Washington State Energy Code HVAC Requirements

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Purpose of this class

- Introduction to duct sealing & testing requirements for the 2015 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 Cooling Season
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

Unsealed Dovetail Connections
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 does not tell us where to find the holes
  - It does not tell us how much the ducts leak under normal operating conditions.
  - **Without a blower door, it does not 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 $\leq 4 \text{ cfm per 100 sf}$ of conditioned floor area @ 25 Pa for a complete system

• Total leakage $\leq 3 \text{ cfm per 100 sf}$ of conditioned floor area @ 25 Pa if air handler *has not been* installed
Duct Testing Standards: Post Construction

- **Total Leakage test:** $\leq 4 \text{ cfm per 100 sf}$ of conditioned floor area @ 25 Pa

- **Leakage to Exterior test:** $\leq 4 \text{ cfm per 100 sf}$ of conditioned floor area @ 25 Pa
Examples

Total leakage

- House size: 2240 Ft²

- $2240 \times 0.04 = 90 \text{ CFM}$ maximum

Leakage to exterior (requires a blower door)

- House size: 2240 Ft²

- $2240 \times 0.04 = 90 \text{ CFM}$ maximum
Resources for Standard and Testing

Duct Testing Affidavit

Test Result Calculator

Glossary
- Rough-in: After installation of the complete air distribution system but before installation of insulation and sheetrock. Allows for access to all duct seams and connections for re-evaluation of seal integrity if standard is not met in initial test.
- Post Construction: At or near final inspection. The home must be complete enough to pressurize the home to 25 Pa.
- Total Leakage: Aggregation of the entire systems duct leakage in a duct test.
- Leakage to Exterior: Aggregation of all duct system leaks to the exterior of the CFA in a duct test.
- Pascal (Pa): Unit of pressure
- CFA: Conditioned floor area in square feet
- CFM25: Cubic feet per minute of air leakage at 25 pascals of pressure
- CFM50: Cubic feet per minute of air leakage at 50 pascals of pressure
- Conditioned Volume: Volume of conditioned space (CFA x ceiling height)
- ACH50: Air changes per hour at 50 pascals of pressure
Duct Testing Standards

Exception:

Duct tightness test is **not** required if

- The air handler and all ducts are located within conditioned space.
- 10 feet of return ducts and 5 feet of supply ducts are allowed to be outside on the conditioned space.
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

Minneapolis DG-700
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

Mask or foam blocks

Integrated fresh air duct sealed
Static Pressure Tap

Insert in *Supply Side* (in or near supply plenum)
**Total Duct Leakage Test**

**Step 3: Connect Duct Blower to System**
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)**
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
- Backing: 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!
Ducts cause problems if installed incorrectly!
“The Electrician’s Revenge”
“The Plumber’s Revenge”
“Currently Unattached”
“The Perpetual Heimlich”
“I’ve Got Some Duct Tape”
Need I Say More?
Residential Duct Insulation

- Attics, crawl spaces, garages require $R-8$

- In slabs or underground require $R-10$

- On a roof or exterior of a building require $R-8$ and a weatherproof barrier
Duct Liner

• Typical duct liner requires 2.5 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.
Programmable T-stats

- Primary 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
Duct Testing for Existing Construction

- Duct testing required when replacing HVAC equipment:
  - Includes:
    - Air handler replacement
    - Outdoor condensing unit (AC or HP)
    - Cooling or heating coils
    - Furnace heat exchanger
Duct Testing for Existing Construction

- Testing must be completed by certified technician

- Results provided to homeowner and building official on affidavit
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 ft²
Duct Leakage Test Results (Existing Construction)

Permit #: ____________________________
House address or lot number: ____________________________
City: __________________ Zip: _________________________
Cond. Floor Area (ft²): __________________

☐ Duct tightness testing is not required for this residence per exceptions listed at the end of this document

Test Result: __________ CFM@25Pa

Ring (circle one): Open 1 2 3

Duct Tester Location: ____________________________
Pressure Tap Location: ____________________________

I certify that these duct leakage rates are accurate and determined using standard duct testing protocol

Company Name: ____________________________
Duct Testing Technician: ____________________________
Technician Signature: ____________________________ Date: __________________
Phone Number: ____________________________

Washington State Energy Code Reference:

R101.4.3.1 Mechanical Systems: When a space-conditioning system is altered by the installation or replacement of space-conditioning equipment (including replacement of the air handler, outdoor condensing unit of a split system air conditioner or heat pump, cooling or heating coils, or the furnace heat exchanger), the duct system that is connected to the new or replacement space-conditioning equipment shall be tested as specified in RS-33. The test results shall be provided to the building official and the homeowner.

Exceptions:
1. Duct systems that are documented to have been previously sealed as confirmed through field verification and diagnostic testing in accordance with procedures in RS-33.
2. Ducts with less than 40 linear feet in unconditioned spaces.
3. Existing duct systems constructed, insulated or sealed with insulation.
4. Additions of less than 750 square feet.
A Better Way: Move the Ducts Inside!

- Habitat for Humanity
- First WA Energy Star
- All Ducts 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
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 panel 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
BD = Blower Door
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<th>CONFIG</th>
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<table>
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• 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)
How to Calculate $\text{ACH}_{50}$

- Determine leakage rate of house with blower door (CFM @ 50 pascals)
- Calculate to volume of the house (ft$^3$)

$$\text{ACH}_{50} = (\text{CFM} \times 60) \div \text{Volume}$$
How to Calculate $ACH_{50}$

- 2,000 $\text{Ft}^2$ house
- $\text{Volume} = 16,000 \text{Ft}^3 \ (2,000 \times 8)$
- Blower door CFM = 1300 CFM
  - $ACH_{50} = (\text{CFM} \times 60) \div \text{Volume}$
  - $ACH_{50} = (1300 \times 60) \div 16,000$
  - $ACH_{50} = 78,000 \div 16,000$
  - $ACH_{50} = 4.8$