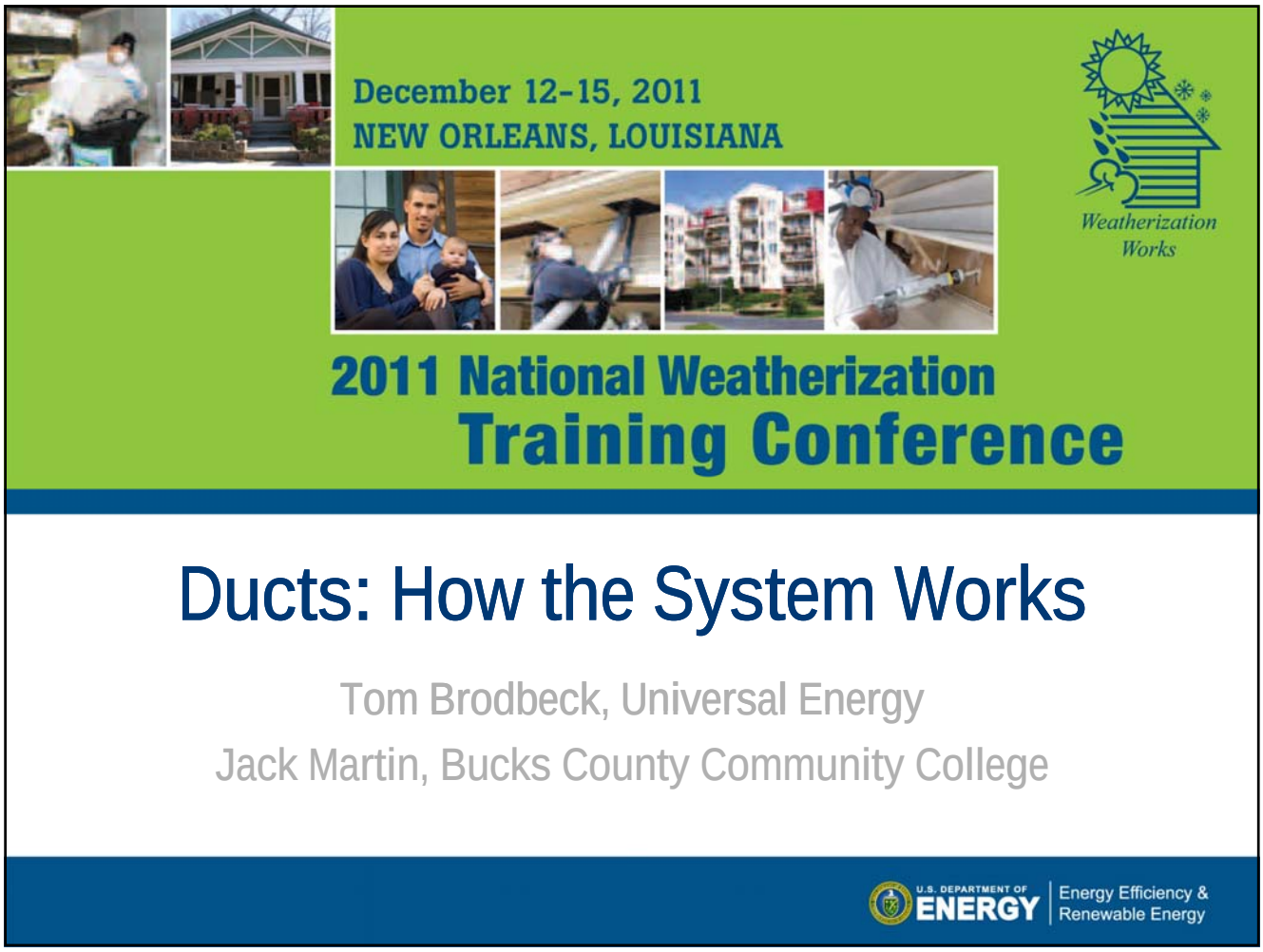

Ducts: How the System Works

Tom Brodbeck, Universal Energy

Jack Martin, Bucks County Community College

HVAC and Duct Systems

- HVAC systems should provide thermal comfort, acceptable indoor air quality, ventilation, and maintain consistent pressures relationships between conditioned spaces
- Ducts supply the conditioned air through out the conditioned spaces building.
- Ducts should be designed to meet the Standards listed in the ACCA Manual D Residential Duct Systems

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Bad Duct Design and Installation

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Duct Systems Should Be Designed to meet the Following Requirements:

- Deliver and *RETURN* the right amount of air from each room to provide comfort year-round
  - Implies room by room heat loss and heat gain calculations
  - System should be dampered, either automatically or manually
  - Ducts are Sealed, Tested for Tightness and Insulated to the R-value Recommended in Your Area

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Benefits of Properly Designed & Installed Duct System

- Adequate air flow
- Less conditioned air leakage
- Higher energy efficiency
- Smaller, less expensive equipment
- Longer equipment service life
- Healthier, safer indoor air quality
- Greater comfort for occupants
- Reduced house air leakage
- Fewer call backs
- No Potential for Backdrafting Appliances

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It Can Be a Bit Confusing? Yes

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Do Not Use Unlined (Sheet Metal) Building Cavities

- Some builders have used joist bays or other building cavities as supplies or returns. Since these areas are very difficult to seal properly, the use of panned joist bays in supply and return air systems is no longer allowed by building codes.

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Pan Over Joist Cold Air Return

Pan Joist Return Sealed w/2 Part Foam

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Sealing Pan Over Joist Returns with 2 Part Foam

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Design Recommendations

- System and duct work designed and installed according to ACCA and ASHRAE handbooks. Four steps should be followed to ensure energy efficiency and comfort.
- 1. Determine room-by-room loads and air-flows by using ACCA Manual J and Manual D calculation procedures.
- 2. Layout Duct System on Floor Plan, account for Potential Obstructions and determine register locations and types locations and types, duct lengths and connections required

Design Recommendations

- 3.Size the Ducts using ACCA Manual D calculations (or equivalent).
- 4. Size HVAC equipment to sensible load and to house characteristics using ACCA Manual S (or equivalent).
- Design Considerations use air tight fittings if available and Provide return air paths in all bedrooms.
- Ensure the System is Balanced: the air in the Supply Ducts is flowing back through the Cold Air Return

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Air Tight Take Offs and Wall Cavity as a Supply Duct

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Heating and Cooling Load and Sizing Ducts

- Guides published by the Air Conditioning Contractors of America (ACCA) should be the foundation for sizing ducts. No contractor should specify a system without using the ACCA's Manual J, which calculates heating and cooling loads, and Manual D, which tells the contractor how to size the ducts.

Design Considerations Don't's

- Avoid toe kick supplies, use pans if installed
- Never use stud cavities as a duct
- Do not use tape to seal ducts
- Do not kink ducts
- Do not allow ducts to touch the ground
- Do not use air filter 'slots'
- No turns greater than 90 degrees in ducts

Toe Kicks Bad Design and Hard to Seal

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Duct on the Ground and Restricted Flex Duct

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Restricted Flex Duct and Disconnected Flex Duct

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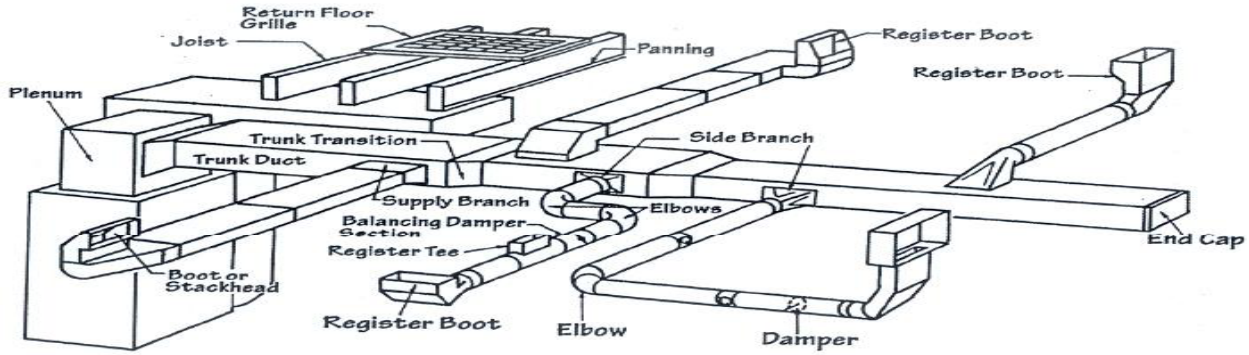
The Parts of a Duct System

Duct Fittings and Air Handler



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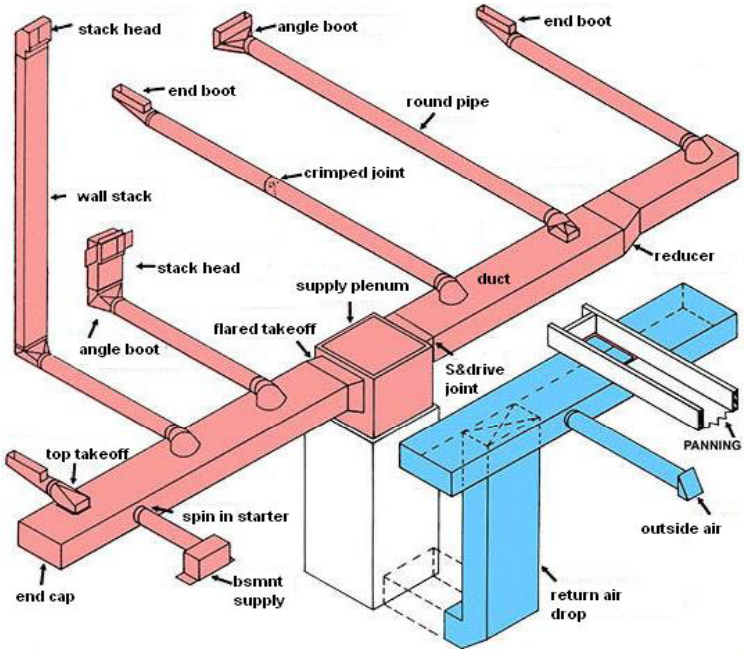
The Parts of a Duct System



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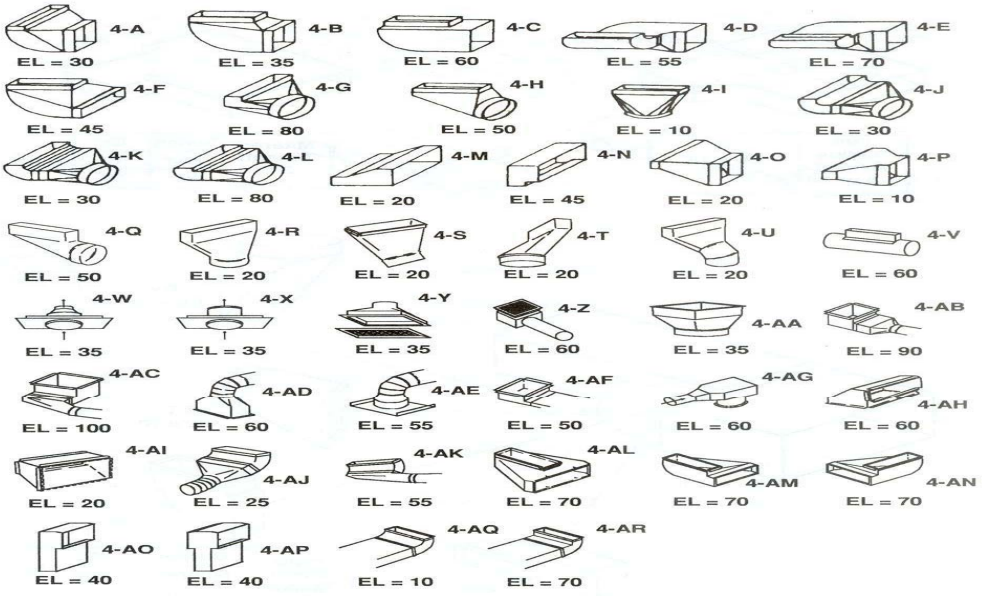
Group 4
Supply Air Boot and Stack Head Fittings
Reference Velocity = 900 FPM
Reference Friction Rate = 0.08 In.Wg. per 100 Feet



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Sizing Return for AC and Heat Pump

- A general rule is one net square foot of return grille per ton

A 20 x 20 inch grill = 400 sq in

400 x .75=300 sq in NFA

300 sq in / 144 sq in = 2.08 sq ft

Just enough for a two ton system

Returns can not be Oversized

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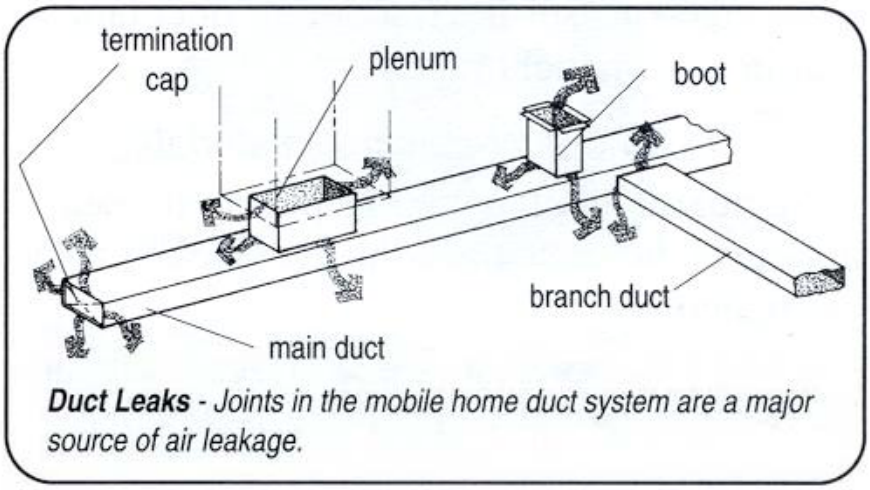
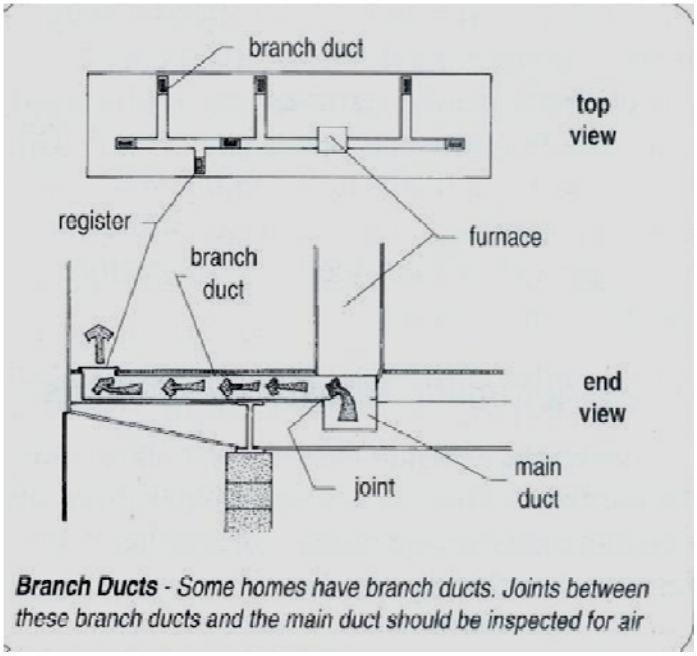
Mobile Home Duct Systems



Duct Leaks *- Joints in the mobile home duct system are a major source of air leakage.*

Branch Ducts in Mobile Homes Needs Sealing



Branch Ducts *- Some homes have branch ducts. Joints between these branch ducts and the main duct should be inspected for air*

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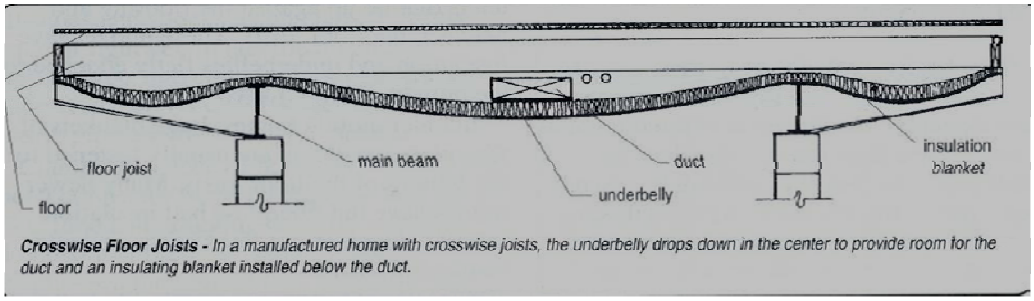
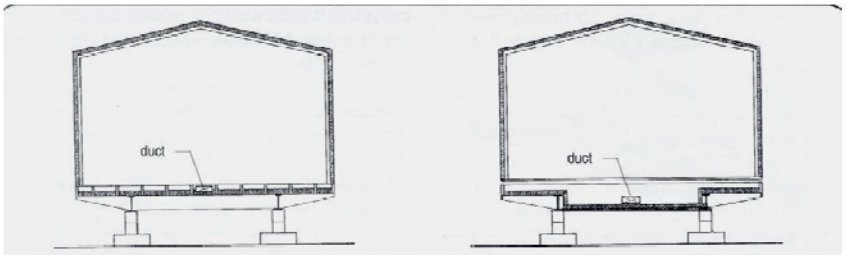
Location of Mobile Home Ducts



Crosswise Floor Joists - *In a manufactured home with crosswise joists, the underbelly drops down in the center to provide room for the duct and an insulating blanket installed below the duct.*



Duct Location - *In homes with lengthwise joists, the main duct is installed between the floor joists, touching the flooring material. In homes with crosswise joists, the main duct is installed below the floor joists.*

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Cut Belly Board & Cut Duct Under Plenum

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Sealing and Inspecting the Plenum

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Plenum Connection Sealed New Sheet Metal & Fiberglass Tape & Mastic

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Mobile Home Ducts Bad Design

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End Sweeps w/ Sheet Metal, Screws, Mastic

Duct Leakage Testing

The main purpose of an air tightness test of a duct system to is to measure and document the amount of leakage in the system at a specified reference duct pressure.

Duct leakage testing is preformed to determine the amount of leakage in a duct. Different methods of duct leakage testing can produce very different results. Any type of duct leakage testing is better than no testing

Methods of Measuring Duct Leakage

- Blower Door Subtraction Method

The test is is simple to understand, relying on two blower door tests, one with the house as found and the other with the supply and return air registers taped off. If ducts or air handler is located in the garage then open the garage door to the outside. The blower door test with all the registers taped off is subtracted from the blower door test with the house as found. The difference is the duct leakage. Depressurize the house to –50 pascals (or test pressure) with the blower door. The test requires the blower door can't reach 50 (or test pressure) multiplier are averaged for the zones in which the ducts are located.

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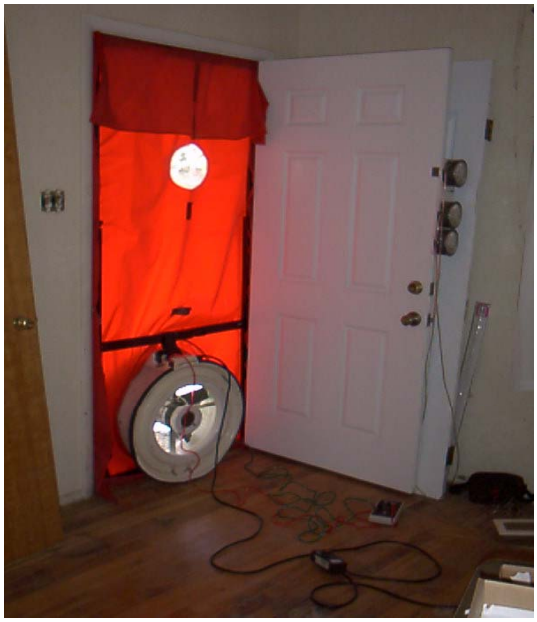
Blower Door Subtraction Method



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Pressure Pan Method

Blower Door and Pressure Pan

Locate supply and return registers and ensure they are open. Remove all the filters in the air handler system. If ducts or air handler is located in the garage then open the garage door to the outside. Depressurize the house to 50 pascals (or test pressure) with the blower door. Connect a small hose to the pressure pan and the digtial manometer or magnehelic gauge. Record the pressure pan numbers. Multiply the pressure pan reading by the appropriate can't reach 50 number.

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Zone Pressure Testing

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Can't Reach 50 Multiplier

Zone Pressure	Can't Reach 50 Multiplier
1	50
1.1	45
1.25	40
1.42	35
1.66	30
2	25
2.5	20
3.5	15
5	10
10	5

Blower Door & Pressure Pan

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Duct Blaster

- Is a calibrated air flow measurement system used to test and document the Air tightness of forced air distribution system. The duct blaster can measure total leakage of a duct system (inside and outside) and with the use of a blower door can measure outside leakage. Outside leakage is important to weatherization programs, unless inside leakage is causing safety or durability issues.

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Can't Reach Pressure Factors (-25 Pa Target)

Duct Pressure	CRP	Duct Pressure	CRP
24	1.02	14	1.42
23	1.05	13	1.48
22	1.08	12	1.55
21	1.11	11	1.64
20	1.14	10	1.73
19	1.18	9	1.85
18	1.22	8	1.98
17	1.26	7	2.15
16	1.31	6	2.35
15	1.36	5	2.63

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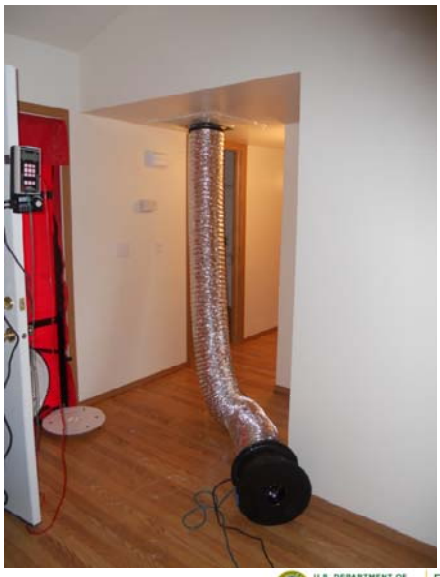
Duct Leakage Testing with the Duct Blaster, Installed at the Furnace and CAR



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Total Duct Leakage Test

- The Total Leakage Pressurization Test is used to measure the duct leakage rate in the entire duct system (including leaks in the air handler cabinet), when the duct system is subjected to a uniform test pressure.
- The Total Leakage Pressurization Test measures both duct leakage to the outside of the building (e.g. leaks to attics, crawlspaces, garages and other zones that are open to the outside), and duct leakage to the inside of the building.
- This test procedure requires use of a Duct Blaster system only.
- There must be an opening to the outside: open window or Blower Door Ring open
- Test pressure typically at 25pa or 50pa

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Leakage to the Outside, Uses Blower Door & Duct Blaster

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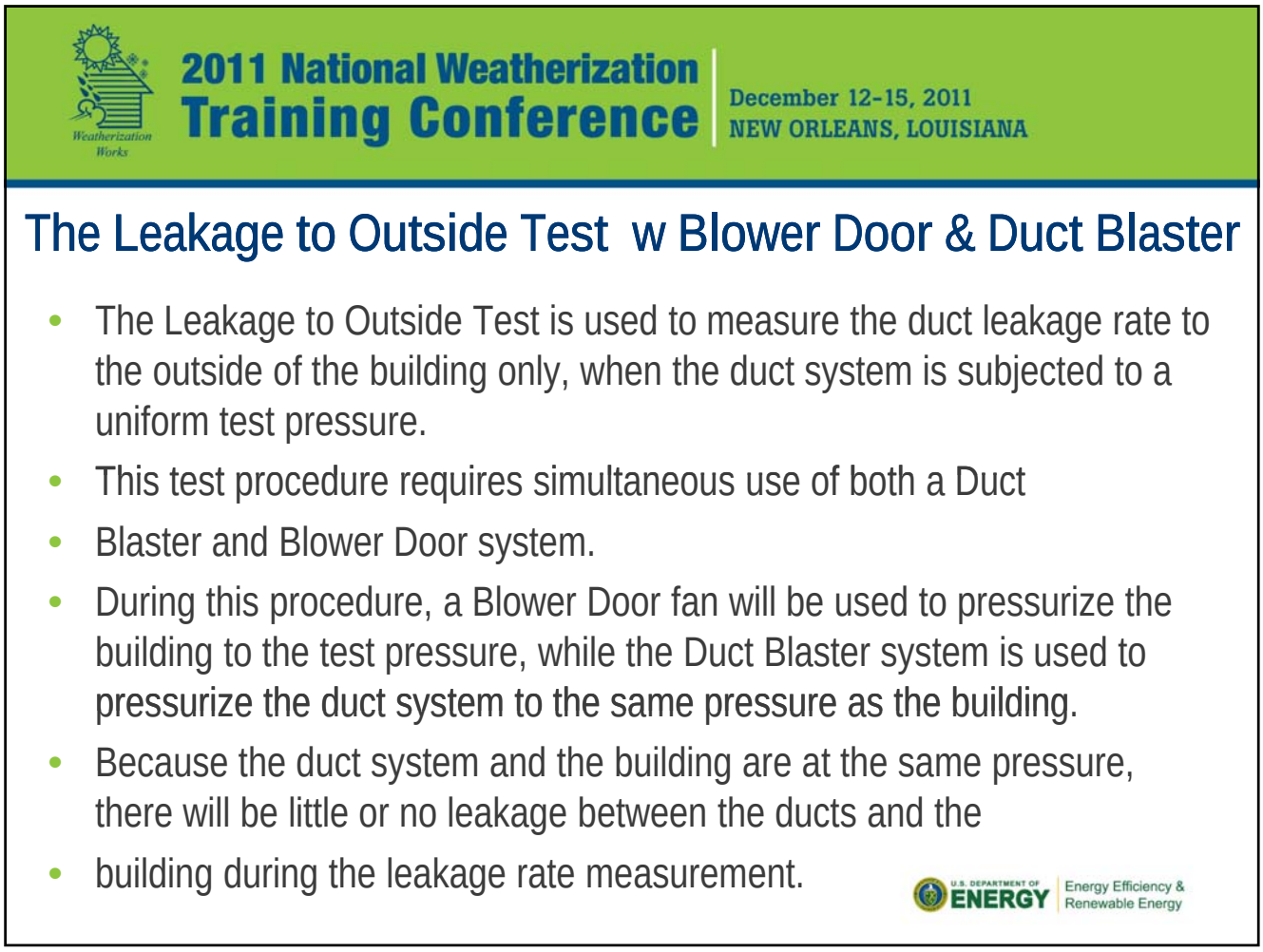
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Weatherization Works
The Leakage to Outside Test w Blower Door & Duct Blaster
• The Leakage to Outside Test is used to measure the duct leakage rate to the outside of the building only, when the duct system is subjected to a uniform test pressure.
• This test procedure requires simultaneous use of both a Duct
• Blaster and Blower Door system.
• During this procedure, a Blower Door fan will be used to pressurize the building to the test pressure, while the Duct Blaster system is used to pressurize the duct system to the same pressure as the building.
• Because the duct system and the building are at the same pressure, there will be little or no leakage between the ducts and the
• building during the leakage rate measurement.
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Setting up the Blower Door for an Outside Leakage Test

- The Blower Door fan should be set up to pressurize (or blow air into) the building. Importantly, we will not be measuring air flow through the Blower Door fan during this test procedure.
- Blower Door Pressurized at 25 pa

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Digital Manometer is put into the PR/FL Mode

- This mode is a multi-purpose mode used to measure a test pressure on Channel A while simultaneously measuring air flow from the Duct Blaster fan on Channel B.
- Increase the fan speed until the pressure between the duct system and the building (displayed on Channel A) reads zero.
- Channel B on the DG-700 will now display the CFM25 leakage to outside estimate

Finding Duct Leaks w Theatrical Fog Machine

- One way to find leaks in a duct system is to use a theatrical fog machine while pressurizing the duct system
- With the registers and grilles temporarily sealed off, the fog machine is used to inject a nontoxic theatrical fog through the Ducts Blaster and into the duct work.
- The theatrical fog is pushed out of the leakage sites.

Delta Q Duct Leakage Test

- Done with a blower door tests with air handler on and off
- Fairly quick and easy screening too
- Requires more equipoment and a laptop
- Complicated, but holds promise to predicting true operating duct leakage
- Very sensitive to wind
- Not ready for field use

Testing Static Pressure

- Typical Fan Curve

ESP	CFM
.3	900
.4	850
.5	800
.7	675

Correct Airflow Across the Evaporator Coil is Important

- 74% of residential systems installed today have improper airflow according to a recent EPA study pertaining to Energy Star.
- Airflow across the evaporator is one of the most overlooked yet the most important parts of verifying proper operation of air conditioning or heat pump systems.
- Air conditioners are designed for a nominal 400 CFM (450 for heat pumps) of airflow per ton depending upon air density.

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TrueFlow Air Handler Flow Meter

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Temperature Rise

- Temperature rise is an important operating parameter for heating equipment. It provides a measure of the sensible heat gain to the air flowing over the heat exchanger and allows specifying technicians to match heating equipment to the comfort level desired in the conditioned space.

  Checking the Temperature Rise and Static Pressure on a Furnace is an important test after Duct Sealing

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Testing Heat Rise

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Exhaust Fan Flow Meter

- ***This is designed too make a quick and accurate measurements of air flow through residential exhaust fans. The effective air flow measurement range is 10 to 124 cubic feet per minute (CFM). The device needs to be connected to a digital manometer to obtain accurate readings.***

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The Exhaust Fan Flow Meter

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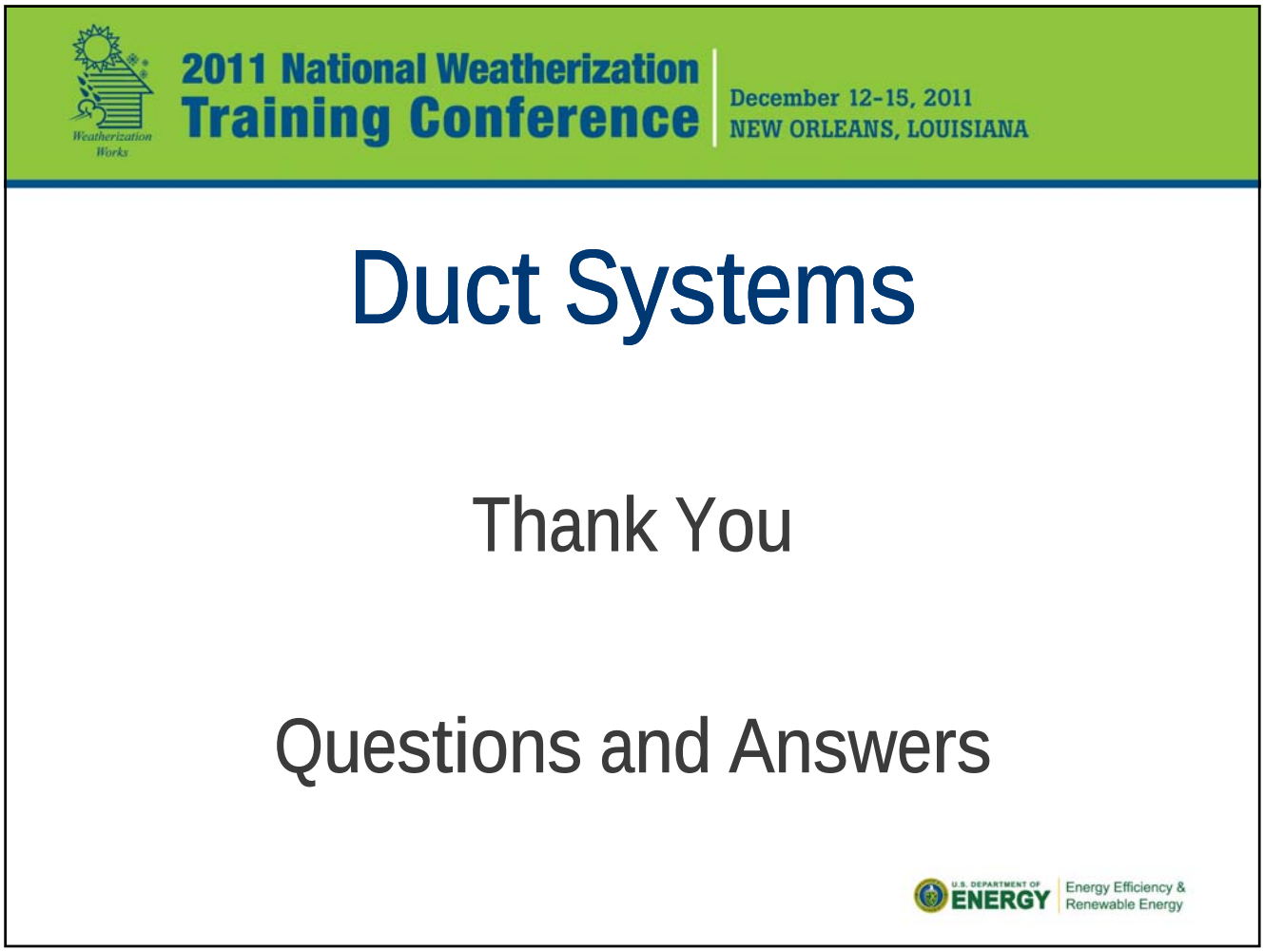
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Duct Systems
Thank You
Questions and Answers
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