Washington State Energy Code HVAC Requirements

Gary Nordeen
Luke Howard
Emily Salzberg
Rich Prill

Washington State University Extension Energy Program

U.S. Department of Energy

neea
Energy Code Support

- Residential
  - Washington State University Extension Energy Program
  - 360-956-2042
  - energycode@energy.wsu.edu
  - www.energy.wsu.edu/code
  - Gary Nordeen, Luke Howard, Emily Salzberg, Tanya Beavers

- Non-residential
  - Northwest Energy Efficiency Council
  - Lisa Rosenow
  - 206-624-0283
  - Lisa@putnamprice.com
  - www.neec.net
Purpose of this class

- Introduction to duct sealing & testing requirements for the 2009 WSEC.
- Basic understanding of the purpose of duct sealing & testing.
- Discussion of benefits of moving ducts to the inside.

Note: this class does not provide qualification for ENERGY STAR, PTCS, tax credits or other beyond code programs.
Why Do We Seal Ducts?

- Health & Safety
- Comfort
- Energy Savings
- More Durable Buildings
Implications of leaky ducts

- Leaky ducts typically raise heating and cooling costs **20% - 40%**

- This figure may **double** if the ducts are not insulated

- A conservative estimate is ducts waste over $10 billion in energy in SFR’s alone
Duct System Supply Leakage
Where is the air coming from?
Duct System Return Leakage in Heating Season
Outside – 30°

Condensing Surface

Dew Point

Inside – 70°

Warm, moist air

R-21
Duct System Return Leakage in Cooling Season
Unbalanced System

Return Air Pathway

Balanced System
Leakage & Energy Loss

- The hole needs to be connected to the outside

- Heat loss is proportional to temperature and pressure differences

- Holes that see high pressures and high temperature differences are most important for energy savings
  - **Heating Climates** this is the supply side near the air handler
  - **Cooling climates** this is the return side near the air handler
System Deficiencies

Hole at Dovetail Connection
Large hole where down drafting furnace connects to supply plenum
Terminology

- **CFM**: Cubic Feet per Minute
- **Pa**: Pascals
- **Conditioned Floor Area (CFA)**: Square footage of all heated areas
- **Manometer**: Digital pressure reading device
- **Duct Tester**: Equipment used to pressurize ducts
- **Blower Door**: Equipment used to pressurize (or depressurize) a structure
Airflow Basics

- **Airflow Requires**
  - *Driving force* (pressure or temperature difference)
  - A hole
  - Air moves from High to Low pressure areas

\[ P_1 - P_2 = \Delta P \]

Airflow \( \approx \) Hole size \( \times \) \( \Delta P \)
Air in = Air out

Perfect Duct System

1 cfm (infiltration)
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)
Duct Testing Details
What a duct tester tells us

- **Airflow in** = **airflow out**, so **flow through fan** = **flow through leaks in system**.

- **CFM_{25}** is an aggregation of all of the holes throughout the entire duct system – that’s all!
  - It doesn’t tell us where to find the holes.
  - It doesn’t tell us how much the ducts leak under normal operating conditions.
  - Without a blower door, it doesn’t tell us how much of the holes are connected to the outside.
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:

At Rough-In

- Total leakage \( \leq 6 \) cfm per 100 sf of conditioned floor area @ 25 Pa for a complete system

- Total leakage \( \leq 4 \) cfm per 100 sf of conditioned floor area @ 25 Pa if air handler has not been installed
Duct Testing Standards:

Post Construction

- **Total leakage test:** \( \leq 8 \text{ cfm per 100 sf} \)
  of conditioned floor area @ 25 Pa

- **Leakage to exterior test:** \( \leq 6 \text{ cfm per 100 sf} \)
  of conditioned floor area @ 25 Pa
Examples:

**Total leakage**
- House size: 2240 Ft$^2$
  - $2240 \times 0.08 = 179 \text{ CFM}$ maximum

**Leakage to exterior** (requires a blower door)
- House size: 2240 Ft$^2$
  - $2240 \times 0.06 = 134 \text{ CFM}$ maximum
Resources for Standard and Testing

Duct Testing Affidavit

Test Result Calculator
Duct Testing Standards

Exceptions:

Duct tightness test is not required if

- The air handler and all ducts are located within conditioned space.
  or

- The furnace is a non-condensing appliance in an unconditioned space with a maximum of 6 feet of ductwork in the unconditioned space*. 

*Note: This exception is subject to specific conditions and guidelines.
Exception Detail:

- The goal is to get condensing equipment inside the conditioned space.
- The code makes an allowance for non-condensing equipment because it is such a large portion of the market.
- A naturally drafted appliance installed inside with combustion air is not in the conditioned space anymore. Mechanical room must then be insulated.
Original
Duck Blaster
Necessary Equipment

- Duct Tester
- Manometer
- Register blocks or “mask”
Set up

- Connect duct tester to furnace cabinet or return grill
- Close/seal outside ventilation air openings
- Block (seal) all registers
- *Remove* furnace filter
- Insert static pressure tap
- Program Manometer
Seal Registers to Pressure Test
1. Insert **Static Probe** into duct
2. Point toward air flow direction
Bent tubing is *NOT* a Static Pressure Tap
Pressure meter set-up: details

- Meters measure pressures only
- Most meters will convert pressures into flow rate
- Attention to meter details is critical:
  
  Garbage in = garbage out
Other Equipment

RetroTec Meter
all the same stuff ...
Color Coded Connections
Total Duct Leakage Test

Step 1: Seal all registers and grills

Also: integrated fresh air duct sealed

Integrated fresh air duct sealed

Mask or foam blocks
Static Pressure Tap
Insert in *Supply Side* (in or near supply plenum)
Total Duct Leakage Test
Step 3: Connect Duct Blower to System

Integrated fresh air duct sealed
Total Duct Leakage Test

1. Seal all registers and grills
2. Seal fresh air duct and/or HRV
3. Install static pressure tap in supply side
4. Attach duct blower to system
5. Set up pressure gauge
6. Pressurize system to + 25 Pa
7. Record air flow into system @ + 25 Pa
8. Document set-up configurations
Duct Leakage to the **Exterior** incorporates **Blower Door**

Yields duct leakage CFM to the *exterior*
Duct Leakage to the *Exterior*

Seal and pressurize ducts to +25 Pa

Blower door pressurizes building to +25 Pa
Duct Leakage to the Exterior
Incorporates Blower Door

1. Seal all registers and grills
2. Seal fresh air duct and/or HRV
3. Install static pressure tap in supply side
4. Attach duct blower to system
5. Install blower door and close-up the house
6. Set up pressure gauges
7. Pressurize house to +25 Pa (Blower Door)
8. Pressurize duct system to +25 Pa (Duct Blower)
9. Record air flow into system @ +25 Pa
10. Document set-up configurations
Duct Sealants

- All joints, seams and connections shall be fastened and sealed.
  - See IMC 603.9 or IRC M1601.3 for details
  - Closure systems must be installed according to the manufacturer’s listing
  - Unlisted duct tape is not permitted as a sealant on any metal ducts
Duct Tape

Duct tape may be used if:

- Installed in accordance with mfg’s installation instructions
- Must contain detailed info specific to application on ducts
- Info must contain approved duct materials and surface cleaning requirements

Please let us know if you find this information from any manufacturer!
Eureka! We found one...

**TECHNICAL DATA**

Appearance ..................... Mill finish aluminum substrate with butyl adhesive/sealant
Backin ............................ Aluminum
Thickness .......................... 17 mils
Sealant Material .................. Modified Butyl
Peel Strength ..................... 7 lbs. per linear inch
Tensile Strength .................. 20 pli/1400 psi avg.
Flexibility ....................... Excellent, no cracking
Bonding Time ..................... Instant high tack, full bond 24 hours
Time to Test ..................... Immediate
Service Temperature ............. -20°F. to 200°F.

**PRECAUTIONS**

Surfaces must be clean and free of moisture and contamination. Do not apply this product in areas where temperatures will exceed 200°F. Keep out of the reach of children. Review MSDS for safety information prior to use. DO NOT use where acidic or alkaline chemicals are present (i.e., lab fume hood, vents, etc.)

For Industrial Professional Use Only.
All Joints Must Be Sealed
Mastic is NOT paint
apply “nickel thick”
What do you expect for $850,000? A good duct system?
Don’t do this!
Residential duct insulation

- Attics, crawl spaces, garages require R-8
- In slabs or underground require R-5
- On a roof or exterior of a building require R-8 and a weatherproof barrier
Duct liner

- Typical duct liner requires 2 inches to meet code
- Most duct liner is R-4 per inch
Related code changes

- Installation of ducts in exterior walls, floors, or ceilings shall not displace required insulation.

- Unlined building cavities *may not* be used as ducts.
Ducts in interior walls
Ducted return inside the house

Unlined cavity return
Related code changes (cont.)

- Duct testing required when replacing HVAC equipment, *and shall be sealed.
  - Includes:
    - Air handler replacement
    - Outdoor condensing unit (AC or HP)
    - Cooling or heating coils
    - Furnace heat exchanger

* The SBCC has issued an emergency rule effective until the end of August requiring duct testing but not sealing
Duct Testing (Existing Houses)

Field Verification Compliance Options

- Maximum leakage rates:
  - 8% CFA for *Total duct leakage*
  - 6% CFA for *Leakage to exterior*

  or

- Post installation duct leakage reduced by 50%

  or

- Verification by 3rd-party inspector that all accessible leaks have been sealed

- SBCC’s emergency rule requires testing results be documented on required affidavit with copies submitted to the building department and homeowner

Duct testing standards are posted at: [www.energy.wsu.edu/code](http://www.energy.wsu.edu/code)
Exceptions for Existing Houses:

- Ducts with less than 40 lineal feet in unconditioned spaces
- Ducts that have been previously tested
- Ducts containing asbestos
A Better Way: Move the Ducts Inside!

- Habitat for Humanity
- First WA Energy Star
- All Duct Inside
- 1000 FT2
- All Electric < $40/month
Ducts in Dropped Ceiling in Hall
After Drywall
Air Handler Inside

Supply Register In Wall
Dropped Soffit with Duct in Bathroom
Vancouver Demonstration
Duct Between Floors
Ducts between floors

High efficiency furnace inside the structure
Insulation in Substantial Contact Exception (502.1.4.7)

For floor/ceiling assemblies only - not for crawl spaces
Testing House Tightness
House Air Leakage Testing
Building Air Leakage/Tightness Testing

Closed house condition
Blower door creates negative pressure
Measure house pressure + air flow out

Use - 50 pascal pressure

High air flow @ 50 pascals = large air leakage
Low air flow @ 50 pascals = small air leakage
Measure the pressure in building

Measure the volume of air out fan

Calculate the leakage area

Estimate air exchange
Necessary Equipment

- Blower door
  - Fan
  - Panel
  - Frame

- Manometer
Set-up

- Assemble frame, place nylon canvas over frame secure in exterior door frame.
- Insert fan in panel
- Connect tubing to manometer, fan and exterior
- Properly program manometer
- Depressurize to -50Pa and record CFM
DG-700 Pressure & Flow Meter

Device Select

Mode Select

Device Configuration Select

“Input” ports

“REF” ports
<table>
<thead>
<tr>
<th>DEVICE</th>
<th>CONFIG</th>
</tr>
</thead>
<tbody>
<tr>
<td>BD 3</td>
<td>OPEN</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MODE</th>
<th>UNITS</th>
<th>CONFIG</th>
</tr>
</thead>
<tbody>
<tr>
<td>PR/FL</td>
<td>Pa</td>
<td>CFM</td>
</tr>
<tr>
<td>DEVICE</td>
<td>CONFIG</td>
<td></td>
</tr>
<tr>
<td>--------</td>
<td>--------</td>
<td></td>
</tr>
<tr>
<td>BD 3</td>
<td>OPEN</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MODE</th>
<th>UNITS</th>
<th>CONFIG</th>
<th>TIME AVG</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pa</td>
<td>CFM</td>
<td>1</td>
</tr>
<tr>
<td>PR/</td>
<td>FL</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
During Testing

- Exterior windows and doors closed
- Fireplace and stove doors closed
- Close dampers (depressurizing the house sucks gravity dampers closed)
- Plumbing traps must be filled with water or blocked in some other manner.
- Interior doors open
During Testing

- Open access hatches to conditioned attics or crawl spaces
- Exterior ventilation openings closed and sealed
- HVAC ducts and registers not sealed
- HVAC, water heater, OFF
What the numbers mean

Pressure (in Pascals)

Flow rate (CFM)
Calculating SLA

(Specific Leakage Area)

\[ SLA = \frac{\text{CFM}_{50} \times 0.055}{\text{CFA} \times 144} \]

\[ SLA = \frac{1790 \times 0.055}{2240 \times 144} \]

\[ SLA = 98.45 / 322,560 \]

\[ SLA = 0.00030 \]