

Whole House Diagnostics for Combustion Safety

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Whole House Diagnostics for Combustion Safety

Topics Addressed in Session


- Some BIG questions.
- Impact of air handler and duct leakage.
- Impact of exhaust fans and building envelope.
- Suggested carbon monoxide emission limits.
- Worst-case draft testing.
- Causes for worst-case draft testing failure.

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The BIG Venting System Question


- The venting system ends at the top of the chimney or at the outlet at the wall.
- Where does the venting system begin for an appliance that is not direct-vent?

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More BIG Questions

- What happens to combustion supply air as homes become tighter?
- What happens to natural or fan-assisted draft as exhaust appliances become more powerful?
- Are you testing to ensure that gas appliances will draft properly under worst-case conditions?
- Are you always complying with codes?

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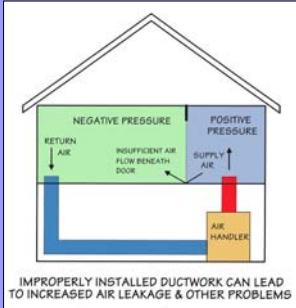
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The Impact of the Air Handler and Duct Leakage

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Impact of an Air Handler



What happens to air leakage as a result of the closed bedroom door?

What if a return is installed in the basement return trunk?

What if the supply trunk leaks to the outdoors?

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The Impact of Exhaust Fans and Building Envelope Tightness

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Blower Door

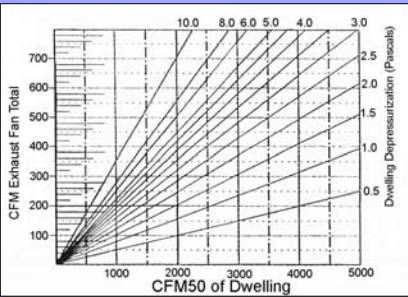


A blower door measures the tightness of a house at a level of 50 Pascals pressure difference from indoors to outdoors.

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Exhaust Fans, Negative Pressure and House Tightness



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Example of Exhaust Appliances in House

- Inventory of exhaust fans in dwelling:
 - Bath 1 = 50 CFM
 - Bath 2 = 50 CFM
 - Kitchen = 250 CFM
 - Dryer = 120 CFM
 - Total = 470 CFM**

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What Negative CAZ Pressures Are OK? (these values are suggested only)

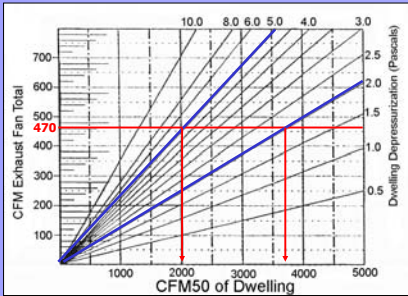
Appliance Type	Pascals
Water heater only, atmospheric gas	- 2
Atmospheric central systems and solid fuel appliances	- 5
Furnace or boiler, gas atmospheric or fan assist., Cat. I	- 5
Oil or gas unit with power burner	- 5
Induced draft appliance (fan at point of exit at wall)	- 5
Direct-vent appliances	- 10

Let's select -2 and then -5 for examples.

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Exhaust Fans, Negative Pressure and House Tightness



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American National Standard Institute (ANSI) Standards for Manufacturers

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ANSI CO Standards for Manufacturers

- Household Cooking Gas Appliances (Z21.1)
 - 800 ppm air-free after all burners operate for five minutes (range top burners have 5 pounds of water on each).
- Storage Water Heaters, 75,000 Btuh or less (Z21.10.1)
 - 400 ppm air-free for natural and induced draft and for power burners.
- Unvented Room Heaters (Z21.11.2)
 - 200 ppm air-free.
- Gas-Fired Low-Pressure Steam and Hot Water Boilers (Z21.13)
 - 400 ppm air-free.
- Gas-Fired Central Furnaces, except Direct-Vent (Z21.47)
 - 400 ppm air-free "with outlet of draft hood blocked"
- Decorative Gas Appliances for Installation in Solid-Fuel Burning Fireplaces (Z21.60)
 - 25 ppm as-measured or 400 ppm air-free.

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Suggested CO Action and Allowable Levels


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Suggested CO Limits


Carbon Monoxide (CO) Action Levels and Allowable Levels			
Appliance	Action CO Level	Allowable CO Level	Comments
Gas Furnace / Boiler	100 ppm / 200 ppm	200 ppm / 400 ppm	as-measured / air-free
Gas Water Heater	100 ppm / 200 ppm	200 ppm / 400 ppm	as-measured / air-free
Gas Range Bake Burner	800 ppm	800 ppm	air-free
Oil Furnace / Boiler	100 ppm	200 ppm	as-measured
Oil Water Heater	100 ppm	200 ppm	as-measured

Action CO Level indicates level above which repair or adjustment to appliance is recommended to lower CO emissions.
Allowable CO Level indicates maximum CO emission levels recommended.

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Measuring Carbon Monoxide (and efficiency)

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Fyrite Pro from Bacharach

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Testo 325-1


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Worst-Case Draft Testing

"Recommended Procedure for Safety Inspection of an Existing Appliance Installation" found in . . .

NFPA 54, 1999 edition, Appendix H, page 120
NFPA 54, 2002 edition, Annex H, page 138


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Worst-Case Draft Test

- Objective of test:
 - To determine if appliance(s) will draft properly under worst-case conditions.
 - To protect the occupants from the hazards of draft reversal.
 - Protect installer from liability.


Need not be performed if there are no vented appliances (especially Category 1) in the dwelling

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Worst-Case Draft Test


- Objective of test setup and procedure:
 - To create the highest negative pressure in the building that might occur under normal use.
 - To determine if combustion appliances are drafting properly during the worst-case condition.
 - To determine if combustion appliances are emitting unacceptable levels of CO during the worst-case condition.

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When to Use W-C Draft Test


- After house in tightened to save energy and/or new or replacement combustion appliances are installed.
 - Exceptions. Do not perform test in:
 - Dwellings with no combustion appliances other than unvented or direct-vented combustion appliances.
 - Dwellings with only unvented or direct-vented combustion appliances.
 - Apartments with no combustion appliances.
- Before replacement combustion appliance is installed. This is recommended when there is ductwork located in the combustion appliance zone.

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Worst-Case Draft Test Procedure

- Worst-Case Draft Test Setup.
 - Put house in winter-time condition.
 - Check furnace filter, replace if dirty.
 - Close operable vents, e.g. fireplace damper.
 - Clean lint filter in dryer.
 - Set combustion appliances to "PILOT".
 - Set up manometer (digital unit is preferred).
 - Start with cool chimney, if possible.

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Digital Manometers



DG-3 DG-2

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Worst-Case Draft Test Procedure

Combustion Appliance Zone (CAZ) Pressures

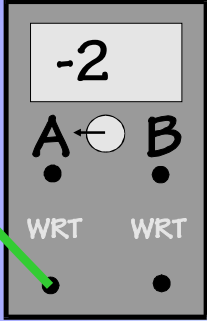
CAZ with reference to (WRT) outdoors →	Test 1	Test 2
Baseline (doors open, fans off)		
Exhaust appliances on		
Air handler on		
Position interior doors to worst-case		
Position CAZ door to worst-case		
Worst-case depressurization		

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Example Baseline Pressure

Hose to outdoors



-2

A ← B

WRT WRT

Analyst in CAZ with pressure gauge.

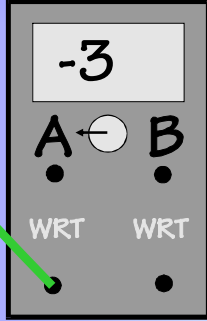
Manometer based on The Energy Conservatory DG-2 and DG-3, digital pressure gauges.

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Example Exhaust Fans Pressure

Hose to outdoors



-3

A ← B

WRT WRT

Analyst in CAZ with pressure gauge.

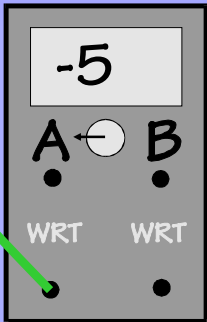
Manometer based on The Energy Conservatory DG-2 and DG-3, digital pressure gauges.

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Example Air Handler Pressure

Hose to outdoors



-5

A ← B

WRT WRT

Analyst in CAZ with pressure gauge.

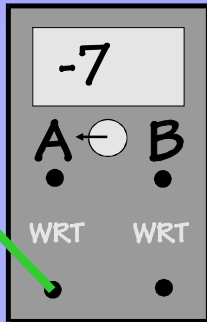
Manometer based on The Energy Conservatory DG-2 and DG-3, digital pressure gauges.

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Example Worst-Case Pressure

Hose to outdoors



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A ← B

WRT WRT

Analyst in CAZ with pressure gauge.

Manometer based on The Energy Conservatory DG-2 and DG-3, digital pressure gauges.


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Worst-Case Draft Test Procedure

What CAZ WRT Outdoor Pressures Are OK?
(these values are suggested only)

Appliance Type	Pascals
Water heater only, atmospheric gas	- 2
Atmospheric central systems and solid fuel appliances	- 5
Furnace or boiler, gas atmospheric or fan assist., Cat. I	- 5
Oil or gas unit with power burner	- 5
Induced draft appliance (fan at point of exit at wall)	- 5
Direct-vent appliances	- 10


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Worst-Case Draft Test Procedure

Backdraft Testing

Draft Reading in Flue after 1 - 3 Minutes →	Test 1	Test 2
Cycled water heater		
Cycled furnace or boiler		
Cycled other vented appliance		
All appliances on simultaneously		
Comments		


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Worst-Case Draft Test Procedure

Acceptable Atmospheric Draft Readings

Temp., F°	<20	21 - 40	41 - 60	61-80	>80
Pascals	-5	-4	-3	-2	-1
W.G."	-0.02	-0.016	-0.012	-0.008	-0.004

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Reasons for Worst-Case Draft Test Failure

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Reasons for W-C Test Failure, Overview

- Possible reasons for worst-case test failure:
 - Negative pressure from exhaust appliances.
 - Very tight house (a condition, not a problem).
 - Negative pressure in CAZ from duct system.
 - Chimney & vent system problems.
 - Insufficient combustion supply air volume.
 - Other combustion appliances.


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1. Reasons for W-C Test Failure

Negative pressure from exhaust appliances.

- Whole-house exhaust fan, summertime use.
- Fireplace operation.
- Jenn Air type range exhaust fan.
- Many smaller fans that add up to large CFM total.
- Exhaust appliance or fan in CAZ.
 - Clothes dryer.
 - Work room exhaust fan.

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2. Reasons for W-C Test Failure

- **Very tight house.**
 - For Category I appliances, such as water heaters.
 - End of vent system is at top of chimney.
 - Beginning of vent system is envelope of house; tightening house might have hazardous impact on vent system.

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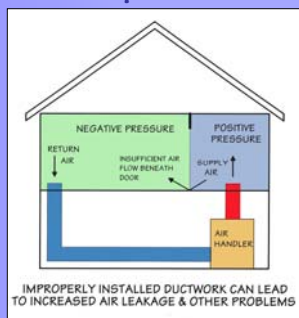
3. Reasons for W-C Test Failure

- **Negative pressure in CAZ from duct system.**
 - Return grilles in CAZ.
 - Return side leaks in CAZ.
 - Supply leaks to outdoors.

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Impact of an Air Handler



What happens to air leakage as a result of the closed bedroom door?

What if a return is installed in the basement return trunk?

What if the supply trunk leaks to the outdoors?

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4. Reasons for W-C Test Failure

- **Chimney & vent system problems.**
 - Chimney height.
 - Total height.
 - Improper termination above roof.
 - Heat loss from venting system (slow priming).
 - Restrictions or blockage.
 - Leaky vent system (ambient air leaking into vent).
 - Vent or chimney improperly sized.
 - Improper common venting.

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5. Reasons for W-C Test Failure

- **Insufficient combustion supply air volume.**
 - Confined space rule from NFPA 54 & 211.
 - Must provide at least 50 ft³ of connected indoor volume for each 1000 Btu/hr of total appliance input rate.
 - If less than 50 ft³ per 1000 Btu/hr, must correct by communicating with other indoor space or providing combustion air from outdoors.
 - Use 1/20 rule to quickly calculate. Example: 100,000 Btu/hr divided by 20 = 5,000 ft³ of indoor volume.

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6. Reasons for W-C Test Failure

- **Other Combustion Appliances**
 - Atmospherically vented combustion appliances.
 - Mechanically vented combustion appliances.

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Summary

- Install equipment according to code.
- Beware of problems duct leakage can cause.
- Beware of impact of exhaust fans and building envelope of proper venting.
- Perform worst-case draft test for client safety and your credibility and future.
- Measure carbon monoxide emissions in flue gases.
- Use your awareness of combustion venting safety as a marketing tool.