Building To, or Beyond, Washington's Residential Energy Code: Past, Present & Future

2019 Northwest Regional Home Performance Conference

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WSU Energy Program
Washington State Residential Energy Code: Now and Future

Incremental Improvement Compared to Targets

<table>
<thead>
<tr>
<th>Year</th>
<th>Residential</th>
<th>Commercial</th>
<th>Target: 8.75% savings compared to the 2006 WSEC</th>
<th>Target: 14% savings compared to each previous code</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>2009</td>
<td>82.7%</td>
<td>86.8%</td>
<td>91%</td>
<td>86%</td>
</tr>
<tr>
<td>2012</td>
<td>76.1%</td>
<td>82.0%</td>
<td>83%</td>
<td>74%</td>
</tr>
<tr>
<td>2015</td>
<td>74%</td>
<td></td>
<td>74%</td>
<td>64%</td>
</tr>
<tr>
<td>2018</td>
<td>65%</td>
<td></td>
<td>65%</td>
<td>55%</td>
</tr>
<tr>
<td>2021</td>
<td>56%</td>
<td></td>
<td>56%</td>
<td>47%</td>
</tr>
<tr>
<td>2024</td>
<td>48%</td>
<td></td>
<td>48%</td>
<td>41%</td>
</tr>
<tr>
<td>2027</td>
<td>39%</td>
<td></td>
<td>39%</td>
<td>35%</td>
</tr>
<tr>
<td>2030</td>
<td>30%</td>
<td></td>
<td>30%</td>
<td>30%</td>
</tr>
</tbody>
</table>
R101.2 Scope

Residential buildings and their associated:

- Sites
- Systems
- Equipment
- Includes R-2, R-3 and R-4 Three stories or less above grade

This code shall be the maximum and minimum energy code for residential construction in each town, city and county.

Check WSU’s Energy Code webpage for compliance tool information: www.energy.wsu.edu/code
R2, R3 and R4 Defined

- **R-2. Apartments, Convents, Sororities, etc.** Residential occupancies containing *sleeping units* or more than two *dwelling units* where the occupants are primarily permanent in nature.

- **R-3. Detached Single-Family and Duplex, Townhomes** Residential occupancies where the occupants are primarily permanent in nature and not classified as Group R-1, R-2, R-4

- **R-4. Assisted Living, Rehab Centers, Halfway Houses, etc.** Buildings for more than five but not more than 16 persons, excluding staff, who reside on a 24-hour basis in a supervised residential environment and receive *custodial care*. 
• *Chapter 1* - Scope and Administration

• *Chapter 2* – Definitions

• *Chapter 3* – Default U-Factors for Windows and Doors

• *Chapter 4* – General Requirements

• *Chapter 5* – Existing Buildings

• *Appendix A* – Default U-Factors for Various Building assemblies
R401.2 Tools for Compliance

- Prescriptive Worksheet – All Climate Zones
- Table R406.2 2015 Energy Credits (PDF)
- Glazing Schedule (area weighted U-Factor)
- Heating System Sizing Worksheet (new only)
- Total UA Alternative (if required)
- Alterations (Remodel) Worksheet
- Energy Credit Option Combination (PDF)
- Performance Approach – as required in R405
Prescriptive Form – Most Use!

### Prescriptive Energy Code Compliance for All Climate Zones in Washington

This project will use the requirements of the Prescriptive Path below and incorporate the minimum values listed. In addition, based on the size of the structure, the appropriate number of additional credits are checked as chosen by the permit applicant.

<table>
<thead>
<tr>
<th>Authenticated Representative</th>
<th>Date</th>
</tr>
</thead>
</table>

#### Table: Prescriptive Path

<table>
<thead>
<tr>
<th>All Climate Zones</th>
<th>R-Value**</th>
<th>U-Factor*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fenestration U-Factor</td>
<td>n/a</td>
<td>0.30</td>
</tr>
<tr>
<td>Skylight U-Factor</td>
<td>n/a</td>
<td>0.50</td>
</tr>
<tr>
<td>Glazed Fenestration SHGC**</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Ceiling*</td>
<td>R-14</td>
<td>0.04</td>
</tr>
<tr>
<td>Wood Frame Wall**</td>
<td>21 in.</td>
<td>0.066</td>
</tr>
<tr>
<td>Mass Wall R-Value</td>
<td>2421”</td>
<td>0.056</td>
</tr>
<tr>
<td>Floor*</td>
<td>20”</td>
<td>0.023</td>
</tr>
<tr>
<td>Slab*</td>
<td>6”</td>
<td>0.001</td>
</tr>
</tbody>
</table>

*Table R402.4.1 and Table R402.1.3 Footnotes included on Page 2

Each dwelling unit in a residential building shall comply with sufficient options from Table R410.2 so as to achieve the following minimum number of credits:

- **1. Small Dwelling Unit: 15 credits**
  - Dwelling units less than 1000 square feet in conditioned floor area or less than 200 square feet of fenestration area. Additional credits may be earned by limiting floor area and reducing fenestration area.

- **2. Medium Dwelling Unit: 35 credits**
  - All dwelling units not included in Item 1. Exception: Dwelling units serving 2 or more occupants shall require 25 credits.

- **3. Large Dwelling Unit: 45 credits**
  - Dwelling units exceeding 5000 square feet of conditioned floor area.

- **4. Additions less than 500 square feet: 5 credits**

### Table R410.2 Summary

<table>
<thead>
<tr>
<th>Option</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a</td>
<td>Efficient Building Envelope 1a</td>
</tr>
<tr>
<td>1b</td>
<td>Efficient Building Envelope 1b</td>
</tr>
<tr>
<td>1c</td>
<td>Efficient Building Envelope 1c</td>
</tr>
<tr>
<td>2a</td>
<td>Air Leakage Control and Efficient Ventilation 2a</td>
</tr>
<tr>
<td>2b</td>
<td>Air Leakage Control and Efficient Ventilation 2b</td>
</tr>
<tr>
<td>3a</td>
<td>High Efficiency HVAC 3a</td>
</tr>
<tr>
<td>3b</td>
<td>High Efficiency HVAC 3b</td>
</tr>
<tr>
<td>3c</td>
<td>High Efficiency HVAC 3c</td>
</tr>
<tr>
<td>4</td>
<td>High Efficiency HVAC Distribution System</td>
</tr>
<tr>
<td>5a</td>
<td>Efficient Water Heating 5a</td>
</tr>
<tr>
<td>5b</td>
<td>Efficient Water Heating 5b</td>
</tr>
<tr>
<td>5c</td>
<td>Efficient Water Heating 5c</td>
</tr>
<tr>
<td>5d</td>
<td>Efficient Water Heating 5d</td>
</tr>
<tr>
<td>6</td>
<td>Renewable Electric Energy</td>
</tr>
</tbody>
</table>

Total Credits: 8.00

*Please refer to Table R410.2 for complete option descriptions.
R402.3.1
Fenestration U-Factor

• An area weighted U-Factor of all fenestration is OK for satisfying general prescriptive requirements and the prescriptive requirements of Options 1a-1d of Table 406.2
### Prescriptive Wood-Framed Construction

<table>
<thead>
<tr>
<th>Building Component</th>
<th>R-Value Table R402.1.1</th>
<th>Equivalent U-Factor Table R402.1.3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fenestration&lt;sup&gt;b&lt;/sup&gt;</td>
<td>N/A</td>
<td>0.30</td>
</tr>
<tr>
<td>Skylight&lt;sup&gt;b&lt;/sup&gt;</td>
<td>N/A</td>
<td>0.50</td>
</tr>
<tr>
<td>SHGC</td>
<td>N/R</td>
<td>N/R</td>
</tr>
<tr>
<td>Ceiling&lt;sup&gt;k&lt;/sup&gt;</td>
<td>49</td>
<td>0.026</td>
</tr>
<tr>
<td>Wood Frame Wall&lt;sup&gt;g, m, n&lt;/sup&gt;</td>
<td>21 int</td>
<td>0.056</td>
</tr>
<tr>
<td>Mass Wall&lt;sup&gt;i&lt;/sup&gt;</td>
<td>21/21</td>
<td>0.056</td>
</tr>
<tr>
<td>Floor</td>
<td>30</td>
<td>0.029</td>
</tr>
<tr>
<td>Below-Grade Wall&lt;sup&gt;c,m&lt;/sup&gt;</td>
<td>10/15/21int + TB</td>
<td>0.042</td>
</tr>
<tr>
<td>Slab&lt;sup&gt;d&lt;/sup&gt; R-Value &amp; Depth</td>
<td>10, 2 ft</td>
<td>N/A</td>
</tr>
</tbody>
</table>
R402.2.9 Slab-on-Grade Floors

- R-10 insulation from top of slab down to the top of footer or 24”, whichever comes first.

- Alternatively, R-10 from the top of the slab down to the bottom of the slab and then horizontal under the slab for a total distance of 24”.
The entire area of a **radiant slab** shall be thermally isolated from the soil with a minimum of R-10 insulation.
Below Grade Wall Insulation

- Exterior Insulation
  - R-10 Continuous
  - or

- Interior Insulation
  - R-15 Continuous
  - or

R-21 Cavity
(allowed but not recommended)
Wall vapor retarders below grade are not recommended.

R702.7 Vapor retarders. Class I or II vapor retarders are required on the interior side of frame walls in Climate Zones 5, 6, 7, 8 and Marine 4.

Exceptions:
1. Basement walls.
2. Below grade portion of any wall.
3. Construction where moisture or its freezing will not damage the materials.

2012 INTERNATIONAL RESIDENTIAL CODE®
Each dwelling unit in a residential building shall comply with sufficient options from Table R406.2 as to achieve the following minimum number of credits.

- This includes multifamily 3-stories or less

### Table 406.2

<table>
<thead>
<tr>
<th>Option</th>
<th>Description</th>
<th>Credits</th>
<th>Reduced Fuel</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Air-Conditioning and Distribution System: The equipment and distribution system components shall be installed in accordance with Section R406.2.</td>
<td>1.2</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Heat Recovery: The heat recovery shall be installed in accordance with Section R406.2.</td>
<td>0.8</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Water Heating: The water heating system shall be installed in accordance with Section R406.2.</td>
<td>0.8</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Energy Management System: The energy management system shall be installed in accordance with Section R406.2.</td>
<td>0.8</td>
<td></td>
</tr>
</tbody>
</table>

**Additional Energy Credits**

Table 406.2

Energy Credits (2015 Code)
**Additional Energy Credits**

**Small Dwelling Unit:** <1500 sf = 1.5 credits

**Medium Dwelling Units:** >1500, <5000 sf = 3.5 credits
  - 2.5 credit for MF (R2’s)

**Large Dwelling Units:** >5000 sf = 4.5 credits
  - 2.5 credit for MF (R2’s)

**Additions:** <500sf = 0.5 credits
  - *This includes multifamily 3-stories or less*
Option 1a (easy)

R-38 floor insulation

U-.28 windows

OR

Reduce the total UA by 5%

.5 Credit
Option 1b (not so easy)

R-38 floor insulation

U-.25 windows

R-21 + R-4 foam sheathing*

OR

Reduce the total UA by 15%

1.0 Credit

* Thermal Break Shear Wall: A Case Study of Rigid Foam Insulation between Frame and Sheathing
Option 1c (not easy)

- R-38 floor insulation
- U-.22 windows
- R-21 + R-12 foam sheathing

**OR**

Reduce the total UA by 30%

2.0 Credits
Continuous Insulation (CI)

Guide to Attaching Exterior Wall Coverings through Foam Sheathing to Wood or Steel Wall Framing

Released September 20, 2010
Updated December 7, 2011
Option 1d

U-.24 windows

The price is dropping quickly – shop around!

.5 Credits
Option 2a (easy?)

Reduce air leakage to 3.0 ACH50

Install good ventilation fan

.5 Credits
Option 2b (not so easy)

Reduce air leakage to 2.0 ACH50

Install HRV with efficiency of .70

1.0 Credits
Option 2c (not easy)

Reduce air leakage to 1.5 ACH50

Install HRV with efficiency of .85

1.5 Credits
Option 2c (not easy)

Reduce air leakage to 1.5 ACH50

Install HRV with efficiency of .85

1.5 Credits
Option 3ab (easy)

Install a high efficiency furnace
AFUE 94% min.

Install a high efficiency boiler
AFUE 92% min.

1.0 Credits

Footnote b. Projects may only include credit from one space heating option, 3a, 3b, 3c or 3d. When a housing unit has two pieces of equipment (i.e., two furnaces) both must meet the standard to receive the credit.
Option 3bb (easy)

Install a high efficiency heat pump

Min HSPF of 9.0

1.0 Credits

Footnote b. -Projects may only include credit from one space heating option, 3a, 3b, 3c or 3d. When a housing unit has two pieces of equipment (i.e., two furnaces) both must meet the standard to receive the credit.
Option 3c\(^b\) (expensive)

Install a ground or water source heat pump

Min COP of 3.3 (ground)
Min COP of 3.6 (water)

1.5 Credits

Footnote b. -Projects may only include credit from one space heating option, 3a, 3b, 3c or 3d. When a housing unit has two pieces of equipment (i.e., two furnaces) both must meet the standard to receive the credit.
Option 3db (easy)

Install a ductless split system heat pump

Must be home where the primary space heating system is electric zonal

Shall be installed and provide heating to the largest zone of the house

1.0 Credit

Footnote b. -Projects may only include credit from one space heating option, 3a, 3b, 3c or 3d. When a housing unit has two pieces of equipment (i.e., two furnaces) both must meet the standard to receive the credit.
Option 4 (might be easy)

All ducts, heating and cooling components inside the conditioned space. Also includes boilers and hydronic piping, radiators, etc. Coordination between builder, sub-contractors and HVAC at the design stage make this a very cost effective but rarely used option.

1.0 Credits
HVAC in Conditioned Space

http://www.energy.wsu.edu/documents/AHT_ACEEE%20Ducts%20inside%5B1%5D.pdf

Figure 1. Habitat for Humanity, Moses Lake - Duct Chase Pre- and Post-Drywall

Figure 2. New Tradition Homes – Ducts Between Floors, Pre- and Post-Drywall

Figure 6. Quadrant Homes – 2nd Floor Mechanical Room, Code (Left), Energy Star/Tax Credit (Right)

Source: Quadrant Homes
Insulation in Substantial Contact Exception (502.1.4.7)

For floor/ceiling assemblies only - not for crawl spaces
Duct Testing (R403.3.3)

Duct testing is not required when ducts and air handlers are located entirely within the building thermal envelope.

- A maximum of 10 linear feet of return ducts and 5 linear feet of supply ducts may be located outside the conditioned space and still qualify for this exception to testing.
HVAC in Conditioned Space

Building Technologies Program

Ducts in Conditioned Space

Ducts in a conditioned space are a crucial component of HVAC systems, as they are responsible for moving air throughout a building. Ensuring that these ducts are properly designed and installed is essential for maintaining the comfort and energy efficiency of a conditioned space.

Key Lessons Learned

- **The benefits of condensing blowers:** Condensing blowers can help reduce the energy consumption of HVAC systems.
- **Use of flexible ducts:** Flexible ducts can be advantageous in certain applications, such as in tight spaces or where flexibility is required.
- **Importance of proper installation:** Proper installation of ducts is crucial to ensure optimal performance and energy efficiency.

**REFERENCES**

- ASHRAE (2014). *HVAC Systems and Equipment.* ASHRAE.
Option 5a (really easy)

Install flow restrictor on kitchen faucet and shower heads

.5 Credits
Option 5b (easy)

Install gas, oil, or propane water heater. Min EF .74

No credit for electric tank less

1.0 Credits
Option 5c (easy)

Install gas, oil, or propane water heater. Min EF .91

Solar water heating

Heat Pump water heater

1.5 Credits
Option 5d (easy but expensive)

Install a drain water heat recovery unit

.5 Credits
Option 6

Onsite solar PV and wind electrical generation systems = 0.5 credit per 1200kWh of annual production, up to 3.0 Credits - Use NREL PV Watts
https://pvwatts.nrel.gov/

See WA Renewable Energy Incentive Program:
http://www.energy.wsu.edu/RenewableEnergySystemIncentiveProgram.aspx
Heating System Sizing

• The output capacity of heating and cooling equipment shall not be greater than that of the smallest available equipment size that exceeds the loads calculated, including allowable oversizing limits.
R403.7.1 Electric resistance zone heated units.

All detached one- and two-family dwellings and multiple single-family dwellings (townhouses) up to three stories in height above grade plane using electric zonal heating as the primary heat source shall install an inverter-driven ductless mini-split heat pump in the largest zone in the dwelling.*

*1.0 credits allowed

*Does not apply to R-2 construction
Programmable T-stats

• Primary (central) space conditioning systems in each dwelling unit require a programmable thermostat

• Heat Pumps with supplemental electric resistance heaters shall have strip heat lockout controls
  • Max. setting of 40°F
  • Set to 35°F or less at final inspection
R403.3.1 Insulation (Prescriptive)

Ducts outside the building thermal envelope shall be insulated to a minimum of R-8.

Ducts within a concrete slab or in the ground shall be insulated to **R-10** with insulation designed to be used below grade.
Combustion Air (R402.4.4)

• Mechanical rooms with outside combustion air are outside the building thermal envelope and shall be insulated, sealed and have a door meeting the prescriptive requirements.

• Combustion air ducts located inside the conditioned space shall be insulated to R-8
R403.5.3 Hot Water Pipe Insulation (Prescriptive)

R-3 pipe insulation required on all hot water pipes outside and within the conditioned space.
R404.1 Lighting Equipment (Mandatory)

A minimum of 75 percent of the lamps in permanently installed lighting fixtures shall be high-efficacy lamps.

HIGH-EFFICACY LAMPS. Compact fluorescent lamps, T-8 or smaller diameter linear fluorescent lamps, or lamps with a minimum efficacy of:

1. 60 lumens per watt for lamps over 40 watts;
2. 50 lumens per watt for lamps over 15 watts to 40 watts; and
3. 40 lumens per watt for lamps 15 watts or less.
R402.1.4 Total UA Alternative

- Total UA Alternative is formerly known as Component Performance (2009 WSEC).

- Default U-factors for typical construction assemblies are included in Appendix A.

- Language was added with a 15% maximum glazing area for the target house when using the “Total UA Alternative” (Component Performance). 15% is the glazing percentage in RCW 19.27A.
# UA Alternative

## Building Envelope Trade-Off

<table>
<thead>
<tr>
<th>Component Performance, R occupancies</th>
<th>Code Target Values</th>
<th>Proposed Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conditioned Floor Area</td>
<td>2,300</td>
<td></td>
</tr>
<tr>
<td>Doors U = 0.300</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overhead Glazing U = 0.500</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Vertical Glazing U = 0.300</td>
<td>345 104</td>
<td>1,628 42</td>
</tr>
<tr>
<td>Flat/Vaulted Ceilings U = 0.026</td>
<td>1,815 102</td>
<td>1,763 106</td>
</tr>
<tr>
<td>Wall (above grade) U = 0.056</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Floors U = 0.029</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Slab on Grade F = 0.540</td>
<td>222 120</td>
<td>222 120</td>
</tr>
<tr>
<td>Below Grade Wall U = 0.042</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Below Grade Slab F = 0.570</td>
<td>0</td>
<td>0</td>
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</table>

<table>
<thead>
<tr>
<th>Target UA Total</th>
<th>367</th>
<th>Proposed UA Total</th>
<th>398</th>
</tr>
</thead>
<tbody>
<tr>
<td>Target Credits from Table 406.2</td>
<td>3.5</td>
<td>Proposed Credits from Table 406.2</td>
<td>3.0</td>
</tr>
</tbody>
</table>
# Chapter 5
Existing Construction

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
<th>K</th>
<th>L</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The Washington State Energy Code requirements for alterations are located in Chapter 5. Alterations (remodels) do not need to obtain energy credits from Table R406.2.

Additions must meet the requirements for new construction. This includes nonconditioned space being altered to become conditioned space.

- **Will the wall cavities be exposed?**
  - Yes
  - No
  - If yes: Exposed wall cavities must be insulated -
    - 2x4 wall studs require R-15 insulation
    - 2x6 wall studs require R-21 insulation

- **Will the roof/ceiling framing cavities or attic be exposed?**
  - Yes
  - No
  - If yes: Exposed roof/ceiling assemblies must be insulated -
    - Vaulted ceilings: Insulate to the full depth of the framing member while allowing for the minimum 1” ventilated space
    - Flat ceilings: Install R-49 insulation or what the attic space can accommodate based on the roof pitch

- **Will the floor framing cavities be exposed?**
  - Yes
  - No
  - If yes: Exposed floor cavities must be insulated to R-30

- **Are the windows and/or doors being replaced?**
  - Yes
  - No
  - (includes both window or door and frames)
  - If yes: New windows and doors must have an area weighted average U-factor of ≤0.30

- **Will the heating or cooling system be replaced?**
  - Yes
  - No
  - If yes: New equipment must meet current requirements and ducts need to be tested

- **Will the hot water system be altered?**
  - Yes
  - No
  - If yes: New water heating equipment must meet current code requirements

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Garage Conversion to Conditioned Space

Equivalent Alternative for Under Slab Insulation

- Ceiling = R-49
- Windows/Doors = U-30
- R-5 foam - assuming 0" star wall
- R-7.5 foam
- 2x4 sheathing
Garage Conversion to Conditioned Space
Equivalent Alternative for Under Slab Insulation

Ceiling = R-49

Windows/Doors = U-30

Fur out wall to accommodate R-21

R-5 foam - assuming 6" stem wall

R-7.5 foam

2 x 4 sleepers
What Does the Code Require?

• Air sealing of all joints & seams on all ducts, air handlers, and filter boxes (See IMC 603.9 or IRC M1601.4).

• Duct testing performed & permanently documented.
  • Signed affidavit (duct tester’s responsibility)
  • Test results must be recorded on certificate for new construction (builder’s responsibility)
Resources for Standard and Testing

### Duct Leakage Affidavit (New Construction)

<table>
<thead>
<tr>
<th>Permit #:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>House address or lot number:</td>
<td></td>
</tr>
<tr>
<td>City:</td>
<td></td>
</tr>
<tr>
<td>Cond. Floor Area (ft²): Source (circle one): Plans Estimated Measured</td>
<td></td>
</tr>
<tr>
<td>Duct tightness testing is not required. The total leakage test is not required for ducts and air handlers located entirely within the building thermal envelope. Ducts located in crawl spaces do not qualify for this exception.</td>
<td></td>
</tr>
<tr>
<td>Air Handler in conditioned space? yes / no</td>
<td>Air Handler present during test? yes / no</td>
</tr>
<tr>
<td>Circle Test Method:</td>
<td>Leakage to Outside</td>
</tr>
<tr>
<td>Maximum duct leakage:</td>
<td></td>
</tr>
<tr>
<td>Post Construction, total duct leakage: (floor area x 0.04) = -------CFM@25 Pa</td>
<td></td>
</tr>
<tr>
<td>Post Construction, leakage to outdoors: (floor area x 0.04) = -------CFM@25 Pa</td>
<td></td>
</tr>
<tr>
<td>Rough-in, total duct leakage with air handler installed: (floor area x 0.04) = -------CFM@25 Pa</td>
<td></td>
</tr>
<tr>
<td>Rough-in, total duct leakage with air handler not installed: (floor area x 0.03) = -------CFM@25 Pa</td>
<td></td>
</tr>
<tr>
<td>Test Result:</td>
<td>-------CFM@25 Pa</td>
</tr>
<tr>
<td>Ring (circle one):</td>
<td>Open 1 2 3</td>
</tr>
<tr>
<td>Duct Tester Location:</td>
<td></td>
</tr>
<tr>
<td>Pressure Tap Location:</td>
<td></td>
</tr>
<tr>
<td>I certify that these duct leakage rates are accurate and determined using standard duct testing protocol</td>
<td></td>
</tr>
<tr>
<td>Company Name:</td>
<td></td>
</tr>
<tr>
<td>Duct Testing Technician:</td>
<td></td>
</tr>
<tr>
<td>Technician Signature:</td>
<td></td>
</tr>
<tr>
<td>Date:</td>
<td></td>
</tr>
<tr>
<td>Phone Number:</td>
<td></td>
</tr>
</tbody>
</table>

**W333.2.1.1 Mechanical Systems:** Where a space-conditioning system intersects the installation or replacement of space-conditioning equipment (including replacement of the air handler, addition, replacement of major or critical systems such as chillers, condensers, and heat pump units, or the removal, reconditioning, or replacement of the heat exchanger in a duct system that is connected to the new or replacement space-conditioning equipment) shall be in accordance with rules 33.01-30. The test results shall be associated with the building official and the homeowner.

**Results:**

1. Duct systems that are documented to have been previously sealed and field verified and diagnostic testing in accordance with procedures in 33.01-30.
2. Ducts with less than 40 linear feet to unconditioned space.
3. Existing duct systems that are maintained, insulated, and sealed with duct tape.
4. Air handler is less than 150 square feet test last.

### Duct Leakage Test Results (Existing Construction)

<table>
<thead>
<tr>
<th>Permit #:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>House address or lot number:</td>
<td></td>
</tr>
<tr>
<td>City:</td>
<td></td>
</tr>
<tr>
<td>Cond. Floor Area (ft²): Source (circle one): Plans Estimated Measured</td>
<td></td>
</tr>
<tr>
<td>Duct tightness testing is not required for this residence per exceptions listed at the end of this document</td>
<td></td>
</tr>
<tr>
<td>Test Result:</td>
<td>-------CFM@25 Pa</td>
</tr>
<tr>
<td>Ring (circle one):</td>
<td>Open 1 2 3</td>
</tr>
<tr>
<td>Duct Tester Location:</td>
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Two Duct Test Options:

- **Total duct leakage** measures leakage to both indoors & outdoors
- **Duct leakage to the outdoors** measures effective duct leakage to the outside
- Combines a blower door with the duct blower

Both tests provide Cubic Feet per Minute (CFM) duct leakage numbers
Duct Testing Standards:

• Leakage ≤ 4 cfm per 100 sf of conditioned floor ft² @ 25 Pa for a complete system (rough-in)

• Leakage ≤ 3 cfm per 100 sf of conditioned floor ft² @ 25 Pa if air handler has not been installed (rough-in)

• Leakage to outside ≤ 4 cfm per 100 sf of conditioned floor ft² @ 25 Pa (final)
Exceptions for Existing Houses

• Ducts with less than 40 lineal feet in unconditioned spaces

• Ducts that have been previously tested

• Ducts containing asbestos

• Ducts in additions less than 750 ft$^2$
Air Barriers and the Energy Code R402.4

What does the Energy Code require?

• Prescriptive air sealing
• Testing of the air barrier (??)
• Maximum leakage targets
  • 2015 WSEC maximum = 5 ACH\textsubscript{50} (air changes per hour) New/Additions
  • Table 406.2 credit available for tighter construction
Air Leakage Testing Exceptions

1. Additions less than 500 square feet of conditioned floor area.

2. Additions tested with the existing home having a combined maximum air leakage rate of 7 air changes per hour. To qualify for this exception, the date of construction of the existing house must be prior to the 2009 Washington State Energy Code.
Addition + existing house = 7.0 ACH

Addition only = 5.0 ACH
Prescriptive Requirements

- Table R402.4.1.1 – Air Barrier and Insulation Installation
- Include checklist of each building component with:
- QA = who, what, when & how?  = < ACH50
Where required by the **code official**, testing shall be conducted by an **approved** third party. A written report of the results of the test shall be signed by the party conducting the test and provided to the **code official**.
Ventilation Code Discrepancies
Whole House Fan Flow Rates

- IMC Table 403.8.1 is intended for multi-family
- IRC Table 1507.3.3(1) is intended for single family

TABLE 403.8.1
VENTILATION RATES FOR ALL GROUP R PRIVATE DWELLINGS, SINGLE AND MULTIPLE
(Continuously Operating Systems)

<table>
<thead>
<tr>
<th>Floor Area (ft²)</th>
<th>Bedrooms</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1</td>
<td>30</td>
</tr>
<tr>
<td>2-3</td>
<td>40</td>
</tr>
<tr>
<td>4-5</td>
<td>45</td>
</tr>
<tr>
<td>6-7</td>
<td>55</td>
</tr>
<tr>
<td>&gt;7</td>
<td>60</td>
</tr>
<tr>
<td>&lt;500</td>
<td></td>
</tr>
<tr>
<td>500 - 1000</td>
<td></td>
</tr>
<tr>
<td>1001 - 1500</td>
<td></td>
</tr>
<tr>
<td>1501 - 2000</td>
<td></td>
</tr>
</tbody>
</table>

TABLE M1507.3.3(1)
CONTINUOUS WHOLE-HOUSE MECHANICAL VENTILATION SYSTEM AIRFLOW RATE REQUIREMENTS

<table>
<thead>
<tr>
<th>Dwelling Unit</th>
<th>Number of Bedrooms</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0 - 1</td>
</tr>
<tr>
<td></td>
<td>2 - 3</td>
</tr>
<tr>
<td></td>
<td>4 - 5</td>
</tr>
<tr>
<td></td>
<td>6 - 7</td>
</tr>
<tr>
<td></td>
<td>&gt; 7</td>
</tr>
</tbody>
</table>

For SI: 1 square foot = 0.0929 m², 1 cubic foot per minute = 0.0004719 m³/s.
M1507.3.4.4 Ventilation openings. Each habitable space shall be provided with outdoor air inlets or operable windows with an openable area not less than 4 square inches of net free area of opening for each 10 cfm of outdoor air required by Table M1507.3.3(1).
Local Exhaust

Kitchens
- 100 cfm intermittent
- 25 cfm continuous
- Systems over 399 cfm must provide makeup air (M1503.8)
- Recirculation hood allowed if exhaust is provided for the kitchen

No Change from 2012
“Built tight, ventilate right?”
WSU Video Resource

Air Leakage in Homes: The Invisible Thief

Produced by WSU Energy Program

www.energy.wsu.edu/code
Overview

• WA State Residential Energy Code—Current Details and Changes Considered
• Home Energy Ratings Programs
• Home Energy Raters Performing Code Compliance Inspections
Benefits of Home Energy Ratings
Why Stop at Energy Code Compliance

• With rising energy costs and focus on climate change, why just meet code?

• Why not differentiate the home and builder to improve sales and rentals?

• As long as a home is inspected for code or one standards program, consider bundling with others
Home Efficiency Standards

- How do they compare?
- Which one best meets my needs?
HERS Family

- A number of the ratings use RESNET’s HERS system as a prerequisite
Home Energy Rating Score (HERS)

• Scores energy efficiency using REM/Rate software

• RESNET certifies trainers and tests raters

• RESNET providers review and register every rating, file QA on 10% of ratings, field QA on 1%

• 1.7 million homes rated

• 30+ raters in the Northwest

• WSU primary RESNET provider
Potential Benefits to Homeowners

- Improved comfort and indoor air quality
- Reduced moisture problems and noise
- Extended structural longevity and higher resale prices
- Multifamily facility owners can attract and retain renters, charge higher rent
Benefit for Builders and Developers

• Command a larger market share as market softens
• Higher home prices
• Access to program incentives, tax credits, EEMs, utility rebates
• Have more satisfied customers, fewer callbacks
• Good publicity for supporting green construction
Benefits for Raters

• Expand customer base by offering a wide selection of ratings and certifications

• Leverage existing customers by offering discounted bundles of other ratings

• Cost effective for one rater to inspect a home for multiple ratings and certifications at one time

• Helps with energy code compliance
Benefits for Regional Programs

- The more ratings that are captured in a common database, such as AXIS, the more regional programs such as NEEA may be able to:
  - Track trends and geographic penetration
  - Develop more effective new initiatives that support or augment current programs
  - Identify lessons learned that can be replicated
Potential Issues

• With over a dozen overlapping rating and certification programs, home owners and builders can be understandably confused

• Some programs lack an independent quality assurance feature and are not captured in a common database such as AXIS or RESNET Registry

• A more robust housing market diminishes willingness of builders and home owners to pay extra for ratings and certifications, especially those that are more expensive and complex
Rater Home Compliance

[Image: Inspection result with 'Passed' checked]
Current Practice

- Energy code compliance is currently performed by code officials/inspectors.
- Builders typically use the prescriptive path by selecting options from R406.2
Code Compliance Verification Options

• Home raters and code officials perform similar inspections

• ICC offers plans examination and inspection certifications for energy code compliance

• Raters using acceptable software are able to model the dwelling to show compliance. Additional documentation is then required to be generated and given to the officials/inspectors
HERS Rater Scenario

• RESNET is developing an optional rater training and certification testing for code compliance.

• WABO will greatly influence raters performing code compliance in Washington.
HERS Rater Scenario

- Raters will submit new homes to their RESNET provider for registration in the RESNET Registry.
- WSEC did not adopt IECC Section 406, so HERS ratings do not equate with code compliance.
- Research needs to determine what ERI/HERS score would reasonably equate with code compliance.
Potential Benefits of Rater Code Compliance

• Some code officials have already expressed their support for specially trained individuals performing third party compliance. Some jurisdictions currently use this method of compliance for the commercial energy code.

• Raters may be better suited to help builders work through energy code utilizing the performance path to achieve savings—although in WA this path requires 20%+ less energy use than prescriptive path.
Potential Benefits of Rater Code Compliance

• RESNET raters have specialized training and certification in energy efficient building science and will have additional training on codes.

• RESNET providers review HERS rating and provide file QA on 10% of ratings and field QA on 1%.

• RESNET is already moving toward requiring geo-tag and time/date stamps to improve credibility of testing data.
Potential Benefits of Rater Code Compliance

• Oversite organizations could better track code compliance with the use of a central registry. (RESNET Registry, AXIS database or similar software)

• Interested third party organizations (NEEA, SBCC, WABO, NEEC…) would have access to the code data to help with energy code policies.

• Unlike code officials, raters model the energy use of home as designed and provide feedback to builders on opportunities for efficiency improvement.

• Building officials/inspectors are unable to advise on which energy credits to take for compliance.

• Performance path means the home actually has to perform. Code compliance testing today, though required by code, has not been well enforced or regulated.
Potential Issues with Rater Code Compliance

• Builders will pay a new fee to raters and may not pay any less in permitting fees.
• Without the use of a database (RESNET registry), it may be problematic performing quality assurance.
• Not all geographic areas have access to a healthy rater market.
• Conflicts between raters and inspectors as codes overlap from energy to structural or mechanical codes.
• Some Raters may be influenced by other products/services they offer.
• If builders can choose a rater, the rater may try to avoid a determination of non-compliance.
Other

• Research into a better alignment of programs and codes as well as establish a well functioning ERI Index.

• Current struggle with code testing include:
  - Who is certified?
  - What is required to be approved to perform code testing?
  - Registration/list?
  - To which standard are they testing to?
  - How do you file a formal complaint about a peer?
  - Quality assurance?
Group Discussion

• Build tight ventilate right challenges as we seek tighter envelopes (M&O, labelling, and flow rates)

• How best to leverage the building science community skill sets within the PNW trained rater community to support WSEC

• Performance path in WSEC and beyond (“approved” software, GIGO, available resources to review, and AXIS data records)