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Standard for Multifamily Energy Auditing

THE SYMBOL OF EXCELLENCE FOR HOME PERFORMANCE CONTRACTORS

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Formulated under the cognizance of the BPI Standards Technical Committee.

Introduction

(Informative)

The Building Performance Institute, Inc. (BPI) publishes standards related to the energy efficiency and performance of residential buildings. Although this standard is primarily focused on energy conservation measures and criteria, it does extend beyond these measures to address the building as a whole. The auditor's role may vary depending on the context in which the evaluation is conducted. The "auditor" may be an independent third party, an employee of a contractor or a weatherization agency; or may also be a person conducting an evaluation of the building for other purposes including post-installation performance verification, quality assurance inspections, or other diagnostic interventions. This standard assumes auditors will also follow in good faith their company's policies and conform to the policies of any participating program sponsor or funding source, as applicable, concerning energy-savings estimates, emissions evaluations and cost-benefit analysis. The recipient of the results of the evaluation may include property owners, program administrators, or other interested parties.

This standard generally aligns with the definition of an American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Level II audit, but is enhanced to accommodate the characteristics of the 20+ million residences in buildings falling under this standard. It recognizes the challenges inherent in having HVAC, lighting and appliance controls, and hence energy consumption, split between an owner and a large number of tenants. It establishes protocols to responsibly manage the safety issues common in buildings with many small atmospheric combustion appliances. It provides guidance in accommodating missing tenant utility data. It establishes sampling protocols to be used where there are large numbers of units or appliances to be evaluated.

Disclaimer: While the on-site evaluation is not intended to be a health and safety inspection, a well-trained auditor with a strong foundation in building science will have a thorough understanding of specific, important health and safety failures that are regularly found in multifamily buildings. Work done in accordance with this standard requires that the auditor alert building staff to adverse conditions when they are identified. When adverse health and safety conditions are identified that are beyond the expertise of the auditor, the energy audit report should contain recommendations to consult with a qualified specialist. This standard does not assume or require that the energy auditor be a credentialed professional in any of the health and safety areas outlined in Section 2.

Program Guidance

(Informative)

Program requirements, laws or regulations, and applicable building codes or ordinances may take precedence over these standards in setting requirements for on-site evaluations, work scopes and Energy Efficiency Measures (EEMs). Consumers and third-party funding sources often impose additional accounting requirements of EEM costs and savings, energy savings, demand savings, and/or emissions reductions. Additionally, regional climate, housing types and market conditions vary. The Energy Auditor and/or program managers will use their discretion as to components of the energy audit that may need to go beyond the minimum criteria set forth in this Standard.

Conversely, the minimum criteria defined in this Standard may go beyond the requirements of some energy efficiency programs. In this circumstance, the BPI Multifamily Energy Auditor standard may still be referenced, even if program managers choose to explicitly define different minimum outcomes and requirements of the audit. Program managers seeking to define minimum requirements are encouraged to align the audit requirements for their program with the industry-recognized definitions of Level I and Level II audit thresholds as described in *ASHRAE Procedures for Commercial Building Audits, Second Edition*[1]. The minimum requirements set forth in this standard are generally equivalent to an ASHRAE Level II audit.

- Level I Audit: “Assess a building’s energy cost and efficiency by analyzing energy bills and conducting a brief on-site survey of the building. A Level I energy analysis will identify and provide a savings and cost analysis of low-cost/no-cost measures. It will also provide a listing of potential capital improvements that merit further consideration, and an initial judgment of potential costs and savings” (ASHRAE Procedures for Commercial Building Audits[1]). The survey will include a list of easily identifiable and immediate building durability and occupant health and safety concerns as well as potential items that may merit further investigation.

- Level II Audit: “This includes a more detailed building survey and energy analysis. A breakdown of the energy use within the building is provided. A Level II energy analysis will identify and provide the savings and cost analysis of all practical measures that meet the owner’s constraints and economic criteria, along with a discussion of any changes to operation and maintenance procedures. It may also provide a listing of potential capital-intensive improvements that require more thorough data collection and engineering analysis, and a judgment of potential costs and savings. This level of analysis will be adequate for most buildings and measures” (ASHRAE Procedures for Commercial Building Audits).

[1] ©ASHRAE, www.ashrae.org. *Procedures for Commercial Building Energy Audits*, Second Edition, 2011

In addition to easily identifiable and immediate durability and health and safety issues, the on-site assessment will require that an auditor conduct certain diagnostic tests. When not specified in the standard, the diagnostic tools selected for these tests should match the scale of the building and the equipment contained within. Based on the results of this diagnostic testing the energy audit report will recommend further investigation and/or repair as needed.

In this Standard, a recommendation to complete post-installation testing/commissioning is called out for some possible recommended measures, but not others. As a best practice, every measure installed should be commissioned before being placed into service. The recommendations that some measures are specifically called out for commissioning reflect industry experience. For some measures, typical installation practices may not be rigorous enough to ensure the measure performs properly. Other measures are so critical to successful implementation of a project that commissioning provides useful assurance that the project goals will, in fact, be met.

This is a standard for evaluating an existing building and making recommendations to upgrade the building to improve the energy and water efficiency and indoor environmental conditions. This standard does not require buildings to be upgraded to a specific standard but rather be evaluated against an explicit standard.

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1 Scope

This Multifamily Energy Auditing Standard defines the minimum criteria for conducting a building-science-based evaluation of existing multifamily buildings and outlines specific technical procedures associated with the evaluation.

Multifamily buildings are defined for purposes of this standard as buildings that have five or more residential units in a building that is primarily residential. For any case where the above definition does not coincide with the local jurisdiction's definition of a multifamily building, the local jurisdiction's definition shall take precedence, and this standard may be applied to that building.

ANSI/BPI-1200-S-2017 Standard Practice for the Basic Analysis of Buildings (ANSI/BPI-1200) will typically apply to 2 - 4 unit buildings based on its scope copied here: "Existing detached single-family dwellings and townhouses that have independent mechanical systems for each dwelling unit (heating, cooling, water heating, and ventilation); direct access to outdoors for each dwelling unit; and were designed to have continuous party walls with no penetrations to adjacent units, with such party walls extending from ground to roof where the dwelling unit is attached to one or more adjacent single-family dwelling units."

For buildings that do not meet the ANSI/BPI-1200 definition, the multifamily standard may be used.

The scope of the on-site evaluation will include an evaluation of the residential units, common area public spaces and all building systems affecting energy use in those spaces. Sampling of space types is permitted when a large number of similar spaces are involved or if there are issues with access. The on-site evaluation will address water and energy usage, and limited aspects of building durability and occupant health and safety. Systems related to the overall site but outside any multifamily building may also be covered to the extent energy and water usage or health and safety concerns are affected. The on-site evaluation will provide data to support a comprehensive report with a list of prioritized recommendations to improve the building(s) and affected systems or components and will include a cost-benefit analysis of all proposed measures.

1.1 Use of Other Standards or Codes

This energy audit standard references a number of existing consensus standards to specify minimum acceptable performance of devices or systems used in the audit process (e.g., *UL 913 Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, and III, Division 1, Hazardous (Classified) Locations* for gas leak detectors) or to describe an established measurement or assessment procedure (e.g., *ANSI/ASTM E-779, Standard Test Method for Determining Air Leakage Rate by Fan Pressurization).* It is assumed that an energy audit completed in compliance with this standard will conform to the referenced standards, unless the audit report explicitly identifies an exception.

Further, a comprehensive audit may compare the performance of some component or system of the audited building to an external performance standard (which may not be mandated for that building). For example, measured exhaust fan rates in individual unit bathrooms may (or may not) comply with the applicable ASHRAE Ventilation Standard, to an applicable local or state building code, or to a program standard. In these cases, the audit report shall report the measured performance. If the auditor includes a compliance evaluation, it shall reference the standard considered, and report compliance with the standard established by the Authority Having Jurisdiction (AHJ). The audit may also report compliance with national consensus standards or program standards.

2 Health and Safety Related Requirements

The on-site evaluation shall not endanger the occupants or the auditor. The energy audit report shall communicate basic health and safety concerns identified through interviews and/or during the on-site evaluation and shall include recommendations for mitigating identified health and safety issues. All identified health and safety concerns, especially combustion-related concerns, and recommendations for mitigation, including deferral to qualified specialists, shall be communicated to the on-site representative upon completion of the evaluation.

2.1 Observations and Interviews

The evaluation shall include the following:

2.1.1 Identification of existing and/or potential moisture issues in accordance with Section 10 (Moisture Control).

2.1.2 Identification of existing pest problems.

2.1.3 Identification of areas containing known or suspected hazardous materials, including, but not limited to lead-based paint, asbestos, or mold. Note: Such materials shall not be disturbed during the on-site evaluation.

2.1.4 Visual inspection for knob and tube wiring.

2.1.5 Identification of obvious electrical hazards such as frayed wiring, open junction boxes, presence or lack of ground fault circuit interrupter (GFCI) outlets.

2.1.6 Visual evaluation of lighting levels, considered from a safety perspective, in spaces including, but not limited to, residences, common areas, hallways, stairwells, entries and parking areas.

2.1.7 Visual inspection for the existence of an Environmental Protection Agency (EPA) guidelines-compliant radon mitigation system.

2.1.8 Visual inspection for carbon monoxide (CO) alarms and smoke detectors.

2.1.9 A summary of interviews of the owners, property managers, maintenance staff and occupants in accordance with Section 3 (Pre-Site Evaluation) about their awareness of energy-related building hazards or other health and safety issues.

2.2 Measurements and Testing

2.2.1 Test the fuel distribution system/s and all combustion appliances in accordance with Section 11 (Combustion Appliance and Fuel Distribution System Testing) and Section 9 (Sampling Procedure).

2.2.2 Measure performance and evaluate ventilation system performance in accordance with Section 12 (Indoor Air Quality and Ventilation).

2.2.3 Monitor ambient CO at all times during the onsite evaluation in accordance with the equipment specifications, monitoring protocol and action levels in the current version of ANSI/BPI-1200-S *Standard Practice for Basic Analysis of Buildings* (ANSI/BPI-1200), Section 7 (See Annex D of this standard).

3 Pre-Audit Planning

Prior to the on-site evaluation, specific information shall be collected and analyzed to facilitate the auditing process.

3.1 General Requirements

To gather information, confirm expectations and scope of the on-site evaluation, a planning meeting or conference call shall be scheduled to outline goals and objectives of audit and compliance requirements, and include the following key participants:

- Auditor and building owner or primary decision maker(s)
- Local jurisdictional staff, engineers, subcontractors, or reviewers
- Energy efficiency program staff

3.2 Data and Documents

During the planning meeting and/or phone calls the following items shall be documented:

3.2.1 Contact Information

Contact information for key building representatives, including: the building owner, manager(s), maintenance staff (including outside maintenance contractors as necessary), and occupant representatives.

3.2.2 Occupant Interviews

Identify the opportunity to conduct a sample of informal occupant interviews to understand existing conditions related to building performance and energy use.

3.2.3 Project Goals

The building owner, client, or decision maker(s)' goals, expectations and priorities.

3.2.4 Existing Conditions

- Major energy consuming equipment and systems
- Any significant or chronic operations and maintenance issues such as occupant discomfort, leaks, indoor air quality, or pests that may require special consideration or diagnosis/equipment at the time of the on-site evaluation

- Ownership of major energy consuming equipment and if the building owner has full ownership

3.2.5 Reports

- Any recent reports or analyses such as physical needs assessments, capital needs assessments, or other related analysis completed for the property that would be useful for the auditor.
- Results and reports of previous tests and evaluations for lead-based paint, asbestos, radon, fire, structural, or health and safety-related structural and/or mechanical issues

3.2.6 Building Renovations and Planned Upgrades

Any current or planned building renovations or upgrades, including energy efficiency, renewable energy, health and safety, or other general aesthetic or functional improvements.

3.2.7 Historical or Landmark Properties

Historical or landmark property requirements or concerns.

3.2.8 Building Systems and Spaces and Access

Energy or building systems or spaces to be included or excluded in the audit. Identify areas to be accessed during the on-site evaluation, such as crawl spaces, attics, mechanical rooms, and residential units, and develop an access procedure.

3.2.9 Economic Analysis

Confirm metrics for economic analysis such as ROI, IRR, SIR, NPV. Identify local wage rates (prevailing wage, union, etc.), expected useful life of existing equipment, utility rates, metering structure, and any other information necessary to perform cost-benefit analysis.

3.2.10 Funding Sources

Subsidies or incentive funding, and how program involvement will impact the on-site evaluation, testing, energy audit report, and cost-benefit analysis.

3.2.11 Demographics

Occupancy/vacancy rates and demographics such as special needs population, senior population, single room occupancy, families.

3.2.12 Translation

Identify if key property staff require translation services.

3.3 Information for Analysis

The following information shall be assembled and reviewed by the auditor:

3.3.1 Utility Bills

The most recent historical energy and water utility data, including bulk-delivered fuels in accordance with Section 4 (Utility Analysis), including benchmarking data when available.

3.3.2 As-Built Drawings

As-built drawings, including updated drawings for any completed renovations or proposed renovations.

3.3.3 Maintenance Logs

Available maintenance logs for all building systems shall be collected. Relevant information shall be reviewed and documentation of such included in the energy audit report.

3.3.4 Previous Analyses and Reports

Any previous energy audit reports identified as beneficial for the auditor and any data regarding commissioning or retrocommissioning projects performed within the last 10 years.

4 Utility Analysis

Complete energy and water consumption data (metered and/or invoiced [for bulk fuels]) shall be analyzed prior to the on-site evaluation in accordance with ASHRAE Guideline 14, Section 5. If complete data in accordance with Section 4.1 of this standard is not available, refer to Section 7 (Energy Simulation) for additional requirements regarding interpretation of modeled results.

4.1 General Requirements

The aggregated utility data used for the cost-benefit analysis shall meet the following requirements:

4.1.1 Continuous Data

The data shall encompass a minimum of 12 consecutive months (24 preferred) of utility data. Analysis intervals shall be in full 12-month periods.

4.1.2 Utility-Aggregated Data

Where utility-aggregated data is available it should be considered in conjunction with any individual billing data for dwelling units and other spaces.

4.1.3 Data Frequency

Annual summations shall not be used. Utility data shall be at least bi-monthly as metered by the utility or provider.

4.1.4 Delivery and Read Dates

The utility data analysis period shall be chosen to minimize the amount of adjustment necessary to have the bills correspond to the same 365-day period.

4.1.5 Date Ranges

All fuel use analyzed shall be from the same date range or time period.

4.1.6 Energy Sources to be Analyzed

Data shall include all metered or delivered energy sources, including but not limited to electricity, natural gas, district steam, district hot water, district chill water, propane, fuel oil, solid fuels such as coal or wood, domestic water, and sewer.

Where onsite energy-generating systems exist, the analysis shall include available energy production data. When energy production data is not available or appears to be incorrect, the energy audit report shall include a recommendation to hire a qualified professional to evaluate energy production and provide the necessary data for analysis.

4.1.7 Itemized Cost Information

When per-unit charges are identifiable against flat fees, data shall include commodity and demand charges and detailed itemized cost information.

4.2 Weather Normalization

Energy usage data shall be weather-normalized using weather data for the weather station most representative of weather at the building location (or adjusted and documented according to local anomalies) and the date range being evaluated. The weather station data used for the analysis shall be included in the report or maintained by the auditor. Report the weather normalization method used, e.g., billing period degree-day regression, average billing period temperature regression, PRISM, etc.

Appropriate industry-recognized indices shall be calculated for each energy use (e.g., Energy Use Index - kBtu/SF/yr) and for water use (e.g., gallons/person/day) and shall be included in the energy audit report.

4.3 Billing Anomalies

Before the on-site evaluation, energy and water consumption shall be evaluated based on utility billing data and analyzed to identify anomalies. In the final energy audit report, identify obvious or potential data anomalies and document resulting changes to the date range used for analysis to avoid the anomalies. If the anomalies cannot be avoided, document and explain the identified anomalies and whether they were confirmed or not during the on-site evaluation.

4.4 Rate Analysis

When available, a hard copy of at least one complete bill which lists all charges and flat fees shall be collected and provided. The effect of the building's current rate structure on overall billing shall be considered. The impacts of the building's current rate structure on overall cost savings for different types of energy and water savings measures shall be evaluated and important effects documented in the energy audit report. The billing impact of onsite generation (if present) shall be reflected in the energy audit report. The calculation of the marginal rate components by energy type and by rate class (owner vs. occupant) shall be determined and documented clearly and shall be referenced and used in the cost-benefit analysis. If the current structure seems incorrect, recommend the building owner investigate further and conduct a utility rate analysis if needed. Additionally, the rate schedule or tariff shall be identified, and its components utilized in EEM economic analyses.

4.5 Low Consumption Periods

When documented consumption is lower than anticipated due to atypical equipment downtime, vacancies, and/or other identifiable factors, then any calculation or estimation methodology that has been developed to adjust for these factors shall be clearly documented in the energy audit report.

4.6 Individual Meters

When units are individually metered and billed, and complete billing information is not provided for the units, unit level fuel analysis sampling in accordance with Section 9 (Sampling Procedure) shall be applied. Where credits for onsite energy production are to appear on individual bills, the analysis and audit report shall reflect those credits. Where billing rates or renewable credits appear to be anomalous, the energy audit report shall recommend the building owner investigate further and conduct a utility analysis if needed.

4.7 Disaggregated Data

Disaggregated consumption shall be calculated based on actual data for: each energy source or appropriate combination of sources: baseload, cooling consumption, and any space heating or combined heating and domestic hot water consumption, and any major energy-using systems.

4.8 Demand and Renewable Energy Analysis

An evaluation of savings opportunities related to electricity demand control and renewable technologies shall be completed.

5 On-Site Evaluation

On-site evaluation shall be based on Pre-Site Visit information collected and analyzed (see Section 3).

5.1 Sampling

Sampling shall be performed in accordance with Section 9 (Sampling Procedure).

5.2 General Requirements

The on-site evaluation shall be based on the minimum technical procedures for conducting a multifamily building energy audit. The scope of the on-site evaluation shall include an evaluation of the following:

- Residential units
- Common area public spaces
- Central building systems affecting energy use in the residential
- Commercial spaces served by systems that also served the residential spaces
- Energy usage
- Limited aspects of building durability
- Limited aspects of occupant health and safety

5.3 Verification of Drawing Information

Information derived from building drawings and equipment schedules shall be verified during the on-site evaluation. Wherever on-site conditions do not match design documents, updated as-built and on-site data shall be used for analysis and reporting.

5.4 Buildings with No Drawings

When building plans do not exist, the physical geometry of building and components shall be measured and documented to the extent necessary to support accurate energy simulations, calculations, and cost-benefit analysis of EEMs.

5.5 Items to Confirm

Information to be documented and verified shall include, but is not limited to, the following:

- Total building square footage, and specify totals of any unconditioned or partially conditioned spaces floor area that are included
- Number of units, bedrooms, and bathrooms
- Building and unit configurations
- Approximate total number of occupants for the whole building
- Special use areas (i.e., commercial retail) and their utility metering configuration
- Area and volume of conditioned space and of partially/unintentionally conditioned spaces
- Location of air barriers or pressure boundaries, and potential air leakage paths
- Rated R-values and rated U-factor of building component assemblies and areas for input into heating/cooling load calculations
- Location of the thermal boundary and location of potential thermal bridges
- Types and schedule of heating, ventilation, and air conditioning (HVAC), domestic hot water (DHW) and other mechanical equipment, related distribution system(s) for each type, and control systems for each type
- Lighting and lighting controls
- Site conditions such as parking, storage spaces, disabled equipment, outdoor pools, sprinkler systems, car wash stations, etc.

5.6 Interviews

Interviews shall be conducted/completed in accordance with Section 3.2.

5.7 On-Site Data

Data obtained during the on-site evaluation shall include sufficient information to produce a comprehensive set of recommendations to address durability and aesthetics, energy efficiency, comfort, limited aspects of occupant health and safety, operations and maintenance, and other cost-savings opportunities.

5.7.1 Areas of Access

Areas accessed and data collected during the on-site evaluation shall be in accordance with all sections outlined in this standard.

5.7.1.1 Accessible Areas

Accessible areas are defined as those areas which are accessible via permanent access systems such as roof hatches with permanent ladders or stairways, or via an appropriate ladder (such as most attics).

5.7.1.2 Inaccessible Areas

Inaccessible areas are defined as those areas which cannot be accessed via an appropriate ladder, are located on pitched roofs, or cannot be accessed via permanent access systems such as roof hatches.

5.7.1.3 Inaccessible Terminations

Inaccessible terminations are defined as flues that are located in inaccessible areas.

5.7.2 Visual Inspection

All spaces and systems included in the audit shall be inspected, including all accessible common building areas, crawl spaces, attics, mechanical rooms, storage areas, and similar non-residential spaces or systems that are within the audit scope.

5.7.3 Onsite Measurements

All measurements will be taken with devices that have current calibration according to the manufacturer's recommended schedule. All measurements are to be taken in accordance with the device manufacturer's instructions. Complete measurements in accordance with generally accepted standard practices when using instruments that do not include manufacturer's instructions (e.g., perform lighting level measurements in accordance with Illuminating Engineering Society Lighting Handbook guidelines). When manufacturer's instructions require "zeroing" sensors before taking measurements, that operation will be performed in space or conditions that are "normal" for the measurements being taken.

5.8 Documentation

Site inspections shall include all documentation of the building's existing conditions, including digital photographic evidence.

6 Energy Audit Report

A comprehensive energy audit report shall be provided to the building decision maker(s) based on the findings gathered during the on-site evaluation and subsequent analysis as outlined in this standard. The report shall include an easily readable summary table with a comprehensive set of evaluated and recommended EEMs, water conservation measures, and related non-energy measures. The recommended measures shall be based upon best-practice installation procedures and be specific to the client and site-specific circumstances.

6.1 General Requirements

The energy audit report shall include, at a minimum:

6.1.1 All observations, interview results, estimates, measurements, and data (including utility bills, maintenance logs collected and analyzed that are necessary to document existing systems' configuration and performance, and to understand, support or validate the audit recommendations. Reference documentation of previous inspections, commissioning reports, audits and/or engineering studies reviewed as part of the audit.

6.1.2 Identification of all instruments used in onsite measurements (including model number and serial number where applicable)

6.1.3 Certification that all measurements were completed with instruments in current calibration and used in compliance with manufacturer's instruction. The report need not include those certificates but shall include a provision to provide certificates of calibration on request.

6.1.4 A list of recommended EEMs and related measures, ranked based on cost-effectiveness, by system, end use, or some other specified, logical criteria

6.1.5 A list of all "Immediate Health and Safety Concerns" communicated to building staff while performing on-site testing and measurement

6.1.6 Recommendations to consult with qualified specialists when specific site conditions or potential EEMs are identified that are outside the scope of the auditor's qualifications or experience

6.1.7 Where neither commissioning nor retrocommissioning reports (within 10 years old) are available, recommendation for a retrocommissioning evaluation to be performed in accordance with National Renewable Energy Laboratory *Chapter 16: Retrocommissioning Evaluation Protocol (The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures, NREL/ SR-7A40-68572)* http://www.nrel.gov/docs/fy17osti/68572.pdf

6.1.8 Measure descriptions including any special installation practices, commissioning or operator training required to successfully implement the recommended measure(s)

6.1.9 A summary of building performance benchmarks and performance standards considered to be applicable to measurements or observations obtained during the audit or to recommendations for upgrades

6.1.10 Description of the analysis methods, including naming of all simulation tools used and external calculation methods required; measure interaction effects and assumptions utilized in the audit, including measure costs; resource/utility prices and inflation projections utilized in cost-effectiveness analyses

6.1.11 Information about any program and utility incentives and Federal, State, local, and historic tax credits included in the cost benefit analysis

6.1.12 Evaluation of current operator training and current operations and maintenance practices in ensuring the effectiveness, durability and persistence of measures recommended in the report

6.1.13 A description of non-energy impacts reasonably expected to be delivered by EEMs or other measures recommended in the report

6.1.14 All observations and mitigation recommendations regarding health and safety concerns that may affect measure implementation, including but not limited to pests, moisture and ventilation performance, possible presence of mold, lead-based paint or asbestos-containing materials, EPA radon zone, and substandard condition of fuel distribution, ventilation, electrical, lighting, plumbing or other systems

6.1.14.1 If measures are proposed that may affect paint in buildings built prior to 1978, the energy audit report shall include a recommendation to adhere to lead safe work practices.

6.1.14.2 If recommended EEMs will disturb suspected asbestos-containing materials identified by the energy auditor during a visual inspection, those materials shall be identified and a recommendation to adhere to best practices for asbestos-containing materials or State regulations shall be included in the energy audit report.

6.1.15 A summary of potential/considered measures that were removed from the final energy audit report, with the rationale for their removal

6.2 Disclosure and Ethics

The energy audit report shall disclose, and related work shall meet, professional ethical standards, including:

6.2.1 Disclosure of any products or services that the auditor(s) or their company provides in addition to energy auditing

6.2.2 Providing recommendations that are manufacturer- or vendor-neutral

6.2.3 Maintaining confidentiality of personal or proprietary information provided in confidence to support the audit

6.2.4 Identification of any normative sections of this standard that were not met, documenting the reasons for the omission

6.2.5 Identification of others who contributed to the generation of the energy audit report, including but not limited to field staff, engineers, subcontractors, and reviewers

7 Energy Simulation

When an energy simulation is required for the determination of the annual weather-normalized energy savings for a comprehensive package of proposed EEMs, the following requirements shall be met:

7.1 General Requirements

The energy simulation analysis shall be performed by a qualified professional using energy simulation software that meets at least one of the following requirements:

a. Listed as approved for the appropriate multifamily housing construction type of the project in the U.S. Department of Energy's (DOE) *Weatherization Program Notice 16-8.* https://www.energy.gov/eere/wipo/downloads/wpn-16-8-revised-energy-audit-approval-procedures-and-other-related-audit-issues

or

b. Listed on US DOE's website as a Qualified Software for Calculating Commercial Building Tax Deductions. https://www.energy.gov/eere/buildings/qualified-software-calculating-commercial-building-tax-deductions
or

c. Meets the requirements of ASHRAE Standard 90.1 Section 11 or Appendix G

7.2 Simulation Calibration

The baseline energy simulation shall be calibrated in accordance with industry best practices. ASHRAE Guideline 14-2014: *Measure of Energy, Demand, and Water Savings* (specifically Section 5.3 and Annex C) provides guidance regarding assessments of model accuracy and true-up to existing energy use data.

7.3 Basis of Simulation Inputs

Pre-retrofit simulation inputs shall be in accordance with Section 5 (Onsite Evaluation) and Section 6 (Energy Audit Report).

7.3.1 Use of Sampled Data

Sampled data shall be extrapolated up to account for the whole building in order to analyze the whole building. In many cases only average values are needed, so the final sample average can be used for the whole building.

7.3.2 Final Translation of Sample Data to Simulation Inputs

The methods and building component representation approaches used to translate observations, field measurements and bill data into the most representative model of the building for energy use simulation shall be reported, documenting clearly and completely how the data are translated to simulation tool inputs. Adjustments and assumptions used in the final calibration version of the pre-retrofit model shall be explicitly reported.

7.4 Minimum Simulated Components

The calibrated pre-retrofit simulation shall account for all building envelope components, HVAC and DHW systems, infiltration loads, miscellaneous equipment loads, and internal and solar gains of the building(s) being evaluated for retrofit.

7.5 Simulation Input Consistency

Inputs of the pre- and post-retrofit simulations shall be the same, with exceptions for new components or changes in operating parameters recommended by the proposed EEMs.

7.6 Increased Consumption

Any increase in energy consumption due to repairs, health and safety or code-related measures proposed in the work scope shall be included in the post-retrofit model and documented in the model adjustments.

7.7 Interactivity

The predicted energy savings for the proposed EEMs shall be calculated to accurately reflect interactivity of energy savings attributed by all recommended EEMs.

7.7.1 External Calculations

Any EEMs not directly supported by the energy simulation software shall still be modeled as part of the proposed simulation by creating the proper workaround in the simulation software in order to account for the interactivity with proposed EEMs. The modeling inputs or adjustments necessary for this shall be informed by the results of external calculations.

8 Cost-Benefit Analysis

The cost-benefit analysis shall meet the requirements of this section.

8.1 General Requirements

The cost-benefit analysis shall document the projected annual reductions in energy cost resulting from the package of recommended EEMs segregated by energy source and account type (owner- or occupant-paid).

8.1.1 Utility Rates

The cost-benefit analysis shall utilize utility rates that reflect account type (owner or occupant paid) in order to calculate annual cost savings or cost increases. For tiered rate schedules, utilize the utility rate in the cost-benefit analysis that corresponds directly to the rate tier affected by the projected savings of that particular EEM. Do not apply inflation values in the analysis. The utility rates, rate tariffs, and any calculations used to determine the effective utility rate applied to the usage shall be clearly documented.

8.1.1.1 Non-Consumption Charges

The utility rate(s) used for determining cost savings from changes in usage shall not include demand charges or flat meter charges. For EEMs that result in a change to the demand charge, the demand cost savings shall be determined independently of the usage savings and separately for each applicable EEM. The demand charge, rate tariff, and any calculations used to determine the effective demand charge shall be clearly documented.

8.1.2 Associated Maintenance Costs

When the EEM has an associated and quantifiable increase or decrease in maintenance costs, such costs shall be clearly documented and included in the cost-benefit analysis.

8.1.3 Non-Energy Efficiency Measures

Quantifiable increases or decreases in annual energy cost due to health and safety or operation and maintenance recommendations shall be documented.

8.2 Material and Installation Costs

The cost-benefit analysis shall document estimated material, installation, and soft costs (e.g., design, program costs, M&V, etc.) for all EEMs, health and safety, and operations and maintenance recommendations. Cost estimates shall be based upon experience with previous projects, detailed conceptual estimates, R.S. Means estimation, and contractor bids. Assumptions for cost estimates shall be documented in the energy audit report.

8.3 Economic Analysis

The cost-benefit analysis shall constitute an economic analysis for the recommended EEMs over their estimated useful lives. It shall reflect all measurable economic benefits as defined in Section 8.1 versus economic costs as defined in Section 8.2, while accounting for the time value of money.

8.3.1 Net Present Value (time value of money)

The cost-benefit analysis shall compare the net present value (NPV) of the energy savings, to the lifespan of the EEM(s), inclusive of all installation costs. The discount rate and EEM lifespans used in the analysis shall be documented.

8.3.2 Capital/Physical Needs Assessments

When the on-site evaluation is performed in conjunction with a physical or capital needs assessment, the cost-benefit analysis should consider the incremental energy savings and life cycle costs of each recommended EEM as compared to a new standard efficiency replacement.

8.4 Cost Effectiveness of EEMs

Cost-effectiveness of recommendations shall be based upon an economic analysis in accordance with Section 8.3. Recommend that more cost-effective EEMs be installed before, or instead of, less cost-effective EEMs if the budget will not allow installation of all EEMs.

9 Sampling Procedure

9.1 Sample Group

A Sample Group is defined as a group of spaces (such as dwelling units, lobbies, mechanical rooms, attics, hallways, stairways, rooftops, etc.), that have similar energy-use characteristics. In cases where there are significant variations, the auditor shall develop and document the criteria used for creating multiple sample groups. The auditor shall verify and document the sample group definitions by visual inspection.

9.2 Sample Rate

Sample Rate is defined as the number of residential units or spaces within a Sample Group that must be tested or visually inspected. In properties that are comprised of sample groups that span across multiple buildings, the sample rate shall be applied across those multiple buildings. In sample groups that span across multiple floors, the sample rate shall be applied across those multiple floors. The sample rate shall be applied across different exposures.

9.2.1 The Sample Rate shall be defined in accordance with Table 9.2.1:

Table 9.2.1- Sample Rate

Sample Group Size (Total number of spaces in the sample group)	Number of Spaces to Sample **Minimum**
5 – 9	2
10 – 19	3
20 – 29	4
30 – 49	5
50-250	10%

9.2.1.1 Sample Rate Exception for **Systemic Failure** During Combustion Appliance Safety Testing
Based upon results of initial CAS testing, an increase in sample size may be required as detailed in Section 11.3.7

9.3 Where schedules of in-unit appliances (HVAC, refrigerator, etc.) exist, verify their accuracy in the sampled units.

10 Moisture Control

The on-site evaluation shall include interviews, inspection for evidence of existing and prior moisture problems as well as potential sources of moisture and locations where measurements are needed.

10.1 Sampling

Sampling shall be performed in accordance with Section 9 (Sampling Procedure).

10.2 Observations and Interview

10.2.1 Interviews

Interview building owners and staff regarding repair or replacement of roofs, roof drains and other moisture control elements, to understand moisture failures exacerbated by extreme weather events and to assess moisture issues resulting from building conditions and occupant behavior. Interview occupants regarding observed condensation or mold growth.

10.2.2 Water Intrusion

Inspect for evidence of current or previous exterior water intrusion and resulting moisture damage.

10.2.3 Interior Water Sources

Inspect for evidence of water damage as a result of interior water sources.

10.2.4 HVAC Systems

Inspect for evidence of active or inactive water leakage, steam leakage, and/or leakage from any water storage, holding tank, cooling tower, or any water source HVAC distribution system. Damaged areas shall be evaluated to determine the source and the damage documented.

10.2.5 Moisture Control

Inspect the condition of existing visible vapor retarders, flashing, gutters, ground water control pumps (e.g., sump pump, French drain), A/C condensate management, or other moisture-control strategies. Visible vapor retarders shall be verified to be in the proper location.

10.2.6 Condensation

Inspect for evidence of condensation on windows, walls, ventilation fans, cold water pipes, and other cold surfaces.

10.3 Measurements and Testing

10.3.1 Diagnostic Testing to Identify Moisture Sources

Where evidence of moisture issue/s is present and sources cannot be identified with a visual evaluation, diagnostic testing using moisture probes, surface moisture meters, infrared scans, hygrometer or psychrometer shall be conducted to try to identify the source of the moisture.

11 Combustion Appliance and Fuel Distribution System Inspection and Testing

This evaluation consists of visual inspections, gas leak detection, ambient CO measurement, flue CO measurement, and spillage test. Complete all inspections and testing referenced in this section in accordance with the current version of ANSI/BPI-1200, Section 7, except where exceptions are detailed.

11.1 Sampling

Inspection and testing shall be completed in accordance with the sampling protocols in Section 9, Sampling Procedure. Sample groups shall be comprised of a representative sample of units or spaces that contain the same type of combustion equipment (wall furnaces, forced air furnaces, natural draft water heaters, etc.).

11.2 Observations and Interviews

11.2.1 Visual Inspection of Combustion Appliance Zone (CAZ)

Inspect the CAZ to verify the area is not used for storage of flammable products (fuels, solvents, varnishes, or adhesives) and is free from other combustibles (rags, trash, paper). Evaluate clearances from all flue vents to combustible building components to ensure they are in accordance with specifications of the AHJ. The energy audit report shall include recommendations to correct any unsafe conditions.

11.2.2 Visual Inspection of Combustion Appliance/s and Venting System/s

The evaluation shall include a visual inspection of the heating system/s, water heater/s and combustion exhaust venting system/s including but not limited to flue material, run and integrity of vent system, terminations, combustion air supply and wiring. The combustion appliances shall be visually evaluated for:

11.2.2.1 Identification of building-related conditions that may require immediate health and safety remediation (blocked/disconnected flues, failed heat exchangers or combustion chambers, excessive fuel leaks, excessive CO emissions, etc.).

11.2.2.2 Inspection or testing of fuel supply system (tank, supply line, burner) for leaks.

11.2.2.3 Inspection of combustion venting systems for damage, leaks, disconnections, inadequate pitch, and other safety hazards.

11.2.3 Interview Building Staff and Residents

Interview building maintenance staff and document the existing routine maintenance performed on all combustion equipment.

Interview building staff and/or residents to determine if any persons notice fuel vapor or combustion gas smells.

11.3 Measurements and Testing

The following adjustments to ANSI/BPI-1200 shall be made for multifamily combustion appliance zone and appliance testing.

11.3.1 Verify that sufficient combustion air is available per AHJ specifications or manufacturer’s specifications, whichever are more stringent.

11.3.2 Test all combustion appliances in the sample group to establish appliance condition and combustion efficiency and safety. At steady state, measure and document the data provided by the combustion analyzer and the results of spillage tests.

11.3.3 Test for spillage by natural draft appliances equipped with a barometric draft control or Category I appliances equipped with a draft hood or appliances connected to a natural draft venting system.

11.3.3.1 Test all combustion equipment for spillage under natural conditions in CAZ spaces that are designed and constructed to be separate from living space (i.e., in a basement or designated mechanical room, detached from living space).

11.3.4 In buildings where a CAZ is connected to living space and contains appliances that get their combustion air from the living space, place the CAZ under the greatest depressurization achievable given the weather/temperature/building conditions at the time of the inspection. Conduct all spillage assessments while the CAZ remains in this depressurized state.

11.3.4.1 The entry door to an apartment shall be considered an exterior door for testing purposes.

11.3.4.2 If dwelling units are equipped with a continuously operated ventilation system, the system shall remain on during all testing, and treated as an element of the "natural conditions" in the unit.

11.3.4.3 If an appliance fails spillage under depressurization, it shall be tested under natural conditions. If the appliance passes under natural conditions, the appliance passes test procedures.

11.3.5 Test gas ovens and unvented appliances for CO.

11.3.6 Inspect solid fuel burning appliances for safe operation.

11.3.7 If an appliance exceeds the CO threshold in Table 1, the appliance fails this test procedure.

11.3.8 Table 1: CO Thresholds for Fossil Fuel-Fired Combustion Appliances

Table 1
CO Thresholds for Fossil-Fuel Fired Combustion Appliances
(Adapted from ANSI Z223.1/NFPA 54, *National Fuel Gas Code,* 2021 Edition)

Appliance	Threshold Limit
Central Furnace (all categories)	400 ppm air free*
Boiler	400 ppm air free
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
Unvented Room Heater	200 ppm air free
Water Heater	200 ppm air free
Oven/Broiler	225 ppm as measured
Clothes Dryer	400 ppm air free
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

*Air free emission levels are based on a mathematical equation (involving carbon monoxide and oxygen or carbon dioxide readings) to convert an actual diluted flue gas carbon monoxide testing sample to an undiluted air free flue gas carbon monoxide level utilized in the appliance certification standards. For natural gas or LP gas, using as-measured CO ppm and O_2 percentage:

$$CO_{AFppm} = \left(\frac{20.9}{20.9\text{-}O_2}\right) \times CO_{ppm}$$

Where:
CO_{AFppm} = Carbon monoxide, air-free ppm
CO_{ppm} = As-measured combustion gas carbon monoxide ppm
O_2 = Percentage of oxygen in combustion gas, as a percentage

An alternate method of calculating the CO air free when access to an Oxygen meter is not available:

$$CO_{AFppm} = \left(\frac{UCO_2}{CO_2}\right) \times CO$$

Where:
UCO_2 = Ultimate concentration of carbon dioxide for the fuel being burned in percent for natural gas (12.2 percent) and LP gas (14.0 percent)
CO_2 = Measured concentration of carbon dioxide in combustion products in percent
CO = Measured concentration of carbon monoxide in combustion products in percent

11.3.9 Testing shall be completed in all accessible areas. CO testing of appliances with inaccessible terminations is not required.

11.3.10 Post-Project Testing Recommendations

The auditor shall evaluate and determine whether the recommended scope of work is likely to affect the pressure dynamics within individual combustion appliance zones. Consider any changes in air pressure that could have an impact on combustion appliance safety, air leakage through the shell, or moisture migration through building cavities. Include this determination in the energy audit report.

11.3.10.1 **Measures Affecting the Pressure Dynamics of Units**

If the recommended scope of work can be predicted to affect the pressure dynamics of a dwelling unit with combustion equipment, recommend combustion safety testing of that unit and CAZ upon completion of all work performed.

11.3.10.2 **Measures That Do Not Affect Pressure Dynamics of Units**

If the recommended scope of work will not affect the pressure dynamics of a dwelling unit with combustion equipment, but that equipment was not tested during the audit, recommend combustion safety testing of that unit and CAZ upon completion of all work performed.

11.3.11 Systemic Failure

If during the audit Combustion Appliance Safety (CAS) test-in, failures occur in 50% or more of the Sample Group, the sample size shall be doubled. If failures occur in 50% or more of the new (increased) sample group, then that sample group is deemed to present a "Systemic Failure". The auditor may choose to make the Systemic Failure determination after the initial sample group has been tested if they have reason to believe that the failure conditions that they have identified are very likely to be present throughout the property.

When Systemic Failures are identified, the auditor shall:

11.3.11.1 Notify the property owner, manager, or their authorized agent.

11.3.11.2 Provide recommendations that the owner have all combustion appliances that were not included in the sample group tested and repaired or replaced as necessary prior to project completion.

11.3.11.3 Include recommendations to address each issue.

11.3.11.4 Recommend, upon project completion, 100% CAS test-out of all combustion appliances and spaces, regardless of whether they were affected by the scope of work.

SYSTEMIC FAILURE EXAMPLE:	**ACTIONS: Auditor shall:**
• 55-unit multifamily building with the same type of combustion appliances in all units (1 Sample Group). • As per *Table 1 - Sample Rate*, sample size = min of 6 units • 1 unit has a gas leak • 1 unit fails spillage under natural conditions • 1 unit fails oven CO test at 350 ppm 50% of the sampled units failed CAS testing; therefore, the sample size is doubled from a total of 6 units (minimum) to a total of 12 units (minimum). • Gas leaks are identified in 2 more of the units, and high CO (400 ppm) is found in the oven of the third unit. **3 or more additional units fail CAS tests (total of 6 out of the 12 units failed); therefore, a Systemic Failure has been identified.**	1. Communicate the spillage test and gas leak failures to the property owner, manager, or their authorized agent. 2. Request that the owner or authorized agent sign an acknowledgement form that indicates that they have been informed of the gas leaks and spillage failures and of their exact locations. 3. Include recommendations in the scope of work that the owner have all remaining units tested and repaired prior to project completion. 4. Include specific recommendation in the scope of work for how to address the spillage issue and the oven CO issues in the affected units. 5. Perform 100% CAS test-out of all units at project completion.

11.3.12 Equipment used for testing including but not limited to combustible gas detector (CGD), CO measurement equipment used for flue gas CO measurement and manometers shall meet requirements in ANSI/BPI-1200.

11.4 Placing Appliances Back in Operation

If no safety concerns or hazards were identified during the inspection and testing of the combustion appliances, return all inspected appliances and systems to their pre-existing state. If appliance-related safety concerns or hazards were identified during the inspection, follow the appropriate actions levels specified by the AHJ. Refer to ANSI/BPI-1200 if the AHJ is silent on a specific issue. Note: In some cases, this will require that the auditor recommend that the appliance be turned off and the homeowner/occupant and/or property owner or owner's representative be advised to contact a qualified repair professional for further evaluation.

12 Indoor Air Quality and Ventilation

While considering recommendations to improve energy efficiency, the recommendations in the energy audit report shall strive to maintain or improve indoor air quality. A comprehensive visual inspection and evaluation of the building ventilation systems shall be completed throughout the building.

12.1 Sampling

Sampling shall be conducted in accordance with Section 9 (Sampling Procedure).

12.2 Observations and Interviews

12.2.1 Identify System(s)

Identify dwelling unit, common area, and whole building ventilation system types and locations, sensors and controls, operation specifications, usage/time schedules, and filter replacement schedules.

12.2.2 Create an Equipment Schedule

Create an equipment schedule of fans, controls and other equipment associated with the ventilation system.

12.2.3 Visually Evaluate System

Where feasible, visually inspect for dirt, leakage, obstructions, and effective system operation.

12.2.4 Review Operations and Maintenance Procedures

Interview building maintenance staff to document the existing routine maintenance performed on ventilation equipment, including historical repairs or ongoing issues.

12.2.5 Pollution Sources

Identify sources of potential indoor air pollution. The energy audit report and cost-benefit analysis shall prioritize removal of pollution sources first, followed by pollutant-source isolation, and then ventilation improvements.

12.2.6 Make-Up Air for Ventilation Systems

Identify and document make-up air sources.

12.2.7 Filtration Material

Inspect condition and type of existing filtration material located on air intakes and within make-up air handlers.

12.2.8 Heating and Cooling Coils

Inspect condition of heating and cooling coils and ensure that all heating and cooling coils are clean and allow for adequate airflow. If coils are not easily accessible for inspection, the energy audit report shall note that the coils were not inspected and/or contain recommendations for the property owner to consult with a qualified HVAC specialist to conduct inspection.

12.2.9 Ventilation Openings to the Outside

Visually inspect all openings to the outside greater than ¼ inch. Make recommendations for a rodent/corrosion-proof screen across identified openings. (Refer to Section 13 [Infiltration and Air Barrier Performance] for inspection of unintentional bypasses to outside.)

12.2.10 Garage Compartmentalization

In buildings where enclosed garages are connected to the residential structure, visually assess and document bypasses between the garage/s and the rest of the structure. The energy audit report shall recommend improvements necessary to ensure effective isolation of the garage from the residential spaces.

12.3 Measurement and Testing

12.3.1 Airflows

Document the measured flow rate of exhaust and supply registers in the units and common areas and at the outdoor terminations, in accordance with a specified standard; using either the current version of Sheet Metal and Air Conditioning Contractors' National Association (SMACNA): *HVAC Systems - Testing, Adjusting and Balancing*

or

The current version of ANSI/ACCA 5 QI: *HVAC Quality Installation Specification* (ANSI/ACCA 5 QI)

or

The current version of ANSI/ASHRAE Standard 111: *Measurement, Testing, Adjusting, and Balancing of Building HVAC Systems* (ANSI/ASHRAE Standard 111)

Evaluate the results against the appropriate ASHRAE Ventilation Standard and include recommendations for improvements based on the findings.

12.3.1.1 Assessment Tools
Flow rates shall be measured with flow measuring hood (bolometer), rotating vane anemometer, hot wire anemometer, pitot tube with micromanometer (analog or digital) or magnehelic gauge, calibrated fans or other instrumented diagnostic tool.

12.3.1.2 Tool Calibration
Airflow measuring equipment shall be calibrated regularly in accordance with the manufacturer's specifications.

12.3.1.3 Outdoor Air Intakes
Inspect existing ventilation outdoor air intakes. Document the net free ventilation area (NFA) by measuring the length and width of all outdoor air pathways. Document the type and condition of the outdoor air pathway covering (louver, grate, mesh, etc.)

12.3.1.4 Compartmentalization
If measures have been taken or recommended to minimize air movement across interior envelope components (compartmentalization), verify that adequate make-up air is provided to the space in accordance with the AHJ.

12.3.1.5 Garages
Measure garage ventilation systems (natural or mechanical) to determine if exhaust flow rates are in accordance with the specifications of the AHJ. The energy audit report shall recommend improvements necessary to ensure CO monitoring and combustion by-product removal from these spaces.

12.3.1.6 Demand-Based Ventilation
Assess the opportunity for demand-based ventilation controls in garages and make recommendations for such controls when feasible.

12.3.1.7 Carbon Monoxide
Monitor ambient CO levels, take appropriate action levels in accordance with ANSI/BPI-1200, Section 7.3 (See Annex D of this standard), and document readings.

12.4 Duct Leakage Testing

When duct sealing is recommended as an EEM or health and safety measure, the energy audit report shall provide documented evidence that duct leakage was assessed during the on-site evaluation.

12.4.1 Assessment Tools

Identify duct leakage sites through visual inspection and/or using industry-approved diagnostic tools such as boroscopes, remote cameras, infrared thermography, smoke, and/or pressure tests (ANSI/RESNET/ICC 380 – *Standard for Testing Airtightness of Building Enclosures, Airtightness of Heating and Cooling Air Distribution Systems, and Airflow of Mechanical Ventilation Systems* (ANSI/RESNET/ICC-380)).

12.5 Fan Assessment

Assess general fan condition and alignment of belts, sheaves, and pulley. Excessive fan noise or movement/shaking of fan housing shall be noted in the energy audit report.

12.5.1 Rotation in Centrifugal Fans

When feasible, inspect centrifugal fans for proper wheel rotation by momentarily energizing the fan. Rotation should correspond with rotational decal that can be found on most fans.

12.5.2 Fan Motor

Where appropriate, evaluate efficiency improvement opportunities. When replacement fan motors are recommended, the recommendation shall include upgrading with NEMA Premium Efficiency Rated motors, electronically commutated motors and/or advanced fan controls. When making recommendations to replace motor or add controls, evaluate existing distribution system and flow rate, and static pressure.

12.6 Ventilation Control Assessment

Existing ventilation controls shall be visually inspected during the on-site evaluation.

12.6.1 Occupancy-Based Systems

Visually verify all sensor locations and ensure that they are properly located. Verify that the occupancy controls activate and de-activate the fans as intended by the designer or controls manufacturer.

12.6.2 Timer-Based Systems

Verify that clocks on timer-based controls reflect the actual time of day, controls on mechanical timers are properly set, and control strategies (on/off times) are optimized and set in accordance with local codes and standards.

12.6.3 Demand-Based Systems

Measure CO_2 levels at a sample of intake grilles and compare to system setpoints. The energy audit report shall recommend that existing CO_2 demand-controlled ventilation systems be maintained and calibrated regularly in accordance with manufacturer's recommendations.

12.6.4 Garage Ventilation Controls

If ventilation controls exist, visually inspect controls, and verify control set-points are appropriate for site-specific conditions.

12.6.5 Ventilation Control Recommendations

When opportunities are identified, the energy audit report shall provide recommendations for improving, repairing, or optimizing existing controls and setpoints. When opportunities are identified, the energy audit report shall provide recommendations for installing new controls.

13 Infiltration and Air Barrier Performance

The audit shall include an evaluation of the performance of all component assemblies of the building enclosure to assess for insulation, moisture control, air leakage and general conditions. The energy audit report shall include recommendations for upgrades as appropriate.

13.1 Sampling

Sampling shall be performed in accordance with Section 9 (Sampling Procedure).

13.2 Observations and Interviews

13.2.1 Interview

Interview building managers and occupants to assess building conditions affected by air barrier performance, including spaces with poor temperature control, odor and odor migration, drafts, or pest movement.

13.2.2 Envelope Inspection

Visually evaluate the building envelope: walls, floors, crawlspaces, basements, roofs, attics, ceilings, windows, doors, ventilation openings, thermal bypasses, etc.

13.2.2.1 Inaccessible Areas

For inaccessible areas such as walls and flat roof assemblies, determine existing assembly construction using minimally-invasive tools and techniques, such as boroscopes, infrared thermography, removal of access panels, probing, etc.

13.2.2.2 Invasive Inspections

Any invasive inspections of the building assemblies shall be discussed and approved by building management prior to performing inspection.

13.2.3 Thermal and Air Barrier System

Where possible, the auditor shall verify that the thermal and air barriers are continuous and properly aligned. Identified deficiencies in these systems shall be documented in the energy audit report, and recommendations to address identified issues shall be included in the cost-benefit analysis.

13.2.4 Window and Door Performance

Evaluate window and door performance and fit by testing operation. Window and doors shall be evaluated visually for air leaks, condition of weather-stripping and other hardware, and movement when closed and latched.

13.2.5 Evaluate Air Leakage

Evaluate air leakage through the building enclosure as a result of stack effect, wind effect, mechanical systems, bypasses, and other mechanisms (stairwells, elevator shafts, open skylights or windows, dampers, mechanical and/or plumbing shafts, garbage chutes etc.). The evaluation shall include visual observations and shall include qualitative evaluation. Quantitative testing shall be completed as useful.

13.2.5.1 Qualitative Evaluation
Qualitative observations include the use of zonal pressure readings (manometer), air current testers (smoke), infrared thermography, etc. to evaluate envelope leakage and enclosure performance.

13.2.5.2 Quantitative Testing
Quantitative testing includes calibrated, induced-pressure tests to evaluate envelope leakage and enclosure performance.

13.2.5.2.1 In buildings with individual unit entrances, perform sampled unit-level blower door tests unless the auditor concludes that no useful information will be provided by testing. The audit report will specify the verified heuristic used to allow development of an accurate energy model.

13.2.5.2.2 In buildings of four units or fewer with shared entrance and shared pressure boundary, perform blower door testing (single-zone or sampled individual units) unless the auditor substitutes (and reports) use of a verified heuristic. In campus properties with multiple small buildings, apply a sampling approach to individual buildings.

13.2.5.2.3 In buildings of five units to 24 units with a shared entrance and shared pressure boundary, the audit report shall recommend blower door testing (single-zone or sampled individual units) be performed as part of project planning, unless the auditor concludes that no useful information will be provided by testing.

13.2.5.2.4 In buildings larger than 25 units and/or with three or more occupied levels, with shared entrance and shared pressure boundary, the audit report shall recommend blower door testing (single-zone or sampled individual units) be performed as part of project planning only if the auditor concludes that sufficient useful information will be provided by testing.

13.2.6 Whole Building Testing

When whole building blower door testing is performed, it shall be performed in accordance with the current version of Localized Unit Testing

When localized dwelling unit blower door tests are performed, take steps to quantify or nullify measured leakage between dwelling units vs. leakage to outside if test results will be used to estimate energy savings from air sealing measures. “Unguarded” localized dwelling unit blower door tests can be performed when the results are used to assess the compartmentalization of the dwelling unit. When localized unit blower door testing is performed, it shall be performed in accordance with ASTM E779.

13.2.7 Testing Methodology

When air leakage testing is performed, document testing methodology, building "set-up," site and weather conditions, and testing results. Testing methods and findings shall be described in sufficient detail that they can be repeated or verified by a third party when necessary.

14 Domestic Hot Water

The domestic hot water system(s) (DHW) shall be identified and assessed during the on-site evaluation. Document findings and recommend upgrades in the energy audit report.

14.1 Sampling

Sampling shall be performed in accordance with Section 9 (Sampling Procedure).

14.2 Observations and Interviews

The on-site evaluation shall include the following elements:

14.2.1 Identify System(s) and Create Schedule

Identify the DHW system(s) and create a schedule documenting all relevant information, including at a minimum: central or distributed, type of equipment, physical conditions, controls, setpoints, input/output capacity, rated efficiency, storage volume, pump/motor model, pump/motor horsepower, supply and return temperatures, location, units/areas served, and any atypical end uses (e.g., community kitchens).

14.2.2 Interview Building Staff and Occupants

Interview building maintenance staff to document the existing routine maintenance performed on DHW equipment.

Interview building staff and/or occupants to determine DHW delivery times, and if DHW temperature imbalances, other comfort complaints, exist.

14.2.3 Observe Operating Conditions

Observe, for a minimum of one operating cycle, the equipment and control functions and document performance.

14.2.4 Evaluate System for Leaks

Evaluate and document all components of the DHW system for leaks including at a minimum, pipes, faucets, tub diverters, storage tanks, and water heaters.

14.3 Measurements and Testing

14.3.1 Combustion Appliance Safety Testing

Complete combustion safety testing per Section 11.

14.3.2 Combustion Efficiency Testing

Combustion efficiency tests shall be completed at steady-state conditions and interpreted based on observed operating conditions to establish overall equipment efficiency.

14.3.3 Hot Water Distribution Testing

In all buildings, measure and record hot water temperatures at a sample of points of use in units and common areas. If temperatures outside the range of 120°F to 125°F are measured at the unit taps, the auditor shall recommend appropriate temperature or distribution adjustments. Measure and record the time for hot water to reach taps. If it is observed to take longer than 30 seconds for the water to reach the intended delivery temperature, distribution improvements shall be recommended.

14.3.3.1 In buildings with central systems, measure and record hot water temperatures at the delivery side of the DHW heating system or mixing valve. Document the temperature drop across the distribution system. If temperature drop is excessive, identify and recommend possible DHW insulation opportunities or water conservation strategies.

14.3.3.2 In buildings with central systems having continuous recirculation, recirculation control methods shall be verified, and possible improvements recommended, based on observed flow modes, and measured temperature drops.

14.3.4 Measure Pipe and Tank Insulation

Measure and document all DHW system insulation type and thickness. Recommendations for improvements to insulation shall reference the following table or local code, whichever is more stringent.

14.3.4.1 Table 6.8.3-1, Minimum Pipe Insulation Thickness (from ANSI/ASHRAE/IES Standard 90.1-2019: *Energy Standard for Buildings Except Low-Rise Residential Buildings*)[2]

Table 6.8.3-1 Minimum *Piping* Insulation Thickness Heating and Hot-Water Systems[a,b,c,d,e] (Steam, Steam Condensate, Hot-Water Heating and Domestic Water *Systems*)

Fluid Operating Temperature Range (°F) and Usage	Insulation Conductivity		≥Nominal Pipe or Tube Size, in.				
	Conductivity, Btu·in/h·ft²·°F	Mean Rating Temperature, °F	<1	1 to <1-1/2	1-1/2 to <4	4 to <8	≥8
			Insulation Thickness, in.				
>350	0.32 to 0.34	250	4.5	5.0	5.0	5.0	5.0
251 to 350	0.29 to 0.32	200	3.0	4.0	4.5	4.5	4.5
201 to 250	0.27 to 0.30	150	2.5	2.5	2.5	3.0	3.0
141 to 200	0.25 to 0.29	125	1.5	1.5	2.0	2.0	2.0
105 to 140	0.22 to 0.28	100	1.0	1.0	1.5	1.5	1.5

a. For insulation outside the stated conductivity range, the minimum thickness (T) shall be determined as follows: $T = r\{(1 + t/r)^{K/k} - 1\}$, where T = minimum insulation thickness (in.), r = actual outside radius of pipe (in.), t = insulation thickness listed in this table for applicable fluid temperature and pipe size, K = conductivity of alternate material at mean rating temperature indicated for the applicable fluid temperature [Btu·in/h·ft²·°F]; and k = the upper value of the conductivity range listed in this table for the applicable fluid temperature.

b. These thicknesses are based on *energy efficiency* considerations only. Additional insulation is sometimes required relative to safety issues/surface temperature.

c. For *piping* smaller than 1.5 in. and located in partitions within *conditioned spaces*, reduction of these thicknesses by 1 in. shall be permitted (before thickness adjustment required in footnote [a]) but not to thicknesses below 1 in.

d. For direct-buried heating and hot-water *system piping*, reduction of these thicknesses by 1.5 in. shall be permitted (before thickness adjustment required in footnote [a]) but not to thicknesses below 1 in.

e. The table is based on steel pipe. Nonmetallic pipes schedule 80 thickness or less shall use the table values. For other nonmetallic pipes having *thermal resistance* greater than that of steel pipe, reduced insulation thicknesses are permitted if documentation is provided showing that the pipe with the proposed insulation has no more heat transfer per foot than a steel pipe of the same size with the insulation thickness shown in the table.

14.3.5 Flow Measurements

Measure and record flow rates at all end use fixtures within each sample unit.

15 Heating Systems

The heating system(s) shall be identified and assessed during the on-site evaluation. Document findings and recommended upgrades in the audit report.

15.1 Sampling

Sampling shall be performed in accordance with Section 9 (Sampling Procedure).

15.2 Observations and Interviews

The on-site evaluation shall include the following elements:

[2] ©ASHRAE, www.ashrae.org. Standard 90.1-2019 Table 6.8.3-1

15.2.1 Identify System(s) and Create Schedule

Identify the heating system(s) and create a schedule documenting all relevant information, including at a minimum: central vs. unitary, location, type of equipment, distribution system and components (flows, pressures), controls (type and locations of sensors, setpoints), nameplate efficiency (or for heat pumps, either Heating Seasonal Performance Factor (HSPF), Coefficiency of Performance (COP), or all component electrical ratings needed to calculate COP), fuel type, heating medium, rated capacity, and operating conditions.

15.2.2 Evaluate Physical Conditions

Evaluate and document the physical conditions of all relevant system components including, but not limited to boiler jacket insulation and potential heat losses, heat emitters, steam traps, radiator valves, air vents, water circulators, fans, ductwork, filters, and compression and expansion tanks.

15.2.3 Observe Operating Conditions

Observe, for a minimum of one operating cycle, the equipment and control functions and document visual or auditory indications of performance concerns, as weather conditions permit.

15.2.4 Evaluate System for Leaks

Evaluate and document all components of the heating system for leaks including at a minimum, steam distribution air vents, pipes, ducts, tanks, and boilers.

15.2.5 Interview Building Staff and Occupants

15.2.5.1 Interview building maintenance staff to gather and document available information regarding the existence, type, and location of any sensors.

15.2.5.2 Interview building maintenance staff to document the existing routine maintenance performed on heating equipment. Collect and review any available maintenance logs. Collect and review information on major equipment upgrades or modifications and any replacement equipment installed.

15.2.5.3 Interview occupants to determine if temperature imbalances or other comfort complaints exist.

15.3 Measurements and Testing

15.3.1 Space Temperatures

Measure space temperatures throughout the building to evaluate opportunities to improve the heating system. If the audit is performed during the shoulder or cooling season, use informational interviews to obtain temperature data.

15.3.2 Supply and Return Temperature

Measure supply and return temperatures and document temperature rise.

15.3.3 Perform Combustion Appliance Safety Testing

Complete combustion safety testing per Section 11.

15.3.4 Combustion Efficiency Testing

Combustion efficiency tests shall be completed at steady-state conditions and interpreted based on observed operating conditions to establish overall equipment efficiency. For modulating equipment, measure combustion efficiency at multiple firing rates.

15.3.4.1 For summertime testing, boiler shall be manually turned on and allowed to reach steady state before commencing with combustion testing. If summertime testing is not feasible due to site restrictions, records from the most recent annual clean and tune shall be utilized to estimate the combustion efficiency.

15.3.5 Measure Pipe and Duct Insulation

Measure and document all heating system insulation type and thickness. Measure length of any uninsulated heating pipes or ducts.

15.3.6 Distribution Diagnostic Testing

When observations and interviews indicate distribution problems or imbalance issues, perform diagnostic testing based on which of the following system types are present:

15.3.6.1 Steam Systems Distribution Testing

Using industry-accepted diagnostic tools, evaluate and document the functional performance of steam traps, thermostatic valves (if applicable) and air vents. Test the time to heat delivery at different points of the distribution system. The test points for heat delivery shall be selected based on the distribution system layout and known problem spots to identify and rectify potential steam balancing issues.

15.3.6.2 Forced Air Systems Distribution Testing

Diagnostic testing should include at a minimum duct leakage, system air flow, temperature rise and static pressure and evaluation of system sizing on sampled units.

15.3.6.2.1 Static Pressure and Temperature Rise

Static pressure and temperature rise shall be measured and compared to manufacturer's specifications. Measurement methods shall comply with OEM specifications. Measurement tools shall comply with ANSI/ASHRAE Standard 111.

15.3.6.2.2 System Flow

Measure system flow at system supply and intake locations and make recommendations as necessary to provide appropriate flow to each zone of the building. When making recommendations, reference the current version of ANSI/ACCA *Manual J Residential Load*

Calculation and *Manual D Residential Duct Systems* or comparable calculation methodologies.

15.3.6.2.3 Duct Leakage

If a duct sealing EEM is to be considered, ducts shall be tested for leakage in accordance with one of the following, whichever is more applicable:

ANSI/BPI-1200

OR

ANSI/RESNET/ICC-380

The energy audit report shall note which test method was used.

NOTE: Duct sealing shall be considered when any ducts are located in unconditioned spaces.

15.3.6.3 Hot Water Distribution and Hydronic Heat
Read and document pressure where gauges exist.

16 Air Conditioning

The air conditioning system(s) shall be identified during the on-site evaluation, documented in the energy audit report, and the energy audit report shall recommend upgrades as appropriate.

16.1 Sampling

Sampling shall be performed in accordance with Section 9 (Sampling Procedure).

16.2 Observations and Interviews

The on-site evaluation shall include the following elements:

16.2.1 Interview Building Staff and Occupants

16.2.1.1 Interview building maintenance staff and document the existing routine maintenance performed on HVAC equipment. Collect maintenance log information for cooling equipment when available and review for recurring maintenance issues and identification of maintenance opportunities.

16.2.1.2 Interview building maintenance staff to gather and document available information regarding the existence, type, and location of any sensors.

16.2.1.3 Interview occupants to determine if there are temperature imbalances or other comfort complaints.

16.2.2 Identify System(s) and Create Schedule

Identify and record the air conditioning system type(s, and equipment nameplate values containing all relevant information such as: voltage and amps for single or 3-phase, refrigerant type, set points, controls, type and location of sensors, cooling medium, rated capacities, and EER/SEER, if provided. Record information about the control strategies and sensors that implement them.

16.2.3 Evaluate Physical Conditions

Evaluate and document the physical conditions of all relevant system components. For chilled water or water-loop heat pump systems, check for any pipe leak issues or control issues, and verify appropriateness of pump sizing and control.

16.2.4 Verify Operation

When maintenance records indicate that equipment maintenance has not been completed in accordance with manufacturer's specified intervals, a recommendation for inspection and maintenance of equipment and controls shall be included in the workscope. Document visual or auditory indications of performance, as weather conditions permit.

16.3 Measurements and Testing

16.3.1 Space Temperatures

Measure space temperatures throughout the building to evaluate opportunities to improve the cooling system. If humidity issues are found, measure space relative humidity (RH) at the problem locations and record measured RH linked to coincident space temperature. If the audit is performed during the shoulder or heating season, use informational interviews to obtain temperature and humidity data.

16.3.2 Supply and Return Temperature and Pressure

Document supply/return temperatures and system refrigerant pressures during the cooling cycle (if relevant gauges are present) and ensure that these setpoints are appropriate.

16.3.3 Pipe/Duct Insulation

Determine that air conditioning ductwork, and any chilled water or condenser water pipes, and refrigerant vapor lines are insulated in all accessible locations of the building. Measure and document all cooling system insulation types, thicknesses, and lengths. Also document length of any uninsulated runs.

16.3.4 Ducted Distribution System Performance

Where visual inspection indicates duct sealing as a potential EEM or health and safety opportunity, diagnostic testing shall include, at a minimum, duct leakage assessment, system air flow, temperature rise and static pressure, and evaluation of system sizing.

16.3.4.1 Static Pressure and Temperature Rise

Measure external static pressure and temperature rise per ANSI/ACCA 5 QI. Compare against manufacturer nameplate requirements and make recommendations per ANSI/ACCA 5 QI.

16.3.4.2 System Flow
Measure system flow at system supply and intake locations and make recommendations as necessary to provide appropriate flow to each zone of the building. When making airflow recommendations reference ANSI/ACCA *Manual J Residential Load Calculation* and *Manual D Residential Duct Systems* or comparable calculation methodologies.

16.3.4.3 Duct Leakage
Ducts shall be tested for leakage in accordance with ANSI/RESNET/ICC 380.

16.3.5 Piped Distribution System Performance
Where inspections, measurements, or interviews indicate potential piped distribution system EEMs, ensure relevant parameters impacting EEM evaluation (e.g., available pressures, key temperatures, pump data) have been obtained.

17 Plug Load

Plug load energy uses shall be identified and assessed during the on-site evaluation. Focus on classes of appliances that have high usage or for which replacements are available that meet or exceed an ENERGY STAR® specification.

17.1 Sampling

Sampling shall be performed in accordance with Section 9 (Sampling Procedure).

17.2 Observations and Interviews

During the on-site evaluation, assess opportunities to reduce plug load energy consumption, especially considering refrigerators, wall or window A/C units, space heaters, entertainment centers, and high-use lighting. For all high-use appliances, identify make, model, estimated date of manufacture, rated annual fuel usage, and location.

17.2.1 Interview occupants as needed to effectively assess and model plug load electric usage.

17.3 Measurements and Testing

For any expected high-use equipment for which rated annual energy usage is not available, verify rated power, if possible, by measuring power (W) when equipment is energized.

18 Elevators (and Escalators)

Elevator system(s) energy uses shall be identified and assessed during the on-site evaluation.

18.1 Observations

During the on-site evaluation, identify number of elevators (and/or escalators), types (including capacities), any lighting, and any fan ventilators. Also evaluate opportunities to reduce elevator system(s) energy consumption. For all subsystems related to the elevator system(s), identify make, model, estimated date of manufacture, and location.

19 Lighting Systems

The on-site evaluation shall include an evaluation of lighting systems. Lighting systems are those that are hard-wired and controlled by switching. Plug-in lamps are handled as part of plug loads.

19.1 Sampling

Sampling shall be performed in accordance with Section 9 (Sampling Procedure).

19.2 Observations and Interviews

19.2.1 Interview

Interview managers and occupants to identify maintenance methods and schedules, and areas where there are concerns or EEM opportunities involving lighting levels and/or lighting quality.

19.2.2 Lighting Schedule

Create a schedule, by space type, of existing lighting, including fixture location, general fixture type, lamp and ballast type, input wattage based on lamp/ballast combinations, percentage of burned out or nonfunctioning lamps, and hours of operation.

19.2.2.1 Ballast and Lamp Type

Fixtures shall be opened to record actual ballast model numbers and lamp types installed. Verify that ballasts and lamp types are compatible. NOTE: On-site maintenance staff can open the fixtures for the auditor.

19.2.2.2 Unique Types

If lighting in a particular space is unique from other instances of that space type, additional instances of that space type shall be evaluated, to determine a representative lighting schedule.

19.2.3 Lighting Controls Assessment

Existing lighting controls shall be visually inspected to verify correct operation during the on-site evaluation.

19.2.3.1 "Auto-Off" and “Auto Dimmer” Controls

Verify opportunities for "auto-off" controls (such as spring-wound interval switches or occupancy sensors) and “auto dimmer” controls to replace wall switches for lights in areas where lights may be inadvertently left on (such as janitor closets, storage areas, laundry rooms), or in low-traffic areas.

19.2.3.2 Daylight Sensors

Verify that all outdoor lighting associated with the building is controlled by daylight sensors or other effective control system.

19.2.3.3 Integrated Controls

Assess opportunities for an integrated lighting control system that combines timing, occupancy sensing, daylight sensing, and manual controls, keeping in mind the

drawbacks of too much complexity. The auditor shall note the use of daylighting including solar tubes installed at the premises.

19.2.3.4 Controls Integrated with Fixtures
Assess opportunities to replace or retrofit fixtures with manual controls with integrated occupancy sensors or daylight sensors.

19.3 Measurements

19.3.1 Lighting Illuminance Measurement

If spaces are reported to be, or appear to be, underlit or overlit, measure and document lighting illuminance levels (e.g., lux, foot candles) of existing lighting in the space in accordance with *Illuminating Engineering Society Lighting Library* standards applicable to measurement of existing lighting.

19.3.2 Power Density

Calculate the most representative lighting power density (watts per square foot) for each space type.

20 Water Efficiency

The on-site evaluation shall include an evaluation of water usage at the building and the energy audit report shall recommend upgrades as appropriate.

20.1 Sampling

Sampling shall be performed in accordance with Section 9 (Sampling Procedure).

20.2 Observations and Interviews

The on-site evaluation shall include the following elements:

20.2.1 Interview Building Staff and Occupants

Interview building maintenance staff to document the existing routine maintenance performed on end use water fixtures and equipment.

Interview occupants to determine end use characteristics and performance issues including, but not limited to leaks, toilet performance (double flushing), water temperature and hot water supply timing.

20.2.2 Identify System(s) and Create Schedule

Identify the water-consuming equipment in the building and document all relevant information, including, but not limited to equipment type, make and model of equipment, water flows of existing equipment, controls, operating conditions, and any atypical end uses (e.g., community kitchens).

20.2.3 Evaluation of Physical Conditions

Evaluate and document the physical conditions of all relevant system components including, but not limited to toilets, shower heads, aerators, washing machines, dishwashers, irrigation systems, non-potable water systems.

For irrigation systems, identify the existing irrigation systems and evaluate for performance. Visually verify and record the following: positioning of sprinkler heads, leaks in the system, signs of overwatering, signs of water damage to the buildings, and types of irrigation distribution (overhead spray, bubbler, drip, subsurface).

20.2.4 Evaluate System for Leaks

Evaluate and document all components of the plumbing and irrigation systems for visual indications of leaks. System evaluation shall be informed by water consumption data analysis as per Section 4.

20.3 Measurements and Testing

20.3.1 Flow Rates

Flow rates of end use fixtures shall be verified using either name plate data or, if unavailable, calibrated flow bag.

20.3.2 Test Toilets for Leaks

Tank style toilets shall be tested for leaks using dye tablets.

21 Renewable Energy Systems

The on-site evaluation shall include an evaluation of existing renewable energy systems to identify opportunities to improve the efficiency or performance of the systems. Where such opportunities are identified, the audit report shall include recommendations for further specialized evaluation, or for refurbishment, repair or retrocommissioning of renewable energy systems.

21.1 Observations and Interviews

For each type of renewable system, collect the following information related to that system:

21.1.1 Assess Current Operation

Assess existing renewable systems for current operation. Interview building maintenance staff to document the existing routine maintenance performed on equipment, including historical repairs or ongoing issues.

21.1.2 Analysis Documentation

If available, auditor shall acquire the original analysis documentation and compare to actual operating conditions. Review common area and/or resident bills to assess that solar credits are being allocated to utility bills as expected.

21.1.3 System Ownership Structure

Identify the ownership structure of existing systems.

21.1.4 System Components and Schematics Diagram

Record the system characteristics and draw a diagram of the system schematics.

21.1.5 Solar Thermal Systems

Collect data on the solar thermal system including the system type (open, closed loop), fluid type (glycol, water, other), storage tank size, storage tank and pipe insulation R-value, pump flow rate and size, collector panel nameplate data, valve types, and control setpoints. Collect actual operating conditions including temperatures from relevant gauges. Identify how the solar thermal system connects with the building system (boiler pre-heat for space heating, DHW pre-heat, or both). Identify the existing conditions of the system components including, but not limited to, soiling, and shading of panels, pipe insulation quality and exposure to environmental elements, mounting systems, and storage tanks.

21.1.6 Solar Photovoltaic (PV) Systems

Collect PV system nameplate data, inverter type, system configuration, generation capacity, metering structure (whole building, residential units, common area etc.). Identify the existing conditions of the system components, including but not limited to soiling and shading of panels, electrical connections, and mounting systems.

21.2 Measurements and Testing

For each type of renewable system, collect the following information related to that system:

21.2.1 Metered Data

If available, the auditor shall obtain metered data for system performance and compare the original analysis documentation to current operation and metered data.

Annex A| BPI-1105-S-202X Referenced Documents

Item	Date
ANSI/ACCA 1 Manual D - Residential Duct Systems	2016
ANSI/ACCA 2 Manual J - 2016 Residential Load Calculation (8th Edition)	2016
ANSI/ACCA 5 QI - 2015, HVAC Quality Installation Specification	2015
ANSI/ASHRAE/IES Standard 90.1-2019 Energy Standard for Buildings Except Low-Rise Residential Buildings	2019
ANSI/ASHRAE Standard 111-2017, Measurement, Testing, Adjusting, and Balancing of Building HVAC Systems	2017
ASHRAE Guideline 14-2014 Measure of Energy, Demand, and Water Savings	2014
ASHRAE Procedures for Commercial Building Energy Audits, Second Edition	2011
ASHRAE Standard 62.2 – 2013: Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings	2013
ANSI/BPI-1200-S Standard Practice for Basic Analysis of Buildings	2017
Illuminating Engineering Society (IES) The Library https://media.ies.org/docs/Lighting-Library-Bibliography-condensed.pdf	
ANSI/Z223.1/NFPA 54: National Fuel Gas Code	2021
NFPA 211: Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances	2019
NREL/ SR-7A40-68572 – Chapter 16: Retrocommissioning Evaluation Protocol (The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures,) http://www.nrel.gov/docs/fy17osti/68572.pdf	2017
ANSI/RESNET/ICC 380 – Standard for Testing Airtightness of Building Enclosures, Airtightness of Heating and Cooling Air Distribution Systems, and Airflow of Mechanical Ventilation Systems	2019
SMACNA HVAC Systems – Testing, Adjusting and Balancing, 3rd Edition	2002
UL 913 Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, and III, Division 1, Hazardous (Classified) Locations	2015
U.S. Department of Energy Weatherization Program Notice 16-8 https://www.energy.gov/eere/wipo/downloads/wpn-16-8-revised-energy-audit-approval-procedures-and-other-related-audit-issues	2016
Qualified Software for Calculating Commercial Building Tax Deductions. https://www.energy.gov/eere/buildings/qualified-software-calculating-commercial-building-tax-deductions	
U.S. Environmental Protection Agency Map of Radon Zones	1993

Documents can be ordered from the following:

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

ANSI: American National Standards Institute
1899 L Street, NW,
11th Floor
Washington, DC, 20036
www.ansi.org

ASHRAE: American Society of Heating Refrigeration and Air-Conditioning Engineers
1791 Tullie Circle, N.E.
Atlanta, GA 30329
(404) 636-8400
www.ashrae.org

BPI: Building Performance Institute, Inc.
107 Hermes Road, Suite 110
Malta, NY 12020
(877) 274-1274
www.bpi.org

IES: Illuminating Engineering Society
120 Wall Street, Floor 17
New York, NY 10005-4001
(212) 248-5000
www.ies.org

NFPA: National Fire Protection Association
1 Batterymarch Park
Quincy, MA 02169-7471
(617) 770-3000
www.nfpa.org

RESNET: Residential Energy Services Network, Inc.
P.O. Box 4561
Oceanside, CA 92052-4561
www.resnet.us

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

U.S. Department of Energy
1000 Independence Ave SW
Washington, DC 20585
(202) 586-5000
www.energy.gov

UL: Underwriters Laboratories
333 Pfingsten Road
Northbrook, IL 60062
877.854.3577
www.ul.com

U.S. Environmental Protection Agency
1200 Pennsylvania Ave NW
Washington, DC 20460
(202) 272-0167
www.epa.go

Annex B | Action Levels for Spillage and Carbon Monoxide in Combustion Appliances (Normative)

From ANSI/BPI-1200 Basic Analysis of Buildings

Annex D.1 Spillage assessment and CO measurement results shall be based on the following criteria:

- CO measured at 5 minutes of main burner operation
- Spillage assessed at 2 minutes of main burner operation for warm vent
- Spillage assessed at 5 minutes of main burner operation for cold vent
- CO level at or below threshold in Section 7.9.5, Table 1 for the appliance being tested is ACCEPTABLE
- CO level exceeding threshold in Section 7.9.5, Table 1 for the appliance being tested is UNACCEPTABLE

TABLE D.1.A ACTION LEVELS FOR SPILLAGE IN COMBUSTION APPLIANCES
The following actions shall be taken when spillage occurs under the specific circumstances detailed below.

TEST RESULT	ACTION REQUIRED
Greatest CAZ depressurization occurs with the air handler on*	Conduct further analysis of the distribution system to determine if leaky ducts or other HVAC-induced imbalances are the cause of the spillage. If so, recommend distribution system repairs that will reduce or eliminate the CAZ depressurization.
Greatest CAZ depressurization occurs with door to CAZ closed, but is alleviated when door to CAZ is open*	Recommend measures to improve air transfer between the CAZ and the core of the house
The cause of spillage has been traced to excessive exhaust** independent of CAZ door position, air handler, or a problem with the flue†	Verify that sufficient combustion air is available per *ANSI Z223.1/NFPA 54* for gas-fired appliances and *NFPA 31* for oil-fired appliances or recommend verification by a qualified professional and/or Recommend further evaluation/service by a qualified professional to address the venting/combustion air issues

*****In the case where both spillage and excessive CO are present, in addition to the specific recommendations above, recommend that the appliance be shut down until it can be serviced by a qualified professional.
** Refers to exhaust caused by mechanical ventilation and/or other means of exfiltration.
†When a recommendation to replace atmospherically-vented combustion equipment inside the pressure boundary is made, and when cost-effective, recommend replacement with direct-vented, or power-vented equipment (or non-combustion equipment, such as a heat pump), which is ENERGY STAR®-labeled.

TABLE D.1 B. ACTION LEVELS FOR CO IN COMBUSTION APPLIANCES	
TEST RESULT	ACTION REQUIRED
Unacceptable CO level	Advise the homeowner/occupant that the appliance should be serviced immediately by a qualified professional Note: If ambient CO levels do not exceed 70 ppm, testing of other appliances and other audit procedures may continue at the discretion of the auditor
Acceptable CO level	No action required

Annex C | Minimum Clearances to Combustible Materials (Normative)

From ANSI/BPI-1200 Basic Analysis of Buildings

Table E.1. Minimum Clearances (in inches) to Combustible Materials for Unlisted Furnaces and Boilers

Appliance	Above and Sides of Furnace Plenum	Top of Boiler	Jacket Sides and Rear	Front	Draft Hood and Barometric Draft Regulator	Single-Wall Vent Connector
1. Automatically fired, forced air or gravity system, equipped with temperature limit control which cannot be set higher than 250°F (121°C)	6	N/A	6	18	6	18
2. Automatically fired heating boilers–steam boilers operating at not over 15 psi and hot water boilers operating at not in excess of 250°F (121°C)	6	6	6	6	18	18
3. Central heating boilers and furnaces, other than 1. or 2.	18	18	18	18	18	18
4. Air-conditioning appliances*	18*	18	18	18	18	18

*Where supply ducts are within 3 ft. (0.9 m) of the furnace plenum, listed air conditioning equipment shall have clearances no less than that specified from the furnace plenum.

Table E.2. Minimum Clearances to Combustible Materials for Vent Connectors Attached to Appliances with Draft Hoods (in inches)	
Vent Material	**Minimum Clearance**
Type B Gas Vent	6
Type L Vent	6
Single Wall Metal Pipe.	9

Annex D | ANSI/BPI-1200-S-2017 Standard Practice for Basic Analysis of Buildings, Section 7

7 Combustion Appliance and Fuel Distribution System Inspection

The auditor shall comply with the requirements detailed in *BPI-1100*, Section 7, Combustion Appliance and Fuel Distribution System Inspection. In addition, the inspection of combustion appliances and fuel distribution systems shall be conducted as follows:

7.1 Equipment requirements for combustible gas and carbon monoxide (CO) detection, CO measurement, depressurization, and spillage tests

7.1.1 Combustible gas detector (CGD)
CGD equipment used for testing shall:

7.1.1.1 Be classified to *UL 913 Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, and III, Division 1, Hazardous (Classified) Locations* or equivalent.

7.1.1.2 Have a variable tick rate or changing tone based on gas concentration levels. Note: The tick rate provides the indication of concentration but only accounts for relative concentration changes, not necessarily identifying hazardous concentration thresholds.

7.1.1.3 Be capable of providing a digital display of percentage of Lower Explosive Limit (LEL) and/or provide an alarm when detecting combustible gas concentrations exceeding 10% Lower Explosive Limit (LEL).

7.1.1.4 Be calibrated and/or operation checked in accordance with the manufacturer's recommendations with available documentation traceable to the individual device.

7.1.1.5 Have the ability to zero ambient conditions.

7.1.2 CO measurement equipment
Equipment/instruments used for flue gas CO measurement shall:

7.1.2.1 Be capable of measuring, and displaying digitally, CO)levels from 0 to 2,000 parts per million (ppm).

7.1.2.2 Be capable of calculating and displaying digitally, CO air free concentrations, or have digital displays of CO as measured and O^2 levels to allow manual calculation of CO air free.

7.1.2.3 Have a resolution of 1 ppm.

7.1.2.4 Have an accuracy of +/- 5% of reading or +/-10ppm, whichever is greater.

7.1.2.5 Be equipped internally or externally with a nitric oxide filter (NOx filter).

7.1.2.6 Be calibrated in accordance with the manufacturer's recommendations with available documentation traceable to the individual device.

7.1.3 Ambient CO monitor

7.1.3.1 Auditors performing CO inspections shall be equipped with a dedicated ambient CO monitor while in the work environment. “Work environment” includes the building being audited and ambient air and other exposure environments preceding entry of the audited property.

7.1.3.2 CO monitors shall be operated in accordance with the manufacturer’s instructions.

7.1.4 Equipment required for depressurization and spillage assessment

7.1.4.1 Mirror, smoke pencils or other smoke visualization equipment.

7.1.4.2 One or more manometer(s) which shall:

7.1.4.2.1 Have a resolution of 0.1 Pa or better and an accuracy of +/- 1% of pressure reading or +/-0.25 Pa, whichever is greater.

7.1.4.2.2 Be calibrated and/or operation checked per current manufacturer’s specifications with available documentation traceable to the individual device.

7.2 Immediate health and safety concerns

7.2.1 The auditor shall identify building-related conditions as covered in the scope of this document that may require immediate health and safety remediation in accordance with subsequent sections of this document.

7.2.2 The auditor shall communicate these situations clearly and immediately to the homeowner/occupant and recommend contacting a qualified professional for proper repair and/or maintenance.

7.3 Conditions for entry and working environment associated with indoor air quality

The auditor shall conduct the procedures within Sections 7.3.2 and 7.3.3 to measure CO and combustible gas levels in the indoor air environment and take action, as required. Only after CO and combustible gas levels are found to be below levels calling for evacuation of the home (per Sections 7.3.2.2 and 7.3.3.3.1) shall further work be undertaken.

7.3.1 CGD, ambient CO monitors, and CO measurement
Instruments shall be turned on outside the building away from any combustion outlets and automobile traffic areas, set to zero, and otherwise prepared for use in accordance with manufacturer’s instructions.

7.3.2 Combustible fuel gases

7.3.2.1 Indoor ambient air shall be sampled with the CGD in at least one location per floor of occupied space upon entering the home.

7.3.2.2 If any measured concentrations of combustible fuel gas exceed 10% of the LEL, the auditor shall inform the homeowner/occupants of the unsafe condition and advise evacuation of the home. The auditor shall leave the home and the appropriate emergency services and fuel gas providers shall be notified from outside the home.[3]

[3] The auditor shall contact the appropriate emergency services only if the homeowner/occupant is unable to do so.

7.3.3 Carbon monoxide

7.3.3.1 Ambient CO monitoring

7.3.3.1.1 The auditor shall have a designated ambient CO monitor operating at all times while in the work environment.

7.3.3.1.2 The auditor shall comply with CO exposure action levels specified in Section 7.3.3.3 of this document and shall not proceed with work when CO concentrations in the work environment exceed 70 ppm.

7.3.3.2 Indoor ambient CO measurements

7.3.3.2.1 Upon entering the building, the ambient air shall be sampled to determine the level of CO in the building by conducting measurements in the occupied space, including utility rooms.

7.3.3.2.2 The auditor shall continue to monitor CO levels in the ambient air at all times while in the work environment.

7.3.3.3 Indoor ambient CO action levels

Actions in response to ambient CO measurements shall be taken as follows:

7.3.3.3.1 If the CO instrument indicates an ambient CO level of 70 ppm or greater, the auditor shall immediately terminate the inspection and notify the homeowner/occupant of the need for all building occupants to evacuate the building. The auditor shall immediately leave the building and the appropriate emergency services shall be notified from outside the home.

7.3.3.3.2 If the CO instrument indicates an ambient CO reading in the range of 36 ppm-69 ppm, the auditor shall advise the homeowner/occupant that elevated levels of ambient CO have been detected. Windows and doors shall be opened. The auditor shall recommend that all possible sources of CO be turned off immediately. Where it appears that the source of CO is a permanently installed appliance, the auditor shall recommend that the appliance be turned off and the homeowner/occupant shall be advised to contact a qualified professional.

7.3.3.3.3 If the CO instrument indicates an ambient CO reading in the range of 9 ppm-35 ppm, the auditor shall advise the homeowner/occupant that CO has been detected and recommend that all possible sources of CO be checked, and windows and doors opened. Where it appears that the source of CO is a permanently installed appliance, the homeowner/occupant shall be advised to contact a qualified professional.

7.4 Order of inspection procedures

After the auditor has verified that combustible fuel gases are below 10% of the LEL (per section 7.3.2.) and that ambient CO readings are below 70 ppm (per section 7.3.3.2.), the following inspections, as applicable to the specific circumstances of the home being evaluated, shall be performed in the order in which they are listed below.

7.4.1 Natural Gas and Liquid Petroleum (LP) Gas Piping System Inspection

7.4.2 Oil Supply System Inspection

7.4.3 Visual Inspection of Combustion Appliance Zone (CAZ)

7.4.4 Combustion Appliance Safety Inspection

7.4.5 Solid Fuel Burning Appliance Inspection

7.4.6 Placing Appliances Back in Operation

7.5 Natural gas and LP gas piping system inspection

An inspection of the fuel piping system/s shall be performed. Where the auditor identifies deficiencies in materials, connections, components, or supports, the deficiencies shall be noted in project documentation along with a recommendation that the homeowner/occupant contact a qualified professional to inspect the system.

7.5.1 Systems shall be inspected and tested in accordance with the *ANSI Z223.1/NFPA 54, National Fuel Gas Code, Chapter 8, Inspection, Testing, and Purging*, and where called for by the local AHJ, shall be tested in accordance with Annex C of *ANSI Z223.1/NFPA 54, Suggested Method for Checking for Leakage*.

22 Alternatively, the auditor shall conduct the following inspection tasks:

7.5.2 Natural gas and LP gas piping system inspection and leakage testing

An inspection of the accessible gas piping and connections, from the natural gas meter or LP gas tank to a point where the supply line connects to the gas valve of all appliances shall be completed.

7.5.2.1 Beginning at the natural gas meter or LP gas tank, conduct a test for gas leakage using a CGD. Where a leak is indicated by the CGD, confirm with leak detection solution. Follow manufacturer's instructions for performing gas leak testing.

7.5.2.2 In the absence of manufacturer instructions, perform gas leak testing as follows:

7.5.2.2.1 Hold the CGD wand within an inch of the line, starting at the first joint closest to the outlet of the LP gas tank or natural gas meter outlet.

7.5.2.2.2 Move the CGD wand along the entire gas line at a rate of 1" per second with the tip above the line for natural gas and below for LP gas. Move

the CGD wand in a 360-degree circle completely around each joint at a rate of 1” per second.

7.5.2.2.3 All connections thereafter shall be tested in the same manner.

7.5.2.3 The gas leakage inspection shall include the following components:

7.5.2.3.1 The entire gas line and all accessible gas piping fittings from the outlet of the natural gas meter or LP gas tank to a point where the supply line connects to the gas valve of all appliances. Do not move appliances.

7.5.2.3.2 Appliance gas valve/regulator housing and connections.

7.5.2.4 Where gas leakage is confirmed, the site shall be marked, and the homeowner/occupant shall be notified that repairs should be made. The auditor shall recommend that the homeowner/occupant immediately notify the gas company and/or a qualified professional to evaluate and perform all necessary repairs. [4]

7.5.2.5 When the CGD indicates that combustible gas exists in the ambient atmosphere (at any level below 10% of LEL) and a gas leak cannot be confirmed with the use of leak detection solution, the auditor shall inform the homeowner/occupants and advise the homeowner/occupant to notify the gas company and/or a qualified professional.

7.5.2.6 Inspect fuel lines for visibly worn flexible gas lines and any flexible connectors manufactured prior to 1973. Inspect flexible appliance connectors to determine if they are free of cracks, kinks, corrosion, and signs of damage.

7.5.2.7 Where fuel lines or connectors are determined to be unsafe or where an uncoated brass connector is found, notify the homeowner/occupant, and recommend that the appliance shutoff valve be placed in the off position and that the connector be replaced.

7.5.2.8 Inspect piping to determine that it is adequately supported, that there is no undue stress on the piping, and if there are any improperly capped pipe openings.

7.5.2.9 Where the auditor identifies deficiencies in gas piping materials, connections, components, or supports, the deficiencies shall be noted in project documentation along with a recommendation that the homeowner/occupant contact a qualified professional to inspect the system.

7.6 Oil supply system inspection

The auditor shall conduct an inspection of the oil-fired appliance fuel supply system (tank, supply lines, burner) for leakage and other deficiencies as detailed in below.

7.6.1 Inspect oil lines for visible signs of oil leakage, kinks, or other deficiencies that may impair the flow of oil or result in leakage and verify the oil line is properly connected to the burner.

[4] The auditor shall contact the appropriate emergency services only if the homeowner/occupant is unable to do so.

7.6.2 Inspect the oil tank, if safely accessible, for evidence of historic or active oil spills or leakage.

7.6.3 Verify that the tank is at least 5 feet from burner or other sources of fire or flame or installed as per local code.

7.6.4 Verify that the fill cap is in place and in good condition.

7.6.5 Verify that the vent pipe is in good condition and free of obstruction and the vent cap is installed and in good condition.

7.6.6 Verify the presence of a working shutoff at the tank.

7.6.7 Verify that all lines properly connect to the tank.

7.6.8 Verify that exposed portions of the fuel line are protected from damage.

7.6.9 Fuel Oil Supply System - Action Levels

7.6.9.1 In the case of a leak, the auditor shall:

7.6.9.1.1 Mark the leak location and notify the homeowner/occupant.

7.6.9.1.2 Advise the homeowner/occupant to contact a qualified professional to repair the leak.

7.6.9.1.3 Follow specific rules and regulations pertaining to the local jurisdiction.

7.6.9.2 The auditor shall document compliance or deficiencies on:

7.6.9.2.1 Project documentation

Or

7.6.9.2.2 National Oilheat Research Alliance's *Routine Fuel Oil Storage Tank Evaluation – Above Ground Tanks Checklist,* and include with project documentation

7.7 Visual inspection of combustion appliance zone (CAZ)

7.7.1 Inspect the CAZ to determine if the area is free of the storage of gasoline or any flammable products such as oil-based solvents, varnishes, or adhesives. Inspect the immediate area where the appliance is located to determine if the area is free of rags, paper, or other combustibles

7.7.2 Determine whether the appliance and its vent connectors have the appropriate clearance from combustible building components in accordance with manufacturer's specifications or Annex E, Table E.1, Clearances to Combustible Material for Unlisted Furnaces and Boilers and Table E.2, Clearances to Combustible Material for Vent Connectors Attached to Appliances with Draft Hoods.

7.7.3 When it is determined that an unsafe condition exists, as specified in Sections 7.7.1 – 7.7.2 above, and the unsafe condition may be alleviated by removal of obstructions and materials, the homeowner/occupant shall be so advised. If the unsafe condition cannot be immediately mitigated, the auditor shall advise the homeowner/occupant that the appliance should not be used until the unsafe condition is mitigated. Note the condition in project documentation.

7.7.4 If a gas or oil-fired storage water heater is located in a garage, the water heater must be a minimum of 18” above the floor unless listed as flammable vapor ignition resistant (FVIR). Advise homeowner/occupant of unsafe condition and note in project documentation.

7.8 Visual inspection of combustion appliance/s and venting system/s

The evaluation shall include a visual inspection of the heating system/s, water heater/s and venting system/s.

7.8.1 Oil-fired, natural gas or LP gas appliances

7.8.1.1 Inspect venting system to ensure the materials and horizontal pitch meet manufacturer’s specification. In the absence of manufacturer’s specifications, verify that the horizontal pitch has a ¼” rise per linear foot.

7.8.1.2 When possible, inspect masonry chimneys to determine if they are lined. If the presence of a liner cannot be determined, recommend that the homeowner/occupant contact a qualified professional to complete a chimney inspection.

7.8.1.3 Inspect venting for blockage or restriction, leakage, corrosion, unusually small or large vent connectors or other deficiencies that could cause an unsafe condition.

7.8.1.4 Inspect vent termination and verify presence of vent cap (if applicable and safely accessible).

7.8.1.5 Inspect visible portions of the furnace combustion chamber for cracks, ruptures, holes, and corrosion.

7.8.1.6 Verify the blower compartment door, filter rack door and covers are properly installed.

7.8.1.7 Wiring: Inspect for bare wires, open connection or worn insulation.

7.8.1.8 If deficiencies are identified per Sections 7.8.1.1-7.8.1.7, recommend further inspection by a qualified professional.

7.8.2 Direct vent appliances

7.8.2.1 Verify the combustion air supply pipes are securely fastened to the appliance.

7.8.2.2 Verify the combustion air source is located in the outdoors or in areas that freely communicate to the outdoors and in a code compliant location.

7.8.2.3 Inspect plastic venting system to determine that it is free of sagging and is sloped in an upward direction to the outdoor vent termination.

7.8.2.4 Inspect vent termination and vent cap, if applicable and safely accessible.

7.8.2.5 If deficiencies are identified per Sections 7.8.2.1-7.8.2.4, recommend further inspection by a qualified professional.

7.8.3 Chimney and/or venting system shared by multiple combustion appliances

7.8.3.1 Combustion appliances vented into a common vertical chimney/flue:

7.8.3.1.1 When a higher BTUh combustion appliance enters the chimney/flue above a lower BTUh combustion appliance, the auditor shall recommend that the homeowner/occupant contact a qualified professional to inspect the venting system.

7.8.3.1.2 When two combustion appliance vents enter at the same horizontal point, the auditor shall recommend that the homeowner/occupant contact a qualified professional to inspect the venting system.

7.8.3.2 Combustion appliances vented into a common horizontal vent connector

7.8.3.2.1 If the vent piping diameter does not increase after the additional combustion appliance connection into the vent piping, the auditor shall recommend that the homeowner/occupant contact a qualified professional to inspect the venting system.

7.8.4 Unvented heaters

7.8.4.1 Check appliance for *ANSI Z21.11.2 –Gas Fired Room Heaters-Volume II* (ANSI Z21.11.2) label.

7.8.4.2 Recommend removal of any unvented heater that is not listed to *ANSI Z21.11.2.*

7.8.4.3 Verify that the heater input is a maximum of 40,000 BTUh, but not more than 10,000 BTUh where installed in a bedroom, and 6,000 BTUh when installed in a bathroom.

7.8.4.4 Recommend removal of any unvented heater that exceeds the maximum allowable BTUh as specified in Section 7.8.4.3.

7.8.4.5 Inform clients of potential dangers of unvented space heaters (CO, moisture, oxygen depletion, NO_2), and how these effects could become exacerbated with changes to the building envelope.

7.9 Combustion appliance safety inspection

After gas or oil piping inspection and a visual inspection of the combustion appliance/s have been completed and no unsafe conditions related to these inspections have been observed, a combustion appliance safety inspection shall be completed to determine if fossil fuel-fired appliances are operating safely under a depressurized condition. The auditor shall use the following procedures to conduct CO measurement and spillage assessment on natural draft appliances equipped with a barometric draft control or Category I appliances equipped with a draft hood or connected to a natural draft venting system. The evaluation shall also include CO measurement on gas ovens, direct-vent, and vent-free combustion equipment. ***Ambient CO shall be monitored at all times during the test and actions taken as per Section 7.3.3.3 of this document*.**

7.9.1 Set-up for conducting combustion appliance safety inspection

The following steps shall be completed for the purpose of placing the CAZ under the greatest depressurization achievable given the weather/temperature conditions at the time of the inspection. Once it has been determined that the greatest possible depressurization has been achieved, the CAZ shall remain in this depressurized state during all spillage assessment and CO measurements conducted in the CAZ.

7.9.1.1 Place all combustion appliances located within the CAZ in their standby mode and prepare for operation.

7.9.1.2 Fires in woodstoves and/or fireplaces shall be fully extinguished, with no hot coals or embers, prior to performing a depressurization test. Close fireplace dampers and any fireplace doors.

7.9.1.3 Close all building exterior doors and windows. Close all CAZ doors. Close the interior doors of all rooms except for rooms with an exhaust fan and rooms with a central forced air system return. Outdoor openings for combustion air shall remain open.

7.9.1.4 Turn off any mechanical ventilation and forced air cooling or heating system blowers.

7.9.1.5 Using a calibrated manometer or similar pressure measuring device intended for this purpose, measure and record the baseline pressure in the CAZ with reference to (WRT) outside. Compare this measurement with subsequent pressure measurements to determine the greatest negative pressure achievable in the CAZ.

7.9.1.6 Turn on the following exhaust equipment: clothes dryers (check and clean the dryer filter and look for blockage at the external vent damper prior to operation), range hoods, and other exhaust fans. If there are speed controls, operate the exhaust equipment at the highest speed setting. Do not operate a whole house cooling exhaust fan.

7.9.1.7 Measure and record the pressure in the CAZ WRT outside.

7.9.1.8 Turn on any central forced air system blowers and measure and record the pressure in the CAZ WRT outside.

7.9.1.8.1 If the pressure in the CAZ becomes more negative WRT outside after the blower is turned on, the blower shall remain on during combustion appliance safety inspection.

7.9.1.8.2 If the pressure in the CAZ becomes more positive WRT outside after the blower is turned on, the central forced air system blowers shall be turned off during the combustion appliance safety inspection.

7.9.1.9 Open interior door/s directly leading to the CAZ. Measure and record the pressure in the CAZ WRT outside.

7.9.1.9.1 If the pressure in the CAZ becomes more negative WRT outside after the door(s) are opened, the door(s) shall remain open during the combustion appliance safety inspection. [5]

7.9.1.10 Starting with the appliance with smallest BTUh input rating, follow lighting instructions and place in operation. Adjust the thermostat or control so the appliance will operate continuously.

7.9.2 Spillage assessment and CO measurement in cold vent (except domestic water heaters)

7.9.2.1 Spillage shall be assessed at 5 minutes of main burner operation.

7.9.2.1.1 Action levels for spillage occurring at 5 minutes of main burner operation shall be in accordance with Annex D, Table D.1.A.

7.9.2.2 CO measurement of undiluted flue gas shall be taken at 5 minutes of main burner operation. The CO measurement shall be compared with the appropriate CO threshold in Section 7.9.5, Table 1, CO Thresholds for Fossil Fuel-Fired Appliances (Table 1).

7.9.2.2.1 Action levels for CO exceeding the appropriate threshold in Section 7.9.5, Table 1 shall be in accordance with Annex D, Table D.1.B.

7.9.3 Spillage assessment and CO measurement in domestic water heaters or warm vent

7.9.3.1 Spillage shall be assessed at 2 minutes of main burner operation.

7.9.3.1.1 Action levels for spillage occurring at 2 minutes of main burner operation shall be in accordance with Annex D, Table D.1.A.

7.9.3.2 CO measurement of undiluted flue gas shall be taken at 5 minutes of main burner operation. The CO measurement shall be compared with the appropriate CO threshold in Section 7.9.5, Table 1.

7.9.3.2.1 Action levels for CO exceeding the appropriate threshold in Section 7.9.5, Table 1 shall be in accordance with Annex D, Table D.1.B.

7.9.4 Multiple combustion appliances sharing chimney and/or venting system
When a chimney and/or venting system is shared by multiple combustion appliances, the auditor shall use the following procedures to test combustion appliances for spillage and measure CO level in undiluted flue gases.

7.9.4.1 Combustion appliances shall be tested in order from lowest BTUh input rating to highest BTUh input rating.

[5] Alternatively, pressure differential diagnostics may be used to determine proper door configuration to create the greatest CAZ depressurization. Pressure differential diagnostics may include manometer readings or a visual indicator, such as smoke.

7.9.4.2 The appliance with the lowest BTUh input rating shall be assessed for spillage and CO measurement in undiluted flue gas shall be conducted in accordance with Section 7.9.2 (Cold Vent) or 7.9.3 (Warm Vent) of this document.

7.9.4.3 Upon completion of spillage testing and CO measurement of the first appliance, the auditor shall place the next largest BTUh combustion appliance in operation while the first appliance is still firing. Do not wait for the chimney to cool.

7.9.4.4 Retest the first appliance for spillage when the second appliance has reached 2 minutes of main burner operation. Test the second appliance for spillage immediately thereafter.

7.9.4.5 Measure CO level in the undiluted flue gas of the second appliance at 5 minutes of its main burner operation. Continue this process for each additional commonly-vented combustion appliance in order of BTUh input rating until all are running simultaneously.

7.9.4.6 CO measurements shall be compared with the appropriate CO thresholds in Section 7.9.5, Table 1.

7.9.4.7 Action levels

7.9.4.7.1 Action levels for spillage on each appliance shall be in accordance with Annex D, Table D.1.A.

7.9.4.7.2 Action levels for CO for each appliance shall be taken in accordance with Annex D, Table D.1.B.

7.9.5 Table 1: CO Thresholds for Fossil Fuel-Fired Combustion Appliances

Table 1
CO Thresholds for Fossil-Fuel Fired Combustion Appliances

Appliance	Threshold Limit
Central Furnace (all categories)	400 ppm air free[6]
Boiler	400 ppm air free
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
Unvented Room Heater	200 ppm air free
Water Heater	200 ppm air free
Oven/Broiler	225 ppm as measured
Clothes Dryer	400 ppm air free
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

7.9.6 Direct-vented and power-vented appliances

[6] See Carbon Monoxide Air Free in Annex B |Terms and Definitions for further details.

7.9.6.1 If the outlet of the exhaust is safely accessible, measure the CO level in the undiluted flue gas on all direct-vented and power-vented appliances (without atmospheric chimneys or vents) at 5 minutes of main burner operation.

7.9.6.2 The CO measurement/s shall be compared with the appropriate CO threshold/s in Section 7.9.5, Table 1.

7.9.6.3 Action levels for CO exceeding the appropriate threshold/s in Section 7.9.5, Table 1 shall be taken in accordance with Annex D, Table D.1.B.

7.9.7 Gas ovens and range tops

Gas ovens shall be tested for vented CO and range top burners shall be visually inspected. Perform appliance testing procedures following the manufacturer's appliance procedure. In the absence of the manufacturer's appliance procedure, the following testing procedures and action levels shall be used.

7.9.7.1 With appliance off, complete the following visual inspection:

7.9.7.1.1 Check the oven cavity for any stored materials and remove before testing.

7.9.7.1.2 Inspect the oven cavity for cleanliness. If the oven area is dirty enough to adversely impact the combustion process recommend that the oven be cleaned to reduce the possibility of unacceptable emissions.

7.9.7.1.3 Check the bottom surface inside of the oven cabinet for air venting that may be present. Any air vent obstruction, such as aluminum foil or silicone liners, must be removed before oven CO testing.

7.9.7.1.4 Check for air blockage at the bottom of the range and drawer and/or broiler compartment under the oven and remove any obstructions before testing.

7.9.7.1.5 Inspect range top burners for cleanliness. If the burners are excessively dirty, recommend that they be cleaned to reduce the possibility of unacceptable emissions.

7.9.7.2 Turn the oven on to a bake temperature of 500°F. Do not turn the oven all the way up to the broil setting or self-cleaning setting.

7.9.7.2.1 After 5 minutes of the oven's main burner operation the auditor shall place the test probe of a CO analyzing tool into the throat of the oven exhaust vent and measure undiluted CO.

7.9.7.2.2 Record the CO measurement once the CO level has become a stable reading.

7.9.7.2.3 The CO measurement shall be compared with the appropriate CO threshold in Section 7.9.5, Table 1.

7.9.7.3 Actions levels for CO exceeding the appropriate threshold in Section 7.9.5, Table 1 shall be in accordance with Annex D, Table D.1.B.

7.9.8 Unvented combustion heating or hearth appliance CO inspection procedures

7.9.8.1 Unvented heaters

7.9.8.1.1 With the appliance on, measure CO after 5 minutes of main burner operation. Compare the CO measurement with the appropriate threshold in Section 7.9.5, Table 1.

7.9.8.1.2 Actions levels for CO exceeding the appropriate threshold in Section 7.9.5, Table 1 shall be in accordance with Annex D, Table D.1.B.

7.9.8.2 Gas log sets

7.9.8.2.1 With the appliance off, if gas logs are installed in wood burning fireplaces equipped with a damper, verify that the fireplace damper is in a fixed open position.

7.9.8.2.2 With the appliance on, measure CO in the firebox (where log sets are installed in wood burning fireplaces) or in the vent (for gas fireplaces) after 5 minutes of main burner operation. Compare the CO measurement to the appropriate threshold in Section 7.9.5, Table 1.

7.9.8.2.3 Actions levels for CO exceeding the appropriate threshold in Section 7.9.5, Table 1 shall be in accordance with Annex D, Table D.1.B.

7.10 Solid fuel burning appliance inspection

7.10.1 The auditor shall perform the following visual inspection and recommend that the homeowner/occupant contact a certified hearth professional to conduct a thorough inspection of the installation and operation of the appliance.

7.10.1.1 Identify the listing nameplate on the appliance and record the model name and model number, if available.

7.10.1.2 Determine through homeowner/occupant interview if the appliance is the primary heating source.

7.10.1.3 If the appliance is the primary heating source, determine when the chimney and vent connector were last cleaned and inspected. If they have not been cleaned and inspected within the past year, recommend servicing by a certified hearth professional.

7.10.1.4 Visually inspect and note the type and condition of flooring material where the appliance is installed.

7.10.1.5 A recommendation for service by a qualified professional or a recommendation for replacement of the appliance shall be made if any of the following indicators are noted:

7.10.1.5.1 Appliances installed on carpets, wood floors or other combustibles.

7.10.1.5.2 Inadequate clearance to combustible materials. Consult the appliance documentation for required clearances. If no documentation is available, refer to NFPA 211: *Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances.*

7.10.1.5.3 Signs of structural failure, such as cracks or broken welds, of any components.

7.10.1.6 When air sealing or insulation measures are recommended in a home with a fireplace insert, recommend the installation of a fireplace insert liner (attached to the insert, not the existing fireplace liner) if an existing insert liner is not in place.

Alternatively, the auditor shall follow the procedure below to inspect wood burning or pellet burning appliances and inserts:

7.10.2 A visual inspection in accordance with Annex J, Alternate Procedure for Solid Fuel Burning Appliance Inspection.

7.11 Placing appliances back in operation

If no safety concerns or hazards were identified during the inspection of the combustion appliances, return all inspected appliances and systems to their pre-existing state. If appliance-related safety concerns or hazards were identified during the inspection, follow the appropriate actions levels specified in the preceding Sections. Note: In some cases, this will require that the auditor recommend that the appliance be turned off and the homeowner/occupant be advised to contact a qualified professional for further evaluation.