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Home Evaluation and Performance Improvement

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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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 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, priority is given to promote safe and healthy homes.

In this update, all of the Appendices are informative. Appendix A provides sample survey questions designed to provide details and homeowner preferences needed in order to successfully complete an audit. Appendix B provides guidance on additional elements of a residential audit that could be offered to the client based on the Auditor's experience or regional considerations. Appendix C identifies commonly accepted values that can be used if the actual information is neither known nor available. For reader edification, Appendix D provides a glossary of terms commonly used in the HVAC industry. Appendix E lists industry resources that are cited in the standard, along with other documents and standards that may aid in the audit, assessment, presentation, implementation, and evaluation of home performance improvements.

In support of this Standard, ACCA developed a *Technician's Guide and Workbook for Home Evaluation and Performance Improvement,* and an on-line **Qtech™** training program that provides continuing education credits for technician certifications. In order to encourage best practices, an educator's lesson plan and PowerPoint™ presentations are available to instructors free of charge. More information on ACCA educational offerings can be found at www.acca.org/qtech.

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1.0 PURPOSE

This standard establishes the minimum criteria by which deficiencies in 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 are met.

2.0 SCOPE

This standard applies to site-constructed or manufactured, one-and two-family dwellings, townhouses, and individual residential units in multifamily buildings.

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.

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, to the client.

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

3.1.3.1 Receiving any compensation or benefit for the audit from a client other than the client.

3.1.3.2 Providing any design work as part of the remediation procedures.

3.1.3.3 Performing consulting, performance testing or diagnostic testing beyond that required for an audit.

3.1.3.4 Financing portions of the payments on the home.

3.1.3.5 They are the seller of the home or their agent.

3.1.3.6 They are an employee, contractor, affiliate, or consultant to the servicing utility company.

3.1.3.7 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.

3.2 HEALTH AND SAFETY: FOSSIL FUEL APPLIANCES

3.2.1 Carbon Monoxide (CO) Testing

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

3.2.1.1.1 The combustion appliance flue gases,

3.2.1.1.2 The accessible venting system, and

3.2.1.1.3 The combustion appliance zone (CAZ)

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

3.2.1.2.1 2015 National Fuel Gas Code, or

3.2.1.2.2 BPI 1200 §7, or

3.2.1.2.2 RESNET Chapter 8 §808, or

3.2.1.2.3 The following carbon monoxide (CO) procedure utilizing testing equipment that meets or exceeds the following specifications:

3.2.1.2.3.1 Carbon Monoxide (CO) Test Equipment Instrument used to measure CO shall:

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

b. Have a resolution of 1 ppm

c. Have a visual readout

d. Have an accuracy rate of $\pm$ 5%

e. Be calibrated annually have evidence of the calibration.

3.2.1.2.3.2 The following carbon monoxide (CO) test Procedure:

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

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

c. The CO detection equipment shall be monitored.

i. When 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.

ii. When CO levels of 25 ppm are detected, then the Auditor shall stop all CO testing and depressurization testing[1].

3.2.1.2.3.3 Additionally, for atmospherically vented appliances:

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

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

c. Sample must be taken during depressurization testing.

[1] Exception for the furnace's startup period until cold exhaust vent has warmed up and established a draft.

3.2.1.2.3.4 Additionally, for direct vented appliances:

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

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

c. Samples must be taken during depressurization test.

3.2.1.2.3.5 Additionally, for unvented heating combustion appliances:

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

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

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

3.2.1.2.3.6 Additionally, for gas fired ovens:

a. Remove any foil or cooking utensils within the oven,

b. Verify that the oven is not in self-cleaning mode,

c. Turn oven on to highest temperature setting,

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

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

3.2.1.2.3.7 Additionally, for Gas fired oven vents, 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 gases in the oven vent.

3.2.1.2.4 CO measurements for appliances tested shall be compared to the threshold limits listed in the National Fuel Gas Code, Table G.6. 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, or equipment manufacturer's instructions, the Auditor shall:

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

3.2.1.2.4.2 Document that the equipment is unsafe for continued operation,

3.2.1.2.4.3 Document that the client was informed of this condition,

3.2.1.2.4.4 Shall not perform air sealing measures on the home until appliance CO levels are corrected.

National Fuel Gas Code, Table G6 CO Thresholds NOTE: The table is provided by permission of the American Gas Association.	
Appliance	**Threshold Limit**
Central furnace (all categories)	400 ppm air free[2]
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

3.2.2 Gas/Oil Leakage Testing

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

NOTE: When there is an odor indicating a gas leak(s), the auditor shall test the ambient concentrations with a calibrated combustible gas meter. Upon detection of concentrations exceeding 10% lower explosive limit (LEL) 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.

3.2.2.2 Acceptable Procedures: The Auditor shall follow the following procedure(s) for fulfilling the desired criteria:

3.2.2.2.1 Gas lines:

3.2.2.2.1.1 Shall, inspect all fittings and joints in supply lines and appliances with the appropriate gas detector capable of measuring 20 ppm.

3.2.2.2.1.2 Shall, confirm measured leaks with leak-detection fluid.

3.2.2.2.1.3 Shall, identify the location of the leak with a clearly visible mark or tag.

3.2.2.2.1.4 Shall, notify the homeowner.

[2] 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.

3.2.2.2.2 Oil lines:

3.2.2.2.2.1 Shall, be visually inspected for signs of oil.

3.2.2.2.2.2 Shall, mark the location of the leak with a clearly visible tag.

3.2.2.2.2.3 Shall, notify owner of the leak.

3.2.3 Unvented Combustion Heating Appliances[3]

3.2.3.1 Requirement: The Auditor shall record the presence, location, and input rating of unvented combustion appliances. The Auditor shall record where gas-fired unvented heaters are located and if they 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.

3.2.3.2 Acceptable Procedures: The Auditor shall confirm that the information required is properly recorded. When appliances are unlisted, or found to be operating unsafely, the homeowner shall be notified.

3.2.4 Combustion Appliance Zone Volume (Atmospherically vented appliances)

3.2.4.1 Requirement: The Auditor shall measure the volume of the space providing combustion air to fossil fuel appliances and, 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 (when openings are provided).

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

3.2.5.2.1 National Fuel Gas Code §9.3, or

3.2.5.2.2 Authority having jurisdiction (AHJ).

3.2.5 Depressurization Test (Atmospherically vented appliances)

3.2.5.1 Requirement: The Auditor shall provide evidence that the combustion appliance operates safely during periods of depressurization generated by the occupants.

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

3.2.5.2.1 BPI 1200 §7.9, or

3.2.5.2.2 RESNET Chapter 8 §887, or

3.2.5.2.3 Follow AHJ procedure, or

3.2.5.2.4 The following Depressurization Test for the combustion appliance zone test procedure:

3.2.5.2.4.1 Depressurization Test Procedure for the Combustion Appliance Zone (CAZ):

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

b. Drain traps must be filled with water.

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

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

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

e. 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.

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

g. Ensure the vent or flue is at room temperature.

h. Fireplace damper shall be closed or a fire simulator must be operating in the fire place (Camping stove, etc.) with fire place damper open.

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

j. 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.

   i. 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.

   ii. 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 test for spillage steps on each appliance being tested.

3.2.6 Combustion Appliance Venting (Atmospherically vented appliances)

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

3.2.6.1.1 Blockages.

3.2.6.1.2 Soot.

3.2.6.1.3 Corrosion or oxidation.

3.2.6.1.4 Improper support, slope, and/or termination.

3.2.6.1.5 Insufficient draft.

3.2.6.2 Acceptable Procedures: The Auditor shall visually inspect the venting systems for items listed in 3.2.6.1 above, and perform a draft test accordance with the National Fuel Gas Code (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 ANALYSIS AND LEAKAGE TESTING

3.3.1 Roof and attic

3.3.1.1 Determine and record the type of attic and related spaces:

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

3.3.1.1.1.1 When the attic is vented, record the area ratios of the soffit to ridge vent, gable to ridge vent, or gable to roof vent.

3.3.1.1.1.2 Record the presence or absence of attic vent baffles to allow airflow from soffit venting to the attic.

3.3.1.1.2 Vented, attic fans (record the number of fans and rated Cfm of each).

3.3.1.1.3 Sealed, or unvented (record type: e.g., encapsulated, finished, closed knee wall etc.).

3.3.1.1.4 Record the presence and condition air sealing and insulation at openings from the conditioned space to the attic (e.g., pull down access doors).

3.3.1.2 Record the type and color of roofing material.

3.3.1.2.1 Identify the type of roofing surface:

3.3.1.2.1.1 Asphalt shingle.

3.3.1.2.1.2 Pebble/gravel built-up roof.

3.3.1.2.1.3 Tile roof.

3.3.1.2.1.4 Wood shingle roof.

3.3.1.2.1.5 Rubber roof/roof coating.

3.3.1.2.1.6 Metal.

3.3.1.2.2 Estimate the approximate age of the roof, record the condition.

3.3.2 Fenestration

3.3.2.1 Record the type(s) of windows (type of frame, number of panes) condition and operation.

3.3.2.2 Record the compass orientation of the windows and surface area for all window assemblies.

3.3.2.2.1 Record when the windows have a low-emissive coating and where the coating is applied.

3.3.2.2.2 Record the presence and condition of weather-stripping.

3.3.2.2.3 Record the presence of thermal breaks.

3.3.2.3 Solar Coefficient: Determine heat gain utilizing Manual J8 procedures or equivalent.

3.3.3 Exterior Doors

3.3.3.1 Record door material: fiberglass, metal, wood, glass, condition and operation.

3.3.3.2 Record the surface area of all door assemblies.

3.3.3.3 Record door labeling.

3.3.3.4 Record the compass orientation of glass doors.

3.3.3.4.1 Record when the door windows that have a low-emissive coating and where the coating is applied.

3.3.3.4.2 Record the presence and condition of weather-stripping.

3.3.3.4.3 Record the presence of thermal breaks.

3.3.4 Leakage rate: The Auditor shall determine and record the leakage rate of the building envelope[4]. Acceptable procedures:

3.3.4.1 A single point (50 Pa) envelope leakage depressurization/ pressurization test must be performed[5] in accordance with:

3.3.4.1.1 RESNET Chapter 8, §802.[6] or,

3.3.4.1.2 The following Envelope Leakage depressurization test procedure:

3.3.4.1.2.1 Prior to blower door, Auditor shall inspect premises for the presence of friable presumed asbestos containing materials (PACMs). When found:

a. Document PACM locations.

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

c. 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).

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

3.3.4.1.2.2 Install the blower door. Prepare the house for blower door testing:

a. Ensure that the building envelope is completely sealed 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).

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[4] 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.

[5] At the discretion of the Auditor or the AHJ, the Auditor may perform an infrared scan of the building envelope to target and record heat loss areas during the blower door testing. This will also allow the Auditor to identify any areas of missing insulation.

[6] 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 RESNET Chapter 8, §802.6.

b. Ensure that all interior doors in the building envelope are open.

c. Adjust all combustion appliances so that they do not turn on during the test.

d. Ensure all fires in fireplaces and wood stoves are extinguished. Close all fireplace and wood stove doors to prevent scattering of ashes[7].

e. Turn off all exhaust fans, vented dryers, and room air conditioners.

f. Tape or temporarily seal off all continuously operating outside air intakes[8].

3.3.4.1.2.3 Perform Air Leakage Test:

a. Turn the Blower Door fan on and bring the house to a 50 Pa pressure difference with respect to the outside.Ensure the configuration input on the gauge matches the actual ring configuration on the blower door fan.

b. Record the cubic feet per minute of leakage at the 50 Pa pressure difference[9].

3.3.4.1.2.4 For a two-family dwelling (e.g., a duplex) that is to be tested as one building, 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.

3.3.4.1.2.5 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.

3.3.4.1.2.6 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.

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[7] 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.

[8] When taping or sealing off 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.

[9] When using a pressure differential 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.

3.4 VENTILATION

3.4.1 Requirements: The Auditor shall determine and record 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 outdoors.

3.4.2 Acceptable Procedures:

3.4.2.1 The Auditor shall follow ASHRAE 62.2 2016, or methodology adopted by AHJ to perform building ventilation calculations and use them in determining the ventilation requirement.

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

3.4.2.3 Recorded confirmation that identified exhaust fans vent to the outdoors.

3.5 INSULATION

3.5.1 Requirement: The Auditor shall determine and record 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 one of the following insulation inspection procedures:

3.5.2.1 RESNET Home Energy Rating Standards of Practice §3, or

3.5.2.2 BPI 1200 §10, or

3.5.2.3 The Auditor shall perform the following insulation inspection:

3.5.2.3.1 Determine, or measure, or estimate R-values and location of insulation as follows:

3.5.2.3.1.1 For Exterior walls:

a. Determine and record the presence of insulation in framed walls; estimate and record the R-value.

b. Insulation in parts of the house that were added later must be determined and recorded separately from the original walls.

3.5.2.3.1.2 For Partition walls: Determine and record the R-value installed in attic knee walls.

3.5.2.3.1.3 For Ceilings: Determine and record the insulation type and R-value which exists in the ceiling area (cavity).

Note: Record if a combination of more than one type of insulation exists.

3.5.2.3.1.4 For Attics: Use the inspection guidelines in Appendix A, RESNET Mortgage Industry National HERS Standards to assess "Grade I", "Grade II", or "Grade III" installation. The following instructions apply to grade rating:

a. 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.

b. Insulation in ceilings with an attic above need not be enclosed to attain a "Grade II" or "Grade I" assessment.

c. 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.

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

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

3.5.2.3.1.5 For Roof: determine and record the insulation R-value affixed to the roof deck.

Note: When an attic is determined to be conditioned, the roof deck is considered part of the building envelope.

3.5.2.3.1.6 For Floors over Crawlspaces or unconditioned Basements: Determine and record the insulation in the walls and/or ceiling of the basement and/or crawlspace.

a. Vented crawlspace: Determine and record the insulation value between the ground floor of the house and the crawlspace.

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

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

3.5.2.3.1.7 For Basement Floors: Determine and record the insulation in the walls and/or ceiling of the basement; insulation type, thickness, and R-value.

3.5.2.3.1.8 For Slab Floors: Determine and record the presence of slab perimeter insulation.

3.6 HEATING AND COOLING SYSTEMS

3.6.1 Heating, venting and air conditioning (HVAC) system requirements:

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

3.6.1.2 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.

3.6.1.3 Record the location and type(s) of thermostat(s).

3.6.1.4 Identify record the presence of other mechanical systems such as attic fans.

3.6.1.5 Duct distribution systems:

3.6.1.5.1 Record the type of ductwork.

3.6.1.5.1.1 Sheet metal, externally insulated.

3.6.1.5.1.2 Sheet metal, internally insulated.

3.6.1.5.1.3 Fibrous glass duct board.

3.6.1.5.1.4 Flexible duct.

3.6.1.5.2 Record the R-value of duct insulation.

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

3.6.1.6 Exhaust fans: Record the following:

3.6.1.6.1 Location.

3.6.1.6.2 Measured airflow rate in CFM.

3.6.1.6.3 Record fan location.

3.6.1.6.4 Determination of whether they are vented to the outdoors and record vent locations.

3.6.2 Airflow testing

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

3.6.2.2 Acceptable Procedures: The Auditor shall test the airflow through the heat exchanger in accordance with the ACCA 5 QI Standard §4.1 accepted procedures[10].

3.6.3 Distribution System Insulation Evaluation Utilizing Temperature Difference (TD).

3.6.3.1 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.

[10] For use of OEM pressure drop tables per 3.6.2.2, equipment must be clean and in like-new condition.

3.6.3.2 The air within the duct distribution systems in unconditioned space shall not lose or gain excessive amounts of heat as the air travels through the distribution system and into the conditioned space[11]. The contractor shall use the following distribution system temperature difference protocol:

3.6.3.2.1 Thermometers used shall:

a. Have a temperature sensing probe at least 6" long[12].

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

c. Have a resolution of 0.1°F.

d. Have an accuracy rate of ± 2.5%.

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

3.6.3.2.2 Energize the HVAC system in heating or cooling mode as appropriate for the season. The test shall be performed as follows:

a. Allow the system to reach steady state.

b. 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).

c. All measurements shall be taken in less than 5 minutes[13].

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

e. 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.

3.6.4 Duct Leakage Testing

3.6.4.1 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[14] of the Auditor or the AHJ, the auditor shall recommend that a quantitative test be performed of the entire duct system[15].

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[11] 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, long runs, low airflow, etc.

[12] May need to take temperature measurements from 4 sides of duct and average to get temperature where airflow stratification is present.

[13] Infrared thermometers are of value to quickly measure the register/diffuser temperature in several rooms for comparison. The temperatures obtained from infrared thermometers do not accurately measure air discharge temperatures. For supply and return air temperature, probe type thermometers should be used for measuring the air in the plenum.

[14] 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.

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

3.6.4.2 Acceptable Qualitative Procedures:

3.6.4.2.1 Qualitative Test: Shall be tested in accordance with one of the following procedures:

3.6.4.2.1.1 Gasketed Pan Test (Pressure Pan) – Prepare the house in accordance with 3.3.4.1 for an envelope leakage test.

a. Depressurize the house by 50 Pa.

b. 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:

i. A gasketed pan with a sealed pressure tap,

ii. Tape,

iii. Combination of gasketed pan and tape[16].

c. Record the pressure in the duct with reference to the house:

i. At the pressure tap on the gasketed pan, or

ii. A static pressure probe inserted through the tape.

d. Remove the cover at the conclusion of each register or grille.

e. Determine the median and the highest measured pan difference for all duct covering. Compare the values to the comparative benchmark in Table 1 in §4 of this Standard.

3.6.4.2.2.1 Blower Door Assisted Smoke Test–B Procedure:

a. Seal all grilles and registers in the duct system.

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

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

3.6.4.3 Acceptable Quantitative Test: procedures shall be tested in accordance with:

3.6.4.3.1 ACCA 5 QI Standard, §5.1, or

3.6.4.3.2 Chapter 8, RESNET Mortgage Industry National HERS Standards.

3.6.5 Room-Pressure Differences

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

3.6.5.2 Acceptable Procedures: The Auditor shall use the following procedure:

[16] 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.

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

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

3.6.5.2.3 Measure the base-line pressure difference in the house WRTOD.

3.6.5.2.4 For isolated rooms (excluding bathrooms), close the door, and measure the pressure difference WRTOD.

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.

3.8 APPLIANCES AND LIGHTING EQUIPMENT

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

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

3.8.2.1 Appliances: Record the following:

3.8.2.1.1 Age and efficiency (if available);

3.8.2.1.2 Condition;

3.8.2.1.3 Quantity and location.

3.8.2.2 Indoor and outdoor light fixtures: Record the following:

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

3.8.2.2.2 Quantity,

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

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

3.9 MOISTURE

3.9.1 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.

3.9.1.1 Requirements: The Auditor shall visually examine and record:

3.9.1.1.1 Evidence of plumbing leaks and moisture deposition or damage[17].

3.9.1.1.2 Areas where moisture migration into the attic is apparent and determine the source of the moisture.

3.9.1.1.3 For the interior of the building, crawlspace, and attic, evidence of moisture at the following locations shall be investigated:

3.9.1.1.3.1 Along the attic floor and roof decking;

3.9.1.1.3.2 Under windows;

3.9.1.1.3.3 On exterior walls behind furniture;

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

3.9.1.1.3.4 In corners of closets on exterior walls;

3.9.1.1.3.5 At flooring adjacent to doors and windows;

3.9.1.1.3.6 Around HVAC supply outlets;

3.9.1.1.3.7 On the ceiling;

3.9.1.1.3.8 Along exterior wall baseboards;

3.9.1.1.3.9 In other areas of stagnation and thermal bridging;

3.9.1.1.3.10 The ground of the crawlspace;

3.9.1.1.3.11 Concrete block foundation walls.

3.9.1.1.4 For the exterior of the building, crawlspace, and roof, evidence of potential sources of water intrusion at the following locations shall be investigated:

3.9.1.1.4.1 Siding,

3.9.1.1.4.2 Windows,

3.9.1.1.4.3 Trim,

3.9.1.1.4.4 Fascia,

3.9.1.1.4.5 Soffit areas,

3.9.1.1.4.6 Door head trim,

3.9.1.1.4.7 Door jambs,

3.9.1.1.4.8 Door sills,

3.9.1.1.4.9 Gutters

3.9.1.2 Accepted procedures: The auditor shall record the visual information.

3.9.2 Drainage

3.9.2.1 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.

3.9.2.2 Accepted procedures: The Auditor shall:

3.9.2.2.1 Record when ground runoff water is or is not directed away from the foundation.

3.9.2.2.2 Record when roof runoff water is or is not directed away from the foundation with downspouts, leaders and splash blocks.

3.9.2.2.3 Record when there is or is not a foundation drain system.

3.10 POOLS AND SPAS

3.10.1 Requirements: The Auditor shall ensure:

3.10.1.1 Safety: Record type of suction outlet cover(s) and flow rating.

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

3.10.1.3 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. Record the presence or absence of an available pool cover.

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

3.11 WATER USAGE

3.11.1 Visually inspect the building's plumbing fixtures, landscape irrigation systems and appliances for leaks, and identify the fixtures and appliances that would benefit from being upgraded to meet Environmental Protection Agency's (EPA) WaterSense™ specifications.

3.11.2 Acceptable Procedures: The Auditor shall note and record the type and quantity of plumbing fixtures, landscape irrigation systems and appliances that do not meet EPA's WaterSense specifications for residential buildings. Examples of fixtures and appliances include the following:

3.11.2.1 Indoor utility faucets

3.11.2.2 Toilets

3.11.2.3 Sink Faucets

3.11.2.4 Shower heads

3.11.2.5 Clothes Washers

3.11.2.6 Dish Washers

3.11.2.7 Sprinkler heads

3.11.2.8 Irrigation timers/times

3.12 DOCUMENTATION

3.12.1 Requirement: An audit file of required and relevant information shall be created and stored by the auditor.

3.12.1.1 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; See Table 1 for data to be collected.

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

3.12.2 Acceptable Procedures: The Auditor shall confirm that the listed requirements are met and the required documentation is maintained and stored.

3.13 UNSAFE CONDITIONS

3.13.1 Requirement: Upon discovery of any ongoing 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 unsafe condition is resoled.

4.0 ASESSING 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.

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. For example, BPI or RESNET comparative benchmarks used for Ambient CO level in CAZ.

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 2015 International Residential Code §G2445.5 and 2015 International Fuel Gas Code §621
§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 2015, §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.
§3.3 Envelope	CFM50:_____	As specified by the ICC IECC 2015 §402.4.

<table>
<tr><th colspan="4">Table 1: Comparison of Current Measurements and Comparative Benchmarks</th></tr>
<tr><th>Improvement Area</th><th colspan="2">Current measurement or value</th><th>Comparative Benchmarks</th></tr>
<tr><td></td><td colspan="2">ACH50:_____</td><td></td></tr>
<tr><td rowspan="3">§3.4
Ventilation</td><td colspan="2">Measured infiltration:
_____CFM50</td><td rowspan="3">As specified by ASHRAE 62.2 2016 or AHJ.</td></tr>
<tr><td colspan="2">Calculated ventilation requirement:
_____Cfm</td></tr>
<tr><td colspan="2">Measured ventilation rate:
_____Cfm</td></tr>
<tr><td rowspan="4">§3.5
Insulation</td><td colspan="2">Ceiling/Attic: _____R-value</td><td rowspan="3">Meet the standards set forth in the IECC 2015 Table 402.1.2.</td></tr>
<tr><td colspan="2">Wall R-Value: _____ R-value</td></tr>
<tr><td colspan="2">Floor/Slab/Crawlspace R-Value:
_____ R-value</td></tr>
<tr><td colspan="2">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 colspan="2"><table><tr><th colspan="3">Gasketed Pressure Pan</th></tr><tr><th>Register / Grille / Diffuser ID + location</th><th>Supply or Return?</th><th>Pressure Reading</th></tr><tr><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td></tr></table></td><td>Median value shall be no more than 3 Pa, no register or grille shall be greater than 8 Pa.</td></tr>
<tr><td rowspan="2">§3.6.4
Duct Leakage Quantitative Test</td><td colspan="2">Measured Duct leakage:

_____CFM25</td><td>As specified by the ACCA 5 QI Standard §5.1.</td></tr>
<tr><td colspan="2">Room Pressure Differences:</td><td>No more than 0.012iwc (3Pa) pressure difference (PD)</td></tr>
</table>

<table>
<tr><th colspan="3">Table 1: Comparison of Current Measurements and Comparative Benchmarks</th></tr>
<tr><th>Improvement Area</th><th>Current measurement or value</th><th>Comparative Benchmarks</th></tr>
<tr><td>§3.6.5
Room Pressure Differences</td><td>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</td><td>between the area with the largest return air duct wrt and an interior room with the door closed with respect to outside of the home (WRTO).</td></tr>
<tr><td>§3.7
Hot Water Heating</td><td>Water Heater nameplate efficiency: _____

Piping Insulation: _____R-value</td><td>As specified by National Appliance Efficiency Conservation Act (NAECA)

Insulate pipes to ICC IECC 2015 §R403.3</td></tr>
<tr><td>§3.8
Appliances and Equipment</td><td>Appliance 1:_____
Appliance 2: _____
Appliance 3: _____
Appliance 4: _____
Appliance 5: _____
Appliance 6: _____
Appliance 7:_____
Appliance 8:_____
Appliance 9:_____
Appliance 10:_____</td><td>Appliances and Equipment efficiency as specified by ENERGY STAR https://www.energystar.gov/products</td></tr>
<tr><td>§3.9
Moisture</td><td>Plumbing leaks:_____
Drainage issues:_____
Exterior rating:_____
Interior rating:_____</td><td>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.</td></tr>
<tr><td>§3.10
Pools and spas</td><td>Suction outlet cover flow rating:_____

Motor Total horsepower: _____Hp

Pool heater type:_____

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</td><td>Suction outlet cover in accordance with ASME A112.19.8 - 2011

1.0 horsepower motors or greater shall be a multi-speed or variable speed motor. Pool pump motor shall be sized per Association of Pool and Spa Professionals (APSP) 15 - 2011.
<table><tr><th>Pool heater type</th><th>Minimum Efficiency</th></tr><tr><td>Fossil Fuel</td><td>78% AFUE</td></tr><tr><td>Electric</td><td>None</td></tr><tr><td>Heat pump</td><td>COP 4.0</td></tr></table>
As specified in the IECC 2015 §404.9

As specified in the IECC 2015 §404.9

Tested and listed ASTM F1346-91 - 2010 and in</td></tr>
</table>

Table 1: Comparison of Current Measurements and Comparative Benchmarks		
Improvement Area	Current measurement or value	Comparative Benchmarks
	water temperature greater than or equal to 80°F) _____	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.

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

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

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

4.2.1.3 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[18]. Acceptable alternatives include:

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

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

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

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).

[18] 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.

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 indicate 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, safety, durability, and comfort improvements shall be prioritized 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[19] savings.

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

5.1.3.2 Improvements with the best cost to benefit ratio.

5.1.4 Comfort, or IAQ, or building durability improvements.

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[20].

5.2.2 Adverse effects[21]: Building performance improvements shall be presented in groupings that will not harm the occupants, the building integrity or degrade the performance of the building.

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[19] 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.

[20] 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.

[21] 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. See also Appendix B20.5

5.3 PROPOSAL ELEMENTS REQUIRED

All proposed improvement shall:

5.3.1 Meet applicable codes and regulations for the jurisdiction.

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

5.3.3 Include a statement indicating that the energy savings are estimated[22].

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 that 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 the client was made aware of any safety or health issues revealed during the audit.

[22] See Appendix B20.4 for an example of the wording to address this issue.

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 the requirements in this standard and all relevant codes. 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 2015 International Fuel Gas Code or manufacturer's installation instructions for gas-fired appliances, or the OEM instructions or §G2407 of the 2015 International Residential Code for appliances other than gas-fired appliances.

6.1.3 CO detectors shall be installed in accordance with OEM instructions and 2015 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:

6.2.4.1 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*".

6.2.4.2 Installation of air impermeable foam insulation.

6.2.5 When air sealing encompasses 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 6.2.7 Attic venting shall be in accordance with 2015 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 62.2-2016 and the IECC 2015

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:

6.4.1.1 Manufacturer's Recommendations.

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

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

6.4.1.4 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 All moisture issues (See Section 3.9) 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 fiber glass 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 ICC IECC 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:

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

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

6.4.8.3 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 ANSI/ACCA 6 QR (*Restoring the Cleanliness of HVAC Systems)*.

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.[23]

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 2015.

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 2015International 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 2015 IECC §403.9.

6.7.4 Vapor retardant covers on heated pools shall be tested and listed in accordance with ASTM F1346-91 – 2016.

6.7.5 New pools or spas shall be constructed in accordance with the ISPSC 2015 standard.

6.7.6 New or replacement HVAC systems serving indoor pools and spas shall be designed per ACCA Manual SPS 2010 (RA2017)

[23] 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[24] 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 standards listed in §6.0, or the standard specified.

NOTE: For newly constructed homes, 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 of this Standard. When unvented combustion appliances are present, confirm their listing to ANSI Z21.11.2 and their use as a secondary heat source.

[24] 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 | RECOMMENDED MINIMUM INTERVIEW QUESTIONS

(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 is an outline of suggested questions designed to provide guidance for developing and implementing interview questions. The question outline provided contains general questions designed to enhance the information gathering process for a typical residential comprehensive performance audit. For specific interviews, questions will generally be expanded upon, added, or dropped as applicable.

APPENDIX A RECOMMENDED MINIMUM INTERVIEW QUESTIONS

The interviewer should seek the following information from the client:

A1 General:

1. Do you own or rent the building? (Note: Renters must have express written permission from building owner prior to having an audit performed.)
2. How many people live (or work) in this building?
3. What year was your building built?
4. How long have you lived there?
5. Of what improvements or changes in the building are you aware?
6. Do you have a set of building plans (architectural, as-built, material or equipment specifications or data sheets, etc.)?
7. Do you have high utility bill complaints?
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?
9. Do you have the last 12 months of utility usage (electric, gas, fuel oil, etc.) records or bills?

A2 Comfort:

1. Do you have any hot or cold rooms?
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.])
3. Where do you feel drafts or where is it drafty?
4. How often do you open your windows instead of using the air conditioner to maintain comfort?
5. Do you have any indoor air quality issues?
6. Does anyone in the building suffer from health issues (allergies, asthma, temperature issues, odors/smells, etc.)?
7. Do you have any health-related air filtration requirements?
8. How often do you change the filter in the HVAC system(s)?

9. When was the last time you had the HVAC system checked for maintenance?
10. Do you know how to use the programmable thermostat (if applicable)?
11. Do you have a lot of dust in the house?

A3 Building Systems (appliances, lighting, water, etc.)

1. Do you use compact fluorescent or LED light bulbs?
2. Do you turn on the kitchen exhaust fan when cooking?
3. Do you turn on the bath exhaust fan when bathing/showering?
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?

A4 Combustion Safety

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?
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?

APPENDIX B | SUPPORTING HOME AUDITING INSPECTION PRACTICES

(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 is added to provide guidance for those implementing the inspection tasks in the standard. Many of the required tasks in the standard may be accomplished using different tools and processes. It is better to have more information recorded than one needs before leaving a job site, than to need information or a measurement, that was overlooked, when developing the comprehensive plan off site.

This Appendix provides additional insight on how to accomplish an organized inspection procedure. It is not a requirement. However, it is offered as an example of how professional auditors gather the data needed for completing the standard's required proposal development process in a uniform manner.

This appendix provides tasks which will enhance the audit.

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.
  - B.1.11.1 Opportunities for renewable technology (i.e., access to sunlight on south side).

B2.0 FOUNDATIONS

- B2.1 Crawlspaces[25]
  - 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.
    - B2.1.1.1 Vented crawl spaces have some form of vent or louver in the crawl space walls, or are constructed in such a manner so that air moves freely from outside the walls to inside the crawl space.
    - B2.1.1.2 Unvented crawl spaces 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.

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

B2.1.2.1 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).

B2.1.2.2 To determine whether a crawlspace is conditioned or not, assess the insulation placement in the walls or floor/ceiling assembly.

B2.1.2.3 A vented crawlspace is considered unconditioned regardless of the location or existence of insulation.

B2.1.2.4 Identify any floors over a crawlspace.

B2.1.2.5 Check for intact vapor barrier with 100% coverage of the ground. Check for visible signs of water damage, mold and standing water[26].

B2.1.2.6 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.

B2.2.1.1 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.

B2.2.1.2 Check for walkout (daylight) access (can be a stairwell, emergency exit window well, or direct ground level exit).

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

B2.3.2.1 If present, slab perimeter insulation is usually installed on the outside of the slab and extends both above and below grade.

B2.3.2.2 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).

B2.3.2.3 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.

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

B2.3.2.4 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.

B2.3.2.5 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[27]:

B3.5.1.1 Insulation was found at the rim joist at the top of the crawl space or basement in the same house; or

B3.5.1.2 Insulation is found in the walls of the same house.

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.

[27] Otherwise, assume no rim joist insulation exists.

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.

B6.1.3 Dryer vent penetrations on exterior walls.

B6.1.4 A/C piping penetrations on exterior 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, 0.5" to 0.6" for interior sheetrock, and 0.5" to 0.75" 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);

B6.3.4.1 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.

B6.3.4.2 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.

B.6.3.5 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.

B7.1.2.1 Note if the windows that are double-pane have a low-emissive coating and where the coating is applied.

B.7.1.2.2 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.

B9.7.1.1 If the ceiling has attic space above (even if the ceiling is vaulted, as in a scissor truss) it is considered ceiling to attic.

B9.7.1.2 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.

B9.7.1.3 Check for an attic access.

B9.7.2 Framed ceilings fall into two categories:

B9.7.2.1 *Roof on exposed beams or rafters* – Exposed beams or rafters will be visible from inside the room.

B9.7.2.2 *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 knee walls.

B10.6 Check the attic knee walls for sheathing (have an air barrier on the attic side). Attic knee walls 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 knee walls for air sealing.

B10.8 Examine the joists under attic knee walls 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 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 (IRC) for One- and Two-Family Dwellings- 2015:

B11.7.1.1 Calculate attic square footage.

B11.7.1.2 Divide attic square footage by 150 to determine net free area required.

B11.7.1.3 Divide result by 2 to get intake and exhaust net free area.

B11.7.1.4 Convert result to square inches by multiplying by 144.

B.11.7.2 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. At a minimum, the suction line should be insulated.

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.

B12.10.1.1 Measure return grilles and calculate net free area, net free area is typically 80% of the gross area.

B12.10.1.2 Note whether filter is installed at the grille or at the return plenum-air handler connection.

B12.10.1.3 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[28]

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

B13.1 The thermometer shall be evaluated for upgrading to a programmable model. For zoned homes the thermostat location must be verified to be in the proper heating/cooling system zone,

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.

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.

14.6.1 Estimate the average distance from the water heater.

14.6.2 Check and record piping insulation levels (thickness).

14.6.3 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,[29] and identify the fixtures that would benefit from being upgraded to meet Environmental Protection Agency'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

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

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

B15.2.2 Sink faucets
B15.2.2.1 Kitchen
B15.2.2.2 Bathroom
B15.2.2.3 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.

B16.2.1.1 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.

B16.2.1.2 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.

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	Incandescent Light Bulbs
Freezers	Imaging Equipment and Printers	Light bulbs (CFLs)
Refrigerators	Set-top Boxes & Cable Boxes	Light Fixtures
Room air conditioners	Televisions	

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[30].

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 should 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 in gallons should be estimated by multiplying 7.48 times the water containing area in cubic feet: (length x width x average depth in feet x 7.48).

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

[30] 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)

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 | GLOSSARY

(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.)

ACCA: Air Conditioning Contractors of America (www.acca.org)

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

Ambient: The air (or temperature thereof) that surrounds an object. For example, the outdoor air (for a house or for air cooled condensing equipment), the conditioned indoor air (for occupants and the thermostat), or the air in an enclosed, unconditioned space (for a partition or a duct run).

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

Attic knee wall: 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

British thermal unit (BTU) The amount of heat required to increase or decrease the temperature of one-pound water one degree Fahrenheit at sea level.

BTU/Hour (BTUH or BTU/Hr): A common metric for rating heating, cooling and refrigeration equipment. The hourly rate of heat flow, measured in Btu units.

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): a poisonous, odorless and colorless gas which is created whenever a fossil fuel (such as wood, gasoline, coal, natural gas, kerosene, etc.) is burned.

CFM: Cubic Feet per Minute of air flow: Flow rate for ducted flow, or for the flow through primary heating and cooling equipment, supply outlets, returns and so forth.

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: A deposit of the air borne water vapor on a surface that has a temperature below the dew point of the air.

Conditioned space: An area, room or space being heated or cooled by any equipment or appliance.

COP: Coefficient of Performance; Calculated by finding the ratio of Btuh divided by Kwh.

DOE: United States Department of Energy (www.doe.gov)

Draft: The movement of air from an area of high pressure to an area of low pressure; usually considered objectionable. Drafts are also caused by excessive velocity from a supply grille or diffuser.

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

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

EPA: United States Environmental Protection Agency; (www.epa.gov).

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, and Air Conditioning

ICC: International Code Council, Inc. (www.iccsafe.org)

IECC: International Energy Conservation Code (www.iccsafe.org)

Inches of water column (IWC): unit of pressure difference

Infiltration: Uncontrolled outdoor air leakage into a conditioned space through cracks and openings in the exposed surfaces, leakage through an attic ceiling, and leakage through the interior partitions that are air coupled to an attic, a leaky crawlspace or a leaky basement. (Infiltration is caused a set of pressure drivers such as: wind, the stack effect, vents, chimneys, exhaust fans and duct leaks.)

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

Isolated room: A room with no local return and an interior door.

Joists: A system of horizontal parallel beams or planks that support a floor or ceiling

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

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

OEM: Original Equipment Manufacturer;

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 A unit of pressure measurement, used for very small pressures. One tenth of an inch of water column is equal to 25 Pascals.

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/ICC 5 – 2012

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 Energy Smart Contractor on the Home Performance Team

Rafters: sloped framing members that form the roof

R-value: A measurement of the resistance to the heat flow through a material when the material is subjected to a temperature difference that does not change with time. R-values are measured in square feet, per degree Fahrenheit, per British Thermal Unit per hour – [(SqFt x °F) / (Btuh)]. The R-value is the reciprocal of the U-Value.

SEER: An equipment efficiency rating that is representative of performance throughout the cooling season and takes into account the startup and shutdown for each cycle. The rating equates to Btu output per watt of energy input, the more Btu's per watt (the higher the SEER), the lower the cost of operating the equipment.

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

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

U-value: A heat transfer performance index that accounts for the thermal resistance through a structural panel (fenestration, wall, ceiling, door, floor, etc.) and the air film resistance at the indoor and outdoor surfaces of the panel. The U-value is the reciprocal or the R-Value. The method of obtaining R-values and U-values depends on the type of panel. See Appendix 4. U-values are expressed as British Thermal Units per hour, per degree Fahrenheit, per square foot — [(Btuh) / (°F x Sq.Ft.)].

Unconditioned space: Areas of a structure that are not heated or cooled that may be part of the useful living space (an unheated basement, for example) or may not be part of the useful living space (a crawlspace, for example).

Vapor: A gas, particularly one near its equilibrium with the liquid phase of the substance. Usually used instead of the term "gas" for a refrigerant.

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

Ventilation: The controlled (engineered) movement of air from the outdoors, through the conditioned space, to the outdoors. The flow of air may exit through cracks and penetrations in the thermal envelope, relief openings, ancillary exhaust systems, dedicated exhaust systems, heat recovery equipment, chimneys or vents.

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

Watt: rate of 1 joule of energy per second

Zone: a room or space or a set of rooms and spaces that has its own point of temperature sensing and control. (The associated comfort system/equipment/devices must be capable of satisfying the requests issued by local control.)

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, 2016
Manual J®	Residential Load Calculation, 8th ed., 2016
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 (RA-2017)
Manual T®	Air Distribution Basics for Residential and Small Commercial Buildings, 1992
Manual Zr®	Residential HVAC System Zoning, 2018
ACCA 4 QM®	Maintenance of Residential HVAC Systems in One- and Two-Family Dwellings Less Than Three Stories, (pending ANSI review process), 2013
ACCA 5 QI®	HVAC Quality Installation Specification, 2015
ACCA 6 QR®	Standard for Restoring the Cleanliness of HVAC Systems, 2015
ACCA 9 QIvp®	HVAC Quality Installation Verification Protocols, 2016

Other Documents

- Bob's House: Understanding the Residential HVAC Design Process, 2016
- Technician's Guide and Workbook for a Quality Installation, 2015
- Technician's Guide and Workbook for Residential Duct Diagnostics and Repair, 2016
- Technician's Guide and Workbook for Duct Design basics, 2016
- 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

AGA **American Gas Association (400 N. Capitol Street, NW, Suite 450, Wash. DC 20001; tel: (202) 824-7000; https://www.aga.org/about)**

ANSI Z223.1/NFPA 54 National Fuel Gas Code 2015 Edition

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 210/240-2017	Unitary Air Conditioning and Air-Source Heat Pump Equipment
Standard 700-2017	Specifications for Refrigerants,
Standard 740-2016	Performance Rating of Refrigerant Recovery/Recycling Equipment,
Standard 880-2011	Performance Rating of Air Terminals,
Guideline K-2015	Containers for Recovered Non-flammable Fluorocarbon Refrigerants,
Guideline N-2016	Assignment of Refrigerant Container Colors
Guideline Q-2016	Content Recovery & 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

ISPSC 2015	International Swimming Pool and Spa Code

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 15-2016	Safety Standard for Refrigeration Systems,
Standard 34-2016	Designation and Safety Classifications of Refrigerants,
Standard 52.2-2012	Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size,
Standard 55-2013	Thermal Environmental Conditions for Human Occupancy,
Standard 62.2-2016	Ventilation for Acceptable Indoor Air Quality in Low-Rise Residential Buildings,
Standard 90.2-2007	Energy-Efficient Design of Low-Rise Residential Buildings,
Standard 111-2008	Practices for Measurement, Testing, Adjusting, and Balancing of Building Heating, Ventilation, Air Conditioning and Refrigeration Systems,
Standard 119-2004	Air Leakage Performance for Detached Single-Family Residential Buildings
Standard 126-2016	Method of Testing HVAC Air Ducts,
Standard 147-2013	Reducing the Release of Halogenated Refrigerants from Refrigerating and Air-Conditioning Equipment and Systems,
Standard 152-2014	Method of Test for Determining the Design and Seasonal Efficiencies of Residential Thermal Distribution Systems,
Guideline 0-2013	The Commissioning Process,
Guideline 1.1-2007	The HVAC Commissioning Process,
Guideline 4-2008	Preparation of Operating and Maintenance Documentation for Building Systems,

Other Documents
- Handbook of Fundamentals, 2017
- Humidity Control; Harriman, Lew, Geoffrey W. Brundrett, and Reinhold Kittler

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

A112.19.12– 2010	Manufactured Safety Vacuum Release Systems (SVRS) for Residential and Commercial Swimming Pool, Spa, Hot Tub, and Wading Pool Suction Systems

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 (2011)	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 (2016)	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 (2016)	Standard Practice for Installation of Exterior Windows, Doors and Skylights
F1346-16	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

ANSI/BPI-1100-T-2014 Home Energy Auditing Standard

ANSI/BPI-1200-S-2015 Standard Practice For Basic Analysis Of Buildings

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, 2015
- International Energy Conservation Code, 2015
- International Fire Code, 2015
- International Residential Code, 2015
- International Mechanical Code, 2015
- International Fuel Gas Code, 2015

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, 2015 NFPA90a Standard for the Installation of Air Conditioning and Ventilating Systems, 2018.
NFPA 90b	Standard for the Installation of Warm Air Heating and Air-Conditioning Systems, 2018.

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, 2017
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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
- ENERGY STAR Homes Building Option Package (BOP) Standard, 2000
- RESNET Procedures for Certifying Residential Energy Efficiency Tax Credits, 2016
- Rating and Home Energy Survey Ethics and Standards of Practice, 2010
- RESNET Procedures for Verification of International Energy Conservation Code Performance Path Calculation Tools, 2004
- RESNET Standards for Qualified Contractors and Builders, 2010
- RESNET Home Energy Rating Standards of Practice , 2014

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, 2006
- HVAC Systems Commissioning Manual. 1994.
- HVAC Systems Duct Design, 2006
- ASHRAE 111 – 2008 HVAC Systems Testing, Adjusting & Balancing.
- IAQ Guidelines for Occupied Buildings Under Construction. 2007
- Rectangular Industrial Duct Construction Standards, 2007
- Round Industrial Duct Construction Standards, 2013

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

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