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ACCA Standard 12

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Home Evaluation and Performance Improvement

Residential One- and Two-Family Dwellings and Townhouses Not More Than Three Stories Above Grade

The Air Conditioning Contractors of America Educational Institute (ACCA-EI) Standards Task Team (STT) develops standards as an American National Standards Institute (ANSI) accredited standards developer (ASD). ACCA develops voluntary standards as outlined in the ACCA Essential Requirements and the ANSI Essential Requirements. ACCA standards are developed by diverse groups of industry volunteers in a climate of openness, consensus building, and lack of dominance (e.g., committee/group/team balance). Essential requirements, standard activities and documentation can be found in the standards portion of the ACCA website at www.acca.org. Questions, suggestions, and proposed revisions to this standard can be addressed to the attention of the Standards Task Team, ACCA, 2800 Shirlington Road, Suite 300, Arlington, VA 22206.

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RESNET
Setting the Standards for Quality

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INTRODUCTION

(This informative appendix is not part of the standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ACCA or ANSI.)

This Standard establishes the minimum requirements to evaluate a residence with regards to energy efficiency, water conservation, occupant comfort, and indoor air quality. From this evaluation, improvement opportunities are presented to the client so that they can select improvements that meet their needs. The standard describes the minimum requirements for the practitioners that effect the selected improvements, and the subsequent verification that the performed work is in compliance to industry standards.

This Standard treats the home as one system comprised of many sub-systems. It is understood that improvements to one sub-system may impact other sub-systems. In identifying and implementing the improvements, attention is given to promote safe and healthy homes.

Appendix A provides normative audit guidance that elaborates and details procedures noted in the body of the standard. Informative Appendix B addresses additional elements of a residential audit that could be offered to the client based on the Auditor's experience or regional considerations. Informative Appendix C identifies commonly accepted values that can be used if the actual information is neither known nor available. Informative Appendix D defines terms as they are used in the QH Standard. Informative Appendix E highlights industry resources that may aid in the audit, assessment, presentation, implementation, and evaluation of home performance improvements.

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1.0 PURPOSE

This standard establishes the minimum criteria by which deficiencies in existing residential buildings are identified by audit, improvement opportunities are assessed, scopes of work are finalized, work is performed in accordance with industry recognized procedures, and improvement objectives were met.

2.0 SCOPE

This standard applies to site-constructed or manufactured one- and two-family dwellings and townhouses not more than three stories above grade in height.

3.0 COMPREHENSIVE PERFORMANCE AUDIT

The comprehensive performance audit shall collect data about the residence in the form of measurements, tests, and observations. This section defines the areas of the residence that shall be evaluated and the information that shall be collected. Prior to conducting the audit, the Auditor shall notify the occupants of the potential for aggravation to persons with environmental sensitivities (e.g., asthma, allergies, chemical sensitivity, etc.) and that it may take hours for the home to settle to pre-test conditions. When conditions listed in Appendix A, §A1.0 exist, the Auditor or auditing company shall disclose the potential for conflict of interest.

3.1 INTERVIEW

3.1.1 Requirement: The Auditor shall conduct an interview to identify occupant behaviors and use patterns that impact energy use, occupant perceived problems and concerns relating to energy use.

3.1.2 Acceptable Procedures: The Auditor shall pose questions similar to those found in Appendix A, §A2.0 to the client.

3.2 HEALTH AND SAFETY: FOSSIL FUEL APPLIANCES

3.2.1 Carbon Monoxide (CO) Testing

a. Requirement: The Auditor shall measure and record the CO level of:

i. The combustion appliance flue gases,

ii. The accessible venting system, and

iii. The combustion appliance zone (CAZ).

b. Acceptable Procedures: The Auditor shall test the CO level in the combustion appliance's flue gasses, the joints and seams of its venting system for leaks, and monitor the CO level in the CAZ using one of the following:

i. The protocol in Appendix A, §A3.0, or

ii. 2015 National Fuel Gas Code, Annex G, §G.6.

NOTE: While performing the Depressurization test, CO level monitoring shall be performed continuously as described in Appendix A, §A3.0.

3.2.2 Gas/Oil Leakage Testing

a. Requirement: The Auditor shall verify that all accessible exposed gas/oil piping in the building has been inspected for leaks, and leak locations have been identified for remediation.

NOTE: If there is an odor indicating a gas leak(s) within the building, the Auditor shall advise the occupants to leave the building, and the

Auditor shall notify the appropriate authorities and utility providers from outside the building. Ensure that switches are not operated while exiting and no ignition sources are present. The audit shall not proceed until the proper authorities have deemed it safe to re-enter the building.

b. Acceptable Procedures: The Auditor shall follow one of the following acceptable procedures for fulfilling the desired criteria:

i. Gas lines: Shall inspect all fittings and joints in supply lines and appliances with the appropriate gas detector capable of measuring at 20 ppm; shall confirm measured leaks with leak-detection fluid; shall mark the location of the leak with a clearly visible tag; shall notify the homeowner.

ii. Oil lines: Shall be visually inspected for signs of oil; shall mark the location of the leak with a clearly visible tag; shall notify owner of the leak.

3.2.3 Unvented Combustion Heating Appliances[1]

a. Requirement: The Auditor shall record the presence, location, and input rating of unvented combustion appliances. The Auditor shall record if gas-fired unvented heaters are listed to ANSI Z21.11.2. The Auditor shall determine and record the total input of all gas-fired unvented heaters installed in the same room, or rooms that freely communicate with each other.

b. Acceptable Procedures: The Auditor shall confirm that the information required is properly recorded.

3.2.4 Combustion Appliance Zone Volume (Atmospherically vented appliances)

a. Requirement: The Auditor shall measure the volume of the space providing combustion air to fossil fuel appliances and, if provided, the net free area of openings which supply combustion air from an adjoining room or the outdoors, including any bird/insect screen on opening terminations.

b. Acceptable Procedures: The Auditor shall follow one of the following acceptable procedures for fulfilling the desired criteria:

i. National Fuel Gas Code §9.3, or
ii. Authority having jurisdiction (AHJ).

3.2.5 Depressurization Test (Atmospherically vented appliances)

a. Requirement: Where required by the AHJ, the Auditor shall provide evidence that the combustion appliance operates safely during periods of depressurization generated by the occupants.

b. Acceptable Procedures: The Auditor shall follow one of the following acceptable procedures for fulfilling the desired criteria:

i. The protocol in Appendix A, §A4.0, or
ii. Follow the methodology/procedure per the AHJ (e.g., IRC APPENDIX D).

3.2.6 Combustion Appliance Venting (Atmospherically vented appliances)

a. Requirement: The Auditor shall document whether the combustion appliance venting system shows evidence of, or insufficient performance, for the following:

i. Blockages,

[1] For example, unvented gas-fired heaters.

ii. Soot,
iii. Corrosion or oxidation,
iv. Improper support, slope, and/or termination,
v. Insufficient draft.

b. Acceptable Procedures: The Auditor shall visually inspect the venting system for i. through iv. above, perform a draft test for v. above in accordance with the NFGC §11.6 (for gas-fired appliances) or NFPA 31 §6.3.1 (for oil-fired appliances), and record the findings for all of the above.

3.3 ENVELOPE

3.3.1 Requirement: The Auditor shall determine the leakage rate of the building envelope[2].

3.3.2 Acceptable Procedures: A single point (50 Pa) envelope leakage depressurization/ pressurization test must be performed[3] in accordance with:

a. The envelope testing protocols contained in Appendix A, §A5.0, or

b. Chapter 8, §801, RESNET Mortgage Industry National HERS Standards.

NOTE: A single point test is the minimum requirement; however, the Auditor may choose to perform a multi-point test. This test must be performed in accordance with ASTM E779-10 or CAN/CGSB 149.10-M86.

3.4 VENTILATION

3.4.1 Requirements: The Auditor shall determine the minimum ventilation requirement for the occupants of the building. The mechanical ventilation airflow shall be measured. The Auditor shall verify that exhaust fans and clothes dryers vent to the outdoors.

3.4.2 Acceptable Procedures:

a. The Auditor shall follow ASHRAE 62.2-2013, or methodology adopted by AHJ, to perform building ventilation calculations and use them in determining the ventilation requirement.

b. Mechanical ventilation airflow shall be measured in accordance with §5.2.2 of ACCA 5 QI Standard.

c. Visual confirmation that identified exhaust fans vent to the outdoors.

3.5 INSULATION

3.5.1 Requirement: The Auditor shall determine the insulation levels in the applicable and accessible building components (walls, ceilings, roofs, floors, slabs, and crawlspaces).

3.5.2 Acceptable Procedures: The Auditor shall follow the methodology defined in:

a. Appendix A, §A10.1, or

b. Appendix A, RESNET Mortgage Industry National HERS Standards.

3.6 HEATING AND COOLING SYSTEMS

3.6.1 Airflow testing

[2] If the auditor suspects that within the envelope there exist hazardous materials that would be dislodged during an envelope leakage test, then the hazardous materials must be remediated before conducting this test.

[3] At the discretion of the Auditor or the AHJ, the Auditor may perform an IR scan of the building envelope in order to target and record any gap during the blower door testing. This will also allow the Auditor to identify any areas of missing insulation.

a. Requirement: The Auditor shall measure and record the airflow through the indoor heat exchanger.

b. Acceptable Procedures: The Auditor shall test the airflow through the heat exchanger in accordance with the ACCA 5 QI Standard §4.1 accepted procedures.

NOTE: Equipment must be in like-new condition in order to use the OEM CFM/static pressure drop coil table method.

3.6.2 Distribution System Temperature Difference (TD)

a. Requirements: The Auditor shall measure the TD between the air leaving the conditioned space and the air entering the heat exchanger, and the TD between the air leaving the heat exchanger and the air delivered into the conditioned space.

b. Acceptable Procedures: The contractor shall use the protocols in Appendix A, §A6.0.

3.6.3 Duct Leakage Testing

a. Requirement: The Auditor shall perform a qualitative test of all accessible ducting to determine opportunities for sealing. However, if an initial visual inspection finds faults/defects in the duct system indicating substantial duct leakage, a qualitative test shall not be required, but these faults/defects shall be recorded. At the discretion[4] of the Auditor or the AHJ, the auditor shall recommend that a quantitative test be performed of the entire duct system[5].

b. Acceptable Procedures:

i. Qualitative Test – Shall be tested in accordance with:

1) Gasketed Pan Test (Pressure Pan) – procedures listed in Appendix A, §A7.0, or

2) Blower Door Assisted Smoke Test – procedures listed in Appendix A, §A8.0.

ii. Quantitative Test – Shall be tested in accordance with:

1) ACCA 5 QI Standard, §5.1, or

2) Chapter 8, RESNET Mortgage Industry National HERS Standards.

3.6.4 Room- Pressure Differences

a. Requirement: The Auditor shall measure the pressure difference between the house, or a zone conditioned by an HVAC system (with reference to [wrt] the outdoors [OD]) and each isolated room (wrt the OD), excluding bathrooms.

b. Acceptable Procedures: The Auditor shall use the procedures listed in Appendix A, §A9.0

3.7 WATER HEATING

3.7.1 Requirement: The Auditor shall determine the name plate efficiency and age of the water heater(s), and the hot water piping insulation R-value.

3.7.2 Acceptable Procedures: The Auditor shall confirm that the information required is properly recorded.

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[4] Discretion considerations include: the amount of ducts in the unconditioned space, whether the duct distribution system is new or modified, and/or condition of the duct system.

[5] For ducts specified for sealing, see §6.5.4 and §7.0.

3.8 APPLIANCES AND EQUIPMENT

3.8.1 Requirement: The Auditor shall identify those appliances and equipment that would result in substantial energy savings if replaced by efficient alternatives.

3.8.2 Acceptable Procedures: The Auditor shall record each energy-saving opportunity while performing the home audit.

3.9 MOISTURE

The Auditor shall investigate for interior or exterior moisture issues to ensure that the building has systems to prevent damage from rain and ground water.

3.9.1 Exterior/Interior

a. Requirements: The Auditor shall visually examine and record:
   i. Evidence of plumbing leaks and moisture deposition or damage[6].
   ii. Areas where moisture migration into the attic is apparent and determine the source of the moisture.
   iii. For the interior of the building, crawlspace, and attic, evidence of moisture at the following locations:
      1) Along the attic floor and roof decking;
      2) Under windows;
      3) On exterior walls behind furniture;
      4) In corners of closets on exterior walls;
      5) At flooring adjacent to doors and windows;
      6) Around HVAC supply outlets;
      7) On the ceiling;
      8) Along exterior wall baseboards;
      9) In other areas of stagnation and thermal bridging;
      10) The ground of the crawlspace;
      11) Concrete block foundation walls.
   iv. For the exterior of the building, crawlspace, and roof, evidence of potential sources of water intrusion at the following locations:
      1) Siding,
      2) Windows,
      3) Trim,
      4) Fascia,
      5) Soffit areas,
      6) Door head trim,
      7) Door jambs,
      8) Door sills.

b. Accepted procedures: The auditor shall confirm that the information required is properly recorded.

3.9.2 Drainage

a. Requirements: The Auditor shall inspect for evidence of ground-water intrusion and shall confirm the appropriate exterior grade, roof drainage, and the presence of a foundation drain system.

b. Accepted procedures: The Auditor shall:
   i. Check to see if the ground slopes away from the building at least 6" over the first 10'.
   ii. Note if roof runoff water is directed away from the foundation with downspouts, leaders and splash blocks.
   iii. Note if there is a foundation drain system.

[6] Signs of excessive moisture levels in the living space such as discoloration, stains, decomposed wood, oxidation, etc.

3.10 POOLS AND SPAS

3.10.1 Requirements: The Auditor shall ensure:

a. Safety: Note type of suction outlet cover(s) and flow rating.

b. Motor efficiency: Record the total horsepower of the pump motor, type of controls, and timers being used for the pool or spa.

c. Heated pools: Record the type of pool heater, the water temperature, the location of the heater's on-off switches, if switch is separate from thermostatic control, and the pool/spa covers used.

3.10.2 Accepted procedures: The Auditor shall confirm that the information required is properly recorded.

3.11 DISCRETIONARY ITEMS FOR COST/BENEFIT ANALYSIS

3.11.1 Requirement: At the discretion of the homeowner or AHJ, a performance improvement cost/benefit analysis of specific attributes of the home shall be undertaken in §4.2 of this standard. This shall require the recording of additional information about the existing building (e.g., R-values, glazing, shading, HVAC systems, etc.).

3.11.2 Acceptable Procedures: The Auditor shall use the procedures listed in Appendix A, §A10.0 to record the information requested by the homeowner or AHJ.

3.12 DOCUMENTATION

3.12.1 Requirement: The Auditor shall ensure:

a. An audit file of required and relevant information shall be created.

i. Required information consists of data (e.g., measurements, observations, test results, etc.) for each specified building audit requirement, a record of the model and serial numbers of all equipment audited, supporting measurements, or calculations.

ii. Relevant information consists of additional information applicable to the audit activity undertaken. This includes drawings and photographs.

b. Copies of documents from §3.12.1.a, including the modeling software file, are maintained at the Auditor's place of business.

3.12.2 Acceptable Procedures: The Auditor shall confirm that the listed requirements are met.

3.13 UNSAFE CONDITIONS

3.13.1 Requirement: Upon discovery of any condition deemed unsafe by the Auditor, the Auditor shall halt the audit process.

3.13.2 Acceptable Procedures: The Auditor shall leave the building and recommend that the occupants do the same until the situation is resolved.

4.0 ASSESSING IMPROVEMENTS

This section establishes the procedures to evaluate the measurements, observations, and client's objectives in order to develop a prioritized list of improvements. Information gathered during the audit shall be analyzed against benchmarks to determine where opportunities for improvement exist. These identified improvement opportunities shall be assigned a cost and then prioritized. The building shall have improvements effected to meet minimum safety, energy, durability, and indoor air quality requirements.

4.1 IDENTIFYING IMPROVEMENTS

Measurements and observations collected during the audit shall be evaluated to determine the impact of their implementation on the performance of the building.

4.1.1 The Auditor shall use Table 1 to compare the recorded measurement or observation to the comparative benchmark, and identify improvement opportunities.

4.1.2 The Auditor shall note if different comparative benchmarks are used and the rationale for the substitution.

Table 1: Comparison of Current Measurements and Comparative Benchmarks

Improvement Area	Current measurement or value	Comparative Benchmarks
§3.2.1 CO of flue gasses	_____ppm	< 100 ppm.
CO at vent piping	_____ppm	0 ppm (i.e., no leaks).
Ambient CO level in CAZ	_____ppm	Less than 9 ppm.
CO of undiluted flue gases	_____ppm	As specified by EPA Air Quality Criteria for Carbon Monoxide (EPA 600/P-99/001F 2000.
§3.2.2 Gas/Oil Leakage Testing	Leaks located at _____ _____	No leaks.
§3.2.3 Unvented Combustion Appliances	Appliance(s) present_____ Location(s) _____ Input rating(s) _____ Listed to ANSI Z21.11.2 Yes/No	Listed per ANSI Z21.11.2. 20 Btuh/hr per cubic feet as stipulated in the 2012 International Residential Code §G2445.5 and 2012 International Fuel Gas Code §621.5.
§3.2.4 CAZ Volume	Measured volume of combustion air: _____ft^3 Measured area of combustion air openings: _____ft^2	As specified by the IRC 2012, §G2407.
§3.2.5 Depressurization (where tested)	Appliance displays proper draft all of the way around the appliance. Yes/No or Pressure in CAZ _____Pa	Appliance drafts at all points around the circumference of the draft hood relief opening. Positive or neutral pressure in the CAZ with respect to outdoors (WRTO).
§3.2.6 Combustion Appliance Venting	Signs of: Blockage Yes/No Soot Yes/No Corrosion, rust Yes/No Proper support, slope and termination Yes/No	No signs of blockage, soot, corrosion, oxidation. Venting system is supported, sloped, and terminated in accordance with NFGC.

<table>
<tr><th colspan="5">Table 1: Comparison of Current Measurements and Comparative Benchmarks</th></tr>
<tr><th>Improvement Area</th><th colspan="3">Current measurement or value</th><th>Comparative Benchmarks</th></tr>
<tr><td>§3.3
Envelope</td><td colspan="3">CFM50:_____
ACH50:_____</td><td>As specified by the IECC 2012 §402.4.</td></tr>
<tr><td>§3.4
Ventilation</td><td colspan="3">Measured infiltration:
_____CFM50
Calculated ventilation requirement:
_____Cfm
Measured ventilation rate:
_____Cfm</td><td>As specified by ASHRAE 62.2 -2013 or AHJ.</td></tr>
<tr><td>§3.5
Insulation</td><td colspan="3">Ceiling/Attic: _____R-value
Wall R-Value: _____ R-value
Floor/Slab/Crawlspace R-Value:
_____ R-value</td><td>Meet the standards set forth in the IECC 2012 Table 402.1.1.</td></tr>
<tr><td>§3.6.1
Airflow</td><td colspan="3">Measured airflow :_____Cfm</td><td>As specified by the OEM in accordance with ACCA 5 QI Standard.</td></tr>
<tr><td>§3.6.2
Distribution System Temperature Difference</td><td colspan="3">Measured TD from heat exchanger discharge to supply grille: _____°F
Measured TD from Return grille to heat exchanger inlet: _____°F</td><td>Cooling mode: The air TD from the cooling coil to any supply air outlet in the conditioned space shall not increase more than 3°F.
Heating mode: The air TD from the heat exchanger to any supply air outlet in the conditioned space shall not decrease more than:
• 5°F for heat exchanger discharge air temperatures at or above 105°F.
• 3°F for heat exchanger discharge air temperatures below 105°F.
The TD from any return air inlet in the conditioned space to the return air plenum shall not change more than 3°F.</td></tr>
<tr><td rowspan="18">§3.6.3
Duct Leakage Testing</td><td colspan="3">Gasketed Pressure Pan</td><td rowspan="18">Median value shall be no more than 3 Pa, no register or grille shall be greater than 8 Pa.</td></tr>
<tr><td>Register / Grille / Diffuser ID + location</td><td>Supply or Return?</td><td>Pressure Reading</td></tr>
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</table>

Table 1: Comparison of Current Measurements and Comparative Benchmarks		
Improvement Area	Current measurement or value	Comparative Benchmarks
§3.6.4 Room Pressure Differences	Measured Duct leakage: _____CFM25	As specified by the ACCA 5 QI Standard §5.1.
	Room Pressure Differences: Baseline (House WRTO): _____Pa Bedroom 1 PD (WRTO):_____Pa Bedroom 2 PD (WRTO): _____Pa Bedroom 3 PD (WRTO): _____Pa Other 1 PD (WRTO): _____Pa Other 2 PD (WRTO): _____Pa	No more than 0.012iwc (3Pa) pressure difference (PD) between the area with the largest return air duct WRT and an interior room with the door closed (WRTO).
§3.7 Hot Water Heating	Water Heater nameplate efficiency: _____	As specified by National Appliance Efficiency Conservation Act (NAECA).
	Piping Insulation: _____R-value	Insulate pipes to IECC 2012 §403.3.
§3.8 Appliances and Equipment	Appliance 1:_____ Appliance 2: _____ Appliance 3: _____ Appliance 4: _____ Appliance 5: _____ Appliance 6: _____ Appliance 7:_____ Appliance 8:_____ Appliance 9:_____ Appliance 10:_____	Appliances and Equipment efficiency as specified by ENERGY STAR.
§3.9 Moisture	Plumbing leaks:_____ Drainage issues:_____ Exterior rating:_____ Interior rating:_____	Plumbing leaks: None. Drainage issues: No evidence of ongoing moisture intrusion. Exterior and Interior Ratings: • "Excellent" indicates no weather damage, new condition. • "Good" indicates little weather damage, nearly new condition. • "Fair" indicates some moderate weather damage (10% - 20% of surface area). • "Poor" indicates weather damage greater than 20% of the surface area.
§3.10 Pools and Spas	Suction outlet cover flow rating:_____ Motor Total horsepower: _____Hp Pool heater type:_____	Suction outlet cover in accordance with ASME A112.19.8 – 2007. 1.0 horsepower motors or greater shall be a multi-speed or variable-speed motor. Pool pump motor shall be sized per APSP 15 - 2011.

Pool heater type	Minimum Efficiency
Fossil Fuel	78% AFUE
Electric	None
Heat pump	COP 4.0

Table 1: Comparison of Current Measurements and Comparative Benchmarks		
Improvement Area	Current measurement or value	Comparative Benchmarks
	Heater efficiency: _____ On/off switch readily accessible: Yes/No Time switches able to be automatically turned on/off: Yes/No Pool and spa vapor retardant listing: (if water temperature greater than or equal to 80°F) _____	As specified in the IECC 2012 §403.9. As specified in the IECC 2012 §403.9. Tested and listed ASTM F1346-91 - 2010 and in continuous contact with the rim of the pool or spa.

4.2 COST/BENEFIT ANALYSIS

At the discretion of the Auditor or client, the opportunities to improve building performance shall be assessed to determine the value of the improvement using the on-site inspection protocols found in Appendix A §10.0.

4.2.1 Costs associated with the implementation of a building performance improvement shall be based on submitted proposals or historical knowledge.

a. Submitted fixed-price proposals for the implementation of a building performance improvement shall supersede estimates based on historical knowledge.

b. The prioritization of building performance improvements shall be revised when fixed-price proposals replace estimates based on historical knowledge.

c. Cost estimates and submitted fixed-price proposals shall be based on implementing the improvement opportunities in accordance with recognized standards and procedures in §6.0.

4.2.2 Cost benefit analysis shall be computed using software and/or engineering calculations capable of predicting energy savings associated with proposed improvement measures and measure packages. Acceptable alternatives include:

a. Software programs accredited by the Residential Energy Services Network (RESNET).

b. Manual J software programs recognized by ACCA that include energy modeling.

c. Other software or calculation methodology as approved by the AHJ.

NOTE: Historical Energy Consumption
The Auditor shall have the discretion to use the previous 12 months of utility bills in conjunction with modeling programs to more accurately estimate the benefits associated with the performance improvement of a particular building.

4.3 ADDITIONAL ELEMENTS

Supplementary information that will affect the decision making process regarding building performance improvement opportunities shall be noted; these include, but are not limited to:

4.3.1 Age,

4.3.2 Condition,

4.3.3 Presence of hazardous materials,

4.3.4 Performance improvements that will lead to further building modification requirements by the AHJ (e.g., when replacing siding will also lead to a requirement for improving wall insulation).

5.0 PRESENTING PERFORMANCE IMPROVEMENT OPPORTUNITIES

The building performance improvements shall be presented in a manner that supports the decision making process. The building performance improvements shall reflect the "house as a system" approach, recognizing that measures interact. The building performance improvement opportunities shall be prioritized based on 1) safety and health, 2) energy or heat transfer benefit, and then 3) those related to comfort, IAQ, or durability benefits. The performance improvements shall ensure that the applicable work is specified and performed in accordance with recognized industry standards and good practices. The client shall have the discretion to adopt building performance improvements of their choosing unless their selection(s) would compromise the safety of the occupants.

5.1 PRIORITIZING AUDIT INFORMATION

The measurements taken, reference benchmarks used, and resulting building performance improvements shall be prioritized and presented in the following order:

5.1.1 Fossil Fuel Appliance Combustion Safety issues: High CO levels, fossil fuel leaks, and unlisted, unvented, combustion appliances used as primary heat source shall be presented as the highest priority.

5.1.2 Ventilation and moisture related health issues.

5.1.3 Building performance improvements with energy or heat transfer[7] savings.

a. Improvements with the largest savings (energy or heat transfer) potential, and

b. Improvements with the best cost-to-benefit ratio.

5.1.4 Comfort, or IAQ, or building durability: For improvement areas with no energy or Btu/h savings, the Auditor shall list the beneficial effect associated with the implementation of the improvement opportunities.

5.2 PRESENTING BUILDING IMPROVEMENT OPPORTUNITIES

Building performance improvements shall be presented in the priority order and sequenced to provide the greatest energy savings, most improved thermal transfer, or to meet the client's objectives for comfort, IAQ or durability.

5.2.1 Building owner interaction: Building improvement opportunities shall be presented based on the priorities listed in §5.1. The client shall have the discretion to select the improvement opportunities that best meet their objectives[8].

5.2.2 Adverse effects[9]: Building performance improvements shall be presented in groupings that will neither harm the occupants, nor degrade the building integrity, nor the performance of the building (See Appendix B20.5).

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[7] Heat transfer is also referred to as Btu/h changes, some software calculates energy savings from a particular building improvement opportunity, and other software calculates the Btu/h reduction in the heating/cooling load.

[8] The Auditor should present both measure-level and package-level cost/benefit analyses. A measure-level analysis helps the homeowner pick the most cost effective items, while a package-level analysis help educate on the interrelation of improvements.

[9] Some building performance improvements, or combinations of improvements, have the potential to adversely affect the occupants or the building (e.g., air sealing the home with a primary heart source from an unvented combustion appliances). These adverse effects include, but are not limited to: elevated CO levels, moisture damage, and poor IAQ.

5.3 PROPOSAL ELEMENTS REQUIRED

All proposed improvements shall:

5.3.1 Meet applicable codes and regulations for the jurisdiction.

5.3.2 Specify duct sealing measures to resolve deficiencies identified during the audit.

5.3.3 Include a statement indicating that the energy savings are estimated; see Appendix B20.4 for an example of the wording to address this issue.

5.3.4 Refer to the minimum standard requirements in §6.0 (Implementing Identified Improvements) to facilitate obtaining comparable bids from multiple sources that desire to effect the improvements.

5.3.5 A contractor's qualified technician, or an independent auditor if required by an AHJ, shall perform a final test-out per §7.0 to ensure the improvement objectives were met.

5.3.6 Identify the recognized software used to determine the energy or Btu/h savings per building performance improvement opportunity.

5.3.7 Recommend radon testing and mitigation in accordance with state and federal requirements (http://www.epa.gov/radon/whereyoulive.html). If none, see US EPA guidance for testing and mitigation.

5.3.8 Recommend allergen testing and mitigation in accordance with protocols established in US HUD *Healthy Homes Issues: Asthma* §3.0 and §4.0 (http://portal.hud.gov/hudportal/documents/huddoc?id=DOC_12480.pdf).

5.3.9 When hazardous materials were found in the home during the audit, include the provision to conduct an envelope leakage test (per §3.3) after the remediation of hazardous materials. Proposed improvements shall include remediation steps based on the results of the envelope leakage test and the procedures in §4.0.

5.3.10 Include the installation of CO detector(s) outside of all bedrooms in homes that use combustion appliances.

5.4 DOCUMENTATION REQUIRED

Provide the client with:

5.4.1 Findings and benchmarks: A record of the audit findings and benchmarks used to develop the resulting Scopes of Work.

5.4.2 Scopes of work: Detailed corrective actions to be performed on the building in accordance with the applicable specifications in §6.0.

5.4.3 Cost/benefit analysis information: Software reports, checklist calculations, and other information used to demonstrate the value of remediation actions.

5.4.4 Release: Signed release from the client indicating that they were made aware of any safety or health issues revealed during the audit.

6.0 IMPLEMENTING IDENTIFIED PERFORMANCE IMPROVEMENTS

The Project Manager shall ensure that the building performance improvement(s) selected by the client is performed in accordance with recognized industry standards and good practices. The Project Manager overseeing the implementation of the building performance improvements shall not make any exclusions or variations from the prescribed work scope that result in the home operating improperly or increasing the risk of flue gas spillage, back-drafting, carbon monoxide production, or moisture problems within the home.

6.1 SAFETY

6.1.1 CO, spillage, and drafting issues are to be addressed by implementing repairs and/or installing the appliance in compliance with local codes and the appliance manufacturer's installation instructions.

6.1.2 Combustion air for fuel burning appliances shall be per §9.3 of the 2015 National Fuel Gas Code, §304 of the 2012 International Fuel Gas Code or manufacturer's installation instructions for gas-fired appliances, or the OEM instructions or §G2407 of the 2012 International Residential Code for appliances other than gas-fired appliances.

6.1.3 CO detectors shall be installed in accordance with OEM instructions and 2012 International Residential Code §R315.

6.1.4 When measures are performed that improve the envelope tightness, the Auditor shall recommend to the homeowner that Radon tests be conducted upon completion of the selected building improvements.

6.2 ENVELOPE

6.2.1 Air sealing measures shall be prioritized to reduce the stack effect and inhibit moisture migration into attics and other interstitial spaces.

6.2.2 An effective and continuous thermal and pressure boundary shall be established through the installation of appropriate air sealing and insulation measures. Air sealing and insulation strategies shall be designed to align the thermal and pressure boundaries to create a single continuous thermal envelope.

6.2.3 Leakage paths identified between attached, or drive-under garages, and the living space shall be sealed.

6.2.4 For leakage paths through enclosed cavities that cannot be accessed or reasonably sealed using conventional air sealing techniques, the following applications are acceptable to reduce airflow through the building envelope:

a. Installation of high density pneumatically applied insulation - which complies with BPI-102 "Standard for Air Resistance of Thermal Insulation Used in Retrofit Cavity Applications – Material Specification".

b. Installation of air impermeable foam insulation.

6.2.5 Whenever air sealing represents 15% or more of the total building shell area, or sealing of ducts outside the thermal envelope is recommended, the work scope must include pre- and post-installation blower door testing.

6.2.6 Any existing interior or exterior moisture issues shall be remediated prior to air sealing the building shell.

6.2.7 Attic venting shall be in accordance with 2012 International Residential Code §R806.

6.2.8 Repairs and renovations to pre-1978 homes shall comply with EPA's Renovation, Repair, and Painting (RRP) Program Rule (40 CFR Part 745).

6.3 VENTILATION

6.3.1 Design the system to comply with ASHRAE 62.2-2013 and the IECC 2012.

6.3.2 The system designer shall install ventilation systems in accordance with OEM instructions, the codes adopted by the AHJ, and accepted industry practices.

6.3.3 Mechanical ventilation airflow shall be measured in accordance with §5.2.2 of ACCA 5 QI Standard.

6.3.4 Attic ventilation shall not be installed without first verifying the presence of an effective air barrier and thermal barrier between the attic and the living space. Refer to local codes for minimum requirements for insulation and ventilation.

6.4 INSULATION

6.4.1 Install insulation per the procedures specified in:

a. Manufacturer's recommendations.

b. ASTM C1029 - 10 Standard Specification for Spray-Applied Rigid Cellular Polyurethane Thermal Insulation.

c. ASTM C1320-10 Standard Practice for Installation of Mineral Fiber Batt and Blanket Thermal Insulation for Light Frame Construction.

d. Applicable recommendations from the Insulation Contractors of Association of America, Spray Polyurethane Foam Alliance, Blown-in-Blankets Contractors Association, and Structural Insulated Panel Association.

6.4.2 Any existing interior or exterior moisture issues shall be remediated prior to insulating the building shell.

6.4.3 Attic insulation shall not be installed without first verifying the presence of an effective air barrier between the attic and living space via visual inspection and pressure differential testing.

6.4.4 Whenever enclosed cavity insulation representing 15% or more of the total building shell area is accepted by the client, the work scope shall include pre- and post-installation envelope leakage testing.

6.4.5 Documentation of material and R-value will be provided to the client or occupant in accordance with 16 CFR 460-17.

6.4.6 Vented eave or soffit baffles: Baffles will be mechanically fastened to block wind entry into insulation, or to prevent insulation from blowing back into the attic. Baffles will be installed to maintain clearance between the roof deck and baffle according to manufacturer specifications. Installation will allow for the highest possible R-value above the top plate of the exterior wall.

6.4.7 Loose fill over pitched ceilings: When using cellulose, only stabilized product will be used. Loose fill fiberglass will only be used on a slope less than or equal to a 6:12 pitch or the slope application approved by the manufacturer, whichever is less. Roof cavities will be insulated with loose fill according to manufacturer specifications without gaps, voids, compressions, misalignments or wind intrusions. Insulation will be installed to prescribed R-value.

6.4.8 Dense pack over pitched ceilings: Using fill tube, 100% of each cavity will be completely filled to a consistent density:

a. Cellulose material will be installed to a minimum density of 3.5 pounds per cubic foot.

b. Loose fiberglass material will be installed and will be specifically approved for air flow resistance to a minimum density of 2.2 pounds per cubic foot.

The number of bags installed will be confirmed and will match the number required on the coverage chart. Insulation will be verified to prevent visible air movement using chemical smoke at 50 Pa of pressure difference.

6.4.9 Unvented flat roof with existing insulation: Roof cavities will be blown with loose fill insulation without gaps, voids, compressions, misalignments or wind intrusions. Insulation will be installed to the prescribed R-value.

6.5 HVAC

6.5.1 New HVAC systems shall be installed in accordance with the ACCA 5 QI Standard (*HVAC Quality Installation Specification*).

6.5.2 Maintenance performed on existing HVAC systems shall be in accordance with ACCA 4 QM Standard (*Maintenance of Residential HVAC Systems*).

6.5.3 Restoration of existing HVAC systems beyond the scope of the ACCA 4 QM Standard shall be conducted in accordance with ACCA 6 Quality Restoration.

6.5.4 The leakage rate of heating/cooling ducts specified for sealing shall meet the tightness standards specified in §6.5.1 and/or by the AHJ, and shall be established by measurements post-remediation. [10]

6.5.5 Heating/cooling ducts specified for sealing and located outside the building's envelope, or cooling ducts that are located in attic spaces, shall be sealed at the air barrier at all accessible connections and insulated in accordance with IECC 2012.

6.5.6 New ventilation systems shall be installed per the OEM instructions, or applicable portions of the ACCA 5 QI Standard, and shall be balanced in accordance with the designer's intent.

6.5.7 Existing venting for bathrooms and kitchens shall comply with the 2012 International Residential Code §M1507.

6.6 MOISTURE

Where moisture problems exist, moisture sources must be mitigated through elimination of the source, isolation of the source, or ventilation of the space around the source before proceeding with other shell-related measures.

6.7 POOLS AND SPAS

6.7.1 Suction outlet covers shall be in accordance with ASME A112.19.8.

6.7.2 The energy efficiency of pool filter pumps, controls, and heaters shall be in accordance with Association of Pool and Spa Professionals (APSP) 15 standard.

6.7.3 Controls, timer switches, and covers shall be per 2012 IECC (2009) §403.9.

6.7.4 Vapor retardant covers on heated pools shall be tested and listed in accordance with ASTM F1346-91 – 2010.

6.7.5 New pools or spas shall be constructed in accordance with the applicable APSP standard.

6.7.6 New or replacement HVAC systems serving indoor pools and spas shall be designed per ACCA Manual SPS 2010.

[10] Leakage testing pre-remediation can be beneficial, or may be required by the AHJ (e.g., utility).

7.0 TEST OUT PROCEDURES

A contractor's qualified technician or an independent Auditor shall ensure the improvement objectives were met.

7.1 The qualified technician or independent Auditor shall review the scope of work[11] and the signed proposal in order to familiarize themselves with the work to be accomplished.

7.2 Per the signed proposal, they shall evaluate the improvement(s) in accordance with the requirements and applicable procedures in §3.0 and to the performance standard listed in §6.0, or the standard specified.

NOTE: For homes under construction, verify new HVAC equipment in accordance with ENERGY STAR Certified Homes HVAC System Quality Installation Rater Checklist. (http://www.energystar.gov/index.cfm?c=bldrs_lenders_raters.nh_v3_guidelines)

7.3 Building performance improvements, or combinations of improvements, that effect the envelope tightness shall result in testing of the combustion appliances in accordance with §3.2.4, §3.2.5, and §3.2.6. When unvented combustion appliances are present, confirm their listing to ANSI Z21.11.2 and their use as a secondary heat source.

[11] The independent Auditor shall have the discretion to report oversights, errors, miscalculations and other issues to the initial Auditor, the Project Manager, and any quality control agencies providing oversight.

APPENDIX A | BUILDING AUDITING PROCEDURES

(This normative Appendix is part of the standard and contains requirements necessary for conformance to the standard.)

A1.0 POTENTIAL CONFLICT OF INTEREST DISCLOSURE

The Auditor or auditing company shall disclose to the client when:

A1.1 Receiving any compensation or benefit for the audit from a client other than the client;

A1.2 Providing any design work as part of the remediation procedures;

A1.3 Performing consulting, performance testing or diagnostic testing beyond that required for an audit;

A1.4 Financing portions of the payments on the home;

A1.5 They are the seller of the home or their agent;

A1.6 They are an employee, contractor, affiliate, or consultant to the servicing utility company;

A1.7 They are a supplier, provider of service or maintenance, or an installer of HVAC systems, insulation systems, duct sealing, air sealing, windows, window shading systems, energy efficient appliances, or is a builder/developer.

A2.0 INTERVIEW QUESTIONS

The interviewer shall request the following information from the client:

A2.1 General:

A2.1.1 Do you own or rent the building? (Note: Renters must have express written permission from building owner prior to having an audit performed.)

A2.1.2 How many people live (or work) in this building?

A2.1.3 What year was your building built?

A2.1.4 How long have you lived there?

A2.1.5 Of what improvements or changes in the building are you aware?

A2.1.6 Do you have a set of building plans (architectural, as-built, material or equipment specifications or data sheets, etc.)?

A2.1.7 Do you have high utility bill complaints?

A2.1.8 Do you have complaints about condensation on windows, any plumbing or roof leaks, dripping ducts, or other building components including moisture problems near the foundation?

A2.1.9 Do you have the last 12 months of utility usage (electric, gas, fuel oil, etc.) records or bills?

A2.2 Comfort

A2.2.1 Do you have any hot or cold rooms?

A2.2.2 Do you have other comfort complaints? (Gather specific information: where in the building are they uncomfortable, the cause of discomfort: drafts, temperature, noise, and the remedy they use [e.g., covering a register, adjusting the thermostat, avoiding the room/space, etc.])

A2.2.3 Where do you feel drafts or where is it drafty?

A2.2.4 How often do you open your windows instead of using the air conditioner to maintain comfort?

A2.2.5 Do you have any indoor air quality issues?

A2.2.6 Does anyone in the building suffer from health issues (allergies, asthma, temperature issues, odors/smells, etc.)?

A2.2.7 Do you have any health related air filtration requirements?

A2.2.8 How often do you change the filter in the HVAC system(s)?

A2.2.9 When was the last time you had the HVAC system checked for maintenance?

A2.2.10 Do you know how to use the programmable thermostat?

A2.2.11 Do you have a lot of dust in the house?

A2.3 Building Systems (appliances, lighting, water, etc.)

A2.3.1 Do you use compact fluorescent or LED light bulbs?

A2.3.2 Do you turn on the kitchen exhaust fan when cooking?

A2.3.3 Do you turn on the bath exhaust fan when bathing/showering?

A2.3.4 Do you have a heated swimming pool? How is the pool heated? When do you use it? How long does the pump run? Is the swimming pool or spa inside your building? If so, how is that space ventilated?

A2.4 Combustion Safety

A2.4.1 Do you have any wood-burning stoves or fireplaces in the building? If so, how do you use them? Do they have outside air for combustion?

A2.4.2 Do you have any unvented fireplaces or space heaters in the building? If so, how do you use them and how is combustion air provided during operation?

A3.0 CARBON MONOXIDE (CO) TEST

A3.1 Equipment used to measure CO shall:

A3.1.1 Be capable of measuring carbon monoxide (CO) levels from 0 to 2,000 ppm (parts per million).

A3.1.2 Have a resolution of 1 ppm.

A3.1.3 Have a visual readout.

A3.1.4 Have an accuracy rate of $\pm$ 5%.

A3.1.5 Be calibrated annually by the manufacturer and have evidence of the calibration.

A3.2 Measure the outdoor CO level before entering the home, this shall be the baseline.

A3.3 CO measurement equipment shall operate continuously in the CAZ during the CO testing of the combustion equipment and during the depressurization test.

A3.3.1 The CO detection equipment shall be monitored.

A3.3.2 If CO levels of 9 ppm are detected for more than 15 minutes, then the Auditor shall have the discretion to stop all CO testing and depressurization testing.

A3.3.3 If CO levels of 25 ppm are detected, then the Auditor shall stop all CO testing and depressurization testing.

A3.4 For atmospherically vented appliances:

A3.4.1 Take a measurement of combustion gases at the flue before the draft diverter and around the external perimeter of accessible vent piping joints.

A3.4.2 Appliance must operate for at least 5 minutes before taking sample.

A3.4.3 Take sample during depressurization test.

A3.5 For direct vented appliances:

A3.5.1 Measurement of combustion gases must be taken at vent connection and around the external perimeter of accessible vent piping joints.

A3.5.2 Appliance must operate for at least 5 minutes before getting sample.

A3.5.3 Take sample during depressurization test.

A3.6 For unvented heating combustion appliances:

A3.6.1 Measurement of combustion gases must be taken from the area surrounding the appliance.

A3.6.2 Appliance must operate for at least 5 minutes before taking sample.

A3.6.3 Acceptability of emissions from unvented combustion appliances shall be based on National Fuel Gas Code, Table G6[12], for carbon monoxide from unvented gas room heaters and fireplaces (also referred to as vent-free room heaters and fireplaces).

A3.7 For gas fired ovens:

A3.7.1 Remove any foil or cooking utensils within the oven.

A3.7.2 Verify that the oven is not in self-cleaning mode.

A3.7.3 Turn oven on to highest temperature setting.

A3.7.4 Close the oven door and begin monitoring the CO levels in the kitchen, 5 feet from the oven at waist height.

a. If CO in the kitchen is higher than 25 ppm at any time during the oven testing, then the Auditor shall stop all CO testing.

A3.7.5 Measure the CO levels within the oven vent.

a. Samples must be taken while burner is firing.
b. Operate burner for at least 5 minutes, or per OEM instructions, while sampling flue gases.

A3.8 CO measurements for appliances tested shall be compared to the threshold limits listed in the National Fuel Gas Code, Table G.6[13]. For threshold limits listed in "air free" units, the Auditor shall use a measurement device set to the "air free" setting, or calculate the air free equivalent to measured CO using the formula provided in Table G.6. Alternatively, the Auditor shall compare measured CO to the manufacturer's instructions. Where CO exceeds the threshold limits in Table G.6, the Auditor shall:

A3.8.1 Notify client of the need to call a qualified technician to have the appliance repaired/tuned, and

A3.8.2 Document that the equipment is unsafe for continued operation,

A3.8.3 Document that the client was informed of this condition,

A3.8.4 Shall not perform air sealing measures on the home.

A4.0 DEPRESSURIZATION TEST FOR THE COMBUSTION APPLIANCE ZONE (CAZ) – WHERE REQUIRED BY THE AHJ

A4.1 Close all exterior windows and doors, and attic hatches. Temporary openings to the outside such as broken windows must be sealed.

[12] See informative Appendix B, §B22.0.
[13] See informative Appendix B, §B22.0.

A4.2 Drain traps must be filled with water.

A4.3 Turn on all indoor fans: bathroom exhaust, range hood, clothes dryer, powered attic ventilation fans (with the exception of a whole house exhaust fans).

A4.4 Turn on the air handler fan. If the pressure differential in the CAZ with reference to the outdoors gets more negative, leave the air handler on; otherwise, turn it off.

A4.5 Open or close interior doors to the CAZ, rooms with exhaust fans (e.g., bathroom), or other interior rooms to achieve the highest pressure differential in the CAZ room with reference to (WRT) the outdoors.

A4.6 Make-up air systems, combustion air ducting, and ventilation systems are to remain as is.

A4.7 Ensure the vent or flue is at room temperature.

A4.8 Fireplace damper shall be closed or a simulator must be operating in the fireplace (camping stove, etc.) with fireplace damper open.

A4.9 Place the smallest Btu input appliance being tested into operation (per OEM instructions) first and adjust the thermostat so the appliance operates continuously.

A4.10 Test for spillage at the draft hood relief opening after five (5) minutes of operation. Use the flame of a match, candle, or smoke. The complete circumference of the draft hood relief opening shall be tested.

A4.10.1 If smoke or flame is pulled into the vent the combustion appliance passes. If draft is not established in 5 minutes around the complete circumference of the draft hood opening, then the combustion appliance fails the test.

A4.10.2 For additional fossil fuel appliances in the same room, turn on the next appliance being tested so it operates at the full input while the previous appliance continues to operate. Repeat step A4.10 on the appliance being tested.

A5.0 ENVELOPE LEAKAGE DEPRESSURIZATION/ PRESSURIZATION TEST

A5.1 Prior to blower door testing, Auditor shall inspect premises for the presence of friable asbestos-like material. If found:

A5.1.1 Consider the material "Presumed Asbestos Containing Material" (PACMs).

A5.1.2 Document its locations.

A5.1.3 Inform occupant that material suspected to be asbestos exists in the dwelling.

A5.1.4 Follow industry guidelines regarding working in a dwelling containing PACMs (e.g., EPA 40 CFR Part 763, Subpart G and OSHA 29 1910.1001 and CFR 1926.1101).

A5.1.5 Document how the presence of PACMs is being addressed in the work scope.

A5.2 Install the blower door.

A5.3 Prepare the house:

A5.3.1 Ensure that the building envelope is complete by closing all windows and doors, attic access panels and pull downs, attic knee-wall doors, and fireplace dampers. Auditor shall NOT temporarily seal holes that exist when the house is being lived in (such as bathroom vent fans).

A5.3.2 Ensure that all doors within the building envelope are open.

A5.3.3 Adjust all combustion appliances so that they do not turn on during the test[14].

[14] At the appliance, leave the keys to the vehicle driven to the site as a reminder to turn it back when you are done.

A5.3.4 Ensure all fires in fireplaces and wood stoves are extinguished. Close all fireplace and wood stove doors to prevent scattering of ashes[15].

A5.3.5 Turn off any exhaust fans, vented dryers, and room air conditioners.

A5.3.6 Tape off any continuously operating outside air intakes. If taping the outside air intake requires the duct to be disconnected, the Auditor shall have the discretion to use an HVAC contractor to detach the outside air intake.

A5.4 Perform Air Leakage Test

A5.4.1 Turn the blower door fan on and bring the house to a 50 Pa pressure difference with respect to the outside (WRTO).

A5.4.2 Record the cubic feet per minute of leakage at the 50 Pa pressure difference.

A5.4.3 Ensure the configuration input on the gauge matches the actual ring configuration on the blower door fan.

A5.4.4 If using a magnahelic gauge or a digital gauge that does not convert fan pressure to fan flow, record the fan pressure value and look up the flow in the table provided for that fan by the fan manufacturer.

A5.5 For a two-family dwelling (e.g., a duplex) that is to be tested as one building[16], the Auditor shall perform simultaneous air leakage tests of each unit and the CFM50 values shall be added together to determine the building's envelope leakage rate.

A5.6 For a row of Townhomes that are to be tested as one building, the Auditor shall perform simultaneous air leakage tests, with neutral pressure difference between adjacent residences, and the CFM50 values shall be added together to determine the building's envelope leakage rate.

A5.7 When finished, return the home to its original operating condition: reconnect the outside air intakes or have the HVAC contractor do so, return HVAC systems and water heaters back to original settings.

A6.0 DISTRIBUTION SYSTEM TEMPERATURE DIFFERENCE

The air within the duct distribution system shall not lose or gain excessive amounts of heat as the air travels through the distribution system and into the conditioned space[17].

A6.1 Thermometers used shall:

A6.1.1 Have a temperature sensing probe at least 15" long,

A6.1.2 Be capable of measuring sensible heat levels from 0 to 200°F (degrees Fahrenheit),

A6.1.3 Have a resolution of 0.1°F,

A6.1.4 Have an accuracy rate of $\pm$ 2.5%,

A6.1.5 Be calibrated as required by the manufacturer and have evidence of the calibration.

A6.2 Energize the HVAC system in heating or cooling mode as appropriate for the season.

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[15] Fireplaces shall be treated with caution as damage to the home's interior is possible during a depressurization test if the flue damper is inoperable or left open and the doors do not provide a good seal. Some strategies to deal with it include laying a small rug in front of the fireplace to protect the building's carpeting, sweeping and vacuuming all the ashes out and applying wet newspapers over any ash residue, etc.

[16] When testing a single residence (duplex or Townhome) for air leakage related to energy use see an example procedure in informative Appendix §B18.0.

[17] This procedure is not aimed at determining the duct distribution effectiveness. Rather, it is to help identify duct problems associated with poor or no insulation, duct leakage, discontinued runs, or long runs, low airflow, etc.

A6.3 Allow the system to reach steady state.

A6.4 Measure the temperature at the return inlet (within 1" of the grille face), the return plenum (within 12" of the equipment), the supply plenum (within 42" of the heat exchanger), and at the supply outlet (within 1" of the register/diffuser face).

A6.5 All measurements shall be taken in less than 5 minutes[18]. The Auditor shall have the discretion to use multiple thermometers: the adjusted tolerances of each must be known and the measured temperatures adjusted accordingly.

A6.6 Temperature measurements must be representative of the area for the grille, plenum, or diffuser/register.

A6.7 Temperature measurements taken in the heating mode at the supply plenum must be taken out of the line-of-sight from any fossil fuel combustion or electric resistance heat exchangers.

A7.0 GASKETED PAN TEST

A7.1 Prepare the house in accordance with A5.3 for an envelope leakage test.

A7.2 Depressurize the house by 50 Pa.

A7.3 Each grille, diffuser, and register (duct cover) in the distribution system will be tested individually. The auditor shall fully cover it using one of the following methods:

A7.3.1 A gasketed pan with a sealed pressure tap,

A7.3.2 Tape,

A7.3.3 Combination of gasketed pan and tape[19].

A7.4 Record the pressure in the duct with reference to the house:

A7.4.1 At the pressure tap on the gasketed pan, or

A7.4.2 A static pressure proble inserted through the tape.

A7.5 Remove the cover at the conclusion of each register or grille.

A7.6 Determine the median and the highest measured pan difference for all duct covering. Compare the values to the comparative benchmark in the Table 1.

A8.0 BLOWER DOOR ASSISTED SMOKE TEST

A8.1 Seal all grilles and registers in the duct system.

A8.2 Inject either theatrical or other non-toxic smoke into the fan pressurization device that is maintaining a duct pressure difference of 25Pa relative to the duct surroundings.

A8.3 Visually inspect all accessible portions of the duct systems for escaping smoke; escaping smoke indicates a leak in the duct.

A9.0 ROOM PRESSURE DIFFERENCE (RPD) TEST

A9.1 Measure the pressure changes that occur within the main area or main zone when the HVAC system is operating:

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[18] Infrared thermometers are of value to quickly measure the register/diffuser temperature in several rooms. The temperatures obtained from infrared thermometers must be correlated to probe type thermometers used for measuring the air in the plenum.

[19] Typically, this is done on registers or grilles that are larger than the gasketed pan. Tape is applied to the perimeter of the duct covering, leaving an uncovered area in the middle that is just smaller than the gasketed pan. The pressure difference is then read by covering that opening with the gasketed pan.

A9.1.1 Close all exterior doors and windows, open all interior doors, energize the HVAC system.

A9.1.2 Measure the base-line pressure difference in the house with respect to the outdoors (WRT OD).

A9.1.3 In isolated rooms (excluding bathrooms), close the door, and measure the pressure difference in the room WRT OD.

A10.0 ON-SITE INSPECTION PROTOCOLS

The Auditor shall perform an inspection of the building for the following:

A10.1 Determine, or measure, or estimate R-values and location of wall/ceiling/floor insulation.

A10.1.1 Walls

a. Exterior walls

i. Assess the presence of insulation in framed walls; estimate and record the R-value.
ii. Check at plumbing outlet under sink or, in order of preference, remove cable outlet plate, telephone plate, electrical switch plates and/or electrical outlet plates on exterior walls.
iii. Probe the cavity around the exposed plate with a non-metal device (such as a plastic crochet hook or wooden skewer). Determine type of insulation (fiberglass, cellulose insulation, foam, etc.). Inspect outlets/switch plates on each side of the house to verify that all walls are insulated.
iv. Multiply the wall framing member size (in inches) by the R-value per inch. Be sure to use the actual thickness of the insulation when calculating the total insulation R-values.
v. Parts of the house that were added later must be checked separately from the original walls.

b. Partition walls: Record the R-value installed in attic kneewalls.

A10.1.2 Ceilings

a. Ceiling: Determine the insulation R-value which exists in the ceiling area (cavity). Use the following method for calculating the overall ceiling R-value:

i. Determine the type of ceiling insulation present (note if a combination of more than one type);
ii. Multiply the R-value of the material by the depth of the insulation.

b. Attic: Use the inspection guidelines in Appendix A, RESNET Mortgage Industry National HERS Standards to assess “Grade I”, “Grade II”, or “Grade III” installation.

i. “Grade I” installation for ceiling insulation: the insulation shall be installed in complete contact with the drywall or sheathing surfaces it is intended to insulate.
ii. For loose fill applications, four measurements of the insulation level (the depth shall be representative of the entire attic area being examined) shall be taken. Multiply the minimum depth of insulation by its R-value per inch to obtain the total R-value.
iii. Insulation in ceilings with an attic above need not be enclosed to attain a “Grade II” or “Grade I” assessment.
iv. For sealed, unvented attic/roof assemblies, the interior sheathing/enclosure material shall be optional in climate zones 1-3,

provided insulation is adequately supported and meets all other requirements, including full contact with the exterior (roof) sheathing.

v. For ceiling insulation, eave baffles or equivalent construction is required to achieve "Grade I".

vi. Auditor shall note whether the cavity insulation leaves the framing elements exposed, or covers them; if covered, note the thickness that covers the framing.

c. Roof: Determine the insulation affixed to the roof deck.

i. If an attic is determined to be conditioned, the roof deck is considered part of the building envelope.

ii. Determine insulation type, thickness and R-value affixed to the roof.

A10.1.3 Floors

a. Crawlspaces: Determine the insulation in the walls and/or ceiling of the crawlspace.

i. Vented crawlspace: Note insulation level between the ground floor of the house and the crawlspace.

ii. Insulated crawlspace perimeter: Determine insulation type, thickness and R-value.

iii. Encapsulated crawlspace: Determine the vapor barrier location, type, and thickness. Determine the insulation type thickness and R-value.

b. Basements: Determine the insulation in the walls and/or ceiling of the basement.

i. Unconditioned basement: See crawlspace.

ii. Conditioned basement: Determine insulation type, thickness and R-value in the walls or ceiling.

c. Slabs: Determine slab perimeter insulation.

A10.2 Measure the square footage, volume, and estimate the approximate age of home.

A10.2.1 Measure floor dimensions in accordance with ANSI Z765-1996 with the exception of §3 Paragraph 6 (floor areas with ceiling heights of less than 5' will be included in finished square footage).

A10.2.2 For conditioned basements and crawlspaces, find dimensions of basement walls and floor. Divide walls into above and below grade sections.

A10.2.3 Measure the house or assembly element (window, wall, ceiling, etc.) to the nearest inch, and record the square footage to the nearest square foot. Use exterior measurements; those measurements shall start at the exterior finished surface of the outside wall. Openings to the floor below shall not be included in the square footage calculation, with the exception of stairways; stairways and associated landings are counted as square footage on both the starting and ending levels.

A10.2.4 Do not include the "footprint" of protruding chimneys or bay windows.

A10.2.5 Do include the "footprint" of other protrusions like a cantilever when it includes finished floor area.

A10.2.6 Do include the square footage of separate finished areas that are connected to the main body of the house by conditioned hallways or stairways.

A10.2.7 Determine conditioned and indirectly conditioned volume of space by multiplying conditioned floor area by ceiling height. For areas with vaulted ceilings, volume must be calculated geometrically.

A10.2.8 To facilitate determining the age of the home:

a. See §A2.1.3.

b. County records (web search).

c. Real estate websites.

A10.3 If performing a cost benefit analysis/energy modeling calculations per §4.2, determine, or measure, or estimate the glazing type(s), frame material(s), and permanently installed shading devices such as screens or applied films.

A10.3.1 Determine area of windows in accordance with Appendix A, RESNET Mortgage Industry National HERS Standards.

a. Measure the area of the window openings using width by height to the nearest inch.

b. Window openings are measured from the outside edge of the framing.

A10.3.2 Use a compass (adjusting for magnetic deviation) to determine orientation of all windows.

A10.3.3 Identify shading by external shade screens, house overhangs/awnings, and shade from trees and other buildings.

a. External Shade Screens.

i. Compare samples of the screen's mesh pattern to those of a window screen sample to determine the type and shading coefficient of the screen.
ii. Use a digital foot-candle meter.
iii. Ask client for documentation for the shading coefficient (SC) of the screen.
iv. Consult ACCA Manual J Table 3A, 3B, or 3C.

A10.3.4 Projection (Overhang)

a. The shading impact of an overhang can be found by measuring the distance of the projection from the exterior wall surface and the distance (height) between the top of the window and the bottom edge of the overhang.

i. Measure the length of the overhangs over each exterior wall.
ii. Measure the height above the window to the bottom edge of the overhang.

A10.3.5 Exterior Shading

a. Full (40% SC) - Consider a 40% SC for an entire side of a house as being roughly equivalent to having a shade screen over a window.

b. Partial (41% - 99% SC) - Partial shading is considered to be anything in between full and none (no shading).

c. None (100% SC) - No shading indicates there are only small plants or shrubs.

A10.3.6 Determine the window framing characteristics

a. Examine each window frame in order to determine the type of material used. Open the window and examine it to see whether the frame is made of metal, wood, or vinyl.

b. Determine if a thermal break is present.

A10.3.7 Determine the solar heat gain factor of the glazing

a. Check product information and/or consulting the NFRC guide, or

b. Consult ACCA Manual J Table 3A, 3B, or 3C.

A10.3.8 Determine the window glazing characteristics.

a. Check all windows in the house for number of panes and existence of tint and/or low-e coating.

b. To determine whether the windows are single-paned or multiple-paned:

i. Look at frame width and spacers;
ii. Look at reflections;
iii. Look at edge thickness.

c. To determine if glazing has a tint or low-e coating:

i. Check the client's product literature, if available;
ii. Perform a "match test" - there will be one reflection per pane or coating, including low-e and tinting (e.g., a double-paned window with low-e and tint will show 4 reflections);
iii. Use a low-E meter to determine the coating level and surface;
iv. Compare to glazing samples with and without tinting;
v. Compare the window within the space, since tinting is often applied only to certain windows in a house. Look for a low-e label or etching on the glass.

A10.3.9 Determine window U-value

a. Use NFRC label on windows (it will display full window U-value), or

b. Use client provided documentation, or

c. Look up product information in NFRC Certified Products Directory to determine U-value, or

d. Consult manufacturer's literature, or

e. Consult ACCA Manual J Table 3A, 3B, or 3C.

A10.4 Heating, venting and air conditioning (HVAC) systems.

A10.4.1 Equipment

a. Record the type of HVAC system, model number, serial number, rated efficiency (if available), and location of heating/cooling system(s);

b. Record the presence and type(s) of combustion equipment; visually identifiable evidence of flame rollout, blocked chimney, rust and corrosion; missing or damaged vent connectors;

c. Identify other mechanical systems such as attic fans.

A10.4.2 Duct distribution system.

a. Record the type of ductwork.

i. Sheet metal, externally insulated
ii. Sheet metal, internally insulated
iii. Fibrous glass duct board
iv. Flexible duct

b. Record the R-value of duct insulation.

c. Visually inspect and record obvious duct leakage, and any indications of previous duct sealing.

A10.4.3 Exhaust fans: Record the following:

a. Location.

b. Measured flow rate.

c. Quantity.

d. Determination of whether they are vented to the outdoors.

A10.5 Determine and record the type of foundation: crawl space, basement, or slab, along with venting and insulation locations.

A10.6 Roof and attic.

A10.6.1 Determine and record the type of attic:

a. Vented, natural (e.g., soffit and ridge-cap, gable vents, etc.).

i. If the attic is vented, note the area ratios of the soffit to ridge vent, gable to ridge vent, or gable to roof vent.
ii. Note the presence or absence of attic vent baffles to allow airflow from soffit venting to the attic.

b. Vented, attic fans (number and rated Cfm).

c. Sealed or unvented.

d. Note the presence and condition air sealing and insulation at openings from the conditioned space to the attic (pull down access doors).

A10.6.2 Record the type and color of roofing material:

a. Identify the type of roofing surface:

i. Asphalt shingle;
ii. Pebble/gravel built-up roof;
iii. Tile roof;
iv. Wood shingle roof;
v. Rubber roof/roof coating;
vi. Metal.

A10.6.3 Estimate the approximate age of the roof, note the condition.

A10.7 Appliances: Record the following:

A10.7.1 Age and efficiency (if available);

A10.7.2 Condition;

A10.7.3 Quantity and location.

A10.8 Indoor and outdoor light fixtures. Record the following:

A10.8.1 Type of fixtures (recessed, pendant, flush mount, etc.),

A10.8.2 Quantity,

A10.8.3 Controls (e.g., dimmers, timers, motion sensors, etc.),

A10.8.4 Type of bulb(s) used in fixture (incandescent, compact fluorescent [CFL], light emitting diode [LED], halogen, etc.).

A10.9 Durability issues: indications of condensation, roof leaks, foundation leaks, ground-water intrusion, ice damming, and plumbing leaks, as well as signs of mold, mildew, insect damage, efflorescence, and stains.

A10.10 Any identified potential combustion appliance safety hazards related to energy retrofit work.

APPENDIX B | ADDITIONAL ELEMENTS FOR HOME AUDITS

(This informative Appendix is not part of the standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ACCA or ANSI.)

This Appendix provides supplemental tasks which will enhance the audit or provides informative procedures to supplement other tasks.

B1.0 GRAPHIC RECORD OF THE BUILDING

- B1.1 Floor plan with exterior dimensions.
- B1.2 Volume of the conditioned and indirectly conditioned space.
- B1.3 Orientation of the building.
- B1.4 Roof configuration.
- B1.5 Attached porch roofs.
- B1.6 Cantilevered floors.
- B1.7 Floors over an unconditioned space.
- B1.8 Bay windows.
- B1.9 Roof dormers.
- B1.10 Attached garage.
- B1.11 Exterior: The auditor should note:
  - B1.11.1 Any shading or solar exposure that may affect comfort levels.
  - B1.11.2 Opportunities for renewable technology (i.e., access to sunlight on south side).

B2.0 FOUNDATIONS

- B2.1 Crawlspaces[20]
  - B2.1.1 A crawlspace is defined as a foundation condition with a clear vertical dimension 4 feet high or less. Crawl spaces may be vented or unvented.
    a. Vented crawlspaces have some form of vent or louver in the crawlspace walls, or are constructed in such a manner so that air moves freely from outside the walls to inside the crawl space.
    b. Unvented crawlspaces are constructed without any form of vents or louvers in the wall, and are constructed to exclude, to the greatest extent possible, air leakage from outside the walls to inside the crawl space.
  - B2.1.2 Crawlspaces may be accessed by a hatchway in the floor of the house or in the wall of the crawl space. To identify a crawlspace, look for foundation vents and/or stairs leading up to floor levels from the outside of the building.
    a. Wall insulation may be located inside the foundation wall (studs and batts, foam under drywall, etc.), integral with the foundation wall (insulated cores of block wall, insulating concrete block such as insulating formwork) or outside the foundation wall (rigid foam insulation).
    b. To determine whether a crawlspace is conditioned or not, assess the insulation placement in the walls or floor/ceiling assembly.
       i. A vented crawlspace is considered unconditioned regardless of the location or existence of insulation.

[20] See the International Residential Code, Section R408 "Under-Floor Space".

ii. Identify any floors over a crawlspace.

iii. Check for intact vapor barrier with 100% coverage of the ground.

1) Check for visible signs of water damage, mold and standing water.

- This does not require the auditor to verify the presence of mold- only use signs of mold as a means of determining moisture damage.

iv. Check crawlspace for the presence of HVAC system components and combustion appliances.

B2.2 Basements

B2.2.1 The Auditor should record the basement characteristics and determine whether it is unconditioned, indirectly conditioned or directly conditioned according to the criteria for crawlspaces in §B2.1 above.

B2.2.2 Identify any floors over a full basement; a full basement has characteristics similar to an unvented crawlspace, except that the clear vertical dimension is greater than 4 feet. Stairs that lead from the main floor to a below grade space are an indication of a basement in a house, although a house may have a basement with access similar to a crawlspace access.

B2.2.3 Check for walkout (daylight) access.

B2.3 Slab-on-Grade

B2.3.1 Determine the perimeter of the slab foundation by measuring each dimension to the nearest ½ foot and adding them together.

B2.3.2 Determining slab-on-grade insulation.

a. If present, slab perimeter insulation is usually installed on the outside of the slab and extends both above and below grade.

b. To identify slab perimeter insulation, look for a protective coating above grade as opposed to the usual exposed slab edge at any conditioned space(s).

c. Move a little bit of dirt away from an edge of the slab where conditioned space is located. If present, the rigid insulation around the perimeter of the slab may be seen. However, it may be difficult to visually verify the existence of slab perimeter insulation because of the protective covering which may be installed over the rigid insulation.

d. Slab insulation may also occur between the foundation wall and the slab itself, although this is harder to assess and verify. If the floor has carpeting, a sharp needle may be poked through the carpet near the baseboard on an outside wall. If the needle penetrates beyond the depth of the carpet, there is probably foam insulation between the slab and foundation wall.

e. Under slab insulation cannot be assumed to exist unless visually verified by a photograph of construction, at chase way, at sump opening or at plumbing penetrations.

B3.0 CONDITIONED FRAMED FLOORS OVER UNCONDITIONED SPACE

B3.1 A floor area that borders an exterior unenclosed space above grade is considered floor to exterior. For example, in a two story house, the second story may extend horizontally further than the first story, creating some floor area that is exposed to the exterior.

B3.2 Examine for unsealed holes or penetrations in the floor system and rim/band joist.

B3.3 Note if there is insulation in the floor system. When visible, determine the quality of the installation and the R-value according to Appendix A, RESNET Mortgage Industry National HERS Standards.

B3.4 Note if the rim/band joists are insulated. Record the R-value.

B3.4.1 From the basement or crawl space, visually identify and measure the depth of insulation at the rim joist.

B3.4.2 The insulation used is generally fiberglass batts, often folded in an L-shape and attached to the rim joist. Rigid board insulation may also be found.

B3.5 Between Stories.

B3.5.1 Look for access to the area from a garage or a utility access trap door. Visually identify and measure insulation if it exists. If no access can be found, assume insulation exists at the rim joist between stories if:

a. Insulation was found at the rim joist at the top of the crawl space or basement in the same house; or

b. Insulation is found in the walls of the same house.

i. Otherwise, assume no rim joist insulation exists.

B3.5.2 Note if there are HVAC ducts in the floor system.

B3.6 Calculating volume: The house may need to be split into different spaces with different ceiling heights and added to each other for both conditioned and indirectly conditioned spaces.

B4.0 RADON TESTING

B4.1 The Auditor should strongly consider initiating Radon testing during the audit, gathering the test at a later date, or gathering the results and presenting the Radon findings/ mitigation with the other portions of their proposed work scope to the client.

B4.2 The Auditor shall follow the test procedures and remediation protocols in accordance with the federal and state requirements. If none exist, then follow Environmental Protection Agency Protocols for Radon and Radon Decay Product Measurements in Homes.

B5.0 ALLERGEN TESTING

B5.1 The Auditor should strongly consider initiating allergen testing during the audit, and then include the findings in their presentation of the information to the home owner.

B5.2 The Auditor shall follow acceptable sampling procedures as outlined in U.S. HUD Healthy Homes Issues Asthma Version 3, March 2006, pages 16-24 http://portal.hud.gov/hudportal/documents/huddoc?id=DOC_12480.pdf.

B5.3 The Auditor should present the results from the testing and methods for remediation as outlined in the reference in §B5.2.

B6.0 EXTERIOR WALLS

B6.1 Inspect the building for penetrations and leakage paths to the outside:

B6.1.1 Plumbing penetrations on exterior walls.

B6.1.2 Electrical penetrations on exterior and interior walls.

B6.2 Determine the type of wall structural system:

B6.2.1 *Wood framing* - is very common in residential construction. Wood studs are located 16" or 24" on center all along the wall. Knocking on the wall will give a

"hollow" sound in the cavities between the studs and a "solid" sound at the stud locations.

B6.2.2 *Metal framing* - can be found in some newer residential construction. A strong magnet that is slid against the wall will hold to metal framing. Also check inside the attic at the edges for evidence of metal wall framing.

B6.2.3 *Masonry walls* - includes walls constructed of concrete, block, or brick. A wood framed wall with brick veneer would not be considered a masonry wall. Also note the siding or finish material on the wall.

B6.2.4 *Foam core walls* - are a sandwich panel consisting of a foam center with outer layers of structural sheathing, gypsum board or outer finish materials. Foam core panels may be structural (load bearing) or non-structural. Non-structural panels are frequently used in post and beam construction.

B6.2.5 *Log walls* - are typically solid wood walls, using either milled or rough logs or solid timbers. Some homes may have the appearance of solid log walls, yet may actually be wood frame walls with siding that looks like solid logs inside and out. Some log walls are manufactured with insulated cores. Unless manufacturer's documentation is available or visual inspection of insulation type and thickness can be made, assume no added insulation exists in a log wall.

B6.3 Estimate insulation thickness, by determining whether 2x4 or 2x6 framing exists:

B6.3.1 Measure the width of the window jambs;

B6.3.2 Subtract the widths of the wall coverings and sheathing materials (approximately .25" to 1.0" for stucco, .5" to .6" for interior sheetrock, and .5" to .75" for other exterior siding materials);

B6.3.3 Compare the remaining width to 3.5" for a 2x4 wall or 5.5" for a 2x6 wall;

B6.3.4 If exposed garage walls exist, examine them for reference (although they will not *always* be the same as other walls);

a. If a wall does not come close to the framing width of a 2x4 or 2x6, inspect for foam sheathing on the inside or outside of the walls. In super-insulated construction, "double stud" or "strapped" walls may account for thickness greater than 5.5". For brick veneer walls, assume 4.5" - 5" for brick, airspace and sheathing material.

b. Check the framing member size on all sides of the house. If an addition has been added, be sure to check the walls of the addition separately. If the house has more than one story, check the framing member size for each floor.

B6.3.5 Insulated sheathing may exist on walls, but can be difficult to verify. Walls with insulated sheathing may be thicker than walls without insulated sheathing. Visual verification of insulated sheathing may be found in the attic at the top of the wall, exterior wall penetrations, and at the connection between the foundation and the wall.

B7.0 FENESTRATION

B7.1 Windows

B7.1.1 Record the type(s) of windows (type of frame, number of panes).

B7.1.2 Record the compass orientation of the windows.

a. Note if the windows that are double-pane have a low-emissive coating and where the coating is applied.

b. Note presence and condition of weather-stripping.

B7.1.3 Solar coefficient: For trees and/or bushes to equal the effect of full shading, there should be a very dense amount of trees and/or bushes along the entire side of the house that shade both its vertical and horizontal surfaces almost totally.

B7.1.4 Window frame material characteristics: Tap the frame with fingernail or knuckle to test if it's vinyl or metal. Wood frames are usually thicker than metal.

B7.1.5 Determining a thermal break: If the window is dual-pane or multiple-pane and is metal framed, and then determine if a thermal break is present by looking for two separated metal extrusions connected by a rubber spacer. Ask the client for documentation if you can't tell.

B7.1.6 Determining cladding: Some wood windows may have vinyl or aluminum cladding. Check both the inside and outside, since some windows will have vinyl cladding on one side only.

B7.2 Skylights

B7.2.1 Determine the area of skylights using the procedures for windows in §A10.3.1.

B7.2.2 Determine the framing and glazing characteristics of skylights using the procedures for windows in §A10.3.6 and §A10.3.8.

B7.2.3 Determine the orientation of the lower edge of the skylight in §A10.3.2. Use this direction as the orientation of the skylight.

B7.2.4 Determine the shading of skylights using the procedures for windows in §A10.3.5.

B7.2.5 Determine the solar heat gain coefficient of skylights using the procedures for windows in §A10.3.7.

B7.2.6 Measure the tilt of the skylight relative to horizontal. This can be done with a level and angle finder instrument, or geometrically with a protractor (from the ceiling length and heights).

B7.2.7 Determine the skylight U-value using the procedures for windows in §A10.3.9.

B8.0 DOORS

B8.1 Judge whether the exterior door(s) is insulated.

B8.2 Determine the surface area of the door(s).

B8.3 Determine if the exterior door(s) is fiberglass, metal, or wood by making a close inspection of its texture, distinguishing the sound produced when knocking on it, and checking its side view.

B8.4 Judge whether the exterior door(s) is insulated (or not) by its sound, temperature transfer, labeling, or thermal break.

B8.4.1 *Sound* - Insulated/solid door will sound dull when knocked on. An uninsulated/hollow door will sound hollow.

B8.4.2 *Heat transfer* - Feel the inside and outside of the door with flat palms. Insulated/solid door will less readily transfer heat. The inside will feel warmer in cold outside weather and cooler in hot outside weather than an uninsulated/hollow door.

B8.4.3 *Labeling* - Check the side view of the door at the hinges for a descriptive label.

B8.4.4 *Thermal break* - Check the side view of metal doors for thermal breaks.

B8.5 Determine the surface area of the door(s) by measuring to the nearest ½ square foot.

B9.0 CEILINGS

B9.1 Obtain measurements of all ceiling areas between conditioned and unconditioned space.

B9.2 Determine the size of the framing members.

B9.3 Determine the framing member size for ceilings exposed to unconditioned spaces.

B9.4 Determine the R-value of insulation in framed ceiling.

B9.5 Obtain measurements of all ceiling areas between conditioned and unconditioned space.

B9.6 Measure the linear perimeter of the ceiling area to the nearest ½ foot and use these measurements to calculate surface area of the ceiling. If a ceiling area is vaulted, it may be necessary to calculate dimensions geometrically.

B9.7 Identify the ceiling as one of the following types:

B9.7.1 Ceiling to attic.

a. If the ceiling has attic space above (even if the ceiling is vaulted, as in a scissor truss) it is considered ceiling to attic.

b. If there is a vaulted ceiling check its angle against the angle of the roof -- if the ceiling angle is gentler there is attic space above the ceiling.

c. Check for an attic access.

B9.7.2 Framed ceilings fall into two categories:

a. *Roof on exposed beams or rafters* – Exposed beams or rafters will be visible from inside the room.

b. *Finished framed ceiling* -if the ceiling is framed (has no attic space above it, but you cannot see the rafters because the ceiling is finished with drywall, plaster, paneling, etc.) consider it a finished framed ceiling. Determine the framing member size for framed ceilings exposed to unconditioned spaces. Check the framing by looking for an access through an attic over another part of the house or by looking at the rafters from the outside.

B9.8 Determine the insulation R-value which exists in the ceiling area (cavity). Use the following method for calculating the overall ceiling R-value:

B9.8.1 Determine the type of ceiling insulation present (may be a combination of more than one type);

B9.8.2 Multiply the R-value of the material by the depth of the insulation.

B9.9 If there is no access to the framed ceiling, ask the client for documentation of insulation or use a default value based on age.

B9.10 Crawl space or Basement: From the basement or crawl space, visually identify and measure the depth of insulation at the rim joist. The insulation used is generally fiberglass batts, often folded in an L-shape and attached to the rim joist. Rigid board insulation may also be found.

B9.11 Check for infiltration paths to the outside or buffered zones.

B9.11.1 Sample a few duct boots for sealing to the surface material.

B9.11.2 Ventilation fans at the ceiling/fan interface.

B9.11.3 Recessed light fixtures at the ceiling/fixture interface.

B10.0 ATTICS

B10.1 Note type, location and integrity of attic access.

B10.2 Check the chases for ductwork and chimneys; should be capped and sealed.

B10.3 Check chases created by interior architectural features such as arched doorways, columns, and dropped soffits; should be capped and sealed.

B10.4 Check penetrations through the top plates (electrical, plumbing) for sealing.

B10.5 Record the R-value installed in attic kneewalls.

B10.6 Check the attic kneewalls for sheathing (have an air barrier on the attic side). Attic kneewalls located within cathedralized attics (insulation along the roofline, no venting) are excluded from the requirements for insulation and air barriers or sealing.

B10.7 Check the attic kneewalls for air sealing.

B10.8 Examine the joists under attic kneewalls for blocking.

B10.9 Record the R-value and type of insulation in attic floor.

B10.10 Check for the presence of bath or kitchen exhaust ducts improperly venting into the attic.

B11.0 ROOFS

B11.1 Determine the roof's construction type.

B11.2 Identify the color of the roof as light, medium or dark. Also check for a special reflective roof coating.

B11.3 Identify the type of roofing surface. Some common types include:

B11.3.1 Asphalt shingle;

B11.3.2 Pebble/gravel built-up roof;

B11.3.3 Tile roof;

B11.3.4 Wood shingle roof;

B11.3.5 Rubber roof/roof coating;

B11.3.6 Metal.

B11.4 Check if there is insulation applied to the underside of the roof sheathing, creating a cathedralized or encapsulated attic.

B11.4.1 Note R-value if insulation is present;

B11.4.2 Check for evidence of air leakage such as outside light entering the attic at the attic perimeter.

B11.5 Check if there is a radiant barrier applied to the roof.

B11.6 Check if the soffit vents are blocked with insulation.

B11.7 Check if there is adequate attic venting.

B11.7.1 Record the number of open attic vents and estimated venting net free area following the International Residential Code for One- and Two-Family Dwellings- 2009.

a. Calculate attic square footage.

b. Divide attic square footage by 150 to determine net free area required.

c. Divide result by 2 to get intake and exhaust net free area.

d. Convert result to square inches by multiplying by 144.

B11.7.2 Check if there are powered attic fans in use. Check if powered attic fan is solar powered.

B11.8 Check for signs of roof leaks or condensation in the attic.

B12.0 HVAC SYSTEMS AND DUCTWORK

B12.1 Verify thermostat settings. If the thermostat has a thermometer, take a measurement of the temperature at the thermostat to confirm thermostat accuracy.

B12.2 Record the type, manufacturer and model number and the location of the installed HVAC equipment.

B12.3 Examine the blower assembly (located in the furnace, fan coil, air handler, etc.) for cleanliness.

B12.4 Determine the age and initial rated efficiency of the installed HVAC equipment.

B12.5 Check all condensate lines for signs of blockage or leaks.

B12.6 Verify the presence of secondary overflow drain pans under equipment capable of producing condensate (e.g., air handler units, fan coils, DX coils, etc.).

B12.6.1 Verify presence of a condensate drain line connected to drain pans.

B12.6.2 Verify presence of a float disconnect switch.

B12.6.3 Verify that all other water producing devices (dehumidifiers, ERV's, etc.) are draining to an appropriate location.

B12.7 Check all exhaust vents for proper fitting and termination.

B12.8 Note any issues with the outdoor coil such as air flow obstructions or blocked coil fins.

B12.9 Check the refrigerant line set for insulation, both outside the building and within attics, basements or crawlspaces.

B12.10 Inspect the ductwork to determine the quality of design and installation.

B12.10.1 Examine supply and return ducts for proper sizing and installation to promote optimum airflow.

a. Measure return grilles and calculate net free area, net free area is typically 80% of the gross area.

b. Note whether filter is installed at the grille or at the return plenum-air handler connection.

c. Note type of filter (MERV rating, etc.).

B12.10.2 Note if all duct components are properly sealed.

B12.10.3 Record the type, location, R-value of insulation and condition of exterior surface of ductwork, including obvious leaks.

B13.0 ROOM TEMPERATURE DIFFERENCE[21]

The building's HVAC system shall control the temperature at the thermostat to within a few degrees of the setpoint during all but the most unusual weather conditions.

B13.1 The thermometer shall meet the requirements of §A6.1,

B13.2 Rooms with external walls: temperatures shall be measured two and one half feet from any exterior wall and five feet off the floor, or

B13.3 Rooms without external walls: temperature shall be measured five feet off the floor at the center of the room.

[21] For comparative benchmarks, refer to https://www.acca.org/industry/system-design/values.

B14.0 WATER HEATING

B14.1 Determine fuel type, manufacturer, model number, approximate age, storage capacity and location of water heater(s). If yellow "Energy Guide" label is present, efficiency rating (ER) can be determined by dividing 150 by the annual consumption on the label in therms for natural gas and 4,396 by the annual consumption on the label in kWh for electric.

B14.2 Verify water heater thermostat settings.

B14.3 Verify that the water heater has a pressure relief valve and it is not obstructed.

B14.4 Check for signs of leakage at the water heater.

B14.5 Conduct visual inspection of the water heater and exposed distribution system for opportunities to improve efficiency by insulating exposed pipes, installing heat traps, and installing tank insulation.

B14.6 Determine the type and number of plumbing fixtures.

B14.6.1 Estimate the average distance from the water heater.

B14.6.2 Check for piping insulation levels.

B14.6.3 Check for location of piping (attic, crawlspace, slab, etc.).

B15.0 PLUMBING FIXTURES

B15.1 Visually inspect the building's plumbing fixtures, measure water flow rates,[22] and identify the fixtures that would benefit from being upgraded to meet the U.S. Environmental Protection Agency's (EPA's) WaterSense specifications.

B15.2 Acceptable Procedures: The Auditor shall note and record the type and quantity of plumbing fixtures that do not meet EPA's WaterSense specifications for residential buildings.

B15.2.1 Toilets

B15.2.2 Sink faucets

a. Kitchen
b. Bathroom
c. Indoor utility faucets

B15.2.3 Showerheads

B16.0 LIGHTING

B16.1 Determine the number of Energy Star and non-qualifying light fixtures throughout the house and all outdoor fixtures mounted on a building or pole.

B16.2 Ask about the usage pattern and determine the estimated percentage of incandescent light fixtures.

B16.2.1 Note the type of lighting in high usage areas (incandescent, compact fluorescent, LED, etc) and whether controlled with a dimming switch.

a. If compact fluorescents are installed in a fixture controlled with a dimming switch, they should be capable of dimming. This is an opportunity to educate the client. Recommend LEDs.

b. Observe or ask if they turn off lights and ceiling fans when no one is in the room. If not, use this as an educational opportunity to explain the impact of choices made in the operation of the building.

[22] Water flow measurement procedures are described in the referenced EPA WaterSense program.

B17.0 APPLIANCES

The Auditor's report should identify appliances and equipment that can be replaced with those that are more energy efficient such as those listed in Table 2.

Table 2: Appliances to Consider

Appliances	Computers & Electronics	Lighting and Fans
Clothes Washers and Dryers	Audio/Video	Decorative Light Strings
Dehumidifiers	Computers and monitors	Fans, Ceiling
Dishwashers	External Power Adapters	LED Light Bulbs
Freezers	Imaging Equipment and Printers	Light bulbs (CFLs)
Refrigerators	Set-top Boxes & Cable Boxes	Light Fixtures
Room air conditioners	Televisions	Residential LED Lighting
	Game Consoles	

B17.1 For refrigerator efficiencies, consult the California Energy Commission Appliance Database or the Association of Home Appliance Manufacturers Directory.

B17.2 Energy Factors for dishwashers can be found at the Federal Trade Commission's Dishwasher Energy Data website (http://www.ftc.gov/bcp/conline/edcams/eande/).

B17.3 Stoves:

B17.3.1 If measured CO levels are between 100-300 ppm, a CO detector should be installed and the client notified that a qualified technician should repair/tune-up the appliance.

B17.3.2 If measured CO levels are higher than 300 ppm, an exhaust fan capable of intermittent exhaust of 100 cubic feet per minute should be installed and the client notified to call a qualified technician for service.

B17.4 Auditors should identify areas where smart plug strips can be used to address plug loads (Home office, Entertainment Centers, etc.) see, www.efficientproducts.org.

B18.0 ATTACHED GARAGES

Use a smoke stick or a manometer in conjunction with the blower door according to procedures described in Chapter 8, RESNET Mortgage Industry National HERS Standards.

B19.0 ENVELOPE LEAKAGE

B19.1 When testing a single residence (duplex or Townhome) for air leakage related to energy use, the CFM50 for the residence shall be obtained while simultaneously pressurizing/depressurizing the adjacent residences to maintain neutral pressure between the primary and adjacent residences.

B19.2 Follow the methodology/procedure per the AHJ.

NOTE: If a building has suspended ceiling tiles creating a buffer zone within the building envelope, measures shall be taken to prevent significant pressure changes within the buffer zone (such as moving some tiles to create openings between the buffer zone and the conditioned space).

B20.0 SAMPLE WORDING FOR PROPOSED BUILDING PERFORMANCE IMPROVEMENTS

B20.1 Inform client of applicable codes and regulations.

B20.2 Inform client of licensing requirements for all proposed improvements.

B20.3 Disclose to client all licenses that the Auditor may hold in these specialties.

B20.4 Proposals should include the statement, "The estimated energy savings contained in the audit report do not constitute any guarantee or warranty of actual energy savings."

B20.5 Regarding building improvement opportunities that will affect the combustions appliances' safe operation, the scope of work should address the "house as a system" approach, recognizing that measures interact. The following statement shall be included whenever a fireplace or combustion appliance is located within the building envelope: "As noted, portions of this scope of work must be implemented together; any exclusions or variations to the identified portions of this scope can result in the home not operating properly and can increase the risk of flue gas spillage, back-drafting, carbon monoxide production, and/or moisture problems within the home.

B21.0 POOLS AND SPAS

The following information should be gathered and made available to a pool professional to facilitate improvements made to a pool or spa:

B21.1 The volume of the pool should be estimated (length x width x average depth x 7.4).

B21.2 The hours of operation, from the pool's timers should be recorded.

B22.0 NATIONAL FUEL GAS CODE, TABLE G6

B22.1 CO thresholds:

NOTE: The table is provided by permission of the American Gas Association.

Appliance	Threshold Limit
Central furnace (all catagories)	400 ppm air free[23]
Floor furnace	400 ppm air free
Gravity furnace	400 ppm air free
Wall furnace (BIV)	200 ppm air free
Wall furnace (direct vent)	400 ppm air free
Vented room heater	200 ppm air free
Vent-free room heater	200 ppm air free
Water heater	200 ppm air free
Oven/boiler	225 ppm as measured
Top burner	25 ppm as measured (per burner)
Refrigerator	25 ppm as measured
Gas log (gas fireplace)	25 ppm as measured in vent
Gas log (installed in wood burning fireplace)	400 ppm air free in firebox

[23] Air free emission levels are based on a mathematical equation (involving carbon monoxide and oxygen or carbon monoxide readings) to convert an actual diluted flue gas carbon monoxide testing sample to an undiluted air free flue gas carbon level utilized in the appliance certification standards.

APPENDIX C | TABLES

(This informative Appendix is not part of the standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ACCA or ANSI.)

The information expressed in the tables of this Appendix is offered to supplement audit information when the actual values cannot be obtained. The life expectancies listed are estimates, regional climate and installation factors may affect the listed life expectancy. In all audits, the actual efficiency should be diligently researched and if obtained, then used.

Life Expectancy of Equipment

Component	Life Expectancy (in years)
Appliances - Clothes Washer	11
Appliances - Dehumidifier	15
Appliances - Dishwasher	15
Appliances - Refrigerator	17
Central Air Conditioner	15
CFL's	7
CFL's Fixtures	7
Heating - Boiler Replacement	25
Heating - Duct Insulation	18
Heating - Furnace w/ECM (92 AFUE)	20
Heating - Furnace w/o ECM (90 AFUE)	20
Heating Repair	10
Pipe Insulation	20
Shell - Air Sealing	20
Shell - Doors	20
Shell - Insulation	40
Shell - Windows	20
Thermostat	11
Water Heating - Indirect	15
Water Heating - Instantaneous	20
Water Heating - Storage Tank	15
Air Conditioner	15
Natural Gas Furnace	18
Electric Furnace	15
Heat Pump	16

Age-Based Default Efficiencies

Systems	Pre-1960	1960-69	1970-74	1975-83	1984-87	1988-91	1992-2006
Gas Storage	0.47	0.47	0.47	0.49	0.55	0.56	0.56
Electric Storage	0.79	0.79	0.80	0.81	0.83	0.87	0.88
Furnace, AFUE	0.60	0.60	0.65	0.68	0.68	0.76	0.78
ASHP, HSPF	4.5	4.5	4.7	5.5	6.3	6.8	6.8
Water GSHP, COP	2.7	2.7	2.7	3.0	3.1	3.2	3.5
Earth GSHP, COP	2.3	2.3	2.3	2.5	2.6	2.7	3.0
ASHP, SEER	5.0	6.1	6.5	7.4	8.7	9.4	10.0
Water GSHP, EER	10.0	10.0	10.0	13.0	13.0	14.0	16.0
Earth GSHP, EER	8.0	8.0	8.0	11.0	11.0	12.0	14.0
Central AC, SEER	5.0	6.1	6.5	7.4	8.7	9.4	10.0
Room AC, EER	5.0	6.1	6.1	6.7	7.7	8.1	8.5

APPENDIX D | DEFINITIONS

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ACCA: nationwide association representing the technical, educational and policy interests of U.S. businesses that design, install and maintain indoor environmental systems.

ACH: Air Changes per Hour.

ACH_{50}: the air exchange rate at a 50 Pa pressure difference; based upon the volume of the building.

AFUE: Annual Fuel Utilization Efficiency; the furnace's fuel efficiency during the course of a heating season, accounting for cycling losses.

AHJ: Authority having jurisdiction.

Ambient: inside or outside conditions.

Atmospherically vented: a combustion appliance vented using a natural-draft venting system.

Attic kneewall: any attic wall that separate unconditioned attic space from conditioned space.

Auditor: a person or company representative who is certified to conduct the evaluation, diagnosis and testing of an existing home's performance, and provide a prioritized work scope for cost-effective energy saving measures and features to the client.

Certified Auditor: an Auditor certified by a cognizant authority as possessing the requisite skills and knowledge.

Independent Auditor: a certified Auditor whose evaluation of a project is objective, not prejudiced by the person, team, or company that performed the retrofit or remediation work on the project.

British thermal unit (Btu): the amount of heat required to raise the temperature of one pound of water one degree Fahrenheit at sea level.

Btu/hour (Btuh or Btu/hr): the rate of heat transfer in Btu's over one hour of time.

Building: a one- or two-family dwelling, or multi-family dwelling of three stories or less.

Building envelope: The physical separator between the interior conditioned space and the exterior unconditioned environment around a building.

Carbon monoxide (CO): an odorless, colorless gas that can cause illness or death.

CFM: the volume of airflow in cubic feet per minute.

CFM_{25}: Cubic Feet per Minute, volume of air flow at a 25 Pascal pressure difference.

CFM_{50}: Cubic Feet per Minute, volume of air flow at a 50 Pascal pressure difference.

Chimney: a primarily vertical component containing one or more pipes for the purpose of carrying combustion gases and air from an appliance to the outside atmosphere.

Combustion appliance zone (CAZ): connected spaces within a building that contain a combustion appliance; the zone may include, but is not limited to, a mechanical closet, mechanical room, or the main body of a house.

Condensation: occurs when water vapor particles move more slowly; the particles change from vapor back to liquid.

Conditioned space: space within a building that is provided with heating or cooling provided by equipment or systems capable of maintaining 60°F during the heating season and 80°F during the cooling season, or communicates directly with a conditioned space.

COP: Coefficient of Performance; watts of heating divided by watts of electricity.

Direct-vent appliances: appliances that are manufactured and installed so that all air for combustion is taken directly from the outside and all flue gases are discharged directly to the outside of the building.

DOE: Department of Energy.

Draft: pressure difference existing between the equipment and the outside, which causes a continuous flow of air and combustion products through the venting system of the appliance to the outside.

Draft hood: nonadjustable device built into a combustion appliance, or made as part of the vent connector, that is designed to provide for ready escape of the flue gases from the appliance; in the event of no draft, backdraft or stoppage beyond the draft hood, prevent a backdraft from entering the appliance, and neutralize the effect of stack action of the chimney or gas vent upon operation of the appliance.

DWH: Domestic Water Heater.

EER: Energy Efficiency Ratio; efficiency rating that is the Btu/h's of cooling divided by the watt hours of electricity and is used for air conditioning and heat pump units.

Energy Factor (EF): a comparison of the amount of energy supplied in heated water to the amount of energy consumed daily by the water heater (including standby losses).

EPA: Environmental Protection Agency; responsible for the ENERGY STAR and WaterSense programs.

Evaluation: analysis of the data collected from any survey or audit, on-site data collection and performance testing, available energy usage records to determine energy use and potential savings from improvements.

Flame rollout: burner flames discharge from the cabinet of a combustion appliance.

Hazardous Materials: solids, liquids, or gases that can harm people, other living organisms, property, or the environment.

Heat exchanger: the component in a heating or cooling system that adds or removes heat to an air stream. Heating mode examples include: a combustion chamber, electric resistance coil, or a coil with hot water or refrigerant (heat pump). A cooling mode example is a coil with cold water or refrigerant.

Heat transfer: the heat gain or heat loss through a building component measured in Btu/h. Load calculations have the ability to demonstrate the increase or decrease in a buildings heating and cooling requirements.

Heated pool: a body of water contained in a fabricated enclosure that is purposely mechanically heated to a temperature that is greater than or equal to 80°F.

Home Performance Team: a team consisting of a RESNET certified Rater/Auditor, an ACCA QA Program participant, and an insulation/air sealing professional.

HSPF: Heating Season Performance Factor; the average annual Btu's of heating divided by the average annual watt-hours of electricity used.

HVAC: Heating, Ventilation, Air Conditioning.

ICC: International Code Council, Inc.; organization that produces national code standards for construction.

IECC: International Energy Conservation Code; energy code produced by the ICC.

Inches of water column (IWC): unit of pressure difference; one inch of water column equals 250 Pascals.

Infiltration: air leaking into a building.

IRC: International Residential Code; residential code for 1- and 2-family dwellings produced by the ICC.

Isolated room: A room that can be secluded from the main living area or zone by a solid door.

Joists: horizontal framing pieces that create floors or flat ceilings.

Kilowatt-hour: 1,000 watt-hours.

Leaders (run-off water): Piping that carries water from gutter drains, down spouts, or other run-off water devices to an area away from the building.

Ledgers: usually attached to girders to support joists.

Listed: equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services; that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services; and whose listing states either that the equipment, material, or service meets appropriate designated standards or has been tested and found suitable for a specified purpose.

Main Living Area: a group of rooms that is connected by cased openings, halls, or open door frames which is served by a forced-air HVAC system.

Main Zone: see Main Living Area.

OEM: Original Equipment Manufacturer; the company that produced the building component or equipment used in the building.

PACM: Presumed Asbestos Containing Material.

Partition walls: non-load bearing interior walls. When those walls intersect with an exterior wall, that junction is called a partition tee; normal framing practices create a void in the insulated exterior wall.

Pascal (Pa): the amount of pressure needed to raise a water column 0.004 inches at sea level.

Performance testing: testing conducted to evaluate the performance of a system or component using specified performance metrics.

Pool: permanently installed above ground/ on ground/ in ground swimming pool intended for use by a single-family for noncommercial purposes and with dimensions as defined by ANSI/APSP-4 – 2007 or APSP 5 – 2003.

Project Manager: the company or individual with whom the homeowner contracts for the coordinated installation of comprehensive energy-saving retrofits prescribed by a certified Rater/Auditor. The Project Manager could conceivably be the Rater/Auditor, or any EnergySmart Contractor on the Home Performance Team.

Rafters: sloped framing members that form the roof.

R-value: resistance to heat flow.

SEER: Seasonal Energy Efficiency Ratio; efficiency ratings that are determined by dividing the average annual Btu's of cooling by the average annual watt-hours of electricity and are assigned to split and package air conditioning systems and air source heat pumps.

Site-built (also called "**stick-built**")**:** buildings that have all the framing materials delivered and are constructed on site by a framing crew.

Solar Heat Gain Coefficient (SHGC): amount of radiant heat released to the interior through glazing (glass) as a percentage of the amount that the glazing received.

Spillage: combustion gases escaping from an appliance or venting system into the combustion appliance zone during burner operation.

Steady State Efficiency: indicates the amount of fuel consumed over the heating season when the combustion gases and stack temperatures are within the manufacturer's specifications.

Top plates: horizontal framing members that are at the top of the wall assembly.

U-value: the rate of heat conduction per unit of envelope area and degree of temperature difference on each side of the building envelope.

Unconditioned space: any enclosed space within the building that is not conditioned as defined in this Standard.

Watt: rate of 1 joule of energy per second.

Vapor: the moisture in the air and is moved through infiltration and diffusion.

Vent connector: pipe that connects a combustion appliance to a vent or chimney.

Ventilation: natural or mechanical process of supplying conditioned or unconditioned air to, or removing such air from, any space.

Venting system: continuous open passageway from the flue collar or draft hood of an appliance to the outside atmosphere to remove flue or vent gases through a vent or a chimney and vent connector.

Zone: a room or rooms served by a separate HVAC system.

APPENDIX E | PERTINENT BIBLIOGRAPHY AND RESOURCES

(This Appendix is not part of this standard. It is informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ACCA or ANSI).

AABC **Associated Air Balance Council (1518 K Street NW, Suite 503, Washington, DC, 20005; tel: (202) 737-0202; www.aabc.com)**

- Commissioning Guideline, 2002
- Test and Balance Procedures

ACCA **Air Conditioning Contractors of America (2800 Shirlington Road, Suite 300, Arlington, VA, 22206; tel: (703) 575-4477; www.acca.org)**

Manuals and Standards

Manual B®	Balancing and Testing of HVAC Systems, 2009
Manual D®	Residential Duct Systems, 2014
Manual J®	Residential Load Calculation, 8th ed., 2011
Manual RS®	Comfort, Air Quality, and Efficiency by Design, 1997
Manual S®	Residential Equipment Selection, 2014
Manual SPS®	HVAC Design for Swimming Pools and Spas, 2010
Manual T®	Air Distribution Basics for Residential and Small Commercial Buildings, 1992
Manual Zr®	Residential HVAC System Zoning, 2012
ACCA 4 QM - 2013	Maintenance of Residential HVAC Systems in One- and Two-Family Dwellings Less Than Three Stories, 2013
ACCA 5 QI - 2010	HVAC Quality Installation Specification, 2010
ACCA 6 QR - 2007	Standard for Restoring the Cleanliness of HVAC Systems, 2007
ACCA 9 QIvp - 2011	HVAC Quality Installation Verification Protocols, 2011

Other Documents

- Bob's House: Understanding the Residential HVAC Design Process, 2008
- Technician's Guide for a Quality Installation, 2010
- Residential Duct Diagnostics and Repair, 2003
- HVAC Practices for Residential and Commercial Buildings: A Guide for Thermal, Moisture and Contaminant Control to Enhance System Performance and Customer Satisfaction, 2003

ADC **Air Diffusion Council (1901 N. Roselle Road, Suite 800, Schaumburg, Illinois 60195; tel: (847) 706-6750; www.flexibleduct.org)**

- Flexible Duct Performance and Installation Standards, 5th edition, 2010

AHRI **Air Conditioning, Heating and Refrigeration Institute (2111 Wilson Blvd, Suite 500, Arlington, VA 22201; tel: (703) 524-8800; www.ahrinet.org)**

Standards and Guidelines

Standard 210/240-2008	Unitary Air Conditioning and Air-Source Heat Pump Equipment, 2008
Standard 700-2012	Specification for Fluorocarbon Refrigerants, 2012
Standard 740-1998	Refrigerant Recovery/Recycling Equipment, 1998
Standard 880-2008	Air Terminals, 2008
Guideline K-2009	Containers for Recovered Fluorocarbon Refrigerants, 2009
Guideline N-2012	Assignment of Refrigerant Container Colors, 2012
Guideline Q-2010	Content Recovery and Proper Recycling of Refrigerant Cylinders, 2010

Other Documents

- AHRI Product Certification directory/database: AHRI certification consists of manufacturers who voluntarily participate in independent testing to ensure that their product will perform according to published claims at specified controlled testing conditions. Go to http://www.ahridirectory.org/ahridirectory/pages/home.aspx for more information.
- Industry Recycling Guide (IRG-2), Handling and Reuse of Refrigerants in the US, 1994
- IBR (or I=B=R) Efficiency Rating Certified product directories provide free, downloadable lists of equipment and ratings tested under their various certification programs. See http://www.ahrinet.org/Content/GAMAIBRCertification_581.aspx.
- Residential Hydronic Heating Installation/Design (IBR Guide), 2009

APSP **Association of Pool and Spa Professionals (2111 Eisenhower Avenue, Alexandria, VA 22314; tel: (703) 838-0083; www.apsp.org)**

Standards

APSP 4	Standard for Aboveground/Onground Residential Swimming Pools, 2013
APSP 5	Standard for Residential Inground Swimming Pools, 2011
APSP 15	Standard for "Residential Swimming Pool and Spa Energy Efficiency", 2013

ASHRAE **American Society of Heating, Refrigerating and Air-Conditioning Engineers (1791 Tullie Circle, NE., Atlanta, GA; tel: (404) 636-8400; www.ashrae.org)**

Standards and Guidelines

Standard 15-2013	Safety Standard for Refrigeration Systems, 2013
Standard 34-2013	Designation and Safety Classifications of Refrigerants, 2013
Standard 52.2-2012	Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size, 2012
Standard 55-2013	Thermal Environmental Conditions for Human Occupancy, 2013
Standard 62.2-2013	Ventilation for Acceptable Indoor Air Quality in Low-Rise Residential Buildings, ANSI Approved, 2013
Standard 90.2-2007	Energy-Efficient Design of Low-Rise Residential Buildings, 20047
Standard 111-2008	Practices for Measurement, Testing, Adjusting, and Balancing of Building Heating, Ventilation, Air Conditioning and Refrigeration Systems, 2008
Standard 119-2004	Air Leakage Performance for Detached Single-Family Residential Buildings
Standard 126-2008	Method of Testing HVAC Air Ducts, 2008
Standard 147-2013	Reducing the Release of Halogenated Refrigerants from Refrigerating and Air-Conditioning Equipment and Systems, 2013
Standard 152-2014	Method of Test for Determining the Design and Seasonal Efficiencies of Residential Thermal Distribution Systems, 2014
Guideline 0-2013	The Commissioning Process, 2013
Guideline 1.1-2007	The HVAC Commissioning Process, 2007
Guideline 4-2008	Preparation of Operating and Maintenance Documentation for Building Systems, 2008

Other Documents

- Handbook of Fundamentals, 2013
- Humidity Control; Harriman, Lew, Geoffrey W. Brundrett, and Reinhold Kittler
- AHHRAE Terminology of Heating, Ventilation, Air Conditioning, & Refrigeration, 1991

ASME **American Society of Mechanical Engineers (Three Park Avenue, New York, NY 10016-5990; tel: (800) 843-2763; www.asme.org)**

A112.19.8 – 2007	Suction Fittings for Use in Swimming Pools, Wading Pools, Spas, and Hot Tubs

ASTM **American Society for Testing and Measuring (100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA, 19428-2959; tel: (610) 832-9500; www.astm.org)**

Standards and Guidelines

C1015-06	Standard Practice for Installation of Cellulosic and Mineral Fiber Loose-Fill Thermal Insulation
C1029-13	Standard Specification for Spray-Applied Rigid Cellular Polyurethane Thermal Insulation
C1158-05	Standard Practice for Installation and Use of Radiant Barrier Systems in Building Constructions
C1320-10	Standard Practice for Installation of Mineral Fiber Batt and Blanket Thermal Insulation for Light Frame Construction
C727-12	Standard Practice for Installation and Use of Reflective Insulation in Building Constructions
E779-10	Standard Test Method for Determining Air Leakage Rate by Fan Pressurization

E1998-11	Standard Guide for Assessing Depressurization-Induced Backdrafting and Spillage from Vented Combustion Appliances
E1827-11	Standard Test Methods for Determining Airtightness of Buildings Using an Orifice Blower Door
E1554-13	Standard Test Methods for Determining Air Leakage of Air Distribution Systems by Fan Pressurization
E2112-07	Standard Practice for Installation of Exterior Windows, Doors and Skylights
F1346-10	Standard Performance Specification for Safety Covers and Labeling Requirements for All Covers for Swimming Pools, Spas and Hot Tubs

BCA **Building Commissioning Association (1600 NW Compton Drive, Suite 200, Beaverton, OR 97006; tel: (877) 666-2292; www.bcxa.org)**

- *The Building Commissioning Handbook*, 2nd Edition, John A. Heinz & Rick Casault

BPI **Building Performance Institute (107 Hermes Road, Suite 210 Malta, NY 12020; (877) 274-1274; http://www.bpi.org/)**

Various standards and guides aimed at enhancing performance development of professional building performance analysis for: Air Conditioning and Heat Pumps, Building Envelope, Manufactured Housing, and Multifamily Buildings

CGSB **Canadian General Standards Board (321 Inverness Drive South Englewood, CO 80112; tel: (800) 525-7052; http://www.ihs.com)**

- CAN/CGSB 149.10-M86 Determination of Airtightness of Building Envelopes by the Fan Depressurization Method

CEE **Consortium for Energy Efficiency (98 North Washington St., Suite 101, Boston, MA, 02114-1918; tel: (617) 589-3949; www.cee1.org)**

The CEE/AHRI Verified Directory identifies a list of products (less than 65 Mbtuh) that the equipment manufacturers represent as meeting energy performance tiers established by the Consortium for Energy Efficiency (CEE) as part of the Residential Air Conditioner and Heat Pump Initiative and the High-Efficiency Commercial Air Conditioning Initiative. These initiatives make use of tiers to differentiate equipment on the basis of energy performance with a higher tier representing a higher level of claimed performance. Go to http://www.ceehvacdirectory.org/

CSA **Canadian Standards Association (8501 East Pleasant Valley Road, Indpendence Ohio, 44131-5516; tel: (877) 235-9791; www.csa.ca)**

- ANSI Z21.11.2 Gas-Fired Room Heaters

DOE **Department of Energy (1000 Independence Avenue, SW, Washington, DC 20585, tel: (202) 586-5000; www.doe,gov)**

- DOE 2.0 (http://gundog.lbl.gov/dirsoft/d2whatis.html)

EPA **Environmental Protection Association (6601 J; 1200 Pennsylvania Avenue, NW, Washington, DC 20004, tel: (202) 272-0167; www.epa,gov)**

- EPA 402- R092-003 Protocols for Radon and Radon Decay Product Measurements in Homes (http://www.epa.gov/radon/pdfs/homes_protocols.pdf)
- EPA 402/K-09/001 A Citizen's Guide to Radon (http://www.epa.gov/radon/pubs/citguide.html)
- EPA 600/P-99/001F 2000Air Quality Criteria for Carbon Monoxide
- 2009 WaterSense Single-Family New Home Specification (http://www.epa.gov/watersense/docs/home_finalspec508.pdf)
- Renovation, Repair, and Painting (RRP) Program Rule (40 CFR Part 745) (http://www.epa.gov/lead/pubs/statetribalguidance.pdf)
- ENERGY STAR for Qualified New Homes Version 3.0 HVAC System Quality Installation Rater Checklist (http://www.energystar.gov)

FTC **Federal Trade Commission (600 Pennsylvania Avenue, NW, Washington, DC 20580; tel (202) 326-2222; www.ftc.gov)**

- Trade Regulation Rule 16 CRF 460, Labeling and Advertising of Building Insulation

HUD **Housing and Urban Development (451 7th Street S.W., Washington, DC 20410; tel: (202) 708-1112; www.hud.gov)**
- Trade Regulation Rule 16 CFR 460, Labeling and Advertising of Building Insulation

IAPMO **International Association of Plumbing and Mechanical Officials (5001 E. Philadelphia Street, Ontario, CA, 91761; tel: (909) 472-4100; www.iapmo.org)**
- Uniform Mechanical Code, 2012
- Uniform Plumbing Code, 2012

ICC **International Code Council (500 New Jersey Avenue, NW 6th Floor, Washington, DC 20001; tel: (888) 422-7233; www.iccsafe.org)**
- International Building Code, 2012
- International Energy Conservation Code, 2012
- International Fire Code, 2012
- International Residential Code, 2012
- International Mechanical Code, 2012
- International Fuel Gas Code, 2012 (see Chapter 4, Tables 402.4(1) - 402.4 (33)

IGSHPA **International Ground Source Heat Pump Association (1201 S Innovation Way, Suite 400, Stillwater, OK 74078; tel: (405) 774-5175; www.igshpa.okstate.edu)**
- Design and Installation Guide, 2009
- Residential and Light Commercial Design and Installation Guide, 2003
- Closed-Loop Geothermal Systems, 2009
- Closed-Loop Geothermal Systems Slinky™ Guide, 2003
- Closed-Loop Geothermal Systems Soil and Rock Classification Field Manual, 2004
- Grouting for Vertical Geothermal Heat Pump Systems Engineering Design and Field Procedures Manual, 2000
- Closed-Loop Ground-Source Heat Pump Systems Installation Guide, 2007

NADCA **National Air Duct Cleaning Association (15000 Commerce Parkway, Suite C, Mt. Laurel, NJ 08054; tel: 865/380-6810; www.nadca.com)**
- ACR Standard, 2013 Edition: Assessment, Cleaning & Restoration of HVAC Systems

NAHB-RC **National Association of Homebuilders – Research Center (400 Prince George's Boulevard, Upper Marlboro, Maryland 20774-8731; tel (800) 638-8556; www.nahbrc.org)**

ANSI Z765-2012 Single-Family Residential Buildings - Square Footage - Method for Calculating

NAIMA **North American Insulation Manufacturers Association (11 Canal Center Plaza, Suite 103, Alexandria, VA 22314; tel (703) 684-0084; www.naima.org)**
- Fibrous Glass Duct Construction Manual, 1st Edition, 1989.
- Fibrous Glass Duct Construction Standard, 2002
- Fibrous Glass Duct Liner Standard, 2002

NATE **North American Technician Excellence (2111 Wilson Blvd., Suite 510, Arlington, VA, 22201; tel: (703) 276-7247; www.natex.org)**

NATE offers certifications tests for service and installation technicians to highlight relevant applied knowledge. Separate 'service' and 'installation' tests are given in the following specialty categories: air conditioning, distribution, air-to-air heat pump, gas heating (air), oil heating (air), hydronics gas, hydronics oil, light commercial refrigeration. Other credentials offered: ground source heat pumps, HVAC efficiency analyst

NEBB **National Environmental Balancing Bureau (8575 Grovemont Circle, Gaithersburg, MD 20877; tel: (301) 977-3698; www.nebb.org)**
- Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems, 2005
- Procedural Standards for Whole Building Systems Commissioning of New Construction, 2009

NFPA **National Fire Protection Association (1 Batterymarch Park, Quincy, MA, 02169, tel: (617) 770-3000; www.nfpa.org)**

NFPA 54	National Fuel Gas Code, 2012 (see Chapter 12, Tables 12.1 - 12.33)
NFPA90a	Standard for the Installation of Air Conditioning and Ventilating Systems, 2012.
NFPA 90b	Standard for the Installation of Warm Air Heating and Air-Conditioning Systems, 2012.

NGWA **National Ground Water Association (601 Dempsey Road, Westerville, OH 43081; tel: (614) 898-7791; www.ngwa.org)**

- Guidelines for Construction of Loop Wells for Vertical Closed Loop Ground Source Heat Pump Systems, 3rd Edition, 2010
- Development Methods for Water Wells, 1991
- Ground Water Hydrology for Water Well Contractors, 1982
- Guide for Using the Hydrogeologic Classification System for Logging Water Well Boreholes, 2006
- Sealing Abandoned Wells, 1994
- Basic Water Systems: A Pump and Hydraulic Training Manual, 2002

PECI **Portland Energy Conservation Inc. (100 SW Main St, Suite 1500, Portland, OR 97204; tel: (503) 248-4636; www.peci.org)**

- Model Commissioning Plan and Guide Specifications (v2.05); available for download
- Operation and Maintenance Service Contracts: Guidelines for Obtaining Best-Practice Contracts for Commercial Buildings, available for download.
- Practical Guide for Commissioning Existing Buildings, Tudi Hassl and Terry Sharp, 1999

PHCC **Plumbing-Heating-Cooling Contractors-National Association (180 S. Washington Street, Suite 100, Falls Church, VA, 22046; tel: (703) 237-8100; www.phccweb.org)**

- National Standard Plumbing Code, 2009
- Variable Air Volume Systems, 1998

RESNET **Residential Energy Services Network (P.O. Box 4561, Oceanside, CA 92052-4561; (800) 836-7057; http://www.resnet.us/)**

- Mortgage Industry National Home Energy Rating Standard, 2013
- RESNET National Standard for Home Energy Audits, 2005
- ENERGY STAR Homes Building Option Package (BOP) Standard, 2000
- RESNET Procedures for Certifying Residential Energy Efficiency Tax Credits, 2005
- Rating and Home Energy Survey Ethics and Standards of Practice, 1996
- RESNET Procedures for Verification of International Energy Conservation Code Performance Path Calculation Tools, 2004
- RESNET Standards for Qualified Contractors and Builders, 2010

RIMA Reflective Insulation Manufacturers Association- International **(14005 W. 147th Street, Olathe, KS 66062, tel: (800) 279-4123; http://www.rimainternational.org)**

- Reflective Insulation, Radiant Barriers and Radiation Control Coatings

RPA **Radiant Professionals Alliance (18927 Hickory Creek Drive, Suite 220, Mokena, IL 60448; tel (877) 427-6601; www.radiantprofessionalsalliance.org)**

- RPA Guidelines for the Design and Installation of Radiant Heating and Snow Ice Melt Systems, 2010
- Modern Hydronic Heating for Residential & light Commercial, 2003

RSES **Refrigeration Service Engineers Society (1911 Rohlwing Road, Suite A, Rolling Meadows, IL, 60008; tel: (847) 297-6464; www.rses.org)**

Various training manuals, self-study courses, classes and CDs to enhance the professional development of practitioners within the refrigeration sector.

SMACNA **Sheet Metal and Air Conditioning Contractors' National Association (4201 Lafayette Center Drive, Chantilly, VA, 20151; tel: (703) 803-2980; www.smacna.org)**

Standards and Guidelines

- Building Systems Analysis & Retrofit Manual, 2011
- Fibrous Glass Duct Construction Standards, 2003
- Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems, 2002
- HVAC Air Duct Leakage Test Manual, 2012
- HVAC Duct Systems Inspection Guide, 2006
- HVAC Duct Construction Standards, Metal and Flexible, 2005
- HVAC Systems Commissioning Manual. 2013, 2nd ed.
- HVAC Systems Duct Design, 2006
- HVAC Systems Testing, Adjusting & Balancing. 2002, 3rd Edition
- IAQ Guidelines for Occupied Buildings Under Construction. 2007
- Rectangular Industrial Duct Construction Standards, 2007
- Round Industrial Duct Construction Standards, 1999

UL **Underwriters Laboratories Inc. (333 Pfingsten Road, Northbrook, IL, 60062; tel: (847) 272-8800; www.ul.com)**

Standards

Standard UL-181	Standard for Safety Factory-Made Air Ducts and Air Connectors, 2013
Standard UL-181A	Standard for Closure Systems for Use with Rigid Air Ducts, 2013
Standard UL-181B	Standard for Closure Systems for Use with Flexible Air Ducts and Air Connectors, 2013