Whole House Diagnostics for Combustion Safety

GasNetworks HVAC Heating Professionals Fall Conference
September 18, 2003

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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.

The BIG Venting System Question

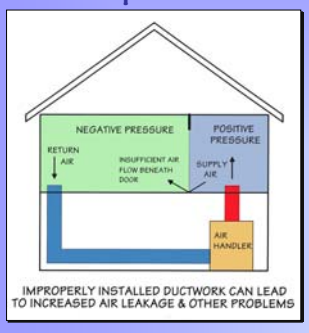
- The venting system ends at the top of the chimney or at the outlet at the wall.
- Where does the venting system begin for an appliance that is not direct-vent?

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?

The Impact of the Air Handler and Duct Leakage

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

7

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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.

8

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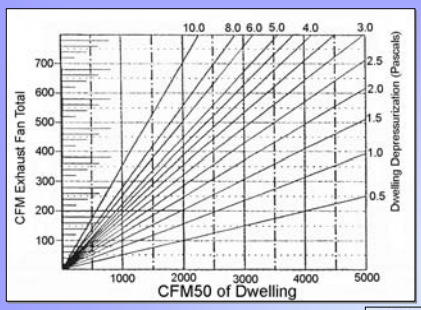
Exhaust Fans, Negative Pressure and House Tightness



9

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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***

10

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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.

11

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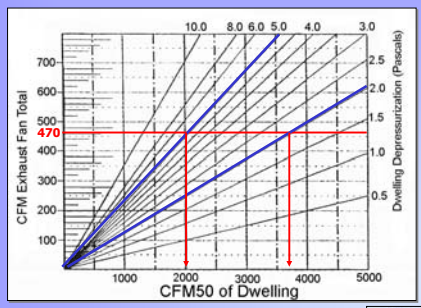
Exhaust Fans, Negative Pressure and House Tightness



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12

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American National Standard Institute (ANSI) Standards for Manufacturers

13

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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 drafthood blocked"
- Decorative Gas Appliances for Installation in Solid-Fuel Burning Fireplaces (Z21.60).
  - 25 ppm as-measured or 400 ppm air-free.

14

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Suggested CO Action and Allowable Levels

15

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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.

16

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Measuring Carbon Monoxide (and efficiency)

17

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Fyrite Pro from Bacharach

18

Testo 325-1

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

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

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.

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.

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

www.energyconservatory.com

25

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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		

26

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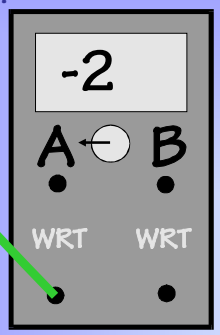
Example Baseline Pressure

Hose to outdoors



Analyst in CAZ with pressure gauge.

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

27

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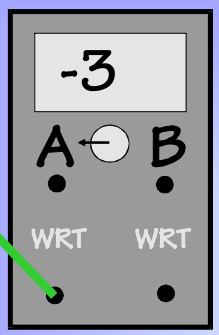
Example Exhaust Fans Pressure

Hose to outdoors



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28

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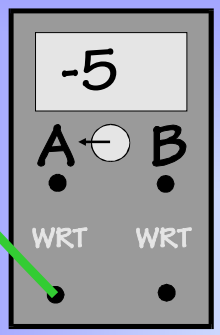
Example Air Handler Pressure

Hose to outdoors



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29

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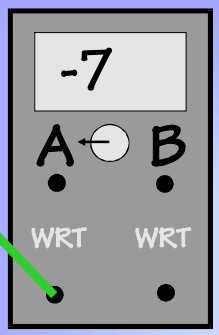
Example Worst-Case Pressure

Hose to outdoors



Analyst in CAZ with pressure gauge.

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30

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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
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31

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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		

32

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Worst-Case Draft Test Procedure

Acceptable Atmospheric Draft Readings

Temp., F⁰	<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

33

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Reasons for Worst-Case Draft Test Failure

34

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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.

35

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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.

36

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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.

37

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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.

38

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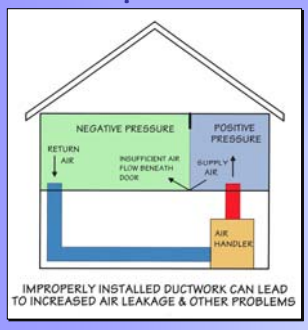
Impact of an Air Handler



IMPROPERLY INSTALLED DUCTWORK CAN LEAD TO INCREASED AIR LEAKAGE & OTHER PROBLEMS

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?

39

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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.

40

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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 ft^3 of connected indoor volume for each 1000 Btu/hr of total appliance input rate.
  - If less than 50 ft^3 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 ft^3 of indoor volume.

41

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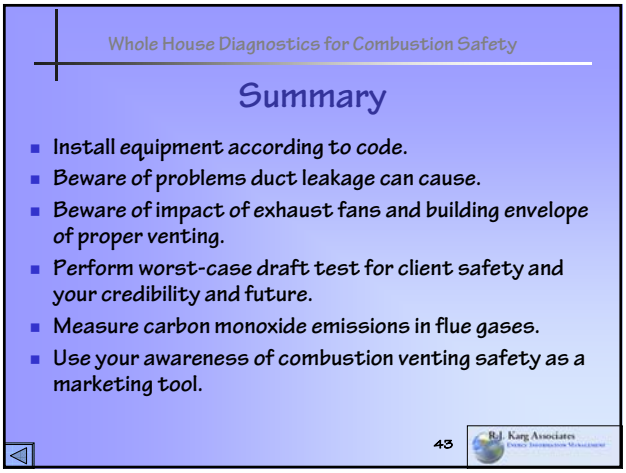
6. Reasons for W-C Test Failure

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

42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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.
43
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