WEATHERIZATION ENERGY AUDITOR SINGLE FAMILY

Audit Process

Learning Objectives

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By attending this session, participants will:

- Understand the steps of a building assessment.
- Understand the role that clients play in helping the auditor determine health, safety, and energy needs.
- Understand the components of an accurate visual assessment.
- Understand the importance of documenting moisture, electrical, and health and safety problems.
- Know the recommended diagnostic procedures.
- Understand how to determine the components of the thermal boundary.

Client Interview #1

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- Assessment begins with meeting and interviewing the client.
- Follow the ground rules of showing respect, honesty, and understanding.
- Making the client part of the auditing process often yields very important clues about:
  - Health and Safety
  - Comfort
  - Energy Efficiency

Photo courtesy of U.S. Department of Energy

Client Interview #2

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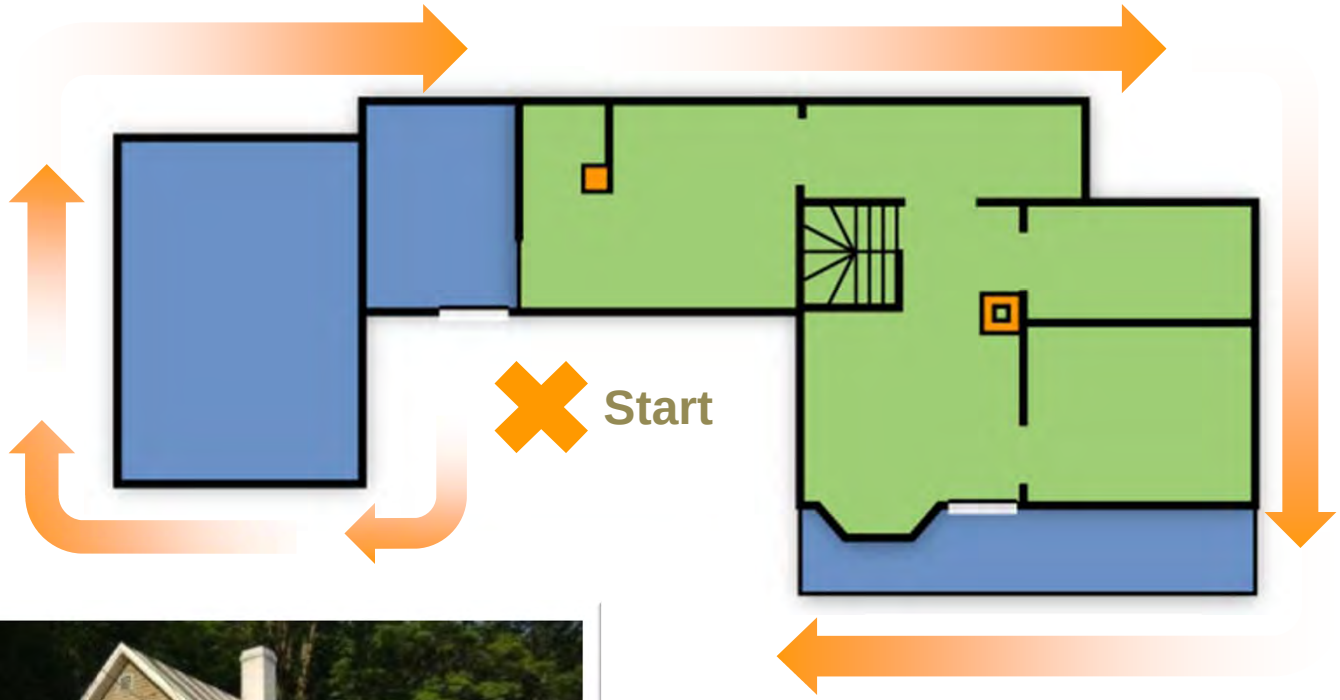
- Use the interview process to learn more about how the home works.
- Ask the client about issues related to health and safety.
- Explain the audit process and discuss retrofit options

Exterior Walk Around Process



Exterior Visual Assessment - Review

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Note and include detail on:

- Building type and framing
- Foundation type and percent above grade
- Additions, porches, attached or tuck-under garages, cantilevers
- Numbers, types, condition, and orientation of windows and doors
- Cardinal direction & orientation
- Siding type and condition
- Chimneys, exhaust vents, and possible safety problems
- Roof type, covering, and condition
- Water management issues (downspouts, flashing, grade, etc.)
- Draw a sketch of the building footprint and sides, note dimensions.
- Remember to note comfort, health and safety, and any other issues discovered in client interview process.

Visual Assessment – Exterior #1

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Note condition of chimneys

- Height of the venting system.
- Capacity of the venting system.
- Restrictions in the venting system.

See a problem here?

Elevations

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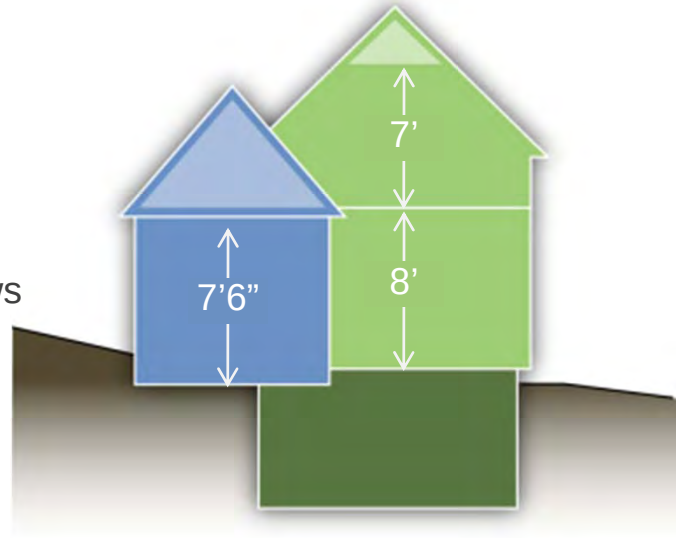
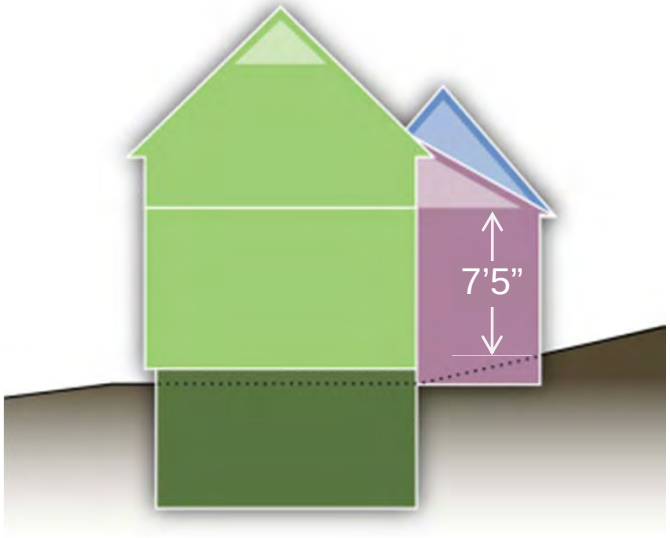
- Main house: 16’ x 26’ – 1 ½ story
- Ell: 12’ x 15’ – 1 story
- Rear addition: 8’ x 16’ – 1 story
- Cellar under main house only

All on very good rubble stone foundation

Heated space windows & doors: (8) 12.5 sq’ windows, (8) 10 sq’ windows and (2) 20 sq’ doors.

Second floor:
Attic flat = 8’
Slopes = 8’
Eaves wall = 3’





Visual Assessment – Exterior #3

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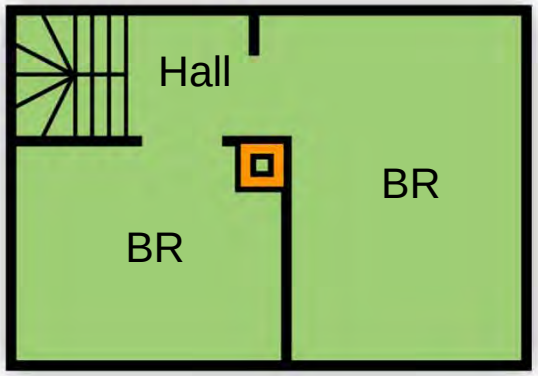
Photo courtesy of PA Weatherization Training Center

The Footprint Sketch



Second Floor

= heated = no heat

- 7’ cellar under main house.
- Den & kitchen floor ≈ 1’ clearance to ground.

Visual Assessment – Conditioned Space

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Note and include detail on:

- Area and volume of the conditioned space
- Pressure and thermal boundaries
- Lead based paint
- Mechanical ventilation
- Evidence and sources of moisture or indoor air quality problems
- Un-vented fossil fuel heaters.
- Identify large air leaks such as broken glass, missing hatchway covers, large penetrations, broken ceilings and wall coverings.
- Electrical or other hazards to occupants and weatherization workers
- Remember to note comfort, health and safety, and any other issues discovered in client interview process.

Visual Assessment – Conditioned Space

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Note the presence, location and condition of:

- Wall insulation
- Windows and doors
- With the blower door running, check for leakage around outlets and fixtures.
- Thermostat
- Fireplace
- Air Registers
- Window A/C unit.
- Recessed light fixtures
- Stored chemicals that might effect IAQ

Auditors should determine underlying causes of moisture damage.

Damaged ceilings may indicate moisture issues.

Mold on walls indicates serious moisture issues in the home. Determine underlying causes and mitigate before *any* air sealing.

Visual Assessment – Dropped Ceilings

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Look above tiles for hidden air leaks.

Check access doors, closets and cabinets for interior leakage paths.

- This opening within the plumbing wall was discovered behind an access door.
- The opening is a major source of air leakage.

Visual Assessment – Space Heaters

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WPN 11-6: Space Heater Policy

- No Weatherization work allowed where unvented gas or liquid fuel space heater is primary heat source
- Strongly encourages removal and replacement of such heaters with vented, code-compliant heating systems prior to weatherization
- Secondary unvented heat sources may be left only if they are ANSI compliant.

- WAP funds may only replace primary heating system, e.g., unvented with vented, code-compliant system. May not replace unvented space heaters left in home as secondary units with code-compliant unvented units.
- Mobile home: must be vented outside

Visual Assessment – Walls

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- Determine framing type (balloon, platform, plank, etc.).
- Determine presence of wall insulation and thickness by one or more of the following methods in multiple locations:
  - Infrared scan.
  - Drill and probe with a non conductive probe or borescope.
  - Remove small sections of siding.
- Inspect interior wall cladding for damage or weakness.
- Look for areas where insulation may spill (pocket doors, suspended ceilings, cabinets, closet spaces, etc).
- Determine practicality of exterior or interior insulation installation.
- Calculate the gross wall area (perimeter X height).

Determine Type of Wall Framing

- From the attic, framing style is often evident.
- Top plates indicate platform framing.

Photo courtesy of U.S. Department of Energy

Probe exterior walls to determine:

- If insulation is present, what kind and how much?
- Depth of the wall cavity

Do this in several locations.

A non-conductive crochet hook is handy for pulling out a sample of existing insulation.

Photo courtesy of U.S. Department of Energy

Note and include detail on the following:

- Framing type (slab on grade, pier and beam, full basement, crawlspace or combination)
- Is basement or crawl space conditioned or un-conditioned?
- Locate and identify components of the thermal boundary.
- Combustion appliances and hot water tank
- Moisture problems, bulk water intrusion and other IAQ issues
- Major air bypasses and direct penetrations to outside
- Ceiling, wall and band joist insulation levels
- Tuck under garages, coal bins, etc.
- Condition and insulation levels of duct system
- Dryer venting
- Electrical or other hazards to occupants and weatherization worker

Visual Assessment - Foundation

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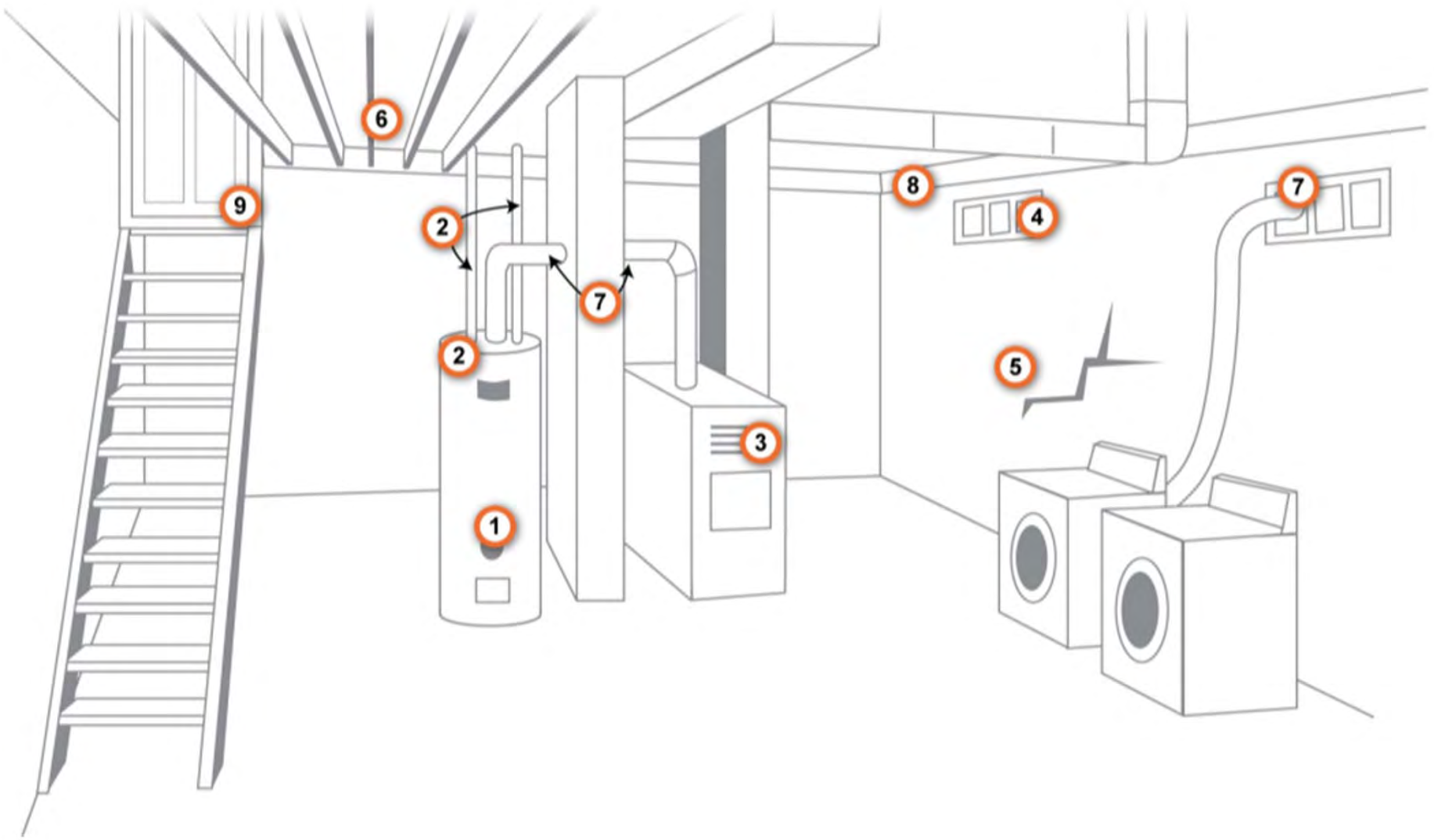

Moisture?

Mold?

Visual Assessment – Foundation #3

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- Note major air leakage sites on sketch.
- Plumbing and wiring penetrations are common air leakage sites.

Photo courtesy of U.S. Department of Energy

Visual Assessment - Perimeter

- Note ceiling, wall and band joist insulation levels.
- This box sill is a common perimeter leakage site in basements.

Photo courtesy of U.S. Department of Energy

Visual Assessment - Floor

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Note type and condition of basement or crawl space floor.

- Radon issues?
- Vapor retarder?

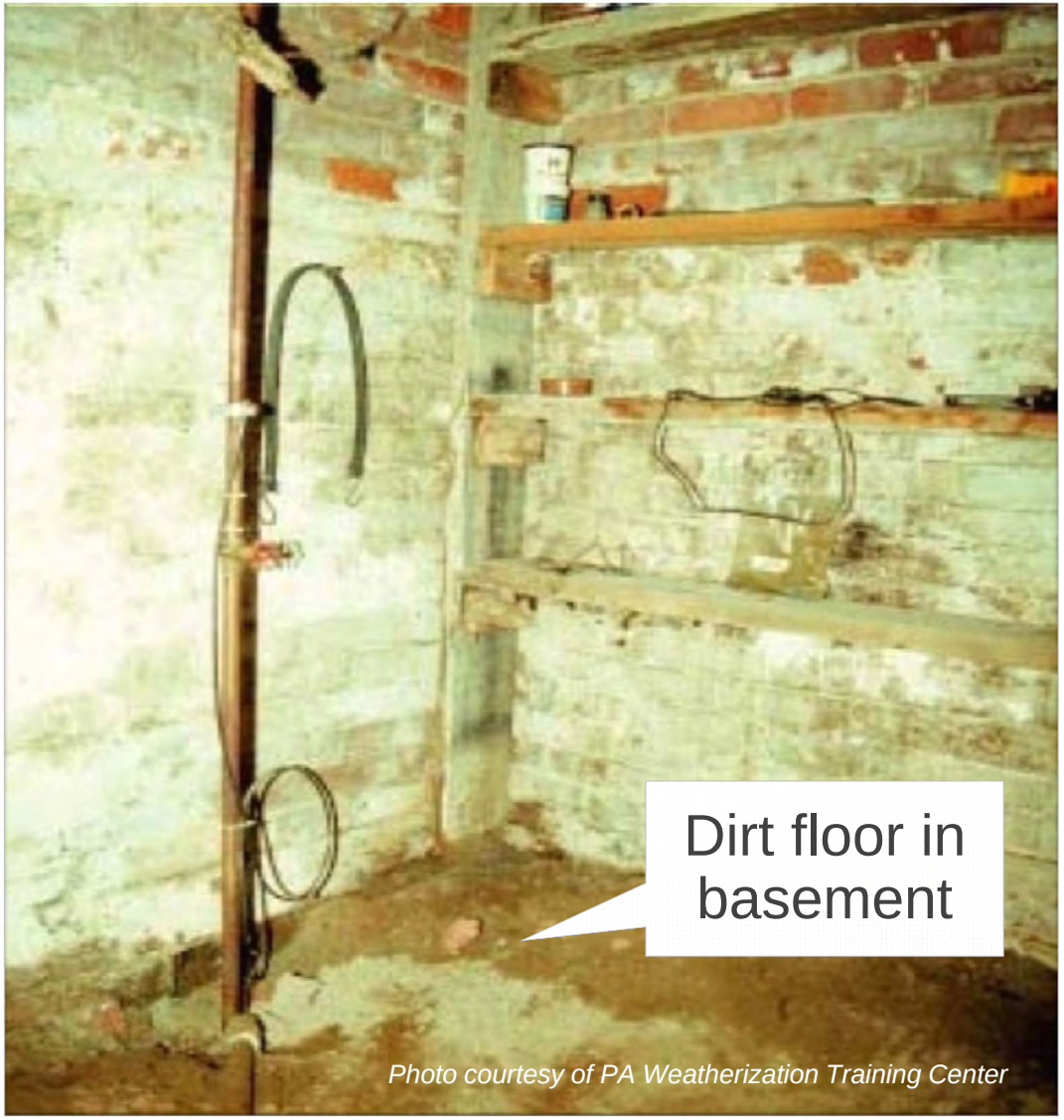

Photo courtesy of PA Weatherization Training Center

Situations like this can hinder weatherization work.

- Workers cannot access ducts, floor cavity.
- Impacts the occupants' health and safety.

Visual Assessment – Attic Spaces #1

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Photo courtesy of U.S. Department of Energy

Visual Assessment – Attic Spaces #2

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Note and include detail on:

- Components of the thermal boundary
- Physical features (floored, un-floored, condition of ceiling, occupants belongings, attic hatch type)
- Existing insulation levels
- Major air bypasses
- Condition and insulation level of duct systems if present
- Evidence of condensation based moisture problems or roof leaks
- Attic ventilation
- Whether mechanical and plumbing terminations are vented to outside
- Knob-and-tube wiring or other electrical hazards
- Other hazards such as vermiculite, vermin droppings, etc

If interior access is not available, attempt to access through an existing exterior vent or with permission create an interior access through a closet ceiling if possible.

Visual Assessment – Attic Spaces #3

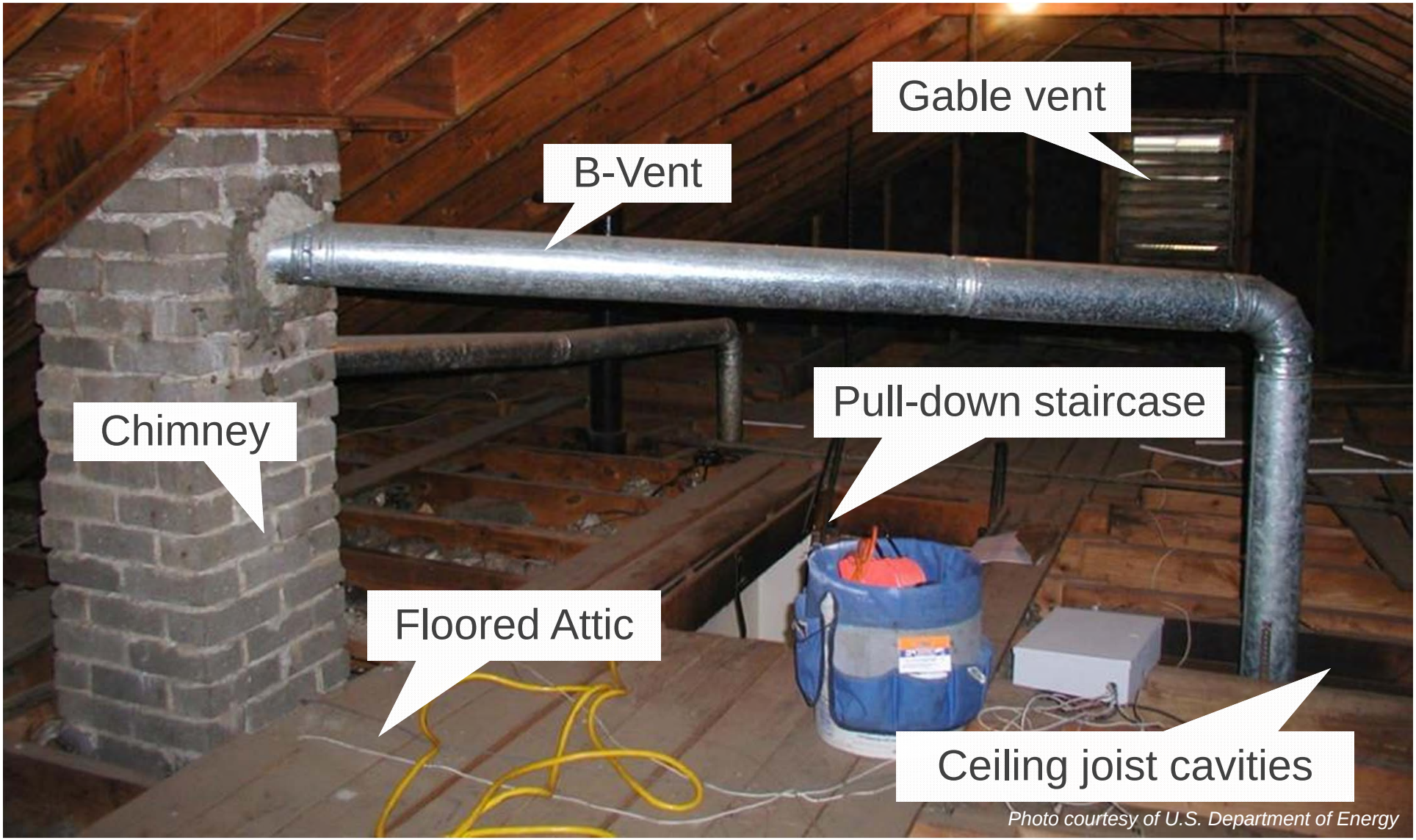


Photo courtesy of U.S. Department of Energy

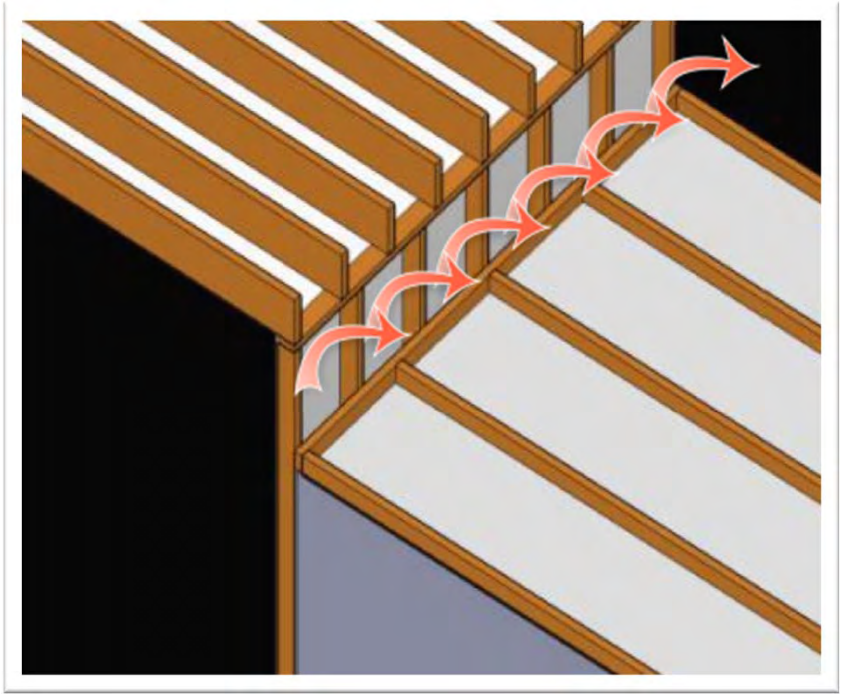
Knob & Tube (K&T) wiring

Attic bypasses:

Open wall cavities

The interior wall cavity acts as a chimney that robs the house of heat and conditioned air.

Photo courtesy of NRCERT



Visual Assessment – Attic Ducts

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Note the location and condition of exhaust vents:

- Are they vented directly outside?
- Smooth, metal vent pipe?
- Moisture damage around roof penetration?

Visual Assessment – Attic Spaces

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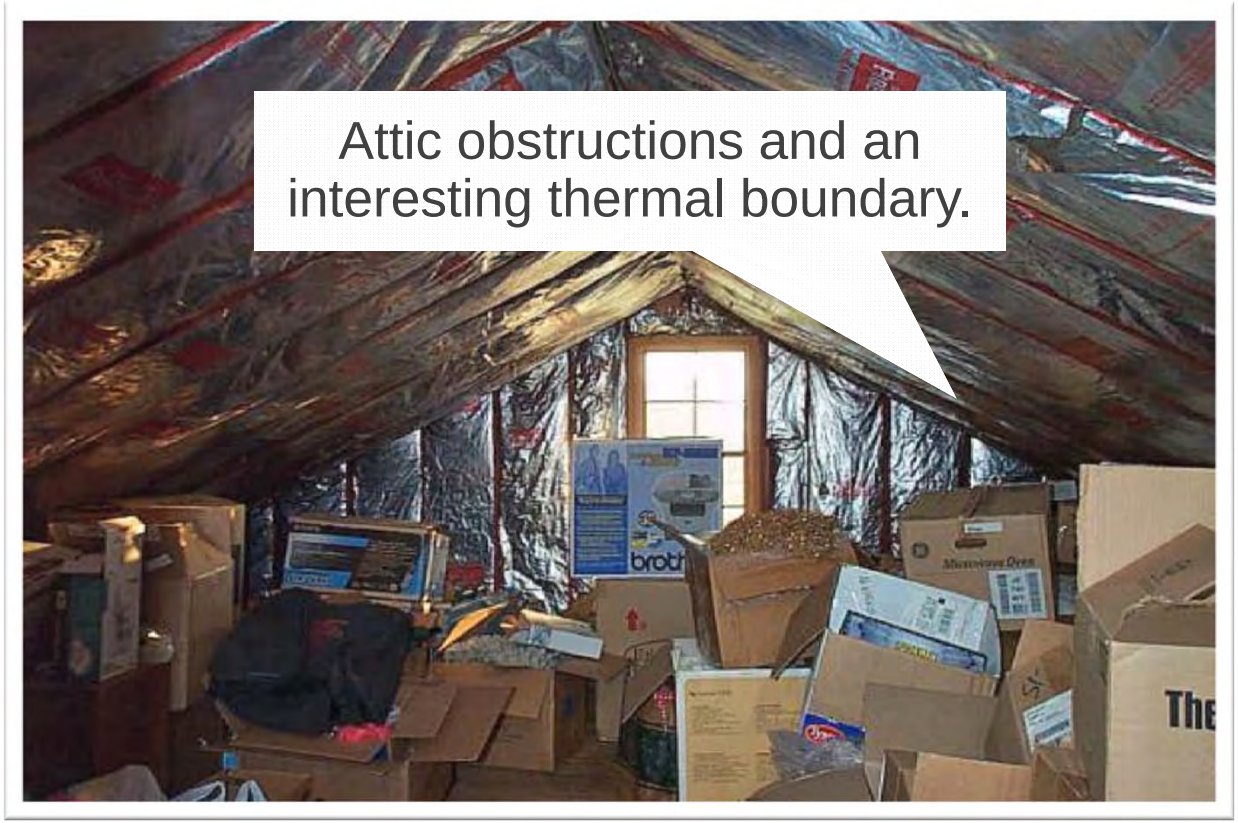
Storage in attics can hinder weatherization work.

Does the client need to remove materials before work begins?



What do we test on combustion appliances?

- Fuel leaks.
- Fuel input rate.
- Sufficient combustion air.
- Worst case draft.
- Carbon monoxide.
- Combustion efficiency.

Fuel Leak Testing

Gas leak detector for gas and propane.

Visual inspection and the personal sniff test for fuel oil.

Selected Testing Equipment

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Draft Gauge

Smoke Tester (for Oil)

Combustion Analyzer

Digital Probe Thermometer

Inspection Mirror

Testing Equipment

Photo Courtesy of NRCERT

BACHARACH, INC
PCA 25
SN: BQ1007

TIME 05:44:12 pm
DATE 03/16/99

FUEL
OIL NO. 2

STACK-TEMP	305°F
AMB. –TEMP	75.0°F
O2	6.5%
CO2	10.8 %
CO	28ppm
0% COR CO	41ppm
EFFICIENCY	87.7%
EX. AIR	33.2

COMMENTS:

If you're not testing, you're guessing!

Why Test Gas Cook Stoves?

- Elevated Levels of CO are Common.
- People often use them as a heat source.
- CO Kills.

Photo Courtesy of NRCERT

Gas Cook Stove Testing - Stove Top

Test each range top burner for CO. Hold probe 6” above flame and measure the CO content in ambient air.

A portable flue section concentrates combustion byproducts for an accurate CO measurement.

Gas Cook Stove Testing - Oven

Prepare the oven for a test by removing stored items, aluminum foil, etc.

Insert the probe of the analyzer into the oven vent and read the CO content after the oven has warmed.

Combustion Appliance Zone (CAZ) Test

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- Find the worst case depressurization in the CAZ.
- **Under worst case conditions conduct:**
  - Spillage Test
  - Draft Test
  - CO Test
- Perform at the time of the audit and at the end of each work day.
- Deactivate appliances until hazard is fixed

Conduct these tests for vented systems only!

Air Leakage Testing

- Blower Door
- Ventilation Requirements
- Zonal Pressure Diagnostics
- Infrared Scanning

Natural driving forces

Pressure differences too small to measure reliably.

Blower door

Exaggerates pressure differences so they can be measured reliably and the results are repeatable.

Exaggerated air leakage measured with the blower door gives us an idea of the amount of air leakage that would occur under natural conditions.

Measuring Building Air Leakage

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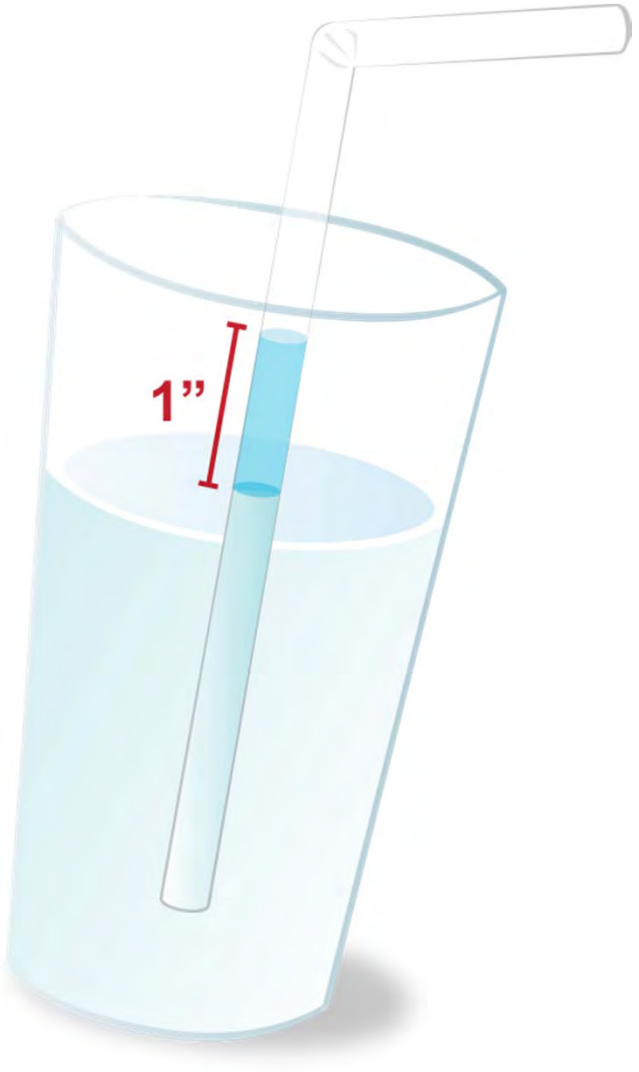
- Air leakage, measured by the blower door, is proportional to the size of the holes in the house between inside and outside.
- We can conduct blower tests before and after air sealing work to determine the effectiveness of the work.
- We can use blower door testing to tell us which houses have the most potential for energy savings through air sealing.

Measuring Pressure & Air Flow

- We don’t measure total pressure, but the pressure difference between one space and another.
- Always one pressure with reference to (WRT) another.
- Sometimes we measure pressures under controlled, artificial conditions, sometimes under normal operating conditions.

Pascal (metric standard)

- **1 Pascal** = weight of one Post-It note
- **249 Pascals** = 1 inch water column (American standard)
- **1” water column** = pressure required to suck 1” of water up a straw



Units for Measuring Air Flow

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Cubic Feet per Minute (CFM)

- Rate of air flow
- Based on the size of a home and the number of occupants, a home should have a certain amount of fresh air when the home is closed up

CFM50 (standard for blower door)

- Blower door measures the rate of air flow in CFM when the pressure difference between the inside of the house with reference to outside is -50 Pascals

Approximate Leakage Area

- Divide CFM_{50} by 10
- *For example:*

  5000 CFM_{50} / 10

  = **500 sq. in.**

Air Sealing Target

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- Usually somewhere between pre-weatherization blower door reading and MVR.
- Different program determine air sealing target differently.
- Some programs require a reduction in CFM_{50} of:
  - **40%** for leaky houses
  - **20%** for somewhat tighter houses
  - **0%** for substantially tight houses
- Apply ventilation standard ASHRAE 62.2 – 2010

Zonal Pressure Diagnostics #1

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Conduct zonal pressure diagnostics and interpret results to determine:

- Location and effectiveness of the air barrier
- Alignment of air barrier and thermal boundary
- If the pressure of the main house WRT garage indicates serious leaks between the two zones

Zone Pressure Diagnostics #2

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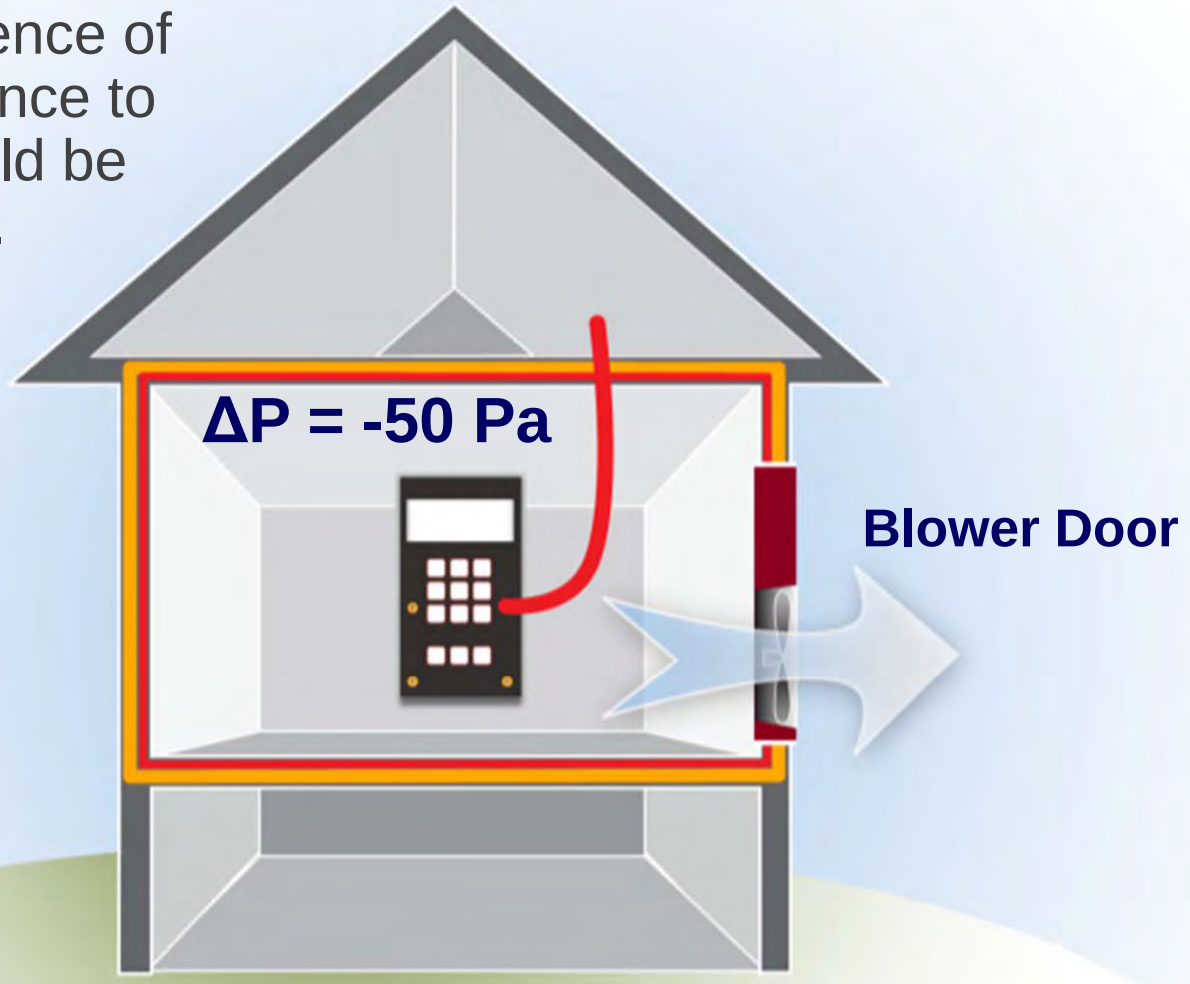
Pressure difference of attic with reference to the house should be close to -50 Pa.



Zone Pressure Diagnostics #3

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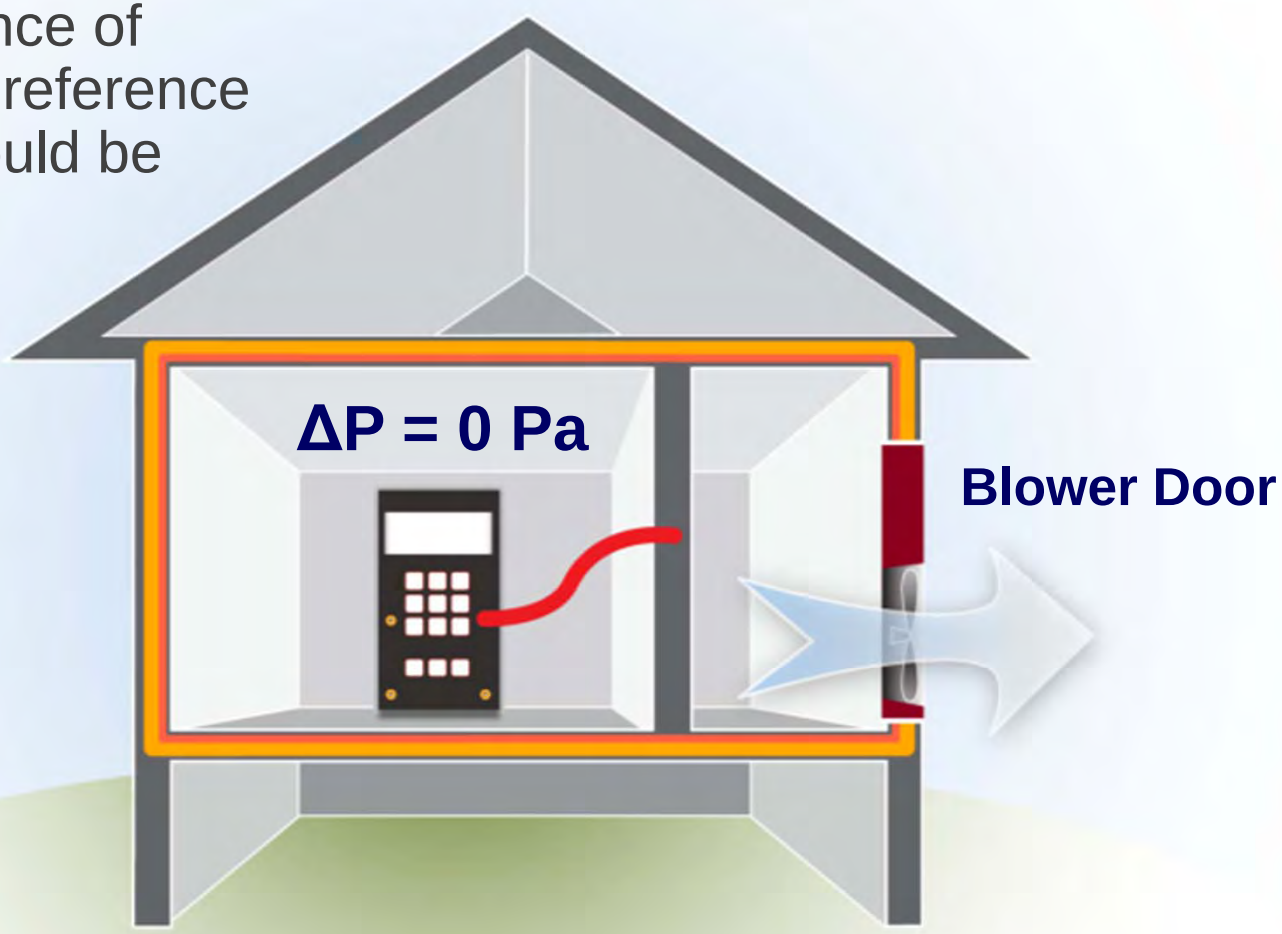
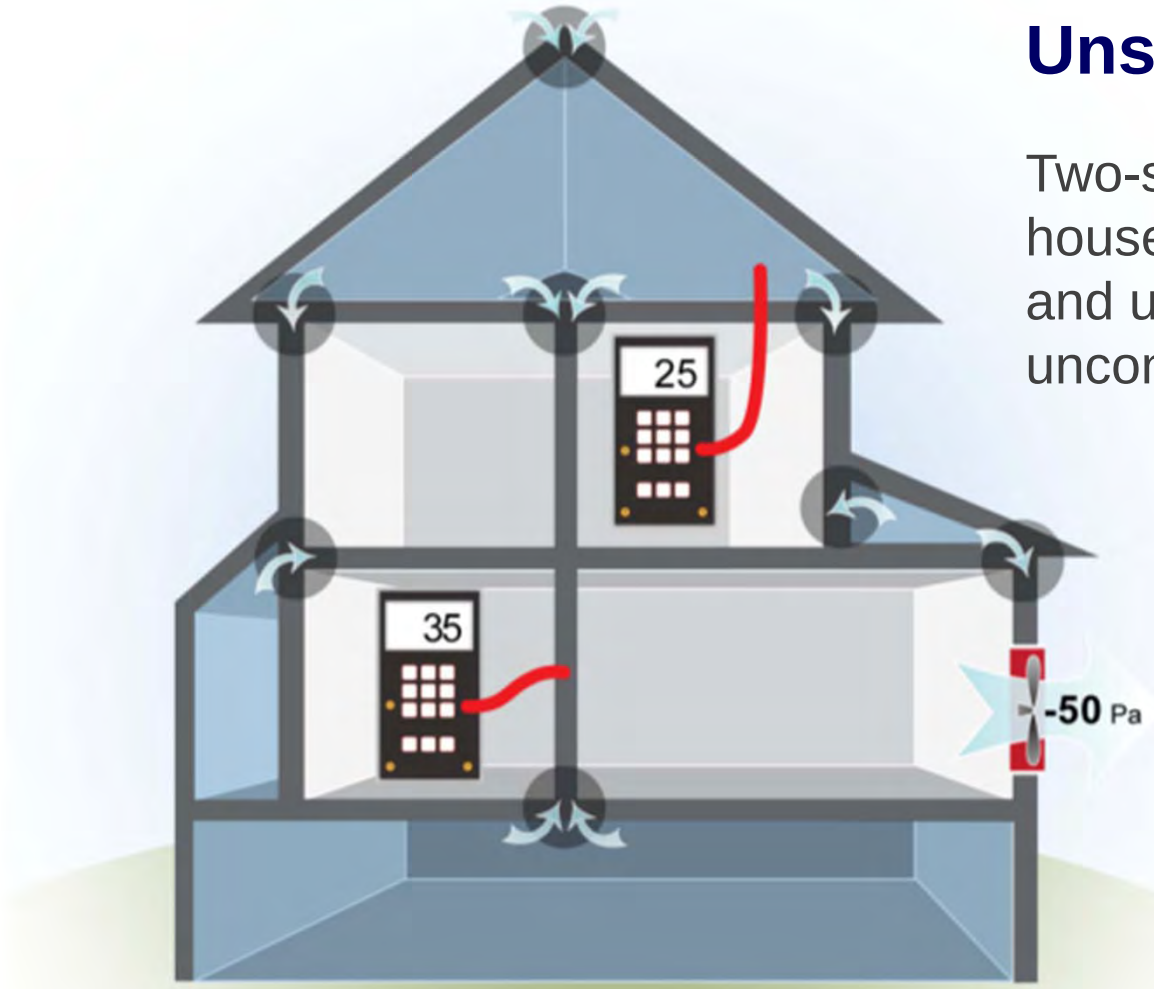
Pressure difference of interior wall with reference to the house should be close to 0 Pa.



Zonal Pressure Diagnostics #4

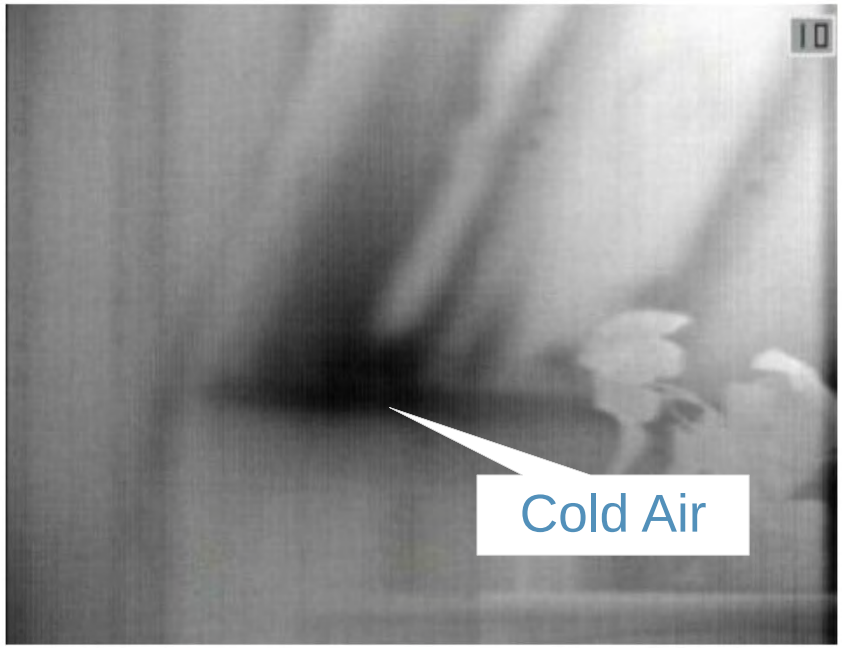


Unsealed/Uninsulated

Two-story balloon-framed house with one-story addition and unheated porch over unconditioned basement

Infrared Scanning #2

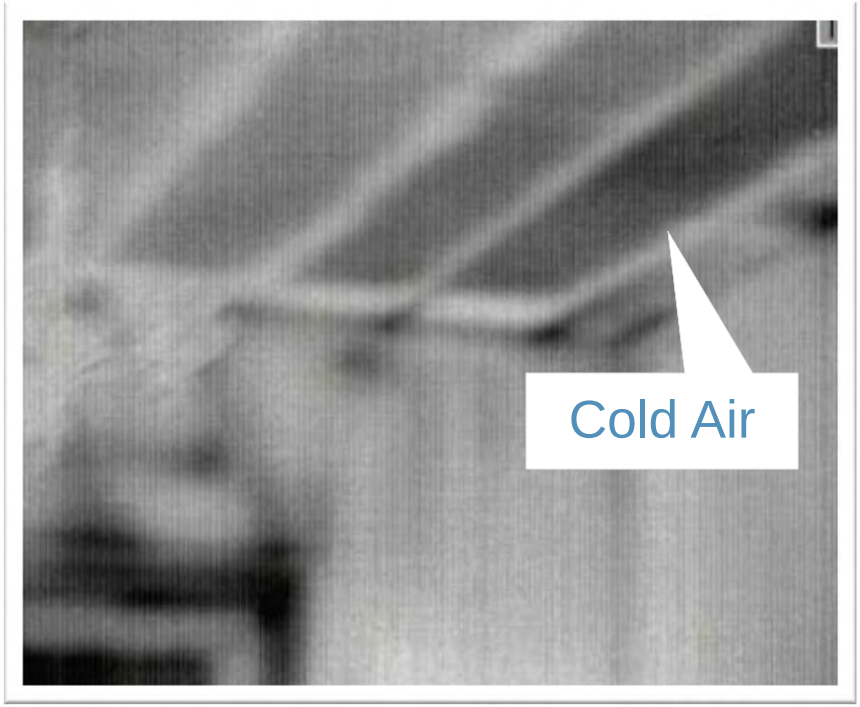
A knee-wall and window dormer detail.



An infrared scan of the same area with the blower door running shows air leakage at the intersection of the knee-wall and rafter cavity.

Infrared Scanning #3

A visible image of a ceiling detail between the first and second story.



An infrared scan of the same area with the blower door running shows air leakage in the ceiling joist cavities.

Quality Control

Diagnostics - Duct Leakage/Performance

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- Pressure Pan Testing or Duct Blower
- Finding Duct Leakage
- Duct Induced Pressure Differences

Pressure Pan

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Test the duct system with a pressure pan and blower door to identify:

- Leakage to outdoors when ducts are located outside the thermal boundary
- Leakage pathways from duct-containing building cavities to outdoors (e.g., floor-joist cavities adjacent to porch roofs, cantilevers)

Photo courtesy of NRCERT

Measure Room Pressure Imbalance

Room pressure imbalances over 4 Pascals should be remedied by adding supply or return air, then retested.

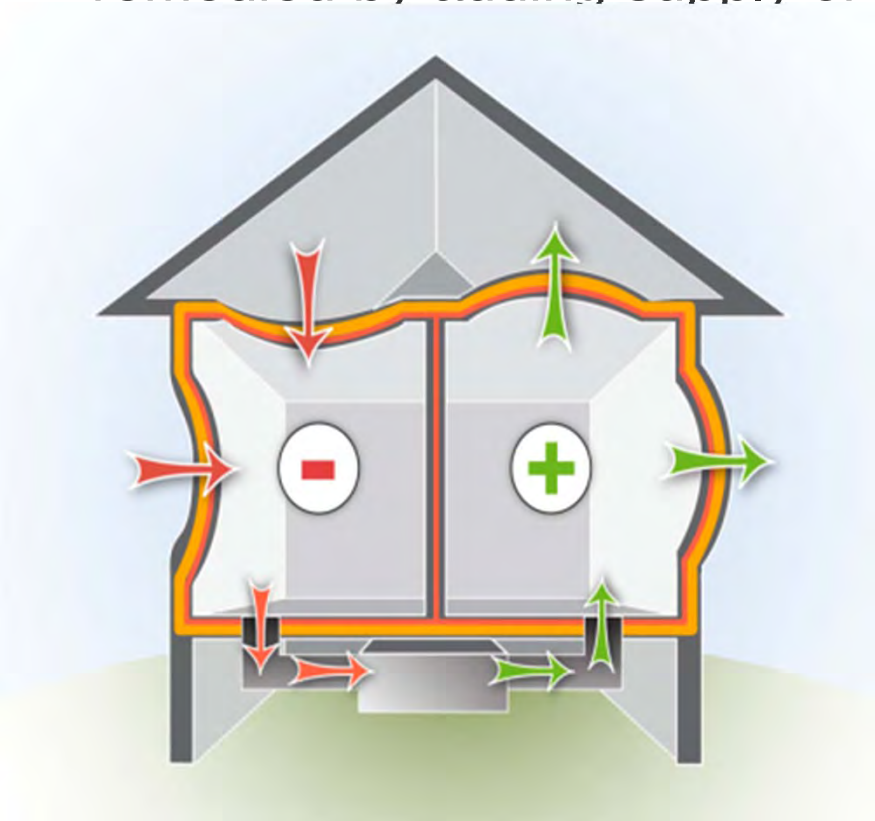


Photo courtesy of PA Weatherization Training Center

Voltage Drop Testing

- Reads the percentage of voltage drop on a circuit.
- A difference above 5% may indicate an unsafe condition.
- A qualified technician should investigate potential wiring problems.

Photo courtesy of PA Weatherization Training Center

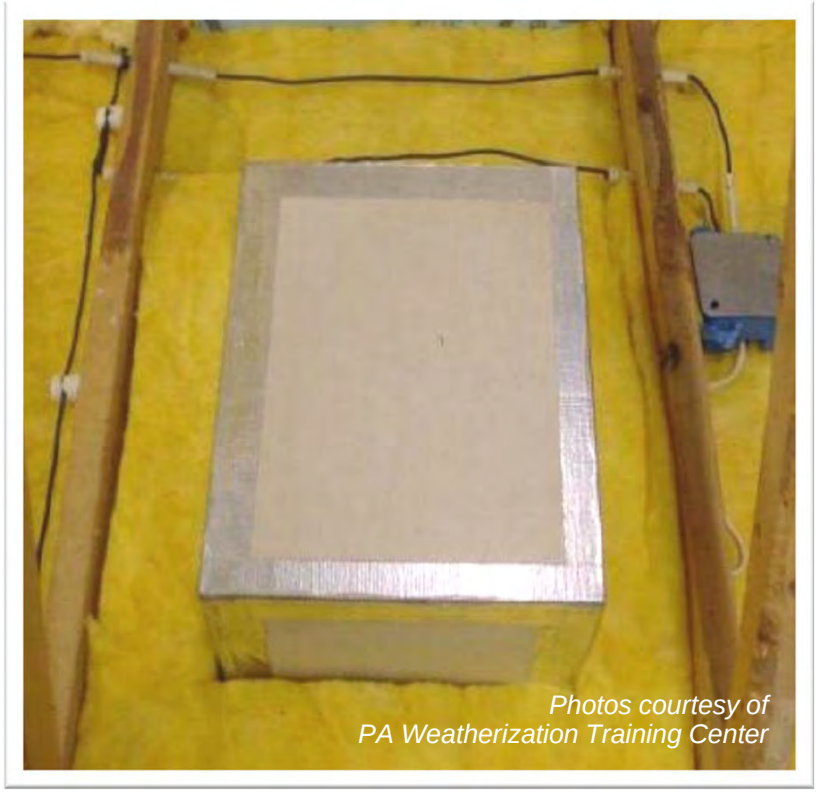
Electrical Assessment - Wiring

Charring on the light fixture and ceiling is evidence of a degraded wiring connection.

Taped and uncovered wiring splices such as these are unsafe and must never be covered with insulation.

Electrical Assessment - Light Fixtures

Provide 3” of air space between recessed lights and insulation or other flammables.



A fabricated airtight drywall box meets electrical code requirements and provides a good seal.

Base Load Measures

- Refrigerator replacement
- Water heater wrap or replacement
- Lighting upgrade

Audit Software Tool - Input

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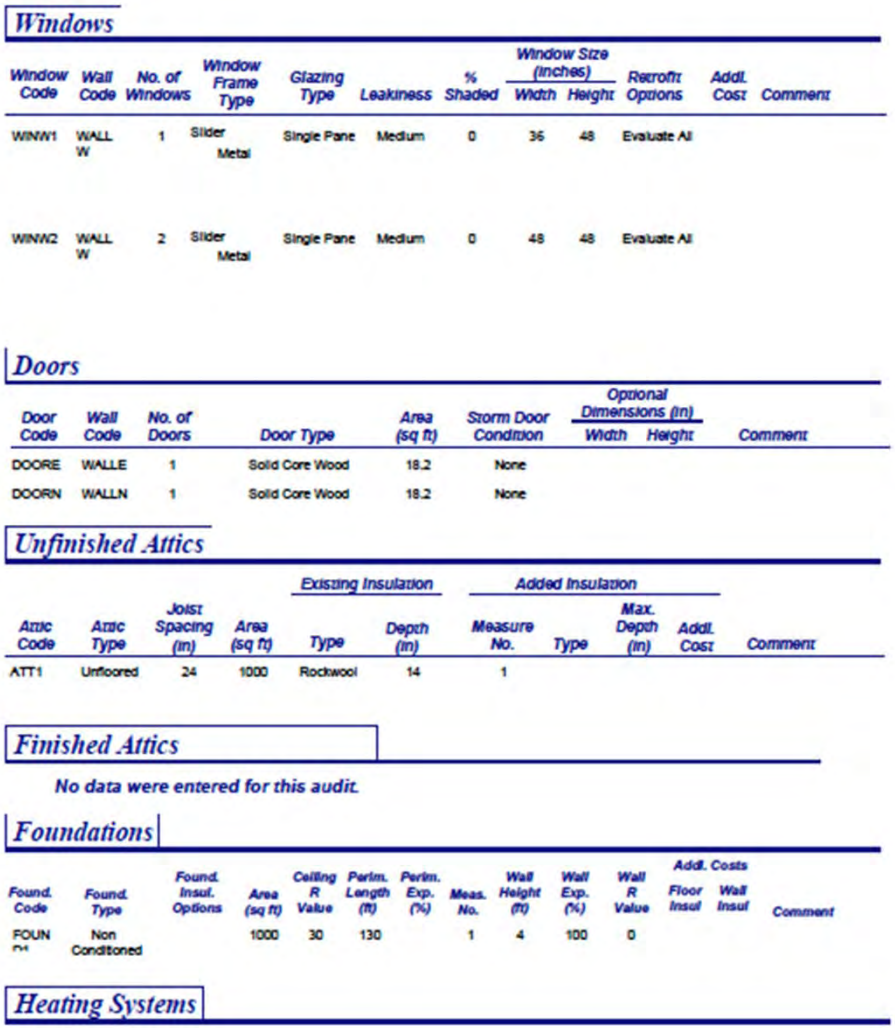

Windows

Window Code	Wall Code	No. of Windows	Window Frame Type	Glazing Type	Leakiness	% Shaded	Window Size (inches) Width	Height	Retrofit Options	Addl. Cost	Comment
WINW1	WALL W	1	Slider Metal	Single Pane	Medium	0	36	48	Evaluate All		
WINW2	WALL W	2	Slider Metal	Single Pane	Medium	0	48	48	Evaluate All		

Doors

Door Code	Wall Code	No. of Doors	Door Type	Area (sq ft)	Storm Door Condition	Optional Dimensions (in) Width	Height	Comment
DOORE	WALLE	1	Solid Core Wood	18.2	None			
DOORN	WALLN	1	Solid Core Wood	18.2	None			

Unfinished Attics

Attic Code	Attic Type	Joist Spacing (in)	Area (sq ft)	Existing Insulation Type	Existing Insulation Depth (in)	Added Insulation Measure No.	Added Insulation Type	Max. Depth (in)	Addl. Cost	Comment
ATT1	Unfloored	24	1000	Rockwool	14	1				

Finished Attics

No data were entered for this audit.

Foundations

Found. Code	Found. Type	Found. Insul. Options	Area (sq ft)	Ceiling R Value	Perim. Length (ft)	Perim. Exp. (%)	Meas. No.	Wall Height (ft)	Wall Exp. (%)	Wall R Value	Addl. Costs Floor Insul	Wall Insul	Comment
FOUN D1	Non Conditioned		1000	30	130		1	4	100	0			

Heating Systems

All the information from the site audit is entered into a DOE-approved audit software tool. Requirements:

- Measure interaction
- Climate specific
- Cost inputs
- Lists measures in order of decreasing SIR

Audit Software Tool - Results

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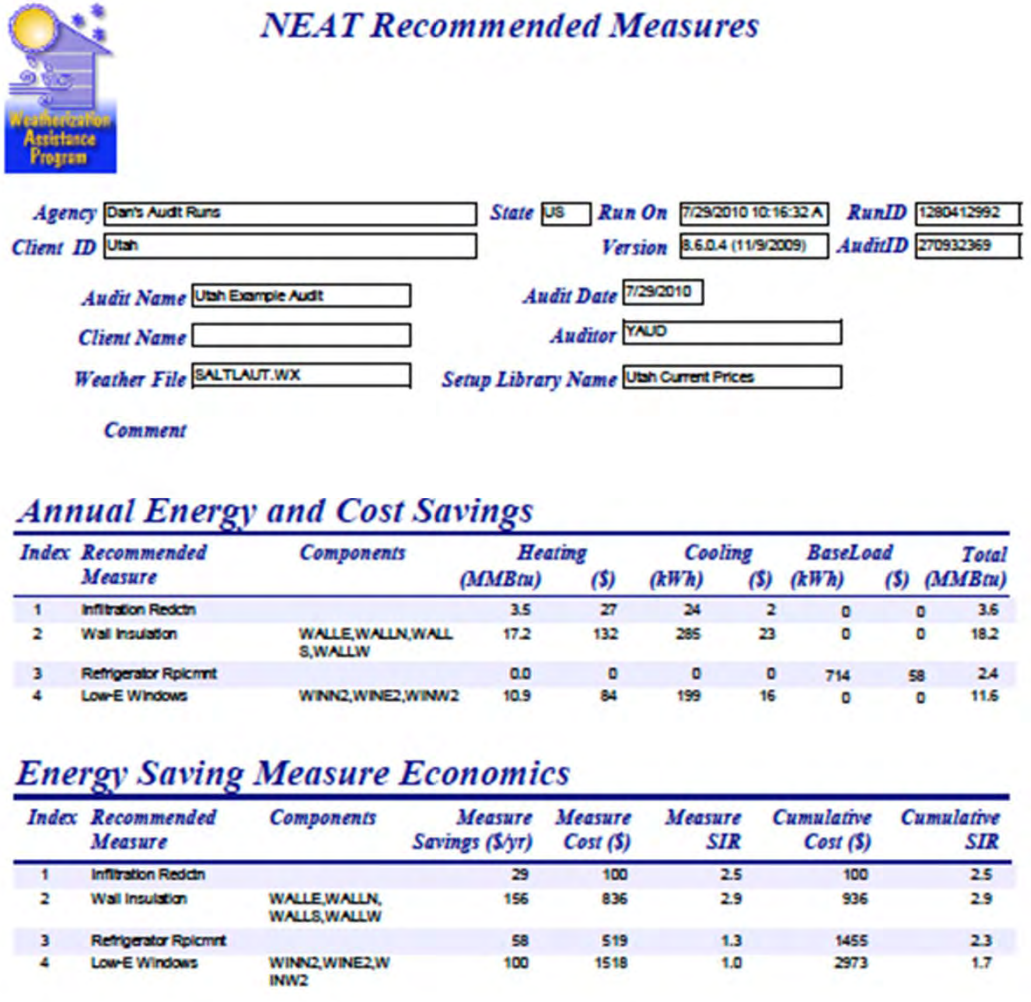
Audit software lists measures with allowable SIR.

Auditor creates work order for the home.



NEAT Recommended Measures

Weatherization Assistance Program

Agency	Dan's Audit Runs	State	US	Run On	7/29/2010 10:16:32 A
Client ID	Utah	Version	6.6.0.4 (11/9/2009)	RunID	1280412992
				AuditID	270932369

Audit Name	Utah Example Audit	Audit Date	7/29/2010
Client Name		Auditor	YAUD
Weather File	SALTLAUT.WX	Setup Library Name	Utah Current Prices
Comment			

Annual Energy and Cost Savings

Index	Recommended Measure	Components	Heating (MMBtu)	Heating ($)	Cooling (kWh)	Cooling ($)	BaseLoad (kWh)	BaseLoad ($)	Total (MMBtu)
1	Infiltration Redctn		3.5	27	24	2	0	0	3.6
2	Wall Insulation	WALLE,WALLN,WALLS,WALLW	17.2	132	285	23	0	0	18.2
3	Refrigerator Rplcmnt		0.0	0	0	0	714	58	2.4
4	Low-E Windows	WINN2,WINE2,WINW2	10.9	84	199	16	0	0	11.6

Energy Saving Measure Economics

Index	Recommended Measure	Components	Measure Savings ($/yr)	Measure Cost ($)	Measure SIR	Cumulative Cost ($)	Cumulative SIR
1	Infiltration Redctn		29	100	2.5	100	2.5
2	Wall Insulation	WALLE,WALLN, WALLS,WALLW	156	836	2.9	936	2.9
3	Refrigerator Rplcmnt		58	519	1.3	1455	2.3
4	Low-E Windows	WINN2,WINE2,WINW2	100	1518	1.0	2973	1.7

Summary

- A successful weatherization project begins with a systematic approach of visual and diagnostic evaluation.
- Good building assessments begin with a thorough client interview.
- A successful audit relies on the application of accurate visual assessment and diagnostic procedures.
- A successful building assessment incorporates all of the knowledge of building systems and the interaction of their components.
- Auditors must document moisture, electrical, and health and safety problems.
- Understanding the components of the thermal boundary will help the auditor determine the most cost effective retrofit strategies.