiples zones triggers the C403.4.4 VAV requirement…

VAV Systems Serving Multiple Zones

- C403.4.4 Mechanical systems serving multiple zones
  - ***Supply air system serving multiple zones shall be VAV***
  - During periods of occupancy, system shall be configured to reduce primary air supply to each zone before reheating, recooling or mixing.
  - Code lists various allowable control options and exceptions to VAV control.
- *Question - How do I avoid opening that can o' worms!?*
  - Hint: Don't oversize the ventilation capacity.
  - Exception 4.2 – Zones without DDC where the volume of air reheated, recooled or remixed is < required ventilation rate per IMC C403.2.
  - Exception 5.1.2 – Zones with DDC where the airflow rate in deadband between heating and cooling does not exceed the required ventilation rate per IMC C403.2.

When is DOAS required in mechanical alterations?

- **Starting point** – All new systems installed in an existing building, and existing systems that are altered or replaced, shall comply with the current Code including DOAS provisions.
- ***Then it depends on the scope of the mechanical system alteration…***
  - Upgrading a portion of an existing system?
  - Replacing a heating only system?
  - Changing to different cooling system type?
  - Replacing cooling system like-for-like?
  - Adding cooling to a space not previously cooled?

Mechanical Alterations

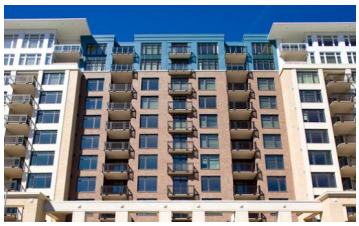
- Scenario #1 - Existing system is altered or part of system replaced
  - ***System not required to be modified to comply with C403.6.***
  - Examples: Fan motor upgrade, distribution system revision to support a space reconfiguration.
- Scenario #2 – Heating only system replacement
  - ***No alternatives mentioned in C503.4, shall comply with C403 including DOAS if serving applicable area type.***
- Scenario #3 – Mechanical cooling equipment replacement
  - ***Shall comply with C403.6 DOAS or C403.3.1 Integrated Economizer controls***
  - Includes changing to a different cooling system type and like-for-like cooling system replacement.

Mechanical Alterations

- Scenario #4 - Cooling is added to space not previously cooled
  - ***Shall comply with C403.6 DOAS or C403.3 Economizer***
  - Exceptions:
    - Alternate design strategies that provide equivalent energy savings, if existing building constraints make full compliance impractical.
    - Qualifying small equipment with 15% higher than Code SEER and EER
    - Chilled water terminals served by chilled water generation equipment with 25% higher than Code IPLV.
- **When can I use Table C503.4?** ***Good question!***
  - *"Other alterations that do not comply with C403~~.2~~.6 or C403.3 shall comply with Table C503.4."* *(We thinks this is a typo)*
  - Suggests that the lower requirements in this table may be allowable, confirm with jurisdiction. Official interpretation inquiry on it's way…

Other provisions inter-related to DOAS

- **Fenestration Prescriptive Alternates**
  - Design alternates that allow a building to have up to 40% prescriptive window-to-wall ratio.
  - Standard prescriptive limit is 30% WWR.
  - **NEW Alternate** - Buildings served by dedicated outside air systems that comply with all applicable DOAS requirements.
  - May not utilize any of the exceptions to C403.6 DOAS



DOAS Additional Efficiency Package Option

- **C406.6 DOAS Option**
  - Not less than 90% of conditioned floor area is served by a dedicated outdoor air system.
  - Unoccupied spaces that do not require ventilation are not included in the conditioned floor area calculation.
  - This option is available to both buildings subject to and not subject to the prescriptive requirements of Section C403.6.
  - ***Double Dip!*** - If project is required by C403.6 to have DOAS systems, this can also be applied as one of the required Options.

Question - Low cost solutions?

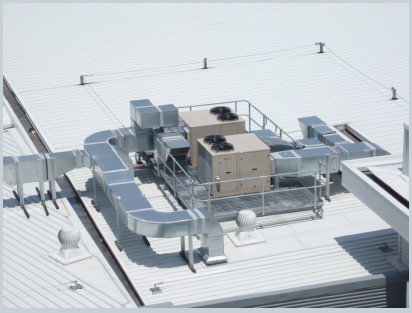
- *"For my client who wants just a plain old VAV/reheat system, what low cost DOAS options do I suggest for:"*
  - **10 story office building** – Floor-by-floor ERVs with VRF fan coils for heating/cooling. Fan coils can potentially be used for destratification/room air mixing if 0.12 watts/cfm at lowest setting.
  - **2 story elementary with gym and library** – ERVs and ductless heat pumps in each classroom, DOAS paired with packaged rooftop air handlers (with economizer for best energy savings potential) for larger zones.
  - **Single-story strip mall with spaces not yet leased out (likely 2/3 retail and 1/3 restaurant)** – ***Ideas?***
  - ***Strategy: Reduce mechanical costs even more by incorporating natural ventilation.***

NEW Design Provision - DOAS

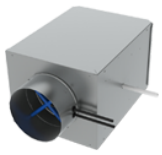
- C403.6 Exceptions and alternatives
  - Occupied spaces that are naturally ventilated per IMC 402.
  - C403.7 High efficiency variable air volume (VAV) systems are an approved alternative to DOAS.
  - C403.6.3 Impracticality clause allows Code Official to approve alternate method of compliance that achieves a comparable level of energy efficiency as a DOAS system.
- Delayed adoption
  - The DOAS provision is optional through 6/30/2017.
  - It becomes a prescriptive requirement on 7/1/2017.

Traditional VAV Systems

- Variable-Air-Volume
  - Serves multiple temperature zones with a single central system and terminal units that vary primary supply air to each zone.
  - Offers a means of providing simultaneous heating and cooling to meet diverse space conditioning demands of multiple zones.
  - Zone with highest cooling demand drives central supply air temperature, often requiring substantial reheat for all other zones.

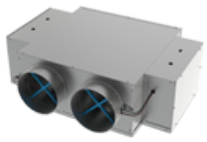


VAV Air Terminal Units



Single duct VAV terminal

- Configured to reduced primary supply air before reheating or recooling

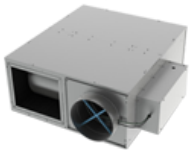


Dual duct VAV terminal

- Includes warm air and cool air duct connections
- Configured to reduce flow from one duct to minimum before mixing with air of other duct

Series fan-powered VAV terminal

- Fan is located within the primary air stream
- Used for constant air delivery
- Include hp in fan power calc



Parallel fan-powered VAV terminal

- Fan is outside the primary air stream
- Intermittent operation, usually in heating mode, not peak conditions
- Not included in fan power calc

Product images courtesy of Titus

VAV Systems Serving Multiple Zones

- C403.4.4 Mechanical systems serving multiple zones
  - ***Supply air system serving multiple zones shall be VAV***
  - During periods of occupancy, system shall be configured to reduce primary air supply to each zone before reheating, recooling or mixing.
  - Control options:
    - 30% of maximum supply air to each zone
    - 300 cfm or less if the maximum flow rate is <10% of the total fan system supply airflow
    - Minimum ventilation per 2015 IMC
    - Required airflow rates to maintain pressure relationships or air change rates as defined by other Codes or standards
  - Various exceptions available such as for systems with DDC controls meeting specific parameters, systems with on-site energy recovery, special humidity level requirements for process applications, etc

VAV Systems Serving Multiple Zones

- C403.4.4.3 Ventilation optimization controls
  - Applies to VAV systems with DDC reporting of air terminal operation to central control panel.
  - Controls configured to reduce outside air intake below design rates in response to changes in system ventilation efficiency (E_v)
  - E_v = "*The efficiency with which the system distributes air from the outdoor air intake to the breathing zone in the ventilation-critical zone, which requires the largest fraction of outdoor air in the primary air stream.*" ASHRAE 62.1
- C403.4.4.4 Supply air temperature reset
  - Controls configured to automatically reset the supply air temperature in response to the building loads or outdoor temperature.
  - System zoning is key to effective supply air temperature reset.

NEW Design Provisions - HEVAV

- C403.7 High efficiency variable air volume systems
  - This provision provides a prescriptive alternative to the DOAS requirements under C403.6, Exception 2.
  - HEVAV systems provide heating, cooling and ventilation.
  - There are 16 requirements under this provision for HPVAV.
  - ***Why so many variables compared to DOAS?***
    - Traditional VAV systems serve multiple temperature zones with a single central system by providing simultaneous heating and cooling to meet diverse space conditioning demands.
    - There are a number of energy inefficiencies with this approach.

Optimizing VAV Systems

- HEVAV system strategies that address common VAV system energy inefficiencies
  - **Fan energy use** – Fan-powered terminals often operate at constant volume, central system requires higher static distribution system.
    - *Solutions:* Lower static pressure distribution system design to minimize brake horsepower, ECM motors in VAV terminals
  - **Ventilation energy** – VAV systems often over-ventilate building to address zone with the highest ventilation requirement.
    - *Solutions:* Airflow measuring devices, dedicated VAV terminals for high occupancy spaces, ventilation rate per ASHRAE 62.1
  - **Reheat energy** – Zone with highest cooling demand often drives supply air temperature down, requiring reheat for all other zones.
    - *Solutions:* Utilize supply air temperature reset, spaces with high cooling loads served by independent systems

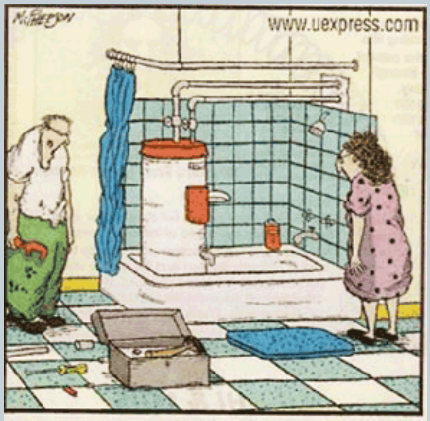
Optimizing VAV Systems

- HEVAV system strategies that address common VAV system energy inefficiencies
  - **Fault detection and diagnostics** – Airside economizer dampers and VAV terminal inlet valves are prone to failure.
    - *Solution:* FDD systems monitor operation and report issues.
  - **Central plant optimization**
    - *Strategy:* High efficiency hydronic heating *OR* cooling plant.
      - For heating ~ High efficiency boilers, air-to-water heat pump, or heat recovery chillers are required. Electric VAV is not allowed.
      - For cooling ~ High efficiency chillers are required. DX package units are not allowed.
  - **DDC Controls** – This provides the capability for advanced system optimization strategies.

Service Water Heating

Efficient Heated Service Water Supply Piping

- Energy and water is wasted when you have to run the faucet for an extended period of time to get hot water
- Methods to reduce this waste:
  1) Locate the source of hot water closer to the fixtures
  2) Reduce pipe size and water volume
  3) Use recirculating hot water or heat trace temperature maintenance systems



"OK, there! I don't want to hear anyone whining about how long it takes for the water to get hot!"

Efficient Heated Water Supply Piping

- C404.3 Sources of hot water
  - Service water heaters
  - Circulating hot water distribution systems
  - Heat trace temperature maintenance systems
- C404.3.1 Maximum allowable pipe length method
  - Use the largest pipe size in the supply piping run to determine the maximum allowed length from the source of heated water to the plumbing fixture per Table C404.3.1.
- C404.3.2 Maximum allowable pipe volume method
  - Calculate the total internal volume of all piping, fittings, valves, meters and manifolds from the source of heated water to the plumbing fixture. Refer to Table C404.3.1 for pipe volume values.

Maximum Allowable Pipe Length or Volume

TABLE C404.3.1
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
11/4	8	0.5	8
11/2	11	0.5	6
2 or larger	18	0.5	4

Per 2015 UPC Table 610.3 - Smallest pipe size for any fixture is **½"**

Public Lavatories

- Public lavatory definition per the 2015 IPC
  - Fixtures located in unrestricted toilet rooms within public buildings, schools, stadiums, hotels, restaurants, theaters, stores, office buildings, transportation stations (airports, bus, train), etc.
- Design details:
  - Minimum supply pipe size for public lavatory per 2015 UPC = ½"
  - Typical design water volume in 1-ft of ½" copper pipe = 1.5 ounces

Public Lavatories

- Methods of complying with C404.3 for public lavatories
  - Route recirculation or heat-traced piping near fixtures so point-to-point length from heated water source to lavatory does not exceed 2-ft.
  - Design distribution system so internal volume of piping & fittings from heated water source to lavatory does not exceed 2 ounces - equates to 1.33 ft of ½" pipe. (Note - More stringent than pipe length method.)
  - Provide point-of-use water heater near fixture.
- Mix and match compliance methods allowed
  - Comply via pipe length method for one branch and pipe volume method for another branch.

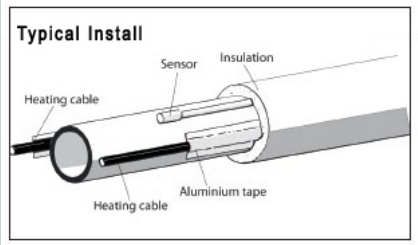
Heated-Water Circulation Systems

- C404.7.1 & C404.8 Circulation systems
  - Controls automatically start/stop pump based on demand for hot water and temperature of heated water in the circulation loop.
  - Where cold-water supply piping is used for heated service water return, controls limit temperature of water in return pipe to 104°F.
- C404.7.3 Controls for hot water storage
  - For pumps that circulate water between a water heater and storage tank, controls limit pump operation to no longer than 5 minutes after end of heating cycle.

Circulation pump with integral timer and aquastat

Temperature Maintenance Systems

- C404.7.2 Heat trace systems
  - Heat trace may be used to maintain the desired water temperature in heated service water piping systems.
  - Controls shall automatically:
    - Adjust the energy input based on the service water temperature.
    - Turn the heat trace system off when there is no hot water demand.



C404.6 Piping Insulation

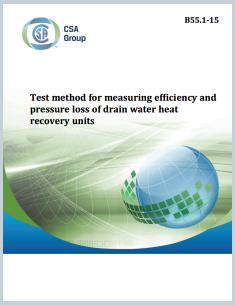
- Piping from the water heater to the termination of the heated service water supply to the fixtures shall be insulated per Table C403.2.9

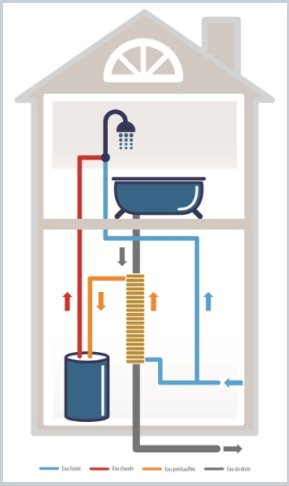
TABLE C403.2.9
MINIMUM PIPE INSULATION THICKNESS (thickness in inches)[a]

FLUID OPERATING TEMPERATURE RANGE AND USAGE (°F)	INSULATION CONDUCTIVITY		NOMINAL PIPE OR TUBE SIZE (inches)				
	Conductivity Btu · in./(h · ft² · °F)[b]	Mean Rating Temperature, °F	< 1	1 to < 1-1/2	1-1/2 to < 4	4 to < 8	≥ 8
> 350	0.32 – 0.34	250	4.5	5.0	5.0	5.0	5.0
251 – 350	0.29 – 0.32	200	3.0	4.0	4.5	4.5	4.5
201 – 250	0.27 – 0.30	150	2.5	2.5	2.5	3.0	3.0
141 – 200	0.25 – 0.29	125	1.5	1.5	2.0	2.0	2.0
105 – 140	0.21 – 0.28	100	1.0	1.0	1.5	1.5	1.5
40 – 60	0.21 – 0.27	75	0.5	0.5	1.0	1.0	1.0
< 40	0.20 – 0.26	75	0.5	1.0	1.0	1.0	1.5

Promoting New Technology

- C404.10 Drain water heat recovery
  - Systems that capture waste heat from waste line to pre-heat potable domestic hot water.
  - Applicable standard – CSA B55.1





NEW! Section C406

Additional Efficiency Package Options

- Buildings shall comply with no less than ***two*** of the following options:
  - Enhanced envelope performance
  - Reduced air infiltration
  - More efficient HVAC performance
  - Dedicated outside air system (DOAS)
  - **High efficiency service water heating**
  - Reduced lighting power density
  - Enhanced lighting controls
  - On-site renewable energy

Reduced Energy Use in Service Water Heating

- C406.7.2 Load fraction
  - At least 60% of annual building service water heating energy use shall be provided by one of more of the following:
    1) Heat pump water heating technology with COP of 3.0
    2) Solar water heating system
    3) Waste heat recovery from:
       - Service hot water
       - Heat recovery chillers
       - Building equipment
       - Process equipment
       - Combined heat & power
  - At least 90% of the conditioned floor area is Group A-2, A-3, Group I-2, Group F, or Group R-1 or R-2.
  - *SBCC Official Interpretation 17-05* ~ Does not include Group I-1 assisted living.
  - Shall cover 100% of annual building service hot water energy use if project is subject to Section C403.5.4 for condenser heat recovery.

Commissioning

Purpose and Value of Commissioning

- **How does it save energy?**
  - Verifies operational details and records are correct and complete ~
    - System configurations
    - HVAC air and water system balancing
    - Sensor calibration – Occupancy, temperature, energy, etc
    - Controls are not just capable of but "*configured to*" operate per Code
    - Testing documentation and O&M manuals
  - Systems not operating as designed and per WSEC requirements often have higher energy consumption than if the technologies were excluded from the project altogether.

Certified Commissioning Professional

- Who can perform commissioning services?
  - Qualified individuals who have received certification through an approved accrediting organization per ANSI/ISO/IEC 17024:2012.
  - Licensed professional engineer in WA State **WSR 16-24-070**
  - If engineer is employed by the same company as the engineer of record, a Conflict Management Plan is required.

Conflict Management Plan

- C408.1.2, Item 4 - In-House Commissioning Disclosure & Conflict Management Plan
  - Required when commissioning professional is an employee of the project design firm or contractor.
  - Discloses commissioning professional's contractual relationship with other team members.
  - Defines process assuring the commissioning professional is free to identify any issues discovered and report this information directly to the owner or owner's representative.

When is commissioning required?

- C408.2 Mechanical Equipment & Controls
  - **Per Unit Threshold** – All mechanical systems included in the project - no individual capacity minimum.
  - **Per Building Threshold** – Total installed building mechanical system capacity is equal to or greater than ***240 kBtu/h*** (20 tons) of cooling or ***300 kBtu/h*** of heating.
  - 2012 WSEC - 480 kBtu/h cooling & 600 Btu/h heating
- C408.2 Refrigeration Equipment & Controls **WSR 16-24-070**
  - **Per Unit Threshold** – All refrigeration systems included in the project that are not listed appliances (self-contained or remote condensing systems). No individual capacity minimum.
  - **Per Building Threshold** – All refrigeration systems - no building capacity threshold defined.

When is commissioning required?

- C408.3 Lighting Controls
  - **Per Unit Threshold** – All automatic lighting controls included in the project.
  - **Per Building Threshold** – Total installed building lighting load is equal to or greater than 20 kW.

    Qualifier – If lighting load is less than 20kW, but 10 kW or more of this load is controlled by occupancy sensors or automatic controls, Cx is required.

When is commissioning required?

- C408.4 Service Water Heating
  - **Per Unit Threshold** – All service water heating systems included in the project - no individual capacity minimum.
  - **Per Building Threshold** – If any service water heating system in the building has capacity of 200 kBtu/h (58,562 W) or more.

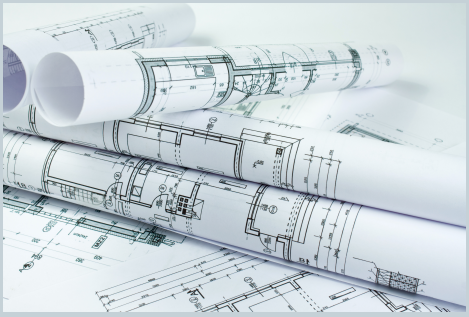
    Qualifier – Cx is require for all service water heating system serving pools or permanently-installed spas, regardless of capacity.
- C408.6 Energy Metering
  - **Per Unit Threshold** – All metering devices and reporting systems include in the project.
  - **Per Building Threshold** – Same as thresholds per C409.

Building System Retrofit Commissioning

- **Retrofit Cx Scope**
  - Cx requirements apply to additions and retrofits where existing equipment and systems are being altered or replaced.
  - Does not apply to repairs.
  - Scope includes system elements that are directly affected by the retrofit.
- **Benefits**
  - Cx was incorporated into the **????** WSEC, thus many existing systems were not formally commissioned.
  - Retrofit Cx provides the opportunity to optimize the affected existing systems.
  - Ensures new equipment & systems are correctly integrated with existing-to-remain systems.

Cx included in project scope

- C408.1.1 Commissioning in construction documents
  - WSEC requires that commissioning requirements for all disciplines be clearly documented in the construction documents (project plans).
  - May refer to specifications for further detail.



Commissioning Plan and Reports

- C408.1.2 Commissioning plan
  - Quality assurance plan that is designed & executed by a team chosen by the owner; it is ***not*** an inspection performed by the jurisdiction.
- C408.1.4.1 Commissioning progress (preliminary) report
  - Report organized into sections per discipline (mechanical, lighting, service water, metering) to allow for independent review.
  - Itemize deficiencies that have not been corrected at time of report.
  - Deferred test with climatic conditions required to complete tests.
  - Status of record documents, O&M manuals, systems operation training.
  - Provide report to building owner or owner's authorized agent.
- C408.1.3 Final commissioning report
  - A report provided to the building owner or owner's authorized agent after all commissioning tasks have been completed.

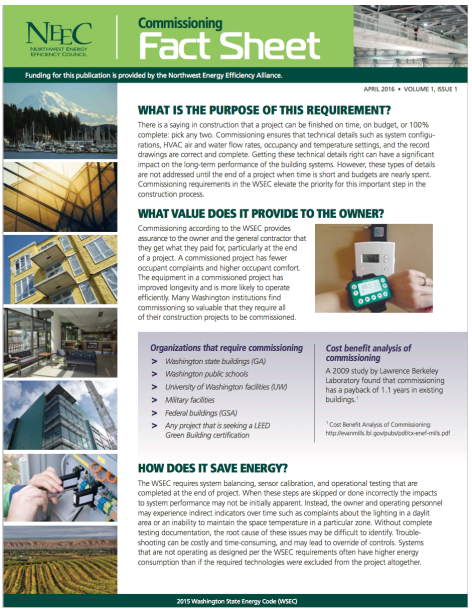
Commissioning Reports

- Prior to final inspection & issuance of Certificate of Occupancy
  - Provide to jurisdiction Figure C408.1.4.2 Commissioning Compliance Checklist, signed by Owner or Owner's Authorized Agent.
  - C408.1.4.3 Copy of report – Jurisdiction may request a copy of the progress report to verify Cx has been performed per WSEC.
  - **NEW TOOL COMING SOON!** – Commissioning checklists CX-CHK
- Small projects and retrofits
  - All required progress & final Cx activities are often finished concurrently
  - Progress and Final Reports issued together
- Large or complex projects
  - The WSEC recognizes that Cx is an on-going process that often continues post occupancy.
  - Progress Report issued prior to Certificate of Occupancy
  - Final Report issued post occupancy

NEEC Resources

NEW! Fact Sheet about Commissioning

- **Commissioning plan**
- **Documentation requirements**
- **Applicability thresholds**
- **Sample Cx plan for mechanical retrofits**



NEEC Northwest Energy Efficiency Council

Commissioning Fact Sheet

Funding for this publication is provided by the Northwest Energy Efficiency Alliance.

APRIL 2016 • VOLUME 1, ISSUE 1

WHAT IS THE PURPOSE OF THIS REQUIREMENT?

There is a saying in construction that a project can be finished on time, on budget, or 100% complete: pick any two. Commissioning ensures that technical details such as system configurations, HVAC air and water flow rates, occupancy and temperature settings, and the record drawings are correct and complete. Getting these technical details right can have a significant impact on the long-term performance of the building systems. However, these types of details are not addressed until the end of a project when time is short and budgets are nearly spent. Commissioning requirements in the WSEC elevate the priority for this important step in the construction process.

WHAT VALUE DOES IT PROVIDE TO THE OWNER?

Commissioning according to the WSEC provides assurance to the owner and the general contractor that they get what they paid for, particularly at the end of a project. A commissioned project has fewer occupant complaints and higher occupant comfort. The equipment in a commissioned project has improved longevity and is more likely to operate efficiently. Many Washington institutions find commissioning so valuable that they require all of their construction projects to be commissioned.

Organizations that require commissioning

- *Washington state buildings (GA)*
- *Washington public schools*
- *University of Washington facilities (UW)*
- *Military facilities*
- *Federal buildings (GSA)*
- *Any project that is seeking a LEED Green Building certification*

Cost benefit analysis of commissioning

A 2009 study by Lawrence Berkeley Laboratory found that commissioning has a payback of 1.1 years in existing buildings.[1]

[1] Cost Benefit Analysis of Commissioning: http://evanmills.lbl.gov/pubs/pdf/cx-enef-mills.pdf

HOW DOES IT SAVE ENERGY?

The WSEC requires system balancing, sensor calibration, and operational testing that are completed at the end of project. When these steps are skipped or done incorrectly the impacts to system performance may not be initially apparent. Instead, the owner and operating personnel may experience indirect indicators over time such as complaints about the lighting in a daylit area or an inability to maintain the space temperature in a particular zone. Without complete testing documentation, the root cause of these issues may be difficult to identify. Trouble-shooting can be costly and time-consuming, and may lead to override of controls. Systems that are not operating as designed per the WSEC requirements often have higher energy consumption than if the required technologies were excluded from the project altogether.

2015 Washington State Energy Code (WSEC)

Project Close Out

Chapter 1 Scope and Admin

- All provisions covering project close out documentation have been moved to Chapter 1, includes:
  - C103.6 – Building documentation and close out submittal requirements
  - C103.6.1 – Record documents
  - C103.6.2 – O&M manuals
    - Applies to all components, devices, equipment and systems ***governed by the WSEC***. **WSR 16-24-070**
  - **NEW** C103.6.3 – Compliance documentation including forms & calcs
  - C103.6.4 – Systems operation training

Project Close Out Documentation

- C103.6 – Building documentation & close out submittals
  - Include documentation and close out submittal requirements in the construction documents.
  - Shall be provided to the building owner within 180 days of the certificate of occupancy.
  - O&M manuals shall include:
    - Narrative of how each system is intended to operate with recommended setpoints & calibration information. **WSR 16-24-070**
    - Wiring diagrams, schematics and control sequences.
    - Routine inspection & maintenance actions and schedules.
  - For retrofit projects, including information about how new systems integrate with existing-to-remain systems can help building operations personnel address unforeseen issues.

Building Operations Staff Training

- Training shall include:
  - Hands-on demonstration of normal maintenance procedures.
  - How to check equipment operating modes relative to recommended settings.
  - Procedures for emergency shutdown and start-up.

Building operator training increases the likelihood that building systems & equipment will function optimally over time.

2015 WSEC Survival Guide

WSEC COMMERCIAL UPDATE

LISA ROSENOW
LISA.ROSENOW@NEEC.NET
(206) 624-0283

NEEC Northwest Energy Efficiency Council

ICC Preferred Education Provider

Smart Buildings Center A project of NEEC