

Energy Savings Plus Health

Indoor Air Quality Guidelines for Multifamily Renovations



Section 1: Introduction



PURPOSE AND SCOPE

Millions of American homes, including apartments in multifamily residential buildings, will be retrofitted in the coming years to renovate their existing structure, improve energy efficiency, improve long-term durability and ensure good indoor air quality (IAQ). Some upgrade activities, however, might negatively affect IAQ if the appropriate building assessment is not made before work begins and issues that can compromise IAQ are not identified and properly addressed. The U.S. Environmental Protection Agency (EPA) developed this document, ***Energy Savings Plus Health: Indoor Air Quality Guidelines for Multifamily Renovations***, to provide practical guidance to ensure healthy indoor environments during multifamily residential building upgrades, retrofits and renovations (including energy upgrades), and to maintain the building upgrades after dwelling units are reoccupied.

In 2021, EPA released an updated version of ***Energy Savings Plus Health: Indoor Air Quality Guidelines For Single-Family Renovations*** (402K21001), which applies primarily to existing single-family homes. The opportunities and challenges to maintain or improve IAQ while upgrading single-family homes often differ from those encountered in multifamily residential buildings. Multifamily spaces, equipment and decision-making often are shared and, in the case of leased space, dependent on the building owner/developer. In addition, some multifamily residential buildings are classified as mixed-use, meaning the buildings can contain, for example, retail spaces, parking garages, conference and meeting rooms, offices, health clubs or aerobic rooms, and beauty or nail salons, in addition to dwelling units.

This Guide applies to multifamily residential buildings containing more than one dwelling unit that share one or more building systems. Each multifamily dwelling unit typically shares at least a floor or a ceiling and one or more walls with other dwelling units. Multifamily residential buildings can range from low-rise to high-rise buildings. A low-rise multifamily residential building is a structure of up to three stories, a mid-rise multifamily residential building has four or five stories, and a high-rise multifamily residential building has six stories or more.

Because of the unique complexities of multifamily residential buildings, this Guide differs from EPA's protocols for single-family homes. For example, the following issues can be significantly different in, or unique to, multifamily residential buildings:

- Environmental tobacco smoke
- Garage air pollutants
- Pests

- Radon
- Heating, ventilation and air conditioning equipment
- Compartmentalization to prevent odor or unwanted air transfer
- Local exhaust
- Mechanical ventilation systems for individual dwelling units
- Mechanical ventilation systems for multiple dwelling units
- Natural (not fan-powered) ventilation systems
- Multifamily building safety
- Protecting IAQ during construction
- Operations and maintenance staff training
- Occupant education

Important Basic Considerations for Protecting IAQ During Building Upgrades

Several energy retrofit and building upgrade activities can cause or aggravate IAQ problems, as described in detail throughout this publication; however, these important basic considerations must always be kept in mind:

- **Occupants' and workers' exposure to airborne contaminants generated during and after building upgrade activities should be minimized.**

Building upgrades can disturb existing contaminants known to cause health problems. Some of these contaminants have specific regulatory requirements (e.g., asbestos, lead) that must be followed.

- **Reducing air leakage across the building envelope should not be performed without ensuring that there will be adequate venting of combustion appliances and outdoor air ventilation to dilute and remove pollutants from within the building after the project is completed.**

Modifications that increase the airtightness of a building's envelope increase the potential for elevated levels of contaminants indoors. Care must always be taken to ensure that these activities do not cause improper venting of combustion appliances and increase occupant exposure to combustion byproducts, including carbon monoxide; introduce increased indoor exposures to other pollutants; or introduce or exacerbate moisture and mold problems within the building.

This Guide is intended for use during multifamily residential building upgrades, renovations and remodeling, including energy efficiency upgrades. The intended audience includes building owners, rehabilitation professionals, contractors and others involved with renovation and remodeling efforts, which include energy-focused residential retrofits. The Guide also can be adopted or used by federal, state, tribal and local weatherization assistance programs; federally funded housing programs; industry standards organizations; private-sector home performance organizations; and other contracting organizations. EPA developed the original version of this voluntary Guide in coordination with the U.S. Department of Energy (DOE) [Standard Work Specifications for Home Energy Upgrades](#).

Programs and contractors undertaking building upgrades are encouraged to coordinate their activities with local health and housing authorities for multifamily residential buildings to provide building owners, property managers and occupants the support they may need.

This document does not do any of the following:

1. Set new EPA regulatory requirements or in any way modify or supersede existing EPA regulatory requirements.
2. Provide guidance on diagnosing occupant health problems or building-related illness.
3. Address emerging issues that have not been linked to adverse health effects.
4. Make training or training documents unnecessary.
5. Provide detailed implementation guidance on how to achieve each recommendation in all situations.
6. Identify funding availability or which programmatic funding sources should be used.
7. Provide guidance for prioritizing building-specific projects during the upgrade process.

HOW THIS GUIDE IS ORGANIZED

This document is organized by Priority Issue (PI) to highlight important indoor environment issues that may relate to home renovations. Each PI has an introduction that provides brief background on why the PI should be considered during a project as it relates to health. Each PI includes a recommended assessment protocol, along with a set of potential actions (minimum or expanded) to be taken during the retrofit project, as described below:

1. **Assessment Protocols** are EPA-recommended or EPA-required protocols for evaluating existing conditions of concern and the potential for additional concerns that may arise from retrofit activities.
2. **Minimum Actions** include critical actions that those performing the work should take to help ensure that their work does not introduce new IAQ concerns or make existing conditions worse.
3. **Expanded Actions** include additional actions to promote healthy indoor environments that can be taken during many energy retrofit projects, if budget and resources allow. National standards and guidance also are referenced; however, work should be conducted in compliance with state and local requirements, as well. All equipment removal should include proper disposal so that hazardous units are not reinstalled or used elsewhere.

National standards and guidance documents related to these guidelines are listed at the end of each PI in an abbreviated format that can be identified with more detailed information in [Appendix D: References](#). However, work should be conducted in compliance with state and local requirements, as well. All equipment removal should include proper disposal so that hazardous units are not reinstalled or used elsewhere.

More detailed information can be found in [Appendix A: Compartmentalization—Additional Information](#) and [Appendix D: References](#). Frequently used abbreviations and acronyms are presented in [Appendix E](#).

The following icons are used in this Guide:



Worker Protection

Indicates an issue that references [Appendix B: Worker Protection](#) for recommended actions and additional resources to minimize health and safety risks for workers performing the building upgrades.



Client Education

Indicates an issue that references [Appendix C: Property Management and Occupant Education](#) for additional information and resources on important building upgrade considerations to ensure that property managers and building occupants do their part to maintain a healthy indoor environment before the upgrade, during the retrofit activities and after the building upgrade is complete.

Examples of multifamily residential building upgrade projects are identified in [Appendix C](#), Table 1, accompanied by descriptions of the IAQ/health risks and opportunities that may be encountered, and in the potentially applicable PIs of this Guide.

Section 2: Assessment Protocols and Recommended Actions



CONTAMINANTS¹ AND SOURCES

PRIORITY ISSUE 1.0: ASBESTOS

Asbestos is a mineral fiber that was used in a variety of building construction materials for insulation and as a fire retardant. Asbestos-containing material (ACM), such as insulation, may be found in attics, within walls and on heating systems (e.g., on boilers and hot water/steam pipes). Asbestos was also used in floor tiles, wallboard and other building materials. When materials containing asbestos are disturbed or damaged, fibers and particles can be released into the air, where they can be inhaled, increasing the risk of developing lung diseases, such as asbestosis (lung scarring), lung cancer and mesothelioma (a cancer of the abdominal lining).



ASSESSMENT PROTOCOLS (AP)

AP 1.1 Determine Potential Asbestos Hazard

Consider the age of the structure—in particular, homes built between the 1930s and the 1970s are more likely to have asbestos-containing building material.

Possible sources of asbestos include, but are not limited to, the following:

- Attic insulation (especially vermiculite)
- Wall insulation (e.g., vermiculite, insulation blocks)
- Insulation on hot water/steam pipes, boilers and furnace ducts
- Vinyl flooring (including 9 × 9-inch or 12 × 12-inch floor tiles, vinyl sheet flooring, and mastics and other adhesives used to secure the flooring)
- Cement sheet, millboard and paper used as insulation around furnaces and wood- or coal-burning appliances
- Door gaskets in furnaces and wood- or coal-burning appliances (seals may contain asbestos)
- Soundproofing or decorative surface materials sprayed on walls or ceilings, including popcorn ceilings
- Patching and joint compounds and textured paints on walls and ceilings
- Roofing, shingles and siding (including cement or adhesives)
- Artificial ashes and embers (used in gas-fired fireplaces)
- Transite (cement and asbestos) HVAC ducts, combustion vent or transite flue
- Original plaster



¹ Contaminants are listed alphabetically and are not in order of importance or prioritized in any way.



If unsure whether the material in question contains asbestos, contact a qualified asbestos professional to assess the material before performing retrofits or any renovations.

Notes

- The EPA vermiculite guidance referenced in the Relevant Standards or Guidance section includes photos to help identify vermiculite insulation.
- Expanded perlite, another mineral product often used in building materials that is not known to contain asbestos, can be mistaken for vermiculite.
- Although perlite is generally white in color, compared with the gray-to-brown coloring of vermiculite, visual identification can be difficult because of natural variations of the material.
- If you are unsure whether the material in question is vermiculite or perlite, contact a qualified asbestos professional for assistance.

MINIMUM ACTIONS (MA)

MA 1.1 Avoid Disturbance

If suspected ACM is undamaged and does not need to be disturbed as part of the retrofit activity, do not disturb it.



MA 1.2 ACM—Damaged Material

If suspected ACM is damaged (e.g., unraveling, fraying, breaking apart), immediately isolate the area(s). For example, separate the work area in question from occupied portions of the building using appropriate containment practices AND do not disturb. For suspected ACM that is damaged or that must be disturbed as part of the retrofit activity, contact an asbestos professional for abatement or repair, in accordance with federal, state and local requirements. EPA recommends using only a licensed or trained professional to abate, repair or remove ACM in homes. To find a trained and accredited asbestos professional check the list for your state asbestos contacts

Typically, trained professionals can repair asbestos by doing one of the following:

- Sealing or encapsulating—Treating the material with a sealant that either binds the asbestos fibers together or coats the material so that fibers are not released. Pipe, furnace and boiler insulation often can be repaired this way.

- Covering or enclosing—Placing a protective layer over or around the ACM to prevent the release of fibers or covering exposed insulated piping with a protective wrap or jacket.
- Removing—Removing ACM is recommended when remodeling or making major changes to a home that will disturb ACM or if ACM is damaged extensively and cannot be repaired otherwise (by covering, enclosing, sealing or encapsulating).

MA 1.3 Work Practices to Avoid

When working around ACM—

- Do not dust, sweep or vacuum ACM debris.
- Do not saw, sand, scrape or drill holes in the material.
- Do not use abrasive pads or brushes to strip materials.
- Do not track material that could contain asbestos through the house.

Do not remove or disturb insulation that looks like vermiculite (e.g., attic or wall insulation). Testing may be performed to confirm whether vermiculite contains asbestos. However, insulation materials throughout the home may have been sourced from different locations, and obtaining a representative sample from all building cavities with vermiculite may be impractical. As such, you should assume that it contains asbestos and manage it accordingly. Hire a professional asbestos contractor if planned renovations would disturb vermiculite in attics or walls to make sure that the material is handled or removed safely.

Any asbestos abatement or repair work should be completed before blower door testing. Exercise appropriate caution when conducting blower door testing where friable asbestos or vermiculite attic insulation is present to avoid drawing asbestos fibers into the living space (i.e., use positively pressurized blower door testing). Do not conduct air leakage tests (e.g., duct blaster tests) on ductwork that contains asbestos insulation.

Notes

- Appropriate identification of ACM or awareness that it is likely present is necessary to ensure the continued safety of the occupants and the safety of workers who may not be aware of asbestos hazards.
- If ACM may be disturbed during a planned retrofit, use a qualified and trained person to conduct an initial exposure assessment to determine potential worker exposures and required exposure controls.





- Asbestos awareness training is recommended for retrofit workers, especially auditors and crew chiefs.
- Asbestos awareness training is recommended for building upgrade workers, especially work planners and crew chiefs.
- If working in a building built before 1980, see [Appendix B: Worker Protection](#) (Asbestos; Confined Spaces).

EXPANDED ACTIONS (EA)

This section is intentionally left blank.

Relevant Standards or Guidance

- Find Labs for Testing Asbestos: [EPA Asbestos Professionals](#)
- The National Institute of Standards and Technology (NIST) maintains a list of asbestos laboratories accredited under the National Voluntary Laboratory Accreditation Program (NVLAP). Call NIST at (301) 975-4016 or email nvlap@nist.gov.
- ASTM (formerly known as American Society for Testing and Materials) E2600
- Building Performance Institute (BPI) Technical Standards: Technical Standards for the Heating Professional
- Department of Labor (DOL), Occupational Safety and Health Administration (OSHA), 29 Code of Federal Regulations (CFR) Part 1926, Subpart Z
- [DOL, OSHA, Asbestos](#)
- [DOL, OSHA, Asbestos—Construction](#)
- EPA [Asbestos](#)

PRIORITY ISSUE 2.0: BELOWGROUND CONTAMINANTS (EXCEPT RADON)

Belowground contaminants, organic and inorganic chemicals in soil or ground water, can result from a variety of intended, accidental or naturally occurring activities and events, such as manufacturing, mineral extraction, waste disposal, accidental spills, illegal dumping, leaking underground storage tanks, hurricanes, floods, pesticide use and fertilizer application. Some belowground contaminants can enter buildings through structural holes and cracks and cause health problems for some occupants. Contaminants in soil gas may include toxins from former industrial sites, local pesticide applications, spills, nearby dry cleaners or leaking landfills, abandoned or leaking gasoline or fuel storage tanks, and so forth. There are many potential belowground contaminants with many possible health effects.

ASSESSMENT PROTOCOLS

AP 2.1 Evaluate Potential Sources and Odors

Perform a walkthrough inspection and visually evaluate potential sources and check for gasoline, sewer gas or fuel oil odors. Pay particular attention to ground-contact spaces; mechanical rooms; and areas with drain, waste and vent piping. Inquire about occupant complaints of odors that might originate from the sewer system or beneath the building.

AP 2.2 Evaluate the Sewer Vent System

Visually evaluate the integrity of the sewer vent system (e.g., ensure that drain traps have water in them, inspect drain lines for breaks or leaks, check for apparent blockages), particularly if there is sewer gas odor in the building (e.g., during the initial assessment or a fan depressurization test).

AP 2.3 Take Proper Actions if the Odor Source Cannot Be Identified

If an odor is detected but its source cannot be identified and the building is in a known area of contamination, notify local or state authorities and/or pursue additional assessments before continuing project work.

AP 2.4 Conduct Further Assessment if Contamination Is Suspected

Contaminated soil gas can enter buildings through cracks, gaps and holes in foundation floors and walls. Sources of contaminants in soil gas may include former industrial sites, local pesticide applications, spills, nearby dry cleaners or leaking landfills, abandoned or leaking gasoline or fuel storage tanks, etc.

If soil or groundwater contamination is suspected on or near the building site (e.g., former industrial site), volatile contaminants or breakdown products may pose an IAQ risk through soil gas intrusion. In such cases, EPA recommends further assessment before air sealing. Consult your state or tribal voluntary Brownfields program or environmental regulatory agency for information on the risks of vapor intrusion in your area. ASTM E2600 describes a tiered approach for screening properties for vapor intrusion, and Table X5.1 of the standard provides a list of state vapor-intrusion guidance websites.

Note

A records search of the property and surrounding areas may provide information regarding past uses and spill reports.

MINIMUM ACTIONS

MA 2.1 Correct Sewer Vent Problems

Repair or replace failed or unattached sewer vent system components before proceeding with energy retrofits or renovation. If the assessments reveal sewer gas odors from drain traps that are dry because of infrequent use, fill the traps with a nontoxic liquid that has a slow evaporation rate (e.g., mineral oil).

MA 2.2 Address Drain Traps Prone to Drying Out

If the assessments reveal sewer gas odors from drain traps that are dry because of infrequent use, develop a maintenance plan to periodically add water to the traps or fill the traps with a non-toxic liquid that has a slow evaporation rate (e.g., mineral oil) to maintain a seal against sewer gases.

Note

Because of their continuous usage, drain traps in sinks, toilets and drinking fountains seldom are a problem. Usually it is a floor drain in an obscure location, such as a mechanical room or a maintenance closet. Dry drain traps in mechanical rooms are especially problematic, because mechanical rooms often contain heating, cooling and ventilation systems that can quickly spread the gases and odors to other parts of the building. Unitary equipment (e.g., heat pumps) can have dry drain traps, which often results in the undesirable odors' being limited to one room.

MA 2.3 Mitigate Soil Gas Vapor Intrusion

If soil gas vapor intrusion is confirmed during the assessments, mitigate in compliance with state or local standards—if within the scope of the upgrade project. Table X5.1 of ASTM E2600 provides a list of state vapor intrusion guidance websites. If there are no state or local standards for your area, follow [EPA's Engineering Issue: Indoor Vapor Intrusion Mitigation Approaches](#).

Note

The causes or sources of contaminants must be identified and corrected before air sealing or other building upgrade actions are performed to ensure that the problem is not exacerbated.

EXPANDED ACTIONS

EA 2.1 Install Floor Drain Seals to Untrapped Floor Drains

If there are untrapped floor drains, install inline floor drain seals to provide protection against sewer gases.

EA 2.2 Install Automatic Drain Trap Primers

Install automatic drain trap primers, available from several major manufacturers, in drain traps that are susceptible to drying out to ensure that a small amount of water is delivered periodically to the trap.

EA 2.3 Take Proper Measures for Brownfields Sites During New Construction or Building Expansion

Projects located on brownfields sites (as classified by a federal, state or local government agency) involving new construction or expansion of a ground-level foundation should include features to prevent migration of soil-gas contaminants into occupied spaces, as described in the ASHRAE [Indoor Air Quality Guide, Best Practices for Design, Construction, and Commissioning](#), Strategy 3.4.

Relevant Standards or Guidance

- ASHRAE Indoor Air Quality Guide
- American Society of Plumbing Engineers (ASPE) Databook
- American Society for Testing and Materials (ASTM) E2121
- EPA Brownfields and Land Revitalization Projects Near You
- [EPA: IAQ Design Tools for Schools. Preventing the Entry of Pollutants from Outside the Building. Drain Traps](#)
- [EPA: Vapor Intrusion](#)

Follow the guidance in these documents while complying with state and local standards:

- ASTM E2600
- EPA Office of Solid Waste and Emergency Response (OSWER) Draft Guidance for Evaluating Vapor Intrusion
- EPA Vapor Intrusion Mitigation Approaches
- EPA: Steps to Safe Renovation and Abatement of Buildings That Have PCB-Containing Caulk

PRIORITY ISSUE 3.0: BUILDING PRODUCTS/MATERIALS EMISSIONS

Potentially important sources of IAQ contaminants are interior building materials, furniture and equipment. Interior building materials—including carpets, carpet padding, paints, sealants and caulking, adhesives, floor and ceiling tiles, cabinets, molding, composite wood products, and other woodwork—can contain contaminants that are gradually emitted (off-gassed) throughout the life of the material. The contaminants include VOCs and semi-volatile organic compounds (SVOCs) and small particulate substances that act as eye or throat irritants.



ASSESSMENT PROTOCOLS

AP 3.1 Review Content and Emissions Documentation for New Products

Review information on the chemical content and emissions for products being considered for purchase and installation during the building upgrade project to determine whether they contain potentially hazardous compounds. Many of these products and materials (e.g., plywood, particleboard, pressed wood, insulation, paints, sealants, cleaning supplies) may contain VOCs or other hazardous compounds to which exposure should be minimized or eliminated during and after the upgrade project.

AP 3.2 Carpet

Identify carpet that is old or in areas prone to wetting or moisture problems, or other fleecy materials that have adsorbed chemical, particle and microbiological contaminants over time and that can release those contaminants back into the air.

AP 3.3 Ventilation

Assess ventilation to determine compliance with the Minimum Actions and Priority Issues [19.0](#), [20.0](#) and [21.0](#).

Note

- Dilution using ventilation will help reduce VOCs and other airborne contaminants from indoor sources in most homes.

In most circumstances, testing for VOCs is not necessary. If odors or occupant complaints indicate potential VOCs or other airborne contaminants, follow the source control and ventilation actions under Minimum Actions and Expanded Actions.



If working with materials associated with chemical emissions or dust generation, including spray polyurethane foam insulation, see [Priority Issue 24.0: Jobsite Safety](#) and [Appendix B: Worker Protection](#).

MINIMUM ACTIONS

MA 3.1 Minimize Occupant and Worker Exposure to VOCs or Other Airborne Contaminants

- Using appropriate dust-control and protective equipment, ensure the proper isolation (e.g., by sealing with plastic sheeting) and exhaust ventilation to the outdoors of work areas during activities that result in VOC emissions (e.g., installing spray foam insulation, painting, sealing, finishing) AND ventilating as close as possible to the source of contaminant emissions.
- Thoroughly clean work areas and allow odors to dissipate before reoccupancy.
- After the use of a product, building occupants and other unprotected individuals may need to be evacuated from work areas for some period of time, per the manufacturer's recommendations.

MA 3.2 Remove Contaminated Building Materials

- Using appropriate personal protective equipment (PPE), remove contaminated building materials found during assessment that cannot be salvaged. These materials should be **double-bagged** in 6-mil or thicker polyethylene bags. The bagged materials usually can be **discarded** as ordinary construction waste. Packaging mold-contaminated materials in sealed bags before removing them from the containment area is important to minimize the spread of mold spores throughout the building. Large items that have heavy mold growth should be covered with polyethylene sheeting and sealed with duct tape before being removed from the containment area.

MA 3.3 Select Least Toxic Materials

When installing new materials, consider using the least toxic product or material that is feasible to effectively do the job.

- **Paints:** Use products that meet VOC content limits for their respective category and VOC content limits for any colorants added to the final product in accordance with South Coast Air Quality Management District (SCAQMD) "Rule 1113—Architectural Coatings, Amended February 5, 2016."
- **Flooring:** Use products that, when tested, meet the California Department of Public Health (CDPH) Standard Method V1.2-2017 for the Testing and

Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers, the VOC emission–testing method for California Specification 01350. Examples of green label programs consistent with the standard method are listed below by flooring type:

- **Carpet:** Carpet and Rug Institute (CRI) Green Label Plus; GREENGUARD
- **Smooth and Resilient Flooring:** FloorScore®, GREENGUARD Gold, Scientific Certification Systems (SCS) Indoor Air Advantage
- **Adhesives:** Use mechanical or peel-and-stick products. Other products should meet SCAQMD Rule 1168 VOC content limits.
- **Composite Wood:** Use materials compliant with Toxic Substances Control Act (TSCA) Title VI or California 93120 Phase 2 requirements. Beginning June 1, 2018, composite wood products sold, supplied, offered for sale, manufactured or imported in the United States are required to be labeled as California Air Resources Board (CARB) Airborne Toxic Control Measures (ATCM) Phase II or TSCA Title VI compliant. Beginning on March 22, 2019, composite wood products must be labeled as TSCA Title VI compliant. These products include hardwood plywood, medium-density fiberboard and particle board, and household and other finished goods containing these products.

MA 3.4 Post-Construction Flush-Out With Outdoor Air

- After construction is completed, ventilate the renovated building/spaces with the design outdoor air ventilation rates before occupancy resumes. Ensure that HVAC systems are operational and capable of adequately controlling indoor humidity levels during the flush-out. Do not conduct a “bake-out” in an attempt to reduce VOC emissions after the building is occupied, because it may cause VOCs to be absorbed by other interior materials and may damage building components.



If possible, follow the post-construction flush-out requirements specified in IgCC 2018/[ASHRAE Standard 189.1-2017](#), Section 10.3.1.4(b), which requires a total number of air changes corresponding to the ventilation system operating at its design outdoor airflow rate continuously, 24 hours per day, for 14 days. A longer flush-out period can be used if there are concerns or complaints about IAQ after the initial flush-out. Additional, periodic flush-out also may be needed for spaces that have intermittent or infrequent occupancy and are not ventilated for extended periods.

EXPANDED ACTIONS

EA 3.1 Hard Surface Flooring

Remove carpeting or other fleecy material, identified during the assessment, that is old or in areas prone to wetting or moisture problems and install only water-resistant hard-surface flooring. Areas prone to wetting include but are not limited to kitchens, bathrooms, entryways, laundry areas and utility rooms.

EA 3.2 New Products Source Control Expanded

When available, choose products and materials that meet stricter independent certification and testing protocols, such as—

- **Paints:** Use products that have (1) VOC emissions compliant with the CDPH Standard Method V1.2–2017 **AND** (2) VOC content meeting SCAQMD Rule 1113. MPI Green Performance® Standards Extreme Green and Green Wise Gold are consistent with these VOC content and emission standards.
- Use paints that do not contain nonylphenol ethoxylate (NPE). (See Health Product Declarations [HPDs] to identify NPE-free products.)

EA 3.3 Existing Condition Source Control/Supplemental Ventilation

If odors, complaints or testing indicate potential VOCs or other airborne contaminants, remove any potential sources (e.g., hobby materials, fiberglass that may contain formaldehyde) from the room or area. If removal is not feasible, consider installing local exhaust ventilation for sources that are isolated in a specific room or area.

EA 3.4 Added Precautions

To reduce emissions of VOCs, including formaldehyde, from composite wood products (e.g., particle board, pressed wood), minimize edges and seal accessible surfaces, including cut edges and holes, especially those of materials manufactured prior to June 2018 (when federal regulations required formaldehyde emission compliance with TSCA Title VI). Use sealants intended to reduce VOC emissions. If these actions do not solve existing problems (e.g., persistent odors, occupant complaints), hiring an environmental professional may be necessary.

EA 3.5 Testing

If VOCs appear to be present based on odors or complaints and source control or ventilation do not alleviate the problem, testing by a qualified professional may be useful.

EA 3.6 Post-Construction Flush-Out or Post-Construction Baseline IAQ Monitoring Per ASHRAE Standard 189.1

After construction is completed, meet the requirements of IgCC 2018/[ASHRAE Standard 189.1-2017](#) section 10.3.1.4(b) for either a flush-out or baseline IAQ monitoring before occupancy resumes in the renovated building/spaces. A flush-out period longer than specified in IgCC 2018/[ASHRAE Standard 189.1-2017](#) can be used if there are concerns or complaints about IAQ after the initial flush-out. Additional periodic flush-out also may be needed for spaces that have intermittent or infrequent occupancy and are not ventilated for extended periods.

EA 3.7 Promote Transparency of Chemical Constituents in Products and Materials

To promote transparency of chemical constituents associated with the manufacture of a product and substances residing in the final product, use products that have submitted their complete chemical inventory to a third party for verification. Make the verification/certification by the third party publicly available.



Relevant Standards or Guidance

- American Chemistry Council: Spray Polyurethane Foam Health and Safety
- [ASHRAE: Indoor Air Quality Guide](#), Strategies 5.1 and 5.2
- [California Department of Public Health: Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources using Environmental Chambers V1.2–2017 \(Emission Testing Method for California Specification 01350\)](#)
- [California Title 17 ATCM to Reduce Formaldehyde Emissions from Composite Wood Products](#)
- [CARB Composite Wood Products ATCM Phase 2](#)
- [Carpet and Rug Institute: Green Label Plus](#)
- [Collaborative for High Performance Schools: High Performance Products Database](#)
- CRI: Green Label Plus
- [EPA Safer Choice](#)
- EPA SPF: Quick Safety Tips for Spray Polyurethane Foam Users
- [EPA: Formaldehyde Emission Standards for Composite Wood Products](#)
- [EPA: Indoor airPLUS Construction Specifications](#)
- [EPA: Volatile Organic Compounds' Impact on Indoor Air Quality](#)
- FloorScore®

- GreenGuard Gold
- [Green Seal: Green Seal Standard for Paintings and Coatings, GS-11](#)
- Green Wise Gold
- HPDs
- IgCC 2018/[ASHRAE Standard 189.1-2017](#)
- [Master Painters Institute: Green MPI Performance Standards, MPI-GS-2, Extreme Green, Greenwise Gold](#)
- [Resilient Floor Covering Institute: FloorScore®](#)
- SCAQMD Rule 1113 and Rule 1168 VOC content limits
- SCS Indoor Air Advantage
- [SCS-EC10.3-2014, Environmental Certification Program, Indoor Air Quality Performance](#)
- [TSCA Title VI: Formaldehyde Standards for Composite Wood Products](#)
- [UL Environment: GREENGUARD Gold Certification Program](#)

PRIORITY ISSUE 4.0: ENVIRONMENTAL TOBACCO SMOKE

Environmental tobacco smoke (ETS) exposures increase the risks of lung cancer, heart disease, ear infections, sudden infant death syndrome and other health issues.

ASSESSMENT PROTOCOLS



AP 4.1 Determine Whether There Is a Smoke-Free Policy

Determine if the building has a smoke-free policy prohibiting smoking in common areas; residential dwelling units; and exterior areas within specified distance (e.g., 10, 20 or 25 feet) of the building's operable windows, outdoor air intakes and entryways.

AP 4.2 Identify Occupants' Smoking-Related Concerns

Assess whether there has been a pattern of complaints from occupants about smoking odors or other smoking-related concerns.

AP 4.3 Assess Whether Compartmentalization Is a Possible ETS Control Strategy in Buildings Without a Smoke-Free Policy

Identify spaces in the building with strong ETS sources that can be isolated using compartmentalization techniques. The intent is to reduce ETS migration by maintaining airtightness, controlling pressure differences, and limiting uncontrolled airflow and cross-contamination among spaces.

- Identify the ETS migration pathways due to pressure differences within the building and across the building envelope, which can be caused by a variety of factors (e.g., thermal stack effect, improperly designed and maintained mechanical ventilation, inadequate air balance, operation of combustion appliances).
- Make visual observations or use infrared thermography, chemical smoke, and/or pressure testing to identify all penetrations at the perimeter of the space/dwelling unit that can be air sealed to reduce ETS transfer. ASTM E1186-03 (2009) Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems can be used to guide the air-sealing assessment.
- Inspect and identify all joints, seams and leaks in the ventilation duct system that can be sealed.

MINIMUM ACTIONS

Eliminating ETS through a building-wide smoke-free policy is the most effective and cost-efficient method of controlling ETS. There is no safe level of ETS exposure, and no engineering technique can eliminate ETS infiltration.

MA 4.1 If There Is No Smoke-Free Policy, Encourage Adoption

If the building does not have an interior and exterior smoke-free policy, provide the owner information on key steps to implement a policy. Such policies prohibit smoking inside the building and outside within a specified distance (e.g., 10, 20 or 25 feet) from the building's operable windows, entryways and outdoor air intakes. Consult HUD Tool Kit and Public Health Advocacy Institute (PHAI) resources. [See Appendix C: Property Management and Occupant Education](#) for guidance on implementing a smoke-free policy.

MA 4.2 If a Smoke-Free Policy Is Not Feasible

Consider the below actions when feasible, in the following order, for the most effective ETS control strategy: (1) Source Control, (2) Ventilation and Air-Pressure Control, and (3) Air Sealing. These actions can help to reduce ETS migration but will not eliminate it.

1. Source Control

- Propose identifying dwelling units where smoking is not allowed, and physically locate these units as far as possible from units where smoking is allowed. Wind- or temperature-induced stack effect and window operation can have a large impact on air transfer between units on different floors. If possible, locate the smoking units higher in the building, where there often is more air exfiltration to the outdoors, which also will make the other compartmentalization strategies more effective.

2. Ventilation and Air-Pressure Control

- Follow the Minimum Actions in Priority Issues [18.0](#), [19.0](#), [20.0](#) and [21.0](#), as applicable to the type of ventilation system.
- For dwelling units served by a central exhaust ventilation system, balance airflows for each unit by sealing duct/shaft leaks and installing air-balancing devices (such as constant airflow regulators or orifice plates) at the exhaust points in each dwelling unit. When flows are the same from adjacent dwelling units with similar leakage characteristics, there is less potential for air and odor transfer between units.

- If possible, increase outdoor air supply ventilation rates to non-smoking dwelling units to pressurize the units and reduce infiltration.

3. Air Sealing

- Follow compartmentalization approaches determined to be a required part of the upgrade project; refer to [Priority Issue 16.0: Compartmentalization to Prevent Odor or Unwanted Air Transfer](#) and [Appendix A: Compartmentalization—Additional Information](#).

MA 4.3 Additional Actions If There Is a History of Complaints and a Smoke-Free Policy Is Not Feasible

If there is a pattern of ETS-related complaints and a smoke-free policy is not feasible, consider additional compartmentalization actions.

EXPANDED ACTIONS

EA 4.1: Added Air Sealing to Address Complaints

- Isolate non-smoking units from smoking units by air sealing the bounding walls, floors and ceilings of either or both. Air sealing occupied units is difficult, because the air leakage sites are hidden by belongings, furnishings, floor coverings, cabinets, appliances, walls, floors and ceilings. In addition to tobacco smoke compartmentalization helps to solve pest and odor problems. See [Appendix A: Compartmentalization—Additional Information](#) for details.
- Conduct a blower door test on each unit or a sampling of units to identify air leakage sites and then quantify the reduction in air leakage.

Refer to [Priority Issue 16.0: Compartmentalization to Prevent Odor or Unwanted Air Transfer](#) and [Appendix A: Compartmentalization—Additional Information](#) for more information on isolating dwelling units.

Note

The activities above are intended to further reduce, but not eliminate, ETS migration.

Relevant Standards or Guidance

- [ASHRAE Standard 62.2-2019, Ventilation and Acceptable Indoor Air Quality in Residential Buildings](#)
- [ASHRAE Standard 189.1-2017, Standard for the Design of High-Performance Green Buildings](#)
- [ASTM E779-19: Standard Test Method for Determining Air Leakage Rate by Fan Pressurization](#)
- [ASTM E1186-17: Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems](#)
- [ASTM E1827-11\(2017\): Standard Test Methods for Determining Airtightness of Buildings Using an Orifice Blower Door](#)
- [HUD: Smoke Free Housing—A Tool Kit for Owners/Management Agents](#)
- [Minnesota Center for Energy and Environment \(MNCEE\): Reduction of Environmental Tobacco Smoke Transfer in Minnesota Multifamily Buildings Using Air Sealing and Ventilation Treatments](#)
- [NCHH: Improving Ventilation in Existing or New Buildings with Central Roof Exhaust](#)
- [NCHH: Improving Ventilation in Multi-Family Buildings That Do Not Have Fan-Powered Ventilation](#)
- [NCHH: Improving Ventilation in New and Existing Multi-Family Buildings with Individual Unit Ventilation Systems](#)
- [Public Health Advocacy Institute \(PHAI\): Smoke-Free Homes](#)
- [UL: Fire-Resistance and Smoke Protection](#)

PRIORITY ISSUE 5.0: GARAGE AIR POLLUTANTS (CARBON MONOXIDE, BENZENE AND OTHER VOCs)

Garage air pollutants (e.g., benzene, carbon monoxide [CO], other volatile organic compounds [VOCs]) may be generated by car emissions and stored household products and, when inhaled, can increase risks of respiratory tract irritation, nervous system damage and cancer.



ASSESSMENT PROTOCOLS

AP 5.1 Identify Location and Configuration of Attached Garages

Identify whether the building has any attached garages. Underground or tucked-under garages, with or without openings to the outdoors, should be considered as attached garages. An attached carport not open to the outside on at least two sides also should be considered an attached garage.

AP 5.2 Check for HVAC Systems Inside Garage

Identify whether HVAC components (such as air-handling equipment and ductwork) serving occupied spaces are inside the envelope of the attached garage.

AP 5.3 Locate Air Leaks

Using ASTM E1186-17, identify all air leaks between the attached garage and occupied spaces that share a surface with the garage.

AP 5.4 Determine Presence of Combustion Appliances or Engines

Identify whether any combustion appliances, hobby equipment, or engines other than automobiles and trucks are operated in the attached garage.

AP 5.5 Occupant Complaints

Inquire about occupant complaints of odors that might originate from the garage.

MINIMUM ACTIONS

MA 5.1 Eliminate or Minimize Unwanted Air Transfer to Dwelling Units via Mechanical Equipment and Ductwork

Do not install in a garage new HVAC equipment or ductwork that serves occupied spaces. Do the following for existing air-handling equipment and ductwork that serves occupied spaces and is located in a garage:

- Air seal all ductwork and fittings. Seal seams, plenums and ductwork with tape and mastic systems that meet the applicable requirements of UL 181A or UL 181B or with gasket systems.
- Seal gaps around ductwork, pipes and cables that penetrate the common walls, floors and ceilings separating occupied spaces from garages.
- Because existing air-handler cabinets are likely to have high leakage rates, seal access panel edges with tape to allow future servicing and permanently seal all other cabinet openings.
- Disconnect and remove supply diffusers and return grilles in the garage that connect to ductwork and air handlers serving occupied spaces; close with end caps and air seal the gaps.

Note

- This may have an effect on your HVAC system's performance. An HVAC professional should be utilized to ensure proper function.
- Cold climate combustion air louvers directed to the outdoors may require interlocked mechanical dampers to prevent pipe freezing.

MA 5.2 Compartmentalize Garage From Occupied Spaces

Isolate the garage from adjacent occupied spaces. For large openings, use sealed gypsum wall board in conformance with the 2018 International Building Code requirements for fire and smoke separation (i.e., at least 1/2" thick on the walls and at least 5/8" thick on the ceiling separating the garage and the occupied spaces above). Tightly seal all penetrations, including electrical, plumbing and duct penetrations through common walls, floors and ceilings separating occupied spaces from garages.

- In occupied conditioned spaces above the garage, seal all connecting floor and ceiling joist bays.
- In occupied conditioned spaces next to the garage, apply weather stripping to all doors, and seal all cracks at or between the mud sill, rim joists, subfloors and the bottom of gypsum board.
- Ensure that a CO alarm is installed in every room that shares a floor, ceiling or wall with the garage.

If possible, include a vestibule that provides an airlock between the garage and stairwells and adjacent occupiable spaces, or provide self-closing gasketed doors with deck-to-deck partitions or a hard lid ceiling.

Also refer to [Priority Issue 16.0: Compartmentalization to Prevent Odor or Unwanted Air Transfer](#) and [Appendix A: Compartmentalization—Additional Information](#).

Provide an exhaust fan in the garage, vented directly to the outdoors. The exhaust rate shall be at least 0.75 cubic feet per minute (cfm) per square foot of garage floor area, with no air recirculation, provided continuously. Add gaskets to any doors or ports that allow access for exhaust fan servicing.

Exception

- Garages that meet the requirements for open parking garages, as defined by [2018 International Building Code](#), Section 406.5.2 Openings

Advise the building owner or property manager that the use of engine-operated equipment other than automobiles or trucks in the garage may generate pollutants that can negatively affect occupied spaces.

EXPANDED ACTIONS

EA 5.1 Remove Air-Handling Equipment From Garages

Relocate air-handling equipment that serves occupied spaces from the garage to an area within conditioned space.

EA 5.2 Perform Additional Efforts to Compartmentalize Garages From Occupied Spaces

- Where concrete block or other air-permeable material is in place between a garage and conditioned space, provide an air barrier membrane or coating on the garage side of common surfaces to occupied space.
- Construct a vestibule at doorways leading from the garage into the occupied portions of the building and exhaust vent the vestibule to the outdoors.
- Enhance the effectiveness of the garage exhaust system. Consider designing the garage exhaust system so that a portion of the exhaust is used to depressurize common walls, floors and ceilings that separate the garage from occupied space.

Note

Install air-sealing materials according to manufacturer specifications. Fire-rated assemblies must be sealed using approved fire-rated materials.

EA 5.3 Recommend Removal of Combustion Appliance or Engine-Operated Equipment Inside the Garage

Advise the building owner or property manager to remove all combustion appliance or engine-operated equipment (except automobiles and trucks) from inside the garage, where feasible.

Relevant Standards or Guidance

- [ANSI Z223.1/National Fire Protection Association \(NFPA\) 54: National Fuel Gas Code](#)
- [ASTM E1186-17: Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems](#)
- DOE: Standard Work Specifications for Multi-Family Home Energy Upgrades, Sections 3.1501.2, 3.1502.1 and 3.1502.2
- [International Code Council: International Building Code, 2018 Edition, Section 406.5.2](#)
- [International Code Council: International Fuel Gas Code, 2018 Edition](#)
- [Underwriters Laboratories \(UL\): Fire-Resistance and Smoke Protection](#)
- [UL 181A: Standard for Closure Systems for Use With Rigid Air Ducts](#)
- [UL 181B: Standard for Closure Systems for Use With Flexible Air Ducts and Air Connectors](#)

PRIORITY ISSUE 6.0: LEAD

Lead exposure can result in neurological damage, decreases in IQ, learning difficulties, slowed growth and—in rare cases—death. Children and pregnant women are at greatest risk. Exposure sources include peeling, flaking lead-based paint and lead in household dust, soil and water.



Note

EPA's Lead Renovation, Repair and Painting Rule (RRP Rule) requires that firms performing RRP projects that disturb lead-based paint in homes built before 1978 (including many of the projects envisioned in this document) be certified by EPA (or an EPA-authorized state), use certified renovators who are trained by training providers accredited by EPA or an authorized state program, and follow specific lead-safe work practices. There are a few exemptions from the RRP Rule for natural disaster recovery. If you believe you might be eligible for this exemption or for more information go to [EPA's website for renovations after a disaster and dealing with lead-based paint](#).

ASSESSMENT PROTOCOLS

AP 6.1 Assess Paint Conditions

Assume the presence of lead-based paint in homes built before 1978, unless testing shows otherwise. Determine whether paint will be disturbed by the work or the assessment. Identify peeling, bubbled or worn paint, which could contain lead. Identify old painted cribs, old painted furniture or vinyl blinds, as these items may contain lead.

AP 6.2 Testing Method

Hire a contractor certified by EPA or an authorized state program to test all components that will be disturbed to determine if lead-based paint is present. Paint testing can be accomplished using EPA-recognized test kits (available in hardware stores), paint-chip sampling or X-ray fluorescence (XRF) analysis. Check local requirements, as some states do not allow paint testing using test kits. The Minimum and Expanded Actions of lead-safe work practices apply only to paint that is assumed or confirmed to contain lead.

Note

Testing performed by uncertified people, including property owners or property managers, is not sufficient. To learn more about EPA-recognized test kits, visit the EPA [Lead Test Kits](#) web page.

MINIMUM ACTIONS

MA 6.1 Comply With EPA's Lead-Based Paint RRP Program Rule

The rule's key instructions are to—

- Use a certified firm.
- Follow lead-safe work practices if disturbing more than 6 ft² per room of interior or 20 ft² of exterior painted surfaces. These minimum surface areas do not apply to window replacement, use of prohibited practices or demolition.
- Contain the work area to avoid resident exposure.
- Minimize lead dust and leave no dust or debris behind.
- Achieve visual post-cleaning criteria.

MA 6.2 Comply With State and Local Lead-Related Regulations

Such regulations may be applicable to lead hazard reduction activities and may require additional certified personnel.

MA 6.3 Inform Maintenance Staff on Requirements for Lead-Safe Work Practices

Inform maintenance staff that if they will be disturbing lead paint, they must be trained and certified under EPA's RRP program for lead-safe work practices. This includes ensuring the information distribution requirements of EPA's RRP program are met. See [Small Entity Compliance Guide to Renovate Right: EPA's Lead-Based Paint Renovation, Repair, and Painting Program](#).



Ensure that EPA lead hazard standards are met, including requirements for no deteriorated paint and for meeting lead dust clearance testing standards. Dust testing must be done by an EPA- or state-certified inspector or risk assessor. If the job affects an outdoor area, ensure that EPA soil hazard standards also are met.

Note

This is not a complete summary of the regulatory requirements. The intent of this protocol is to provide information regarding regulatory requirements and promote the most health-protective steps that are feasible and practical. The Minimum Action recommended in this protocol is to comply with whatever the most current version of the RRP Program Rule prescribes and with all local and state regulations that may apply.

EXPANDED ACTIONS**EA 6.1 Follow HUD's Lead-Safe Rehabilitation Work Practices**

Follow U.S. Department of Housing and Urban Development (HUD) lead-safe rehabilitation practices. In addition to EPA's RRP, these HUD practices are recommended:

- Do not allow the use of test kits to identify lead-based paint. Acceptable test methods are laboratory or XRF analysis and must be performed by a certified inspector or risk assessor.
- Lower the thresholds for interior painted surface area from 6 ft² to 2 ft² per room or 10 percent of a small component type.
- Require a risk assessment to identify lead hazards and recommend either interim controls or an abatement to address them, depending on the amount of federal assistance.
- Require meeting lead dust clearance testing standards if more than 2 ft² of paint or more than 10 percent of a small component is disturbed.

Note

Lead dust clearance testing includes measuring for lead dust on floors, windowsills and window troughs after the work is conducted. See HUD Guidelines for [Clearance Testing](#).

EA 6.2 Replace Windows Containing Lead-Based Paint

Replace windows that have suspected or known lead-based paint with energy-efficient ENERGY STAR® windows. Repair flaking, peeling or bubbled paint suspected or known to contain lead, following applicable lead-based paint requirements.

EA 6.3 Install Walk-Off Mats

Install walk-off mats in areas with potential lead in soil (e.g., urban areas and neighborhoods with homes built before 1950).

EA 6.4 Replace Lead Service Lines

Determine whether a lead service line (LSL) connects the drinking water main under the street with the building. If an LSL is present, replace it before or while replacing the water heater. Follow ANSI/American Water Works Association (AWWA) C810-17 Standard when replacing the LSL. To determine if the service line is lead, contact the utility company for guidance and inspect the line where it enters the property. See the LSL replacement collaborative source below for additional guidance.



EA 6.5 Client Engagement

Advise clients that older painted cribs, furniture and vinyl miniblinds may contain lead.

Relevant Standards or Guidance

- DOL, OSHA, EPA
- EPA Lead Website
- EPA Lead-Based Paint RRP Program: Small Entity Compliance Guide to Renovate Right
- EPA Post-Disaster Renovations and Lead-Based Paint
- EPA RRP Rule: 40 CFR Part 745, Subpart E
- HUD Lead-Safe Housing Rule: 24 CFR Part 35, Subpart J
- Lead Service Line Replacement Collaborative
- HUD Guidelines for [Clearance Testing](#)

If working in a building built before 1978, see [Appendix B: Worker Protection \(Lead\)](#).



PRIORITY ISSUE 7.0: MOISTURE CONTROL AND MOLD

Excess moisture indoors can support biological growth. Potential health effects and symptoms associated with mold exposures include allergic reactions, asthma and other respiratory complaints. There is no practical way to eliminate all mold and mold spores in the indoor environment; the best way to control indoor mold growth is to control moisture .



ASSESSMENT PROTOCOLS

AP 7.1 Inspect for Moisture Problems

Inquire about occupant complaints of visible suspected mold or water stains or moldy odors that might indicate the presence of a moisture and mold problem.

Inspect the interior and exterior of the building and the building's mechanical systems for evidence of moisture problems. Examples of moisture and mold problems include, but are not limited to, the following:

- Water damage or stains (e.g., on walls, ceilings or floor coverings)
- Foundation cracks that leak water
- Signs of seepage or wicking (e.g., salt deposits left behind from water, peeling paint, delaminating materials)
- Visible mold growth
- Mold growth in ductwork and plenums
- Wet or damp spots
- Musty odor
- Groundwater, surface water and rainwater intrusion
- Plumbing leaks
- Leakage through penetrations in the building envelope (e.g., utility entry points)
- Condensation or moisture damage on and around windows
- Condensation or moisture damage in attics
- Improperly functioning heating, ventilation and air conditioning (HVAC) condensate drainage
- Other condensation (consider surface temperature, relative humidity and dew point temperature when evaluating the potential for condensation problems)

Notes

- Be aware of all rainwater drainage systems to ensure that they all are functioning properly.
- If the assessments reveal that an atmospherically vented combustion device is causing an indoor humidity problem, the device should be repaired in accordance with the guidance provided in [Priority Issue 14.0: Combustion Safety, Vented Combustion Appliances](#).

AP 7.2 Determine Whether Mold Remediation Is Required

- Determine whether the project requires mold remediation and/or additional moisture control measures (e.g., as determined during a Weatherization Assistance Program audit).
- Identify the sources of moisture problems.

Isolate and contain areas of significant mold contamination until these areas can be remediated (see EPA [Mold Remediation in Schools and Commercial Buildings](#) and [Institute of Inspection Cleaning and Restoration Certification \(IICRC\) Mold Remediation Standard S520](#) for additional information).

AP 7.3 Identify Moisture or Mold Problems to Address/Repair Before Building Upgrades

Document the moisture or mold problems that will be addressed as part of the building upgrade project, and identify which must be repaired before the building upgrades are performed. EPA recommends first addressing moisture issues, then remediating all mold problems.

AP 7.4 Identify Moisture Problems That May Limit Other Building Upgrades

If significant moisture problems exist that cannot be addressed or are outside the scope of the project, do not install building upgrades that would reduce the building's air infiltration rate or would not be durable in a wet environment. Examples of such moisture problems include buildings that have damp or water-stained materials or significant condensation or humidity problems, such as condensation on multiple windows and in attics. Water-sensitive renovation materials—such as fibrous insulation or gypsum board—will be damaged and their energy-conserving benefits compromised.

MINIMUM ACTIONS

MA 7.1 Repair Moisture Problems

Repair all moisture problems identified during the assessments. It is important to correct a moisture problem at its source. The following actions to correct moisture issues should be taken or referred to the client before the retrofit work begins:

- Repair roof leaks before air sealing or insulating the attic.
- Address surface water pooling near the foundation before insulating basement or crawlspace walls near wet areas. Address standing water problems, such as water pooling near the foundation and water that does not drain from flat roofs, by ensuring that there is adequate slope and drainage away from the building, particularly for downspouts that carry rainwater from the roof. Correct standing water problems near foundations and crawlspaces before insulating and weatherizing.
- Manage rainwater in assemblies receiving retrofits (e.g., drainage planes and flashings), following guidance in [EPA's Indoor airPLUS Construction Specifications](#) 1.5 and 1.6.

MA 7.2 Conduct Mold Remediation

Conduct any necessary mold remediation by following professional guidance, such as EPA's [Mold Remediation in Schools and Commercial Buildings](#) and American National Standards Institute (ANSI)/IICRC/Mold Remediation Standard S520. Do not disturb mold growth without following professional guidelines or employing the services of trained mold remediation professionals.



MA 7.3 Ensure Proper HVAC Condensate Drainage for New and Existing Equipment

Document which moisture problems will be addressed as part of the building upgrade project and which must be repaired by the building owner, property manager or another contractor before the building upgrades are performed. EPA recommends addressing moisture issues, then remediating mold growth.

The assessments also may reveal moisture problems that fall outside the scope of work for the upgrade project (e.g., condensation or insulation problems) that should be communicated to the building owner or property manager. Remediating mold without addressing the moisture problem that initiated mold growth will not adequately resolve your mold problem.



MA 7.4 Prevent Condensation in the Building Enclosure

As part of an energy project, ensure that air sealing of the enclosure limits flow of moist air into contact with cool surfaces and materials. Ensure that all piping, valves and ductwork with condensation potential—including surfaces that will pass through unconditioned spaces—are adequately covered with airtight, vapor-impermeable insulation.

Notes

- Air sealing the interface between the ceiling and attic also helps prevent ice dams on roofs in cold, snowy climates.
- Carefully select and place insulation and air/moisture retarders to control moisture flow, energy flow and temperature to avoid condensation and moisture accumulation on surfaces and within materials.
- Strictly follow all building codes for vapor retarder placement.
- Control indoor humidity sources.
- Ensure that existing bath and kitchen exhaust fans (see [Priority Issue 21.0: Source Ventilation/Local Exhaust Ventilation](#) for more detail) are operating properly and vented directly to the outdoors.
- Ensure that clothes dryers exhaust directly to the outdoors. Condensing clothes dryers piped to a drain are exempt.
- When work involves a crawlspace, ensure proper crawlspace ventilation that meets applicable building codes. (e.g., ventilation openings through foundation walls per the [2018 International Building Code](#), Section 1203.3).
- If work is done in the attic, ensure proper attic ventilation that meets applicable building codes.
- Install dehumidifiers in humid climates to avoid moisture problems if air conditioning systems cannot effectively control relative humidity below 60 percent under partial cooling load conditions.
- Remove unvented combustion space heaters.

MA 7.5 Use Nonporous Materials in Moisture-Prone Areas

Install only water-resistant, hard-surface flooring in kitchens, bathrooms, entryways, laundry areas and utility rooms.

MA 7.6 Control Moisture During Roofing Modifications

For roof repairs or modifications that are determined to be a necessary part of the upgrade, take precautions to control moisture, such as—

- Protect open roof areas from rain during construction.

- Design and construct roofing systems and flashing details to ensure proper moisture barriers.
- Repair roof leaks before air sealing or insulating the attic.

MA 7.7 Protect On-Site Materials From Moisture

Protect materials onsite from moisture damage. Do not install materials that show visible signs of biological growth resulting from the presence of moisture. Store and install all building products, systems and components in strict accordance with the manufacturers' printed instructions.

Conduct any required mold remediation following EPA or other professional guidance (see [Appendix B: Worker Protection](#) [Mold—Suspected]).

See Mold and Moisture section in [Appendix C: Property Management and Occupant Education](#).



Notes

- Replacing an atmospherically vented or fan-powered combustion device that draws combustion air from inside the home with a high-efficiency sealed combustion device can reduce the ventilation rate, which could result in cold-weather condensation in some building enclosures.

An atmospherically vented combustion device that is causing an indoor humidity problem should be repaired in accordance with [Priority Issue 11.0: Combustion Safety, Vented Combustion Appliances](#).

MA 7.8 Ensure Proper Operation of HVAC Humidifiers

Identify the presence of humidification equipment connected to forced-air heating and cooling systems and ducts and determine whether it is operating properly and not wetting HVAC components and ducts. Repair any malfunctioning equipment, or consider eliminating or replacing it with alternate humidification systems.

EXPANDED ACTIONS

EA 7.1 Retrofit Crawlspace

Where permitted by building codes, retrofit crawlspaces so that they are sealed, insulated, ventilated with conditioned air, properly drained and waterproofed (see Section 1.4 of [EPA's Indoor airPLUS Construction Specifications](#); EPA's [Moisture Control Guidance for Building Design, Construction and Maintenance](#); and the [2018](#)

[International Building Code](#), Section 1203.3.2). For example, cover earthen floors in basements and crawlspaces with sealed vapor barriers (with appropriate capillary break and drainage), seal sump covers and add a high-capacity, energy-efficient dehumidifier in the crawlspace if the climate conditions warrant it.

EA 7.2 Address Mold Growth in Ducts

Inspect supply and return ducts located beneath slab-on-grade floors for evidence of moisture and mold accumulations. Flooding events and ground moisture can enter ducts and cause mold growth, which can be distributed throughout the building. Mold growth may require abandoning and rerouting ducts.

EA 7.3 Use HVAC Systems to Manage Moisture

Use HVAC systems to manage moisture inside the building:

- Ensure proper sizing when specifying new or replacement air conditioning systems. Base the calculations on post-upgrade project conditions. Use Air Conditioning Contractors of America (ACCA) Manual J, the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Load Calculation Applications Manual, or the ASHRAE Handbook for HVAC load calculations. Use ACCA Manual S or the ASHRAE Handbook for equipment selection.
- If it is not possible to maintain the indoor relative humidity below 60 percent, evaluate whether the air conditioning system has an oversized design-sensible capacity or an undersized design-latent capacity.
- Consult and use HVAC professionals when evaluating or changing systems.

EA 7.4 Ensure Proper Operation of HVAC Humidifiers

Identify the presence of humidification equipment connected to forced air heating and cooling systems and ducts, and determine whether it is operating properly and not wetting HVAC components and ducts. Repair malfunctioning equipment or consider eliminating or replacing it with alternate humidification systems. In cold climates, one of the primary reasons for dry conditions indoors is the presence of excessive air infiltration. Air sealing may help in maintaining more moderate relative humidity conditions.

Relevant Standards or Guidance



- [Appendix B: Worker Protection](#) (Mold—Suspected; Confined Spaces) as appropriate
- [ANSI/ACCA Manual J](#)
- [ANSI/ACCA Manual S](#)
- [ANSI/IICRC S500-2015 Water Damage Restoration](#)
- [ANSI/IICRC S520-2008 Mold Remediation](#)
- ASHRAE Applications Manual
- [ASHRAE Handbook](#)
- [EPA Indoor airPLUS Specifications: 1.4, 1.5, 1.6](#)
- [EPA Moisture Control Guidance for Building Design, Construction and Maintenance](#)
- [EPA Mold Remediation in Schools and Commercial Buildings Guide](#)
- [International Building Code 2018](#)

PRIORITY ISSUE 8.0: OUTDOOR AIR SOURCES AND CONDITIONS

ASSESSMENT PROTOCOLS

AP 8.1 Consider Outdoor Pollutant Sources and Conditions That Impact the Indoor Environment

Identify potential outdoor environmental conditions or sources of pollution and noise that might affect indoor environmental quality or occupant comfort. These conditions could be routine, episodic or unusual events. They may directly impact air quality, as when contaminants migrate to the indoors, or indirectly, by degrading the structure or disrupting mechanical systems in the building.

- Chronic neighboring sources, such as busy highways, airport, dry cleaners, industrial facilities, agricultural dust, etc.
- Potential acute sources, such as blowing dust and smoke from wildfires
- Higher outdoor temperatures due to heat waves or climate changes
- Storms, hurricanes, floods
- Earthquakes
- Industrial spills, releases, explosions

AP 8.2 Occupant Complaints

Inquire about occupant complaints of odors, noise or temperature/humidity control that might indicate outdoor conditions are affecting the indoor environment.

MINIMUM ACTIONS

This section is intentionally left blank.

EXPANDED ACTIONS

EA 8.1 Assist in Developing Plans for Emergencies and Air Quality Events

Encourage property management and operations and maintenance personnel to develop plans for responding to poor outdoor air quality conditions, power outages, or natural or human-caused disasters. For more information on emergencies and IAQ, visit EPA's web pages on [Emergencies and IAQ](#) and [General Emergency Response](#).

Responses might include—

- Provide filtered ventilation, and avoid passive make-up air sources (e.g., trickle vents, z-ducts).
- Restrict or close outdoor air intake or other ventilation systems when appropriate during periods of poor outdoor air quality (e.g., when filter efficiency is insufficient to reduce particulate matter concentrations or when ozone concentrations are high).
- If possible, provide natural ventilation in mechanically ventilated buildings when power to the mechanical equipment is disrupted.
- Make arrangements for temporary electrical power or space heating or cooling.
- Provide occupants with combustion safety guidelines that specify generators, camp stoves, and cooking appliances should not be used indoors or on balconies during power or fuel outages.
- Drain hydronic and plumbing equipment during freezing indoor temperatures.
- Prepare to dry, clean, and remove or replace building materials as soon as possible after flooding.

EA 8.2 Improve Outdoor Air Filtration

For new HVAC systems, select equipment that will accommodate air filters with a minimum efficiency reporting value (MERV) rating of at least 13.

For existing systems, check with the manufacturer to determine whether filters with higher MERV ratings can be installed. Install filters with the highest MERV rating that can be accommodated by the equipment. Check that filters are properly installed with a good fit and seal to prevent bypass. Advise building managers to check and replace filters regularly and to be prepared to do so more often during periods of poor air quality.

EA 8.3 Install Modifications to Stop Outdoor Air Intake

Although mechanical ventilation systems should be normally operated, modify outdoor air dampers and controls so that dampers can be more easily sealed off to prevent entry of outdoor air through the HVAC system during a biological or chemical attack or when the contaminant is gaseous and cannot be easily removed by filtration.

EA 8.4 Provide for Backup Natural Ventilation

Although mechanical ventilation systems should normally be operated, consider adding provisions for natural ventilation when mechanical ventilation systems become inoperative. This might involve installing manually operated dampers or operable windows high and low in the building and in dwelling units to induce natural draft.

EA 8.5 Relocate Vulnerable Building Equipment

Move HVAC system and electrical equipment to floors above possible flood levels.

EA 8.6 Install Backup Generators

Consider installing backup electrical generation and fuel storage capacity so that essential building and HVAC systems can continue to operate during power outages.

EA 8.7 Provide Shelter-in-Place and Evacuation Locations

Building managers should consider marking shelter-in-place (SIP) locations and inform residents of SIP and evacuation plans and possible gathering locations in the event of an evacuation (e.g., in the event of a fire or following an earthquake) where families can meet far enough away from the building.

Relevant Standards or Guidance

This section is intentionally left blank.

PRIORITY ISSUE 9.0: PESTS

Pests, such as rodents and cockroaches, leave behind urine and droppings that can cause disease or increase asthma risks when inhaled. Some pests, such as mosquitos and pigeons, can be responsible for many diseases or lung infections.

ASSESSMENT PROTOCOLS

AP 9.1 Identify Potential Pests and Integrated Pest Management (IPM) Resources

Identify pests likely to colonize the building given the project location. Identify and acquire resources to assist with implementing IPM (e.g., state/county extension, publications and online resources, nongovernmental organizations, pest management professionals with expertise in IPM), including the proper identification of pests.

AP 9.2 Identify Evidence of Pests

Identify evidence of pests (e.g., rodents, squirrels, termites, birds, bats, cockroaches) in common areas and dwelling units. Note the location and identify pest-contaminated materials. Determine whether pesticides (rodenticides, insecticides, fungicides) presently are being used. See MA 9.1 for minimum actions to address pest infestations.

Inquire about occupant complaints of pests in the building.

Notes

- Areas that have a significant potential for pest infestations include attics; basements; crawlspaces; and around chimneys, mechanical stacks and plumbing cleanouts.
- Termites and some other types of pest infestations often are an indication of moisture problems. See [Priority Issue 7.0: Moisture Control and Mold](#) for diagnosing moisture problems.

AP 9.3 Assess Whether the Building Has an IPM Plan

Consult with building management to determine whether the building has an IPM plan or other pest management plan and the degree to which the plan is being followed.

MINIMUM ACTIONS



MA 9.1 Mitigate Pest Infestations

If there is indication of current or past infestations within the building, seek assistance from a pest professional with IPM certification or training (e.g., GreenPro, Green Shield, or equivalently trained IPM professionals).

Do not begin work in pest-infested zones until infested materials are properly removed. In some cases, professional assistance may be needed to remove infested materials.

Note

Many states require pest management professionals to be licensed.

MA 9.2 Reduce Potential for Pest Entry

Block, seal and eliminate pest entry points around the building envelope, using pest-resistant materials (e.g., copper mesh, hardware cloth, rodent-proof filled neoprene rubber door sweeps, sheet metal, concrete). Examples include gaps around doors and windows; between the foundation and the upper portion of the building; and around utility pipes, conduits or wires.

MA 9.3 Patch Openings to Eliminate Rodent Pathways

In areas with evidence of rodent infestation, patch and seal exterior holes that are larger than 1/4" by 3/8" with pest-resistant materials (e.g., copper mesh, hardware cloth, sheet metal, concrete) before applying insulation or weatherization materials that may be susceptible to gnawing by rodents (e.g., caulk or foam).

MA 9.4 Block Pest Movement Through Building

Seal and block passageways that pests can use to move freely to obtain food, water and harborage. This includes gaps around floor and ceiling joists; penetrations in walls, floors and ceilings; and openings around shafts and chutes.

MA 9.5 Protect Outdoor Air Intakes and Exhausts

Protect air intakes from bird and pest entry (e.g., cover openings with corrosion-resistant 1/2" screen or galvanized mesh). Protect exhaust vents from rodent, bird and pest entry (e.g., cover openings with louvers). Avoid creating conditions that can clog exhaust vents.

Advise the property manager to regularly inspect, clean and repair screens or louvers over air intakes and exhausts (e.g., at least semiannually or when replacing HVAC

filters). Make sure that rooftop air handlers, including exhaust fans, are air sealed to their roof curbs to prevent pest entry.

MA 9.6 Do Not Disturb Existing Pest Protections

Do not disturb or eliminate any building-related materials that are in place to exclude pests. If temporary disruption is necessary for a project, provide appropriate protection from pest entry while the pest barriers are removed.

MA 9.7 Keep Vegetation and Clutter Away From Building and Mechanical Systems Components

Remove clutter, eliminate woodpiles and waste near the building, and remove any bushes, trees or other vegetation within 2 feet of the structure, which can serve as rodent harborage. Keep vegetation away from outdoor air intakes and outdoor mechanical equipment. Do not pile soil or mulch against the building's exterior walls.

EXPANDED ACTIONS

EA 9.1 Create an IPM Plan

If there is no IPM plan for the building, work with the building owner and property manager to develop and implement one. Use the HUD, National Center for Healthy Housing (NCHH), Local Initiatives Support Corporation (LISC), and New York City (NYC) resources listed below when developing the plan. Use pamphlets and active engagement (e.g., information sessions, peer-to-peer education) to teach property managers and occupants about IPM. Refer to Appendix B for more information about property management and occupant education on IPM.



EA 9.2 Use Sealable Garbage Containers Outside

Ensure that exterior garbage cans and dumpsters are sealable and sanitized regularly.

Relevant Standards or Guidance

- [ASHRAE: Indoor Air Quality Guide](#), Strategy 3.6
- [Centers for Disease Control and Prevention \(CDC\): Rodents](#)
- [EPA: Integrated Pest Management \(IPM\) Principles](#)
- [HUD: HUD's Guidance on Integrated Pest Management](#)
- [LISC: Green & Healthy Property Management: A Guide for Multifamily Buildings](#)
- [NCHH: Integrated Pest Management: A Guide for Affordable Housing](#)
- [NYC: Integrated Pest Management Tool Kit for Building Owners, Managers, and Staff](#)
- [San Francisco Department of the Environment: Pest Prevention by Design Guidelines](#)
- [U.S. Department of Agriculture: Rural Development Cooperative Services](#)

PRIORITY ISSUE 10.0: POLYCHLORINATED BIPHENYLS (PCBS)

Polychlorinated biphenyls (PCBs) can be found in some building lights, electrical equipment, paints and other industrial products. If lights or electrical systems are damaged or if they leak, people can be exposed to toxins. EPA classified PCBs as a probable human carcinogen, or cancer-causing agent. Long-term exposures also may have significant toxic effects on the immune, nervous, reproductive, and endocrine systems and may present other health concerns. For more information on PCBs, visit [EPA's PCBs web page](#).



ASSESSMENT PROTOCOLS

AP 10.1 Determine Whether Fluorescent Light Ballasts Containing PCBs Are Present

Some multifamily residential buildings may contain fluorescent light fixtures with ballasts manufactured before 1979 that contain PCBs. Ballasts manufactured between July 1, 1978, and July 1, 1998, that do not contain PCBs were required to be labeled “No PCBs.” Newer fluorescent lighting typically uses electronic ballasts that do not contain PCBs and should be clearly marked as electronic.

If fluorescent light ballasts do not have the statement “No PCBs” or are not marked as electronic, assume that the ballasts contain PCBs, or contact the manufacturer to determine whether the ballasts contain PCBs. If the manufacturer is not sure whether the ballasts contain PCBs, assume that they do.

AP 10.2 Assess Caulk That Will Be Disturbed

Assess whether caulk will be disturbed during the building upgrade activities. Consider the age of the structure, because buildings built or renovated between 1950 and 1979 may be more likely to contain PCBs in caulk. Typical locations include around windows, door frames, masonry columns and other masonry materials.

Note

PCBs were not added to caulk after 1979; however, caulk containing PCBs that was manufactured before 1979 could have been used in buildings after that time.

MINIMUM ACTIONS



MA 10.1 Replace PCB-Containing Fluorescent Light Ballasts

Whether PCBs are confirmed or assumed to be present, new lighting fixtures can be used to replace the existing fixtures. PCB-containing fluorescent light ballasts that are leaking must be replaced and properly disposed of pursuant to EPA regulations, as described in 40 CFR Part 761 Subpart D. Any oil and stains leaked from PCB-containing ballasts also must be properly cleaned up or disposed of in accordance with the PCB decontamination or disposal regulations. EPA recommends that non-leaking PCB-containing fluorescent light ballasts also be replaced because of their increased likelihood to fail and leak and because of the increased energy efficiency of new ballasts.



MA 10.2 Address Caulk Potentially Containing PCBs When It Will Be Disturbed During Building Upgrades

If PCBs potentially are present in caulk and the caulk will be disturbed during the building upgrades (e.g., window or door replacement, improved weatherization sealing), take steps to minimize exposure. For more information, go to EPA's [Information for Contractors Working in Older Buildings that May Contain PCBs](#) web page.



MA 10.3 Properly Dispose of PCB-Containing Light Ballasts, Caulk and Other Materials

When removing PCB-containing light ballasts, caulk and other materials contaminated by PCBs, specific notification, packing, reporting, storage, transportation and disposal requirements apply—see 40 CFR Part 761. Ensure that waste management also meets local and state requirements. Document and store copies of all test results. Include documentation of all sampling locations and disposal measures, including disposal companies used and final destination of waste materials.

EPA's regional PCB Coordinators are a resource for all PCB issues.

Note

Fluorescent light bulbs contain small amounts of mercury. Ensure that the bulbs are handled properly to avoid breakage and the release of contaminants. More information on fluorescent bulb disposal requirements may be obtained from your state solid and hazardous waste agencies. See [Priority Issue 23.0: Protecting IAQ During Construction](#) for more information on limiting exposure to mercury.

EXPANDED ACTIONS

This section is intentionally left blank.

Relevant Standards or Guidance

- [EPA: Polychlorinated Biphenyls \(PCBs\) in Building Materials](#)
- [EPA: PCB-Containing Fluorescent Light Ballasts \(FLBs\) in School Buildings](#)
- [EPA: Polychlorinated Biphenyls \(PCBs\)](#)
- [EPA: Polychlorinated Biphenyls \(PCBs\) Manufacturing, Processing, Distribution in Commerce, And Use Prohibitions, 40 CFR Part 761 Subpart D—Storage and Disposal](#)
- [EPA: Recycling and Disposal of CFLs and Other Bulbs that Contain Mercury](#)
- [EPA: Regional PCB Coordinators](#)

PRIORITY ISSUE 11.0: RADON

Radon is a radioactive gas generated by the natural decay of uranium in the soil and rock below and around buildings. It can enter homes through holes and cracks. Breathing radon gas increases the risk of lung cancer.

ASSESSMENT PROTOCOLS

AP 11.1 Determine Whether the Building Has an Active Radon Mitigation System

Active mitigation systems include a radon vent fan (usually located in an attic, in an attached garage or on the building exterior) and an indicator (visual or sound) that the fan is operating. You may want to consult a radon professional with help locating and properly identifying an active radon mitigation system. If the active system is functioning, no further action is required as part of the upgrade.

Note

EPA recommends testing buildings with active radon systems every 2 years to ensure that systems are functioning properly.

AP 11.2 Select a Radon-Testing Professional for Buildings Without an Active Radon System

Qualified measurement professionals are individuals who have demonstrated a minimum degree of appropriate technical knowledge and skills specific to radon testing in large buildings (1) as required by a state licensing or certification program, as applicable, or (2) as established in certification requirements of the National Radon Proficiency Program (director@aarst.org) or the National Radon Safety Board (info@nrsb.org).

Those who wish to perform their own radon testing may learn more about obtaining a radon test kit at [EPA's Find a Radon Test Kit web page](#).

AP 11.3 Test Either (1) Both Pre- and Post-Upgrade Work or (2) Only Post-Upgrade Work

Follow sampling guidance in the American Association of Radon Scientists & Technologists (AARST) Protocol for Conducting Radon and Radon Decay Product Measurements in Multifamily Buildings, MAMF-2017, summarized below. EPA recommends testing be conducted by a radon testing professional who has demonstrated a minimum degree of appropriate technical knowledge and skills

specific to radon testing in large buildings (1) as required by a state licensing or certification program, as applicable, or (2) as established in certification requirements of the National Radon Proficiency Program (director@aarst.org) or the National Radon Safety Board (info@nrsb.org).

Those who wish to perform their own radon testing may learn more about obtaining a radon test kit at [EPA's Find a Radon Test Kit web page](#).

- Sample all dwelling units in contact with the ground.
- Sample all common areas and office spaces in contact with the ground.
- Sample nonresidential rooms or areas (e.g., utility rooms, storage rooms, and maintenance rooms) in contact with the ground that—
 - Can be occupied with little or no modification
 - Have air communication with areas that can be occupied (e.g., via such pathways as stairwells, air-handling equipment, elevator shafts)
- Sample 10 percent of dwelling units on each higher floor or, if 10 percent is less than one unit, sample at least one dwelling unit on each higher floor.
- If more than one sample is taken in a dwelling unit or nonresidential room, average the results for that specific location. Do not average results across dwelling units or building levels.

Note

Testing on every floor is necessary to (1) assess whether radon from a ground-contact source is traveling upward through the building via a chase, shaft or other pathway and (2) assess whether there are building materials that emit radon. In higher floors where only one dwelling unit is tested, it can be useful to test a dwelling unit adjacent to potential radon pathways, such as a stairwell or elevator shaft

Short-term tests offer an affordable screening method. Longer-term testing may provide a more accurate representation of annual exposure to radon and the need for mitigation. If short-term results are between 2 and 10 picocuries per liter of air (pCi/L), consider a long-term radon test (minimum 90 days).

MINIMUM ACTIONS

MA 11.1 Take Precautionary Measures Before Completing Energy Efficiency Upgrade Activities

If pre-work radon results are > 2 pCi/L or if pre-work testing is not feasible **AND** mitigation is not planned, undertake the precautionary measures below, which may help to prevent increases in radon in living areas.

1. Cover exposed earthen floors in basements and crawlspaces according to Section 1.2 of EPA's Indoor airPLUS Construction Specifications.
2. Air seal sumps (e.g., install an airtight sump cover) in such a way that water can drain from above, such as with a ball valve, and below the sump cover.
3. Ensure that drain traps have water in them, inspect drain lines for breaks or leaks, and check for apparent blockages.

Note

These foundation air-sealing strategies also are important elements of radon mitigation according to AARST Radon Mitigation Standards for Multifamily Buildings, RMS-MF 2018.

MA 11.2 If Pre- and Post-Upgrade Test Results Indicate a Potential Increase and/or Post-Upgrade Levels Are ≥ 4 pCi/L

If radon levels after energy upgrades or renovations are ≥ 4 pCi/L, install mitigation in accordance with AARST Radon Mitigation Standards for Multifamily Buildings, RMS-MF 2018. (For pre-upgrade levels ≥ 4 pCi/L, consider EA 5.1 and recommend mitigation to the owner. For post-upgrade test levels between 4 and 10 pCi/L consider a long-term test [minimum 90 days] to confirm an increase before undertaking mitigation.)

MA 11.3 If Pre-Upgrade Test Results Are Not Available and Radon Levels After Energy Upgrades or Renovation Are ≥ 4 pCi/L

Install mitigation in accordance with AARST Radon Mitigation Standards for Multifamily Buildings, RMS-MF 2018. (For levels between 4 and 10 pCi/L consider a long-term test [minimum 90 days] to confirm levels ≥ 4 pCi/L before undertaking mitigation.)

MA 11.4 Poorly Operating Mitigation System

If a previously installed radon mitigation system is not operating correctly, advise the client to contact the installer of the system or consult the state radon office.

MA 11.5 Notify the Building Owner/Property Manager About Radon-Reduction Measures

Notify the building owner and/or property manager about the test results and radon-reduction measures that were implemented. Inform the building owner and/or property manager that the radon testing protocols were completed to ensure that the building upgrade work did not introduce indoor radon problems, but the protocols did not necessarily mitigate a prior radon problem in the building. If the post-work radon level is between 2 and 4 pCi/L, the building owner and/or property manager are encouraged to refer to [EPA's Home Buyer's and Seller's Guide](#) to learn about the risk and how to mitigate, if desired, because no level of radon is safe. Advise the building owner and/or property manager to perform periodic retesting in areas of the building that have been mitigated for radon.

MA 11.6 Add Precautionary Measures in Building With Levels > 2 pCi/L Prior to Work

Install airtight drain fittings (e.g., trap or flange system) in foundation floor drains. Seal and caulk penetrations, openings or cracks in below-grade walls and floors that contact the ground with a sealant that meets the requirements of ASTM C920.

EXPANDED ACTIONS**EA 11.1 Install/Perform Radon Mitigation**

Install radon mitigation in any building with radon levels ≥ 4 pCi/L either before or after the energy upgrade or renovation in accordance with AARST Radon Mitigation Standards for Multifamily Buildings, RMS-MF 2018.

Relevant Standards or Guidance

- [AARST: Protocol for Conducting Radon and Radon Decay Product Measurements in Multifamily Buildings, ANSI/AARST MAMF-2017](#)
- [AARST: Radon Mitigation Standards for Multifamily Buildings, RMS-MF 2018](#)
- [ASTM: C920-14a Standard Specification for Elastomeric Joint Sealants](#)
- [EPA: A Citizen's Guide to Radon](#)
- [EPA: Consumer's Guide to Radon Reduction](#)
- [EPA: Where You Live \(State Radon Contact Information\)](#)

PRIORITY ISSUE 12.0: TRACKED-IN POLLUTANTS

Contaminants from outside the building can be brought into apartments and common areas on shoes.

ASSESSMENT PROTOCOLS

AP 12.1 Inspect Floor Surfaces at Building Common Entrances

Inspect all building common entrances for walk-off mats or entry mat systems. Note accumulation of dirt or moisture on interior floors near building entrances that might indicate need for walk-off mats or entryway floor-cleaning systems.

MINIMUM ACTIONS

MA 12.1 Provide Walk-Off Mats

Provide walk-off mats to trap dirt and moisture at all building common entrances. The mats need to be long enough to allow at least five full steps for people entering the building (a minimum of 10 feet long). Walk-off mats should be vacuumed regularly and cleaned according to manufacturer's printed instructions. Mats should have anti-slip backings or other means to reduce sliding and tripping hazards. Mats should not be placed over carpeted areas and should have an impervious, readily cleanable surface beneath them.

Note

Mats should be periodically moved and allowed to dry. Mats in high-traffic areas and over vinyl flooring should be moved frequently during wet weather conditions and allowed to dry (e.g., on a daily basis).

EXPANDED ACTIONS

EA 12.1 Install Permanent Entryway Systems

Install permanent entryway systems at all regularly used building common entrances to capture dirt and moisture, as described in IgCC 2018/ASHRAE Standard 189.1-2017, Section 8.3.1.5, or [EPA's IAQ Design Tools for Schools: Entry Mat Barriers](#). The entryway system should—

- Provide a scraper surface, an absorption surface and a finishing surface, in sequence in the direction of travel into the building.

- Be as wide as the entry doors.
- Have anti-slip backings or other locking mechanisms to reduce sliding and tripping hazards.
- Be designed for regular cleaning to remove accumulated dirt.
- Not be installed over an existing walk-off mat or other entryway system.

Relevant Standards or Guidance

- [ASHRAE: Indoor Air Quality Guide](#), Strategy 3.5
- [IgCC 2018/ASHRAE Standard 189.1-2017, Section 8.3.1.5](#)
- [EPA: IAQ Design Tools for Schools: Entry Mat Barriers](#)

PRIORITY ISSUE 13.0: UNVENTED COMBUSTION APPLIANCES

Unvented combustion appliances can create CO and combustion byproducts, as well as moisture. Exposure to CO and combustion byproducts can increase the risk of respiratory issues that can result in respiratory infection; lung disease, such as emphysema; lung cancer; or, in extreme cases, death.

ASSESSMENT PROTOCOLS

AP 13.1 Identify Unvented Combustion Appliances and Applicable Regulations

Identify any unvented gas or kerosene space heaters or vent-free combustion appliances (e.g., ovens, cooktops, fireplaces).

- Determine whether any local or state regulations prohibiting these devices apply.
- Check locations of unvented gas or kerosene space heaters, and assess the potential for the unvented heaters to influence the thermostat that controls the primary heat source (e.g., the central heating system).

AP 13.2 Conduct a Combustion Safety Inspection

Conduct a combustion safety inspection of all unvented combustion equipment in the building following ANSI BPI-1200-S-2017 and manufacturer's instructions. The inspection shall include observations for ensuring proper clearances, acceptable CO production and evidence of soot.

AP 13.3 Determine Whether CO Detection and Warning Equipment Is Installed

Determine whether CO detection and warning equipment is installed in dwelling units with unvented combustion appliances.

AP 13.4 Inquire About Occupant Complaints

Inquire about occupant complaints of odors or health effects that might be attributable to improperly operating combustion equipment.

MINIMUM ACTIONS

MA 13.1 Ensure Adequate Exhaust and Ventilation in Kitchens Equipped With Gas Cooking Appliances

Ensure that ASHRAE Standard 62.2-2019 requirements and any applicable building code requirements for local exhaust and outdoor air ventilation are met for kitchens equipped with gas cooking appliances. Ensure that kitchen exhaust fans vent directly to the outdoors. See [Priority Issue 21.0: Source Ventilation/Local Exhaust Ventilation](#) for additional guidance.

MA 13.2 Remove Unvented Combustion Space Heaters

With the owner's and/or occupants' permission, remove—

- Any unvented gas or kerosene space heaters that do not conform to local or state regulations. If the heaters are used as the primary source of heat for a space, replace them with electric or vented code-compliant heating systems.
- Other unvented heaters, except when used as a secondary heat source and it can be confirmed that the unit is listed to ANSI Z21.11.2. Heaters that are not listed to ANSI Z21.11.2 should be removed prior to the building upgrade, if feasible, but may remain until a replacement heating system is in place.

Note

All equipment removal should include proper disposal so that hazardous units are not reinstalled or used elsewhere.

If owners/occupants object to these recommendations, refer them to [Appendix C: Property Management and Occupant Education](#) (Carbon Monoxide and Combustion Safety).

Note

The proper size of a space heater depends on a room's dimensions and its heat loss characteristics. A 5,000 BTU/hour space heater often can be a suitable size for a room with a floor area of 150 ft².

MA 13.3 Advise Occupants on Proper Operation and Maintenance

Advise the owner/occupants to always consult and follow the manufacturer's printed instructions for proper operation and maintenance. If the manufacturer's instructions are not available, advise or assist occupants in obtaining replacement instructions.

Note

The Air-Conditioning, Heating, and Refrigeration Institute (AHRI) can be a source of information to obtain manufacturers' instructions for unvented combustion appliances.

Advise occupants that unvented space heaters should not be used in a manner that influences the thermostat controlling the primary heat source, thereby causing the space heater to operate in place of the primary heat source.

MA 13.4 Ensure That CO Detection and Warning Equipment Is Installed and Working

Ensure that CO detection and warning equipment is installed, working and located according to NFPA 72 (NFPA 720) and any applicable local or state requirements.



EXPANDED ACTIONS

This section is intentionally left blank.

Relevant Standards or Guidance

- [AHRI: Air-Conditioning, Heating, & Refrigeration Institute](#)
- [ANSI Z21.11.2-2013: Gas-Fired Room Heaters Volume II, Unvented Room Heaters](#)
- [ASHRAE Standard 62.2-2019, Ventilation and Acceptable Indoor Air Quality in Residential Buildings](#)
- [Consumer Product Safety Commission \(CPSC\): Carbon Monoxide Questions and Answers](#)
- [DOE: Standard Work Specifications for Multi-Family Home Energy Upgrades, Section 2.0202.1, Unvented Space Heaters](#)
- [EPA: Carbon Monoxide's Impact on Indoor Air Quality](#)
- [National Renewable Energy Laboratory \(NREL\) Section 2 Health & Safety](#)
- [NREL Section 6 Ventilation](#)
- [NFPA 720: Standard for the Installation of Carbon Monoxide \(CO\) Detection and Warning Equipment](#)

PRIORITY ISSUE 14.0: VENTED COMBUSTION APPLIANCES

Proper venting of combustion appliances reduces the risks of exposure to CO and other combustion byproducts. Proper venting also can ensure that combustion appliances function correctly and efficiently.

ASSESSMENT PROTOCOLS

AP 14.1 Conduct a Combustion Safety Inspection

Conduct a combustion safety inspection of all vented combustion equipment in the building (e.g., furnaces, boilers, water heaters). The inspection shall include observations for ensuring proper clearances, acceptable condition of venting, assessment of the potential for excessive spillage/back-drafting, integrity of fuel lines, and obvious electrical problems. Document deficiencies and proposed repairs.

- For gas-fired appliances and equipment, conduct a combustion safety inspection following ANSI/BPI-1100-T-2014, ANSI BPI-1200-S-2017 and manufacturer's instructions. Consider evaluating whether gas-fired appliance installations comply with Section 9.3, "Air for Combustion and Ventilation," of ANSI Z223.1/NFPA 54 for proper venting, including influences of other building ventilation and exhausting equipment.
- For oil-fired appliances and equipment, consider evaluating using applicable installation standards, including the Standard for the Installation of Oil-Burning Equipment, ANSI/NFPA 31, Chapters 5 and 6, and manufacturer's printed instructions.
- Identify combustion appliances that have pilot burners. Perform test on vented combustion appliances (e.g., boilers, furnaces, space heaters, water heaters) using qualified professionals (e.g., BPI-certified Multifamily Building Analyst, trained heating system professional) to ensure that excessive spillage does not occur under worst-case depressurization, and perform CO testing. Conduct combustion appliance safety inspection for the purpose of placing the Combustion Appliance Zone (CAZ) under the greatest depressurization achievable in accordance with ANSI/BPI-1200-S-2017, to determine whether any combustion safety issues may result from changes to the building envelope.

AP 14.2 Determine Whether CO Detection and Warning Equipment Is Installed

Determine whether CO detection and warning equipment is installed in dwelling units and other locations within the building (e.g., mechanical rooms with combustion equipment).

AP 14.3 Inquire About Occupant Complaints

Inquire about occupant complaints of odors or health effects that might be attributable to improperly operating combustion equipment.

MINIMUM ACTIONS**MA 14.1 Correct Deficiencies and Ensure Proper Operation of Combustion Equipment**

Correct all safety deficiencies identified during the assessments; repair, remove or replace combustion equipment as needed; and address other issues or deficiencies as needed. Replacement equipment should meet the appropriate and applicable codes and standards, to the extent practical.

Note

It may be impractical to modify or upgrade equipment to meet current codes and standards, so talk with the building owner about the replacement of equipment.

All equipment removal should include proper disposal so that hazardous units are not reinstalled or used elsewhere.

Address depressurization and potential spillage/back drafting problems (e.g., with combustion make-up air, fan interlocks, transfer grilles, jumper ducts, louvered doors, door undercuts, duct leakage repair) identified during worst-case depressurization testing with the combustion zone at the greatest depressurization achievable, or adjust the exhaust equipment causing the problems, provided doing so does not conflict with the specific exhaust requirements for spaces served by the exhaust equipment.

Conduct draft and venting testing following repairs or replacement of combustion equipment. Ensure that combustion appliances are installed with sufficient access for proper maintenance and are operating in compliance with the original manufacturer's printed specifications.

MA 14.2 Ensure Proper Exhaust Locations

Ensure that combustion exhaust is captured as close to the combustion source as possible; exhausted directly outdoors; and not vented into other indoor spaces, such as attics, crawlspaces or basements.

MA 14.3 Ensure Adequate Make-Up Air

Ensure that vented appliances have sufficient make-up air to replace vented air and maintain normal operating conditions.

MA 14.4 Ensure Proper Boiler Operation

Ensure that boiler-firing adjustments are working properly so that soot is not dispelled out of the atmospheric dampers into boiler rooms. Confirm that boilers do not release black smoke through the chimney after initial startup.

**MA 14.5 Ensure CO Detection and Warning Equipment Is Installed and Working Properly**

Ensure that CO detection and warning equipment is installed, working, and located according to NFPA 72 (NFPA 720) and any applicable local or state requirements.

EXPANDED ACTIONS**EA 14.1 Install Power-Vented or Sealed-Combustion Equipment**

If replacing combustion equipment located in occupied or conditioned spaces as part of the building upgrade, recommend power-vented or sealed-combustion equipment. Install new combustion equipment in accordance with ANSI/ACCA 5 QI 2010 HVAC Quality Installation Specifications.

EA 14.2 Upgrade Combustion Appliances

Consider replacing older, lower-efficiency appliances that have pilot burners with higher-efficiency appliances incorporating electronic ignition.

EA 14.3 Ensure Sufficient Access

Ensure that combustion appliances are installed with sufficient access for proper maintenance and are operating in compliance with the original manufacturer's printed specifications.

Relevant Standards or Guidance

- [ACCA: Standard 5 QI-2010, HVAC Quality Installation Specification](#)
- [ANSI Z223.1/NFPA 54: National Fuel Gas Code](#)
- [ANSI Z21 Series Standards for Residential Gas-Fired Appliances](#)
- ANSI/BPI-1100-T-2014, Combustion Appliance Inspection
- ANSI BPI-1200-S-2017 Standard Practice for Basic Analysis of Buildings
- [DOE: Standard Work Specifications for Multi-Family Home Energy Upgrades, Section 5, Heating and Cooling & Subtopic 5.0503 Appliance Venting](#)
- [NFPA 31: Standard for Installation of Oil-Burning Equipment](#)
- [NFPA 72: National Fire Alarm and Signaling Code \(replaces NFPA 720: Standard for the Installation of Carbon Monoxide \(CO\) Detection and Warning Equipment\)](#)
- [NFPA 211: Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances](#)

PRIORITY ISSUE 15.0: WOOD SMOKE AND OTHER SOLID FUEL EMISSIONS

Smoke from wood- and solid fuel–burning appliances contains a wide variety of hazardous gases and particulate air pollutants. Breathing this smoke can cause or aggravate burning eyes; heart disease; heart attacks; and respiratory ailments, such as asthma, chronic obstructive pulmonary disease and bronchitis.

ASSESSMENT PROTOCOLS

Note

Many of the following may require input from certified/trained professionals. For a certified professional near you, consult the [Chimney Safety Institute of America \(CSIA\)](#) or the [National Fireplace Institute \(NFI\)](#).

AP 15.1 Determine Whether Wood- or Coal-Burning Appliances Are Present

Determine whether there are wood- or coal-burning appliances (e.g., wood stove or furnace, wood pellet stove, fireplace) in the building. If a building policy on wood- and coal-burning devices exists, review it for compatibility with the Minimum Actions in this section.

AP 15.2 Assess Proper Size and EPA Certification of Wood- or Coal-Burning Appliances

- Assess what the proper size of any solid fuel–burning appliances will be after the building upgrade is complete (see EPA [Burn Wise](#)).
- Determine whether the solid fuel–burning appliance is EPA certified (i.e., more energy efficient and cleaner burning). An EPA-certified wood heater can be identified by a permanent metal label affixed to the back or side of the wood heater.

AP 15.3 Assess Appliance Safety

Assess by considering the following:

- Condition of the appliance (especially leaks, cracks or faulty flue connections)
- Proper distance of appliance to combustible materials (minimum clearances) and proper protection of combustibles
- Proper size and materials of floor protection
- Proper venting system (see [Priority Issue 14.0: Combustion Safety, Vented Combustion Appliances](#) and [Priority Issue 13.0: Combustion Safety, Unvented Combustion Appliances](#))

- Effect of exhaust ventilation equipment on proper draft of appliance

Contact the manufacturer regarding installation guidance for proper venting, distance from combustibles and floor protection, as well as adhering to local building code.

AP 15.4 Identify Presence of Indoor Smoke

If wood- or other solid fuel–burning appliances are present, determine whether there is evidence of indoor smoke emissions affecting the home by using any of the following or equivalent practices:

- Look for evidence of soot on the walls or ceiling or creosote staining near the flue pipe.
- Determine whether the inside of the home smells like wood smoke.
- Ask occupants whether they regularly smell wood smoke indoors during the heating season.

AP 15.6 Determine Whether Hydronic Heating Equipment Is Present

Determine whether an outdoor wood- or coal-fired appliance is generating hydronic heat.

AP 15.7 Observe Heating Equipment in Action

If the wood- or coal-burning appliance is operating during the assessment, observe the opacity of the smoke leaving the chimney.

Note

One hundred percent opacity means nothing can be seen through the smoke. At 20 percent opacity, there is very little smoke, and you can see almost completely through it. Smoke with opacity of more than 20 percent is an indication that unseasoned wood is being burned, a non-EPA-approved stove is in use, or the heater is operating poorly. Ensure that trash and vegetation are not being burned in the units. Refer to the EPA [Burn Wise](#) website for additional information.

MINIMUM ACTIONS

MA 15.1 Ensure Proper Operation of Wood- or Coal-Burning Appliances

Correct any problems identified during the assessments. If evidence of soot, wood smoke, or other health or safety concerns is apparent, work with a certified fireplace or chimney safety professional to identify and correct the problems.

MA 15.2 Install Properly Sized New Appliances

If a new appliance is installed during the upgrade, ensure that it is properly sized for the post-upgrade heating load. Ensure that any new wood-burning appliances are EPA-certified.

MA 15.3 Recommend Periodic Inspection and Maintenance of the Chimney and Appliance

Encourage the building owner or property manager to have a certified professional inspect and maintain the chimney and wood- or coal-burning appliance annually.

**MA 15.4 Share EPA Burn Wise Tips**

Share EPA's [Burn Wise Tips](#) with the building owner or property manager.

MA 15.5 Also Refer to [Priority Issue 14.0: Vented Combustion Appliances](#) to Ensure That the Equipment Is Venting Properly and Working Correctly

EXPANDED ACTIONS**EA 15.1 Install Properly Sized, EPA-Certified Wood-Burning Appliances**

Replace non-certified wood- or coal-burning appliances with properly sized and installed wood pellet stoves or EPA-certified appliances. For fireplaces, consider installing retrofit devices that reduce emissions. Appliances should be installed according to the manufacturer's written instructions.

Alternatively, replacement heating equipment that does not burn solid fuels also can be considered.

Relevant Standards or Guidance

- [EPA: List of EPA-Certified Wood-Burning Appliances](#)
- [EPA: Burn Wise, Consumers – Best Burn Practices](#)
- [EPA: Burn Wise, Consumers – Choosing Appliances](#)
- [EPA: Burn Wise, Consumers – Frequent Questions](#)
- [EPA: Burn Wise Tips](#)
- [EPA: Burn Wise Voluntary Programs for More Efficient Wood- Burning Appliances, Hydronic Heaters Program \(terminated\)](#)
- [NFPA 211: Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances](#)

COMPARTMENTALIZATION

PRIORITY ISSUE 16.0: COMPARTMENTALIZATION TO PREVENT ODOR OR UNWANTED AIR TRANSFER

Effectively sealing or restricting air flow between apartments or areas of the building can help reduce exposures to contaminants.

Note

More detailed guidance on compartmentalization is provided in [Appendix A: Compartmentalization—Additional Information](#). Users are encouraged to consult this appendix.

ASSESSMENT PROTOCOLS

AP 16.1 Determine Locations in the Building With Strong Pollutant Sources

Determine which areas or dwelling units in the building are likely to be sources of irritating pollutants or noxious odors or where unwanted air transfer occurs. Refer to complaint logs and building owner/property manager reports, and perform an IAQ walkthrough inspection. Include common areas and nonresidential spaces in the building (e.g., retail spaces, fitness facilities, beauty and nail salons). To the extent possible, work with the building owner, property manager and occupants to identify IAQ concerns that arise from pollutant migration among dwelling units, common areas and commercial spaces. Refer to [EPA's Building Air Quality Action Plan](#) for more information on IAQ walkthrough inspections.

AP 16.2 Assess Spaces for Compartmentalization

Identify spaces in the building—including dwelling units, common areas and nonresidential spaces (e.g., conference/meeting rooms, health club/exercise rooms, retail spaces, attached garages, combustion appliance rooms, utility shafts, elevators, stairwells)—with strong pollutant sources that could be isolated using compartmentalization techniques. The intent is to reduce pollutant and odor migration by limiting uncontrolled airflow and cross-contamination among spaces, achieved by air sealing and controlling pressure differences.

- Identify the pollutant migration pathways due to pressure differences within the building and across the building envelope, which can be caused by a variety of

factors (e.g., thermal stack effect; mechanical ventilation, if not properly designed and maintained; inadequate air balance; operation of combustion appliances).

- Make visual observations or use infrared thermography, chemical smoke and/or pressure testing to identify all penetrations at the perimeter of the space/dwelling unit that can be air sealed to reduce transfer as part of the building upgrade. ASTM E1186-03 (2009) Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems can be used to guide the air sealing assessment work.
- Inspect and identify all joints, seams and leaks in the ventilation duct system that can be sealed.

MINIMUM ACTIONS

MA 16.1 Minimize Pollutant Transfer Between Spaces

Follow the guidance in the order listed below for the most effective strategy: (1) source control and (2) ventilation and air pressure control.

1. Source Control

If pollutant sources and odors were identified and can be readily addressed see the relevant PIs in this Guide. For example—

- For sewer gases or other pollutants, see [Priority Issue 2.0: Belowground Contaminants](#).
- For suspected VOCs, see [Priority Issue 3.0: Building Products/Materials Emissions](#).
- For tobacco smoke transfer control, see [Priority Issue 4.0: Environmental Tobacco Smoke](#).
- For contaminants from attached garages, see [Priority Issue 5.0: Garage Air Pollutants](#).
- For wood smoke, see [Priority Issue 15.0: Wood Smoke and Other Solid Fuel Emissions](#).
- For emissions from vented combustion appliances, see [Priority Issue 14.0: Vented Combustion Appliances](#).
- For emissions from unvented combustion appliances, see [Priority Issue 13.0: Unvented Combustion Appliances](#).
- For cooking odors, see [Priority Issue 21.0: Source Ventilation/Local Exhaust Ventilation](#).

2. Ventilation and Air Pressure Control

Follow the Minimum Actions in Priority Issues [18.0](#), [19.0](#), [20.0](#) and [21.0](#), as applicable to the type of ventilation system. For more information on compartmentalization by both ventilation and air pressure control, as well as air sealing, refer to [Appendix A: Compartmentalization—Additional Information](#).

EXPANDED ACTIONS

EA 16.1 Expanded Ventilation and Air Pressure Control

Follow the Expanded Actions guidance in Priority Issues [18.0](#), [19.0](#), [20.0](#) and [21.0](#), as applicable to the type of ventilation system. Reduce excess negative pressures inside the dwelling units resulting from unbalanced exhaust systems.

Refer to [Appendix A: Compartmentalization—Additional Information](#).

Relevant Standards or Guidance

- [ASTM E779-19: Standard Test Method for Determining Air Leakage Rate by Fan Pressurization](#)
- [ASTM E1186-17: Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems](#)
- [ASTM E1827-11\(2017\): Standard Test Methods for Determining Airtightness of Buildings Using an Orifice Blower Door](#)
- [EPA: Building Air Quality Action Plan](#), Step 2: Develop an IAQ Profile of Your Building, Part 2: Conduct a Walkthrough
- [International Code Council: International Building Code, 2018 Edition](#)
- [NREL Section 3: Air Sealing](#)
- [UL: Fire-Resistance and Smoke Protection](#)

HEATING, VENTILATION AND AIR CONDITIONING (HVAC)

PRIORITY ISSUE 17.0: HVAC EQUIPMENT

HVAC equipment can help improve indoor air quality by bringing in outdoor air and reducing the risk of respiratory health effects and exposures to pollutants. Most existing HVAC systems do not have the proper features or functionality to achieve this result. In addition, poorly functioning equipment can produce unwanted health effects.

ASSESSMENT PROTOCOLS

AP 17.1 Evaluate the Condition of Existing HVAC Systems and Components

Working with a qualified professional, evaluate the condition of existing HVAC systems and their components (e.g., furnaces, boilers, cooling equipment, air handlers, exhaust air systems, make-up air systems, heat pumps, ductwork) in accordance with minimum inspection standards of ASHRAE/ACCA Standard 180 or other equivalent industry standards.

Refer to Priority Issues [17.0](#), [18.0](#), [19.0](#), [20.0](#) and [21.0](#) for outdoor air ventilation, as applicable to the type of ventilation system.

AP 17.2 Determine Appropriate HVAC System Sizing

Determine whether the existing HVAC systems are sized properly. Refer to ACCA Manual J for low-rise residential applications; ACCA Manual N for commercial applications; and the ASHRAE Load Calculation Applications Manual, ASHRAE Standard 183 or ASHRAE Handbook for HVAC load calculations. Refer to ACCA Manual S or the ASHRAE Handbook for equipment selection. If HVAC system replacements or modifications are anticipated, base heating/cooling load and equipment sizing calculations on post-upgrade conditions.

AP 17.3 Occupant Complaints of Temperature, Humidity or Noise

Inquire about occupant comfort complaints of temperature or humidity in the conditioned spaces or unusual noise from HVAC equipment.

MINIMUM ACTIONS

MA 17.1 Repair Improperly Operating HVAC Equipment

Based on the results of the system assessment (e.g., equipment condition, size and feasibility of corrective actions), repair, modify or recommend installing new HVAC equipment to ensure that it can provide the needed ventilation, local exhaust, temperature and humidity control. The ability to modify and adjust the existing HVAC equipment may be limited by its initial design. Review the original equipment specifications, consulting with HVAC technical/engineering professionals.

If maintenance, cleaning, repairs or tuning are needed to restore HVAC equipment to proper functioning, conduct those activities in accordance with ANSI/ACCA Standard 6 (Restoring the Cleanliness of HVAC Systems), ANSI/ACCA Standard 4 (Maintenance of Residential HVAC Systems), or equivalent standards and guidelines.

MA 17.2 Properly Size and Install New HVAC Equipment

If replacing equipment, base equipment sizing calculations on the post-upgrade heating and cooling load calculations. Use ACCA Manual J for low-rise residential applications; ACCA Manual N for common areas or commercial spaces; and the ASHRAE Load Calculation Applications Manual, ASHRAE Standard 183 or ASHRAE Handbook for HVAC load calculations. Use ACCA Manual S or the ASHRAE Handbook for equipment selection.

Install new equipment in accordance with ACCA Standard 5, and verify installation in accordance with ACCA Standard 9, the ASHRAE Handbook, or equivalent standards and guidelines.

MA 17.3 Ensure That There Is Adequate Air Filtration

For HVAC equipment that serves dwelling units, ensure that new HVAC systems have air filtration with a minimum MERV 11 rating, located upstream of thermal conditioning equipment, as stated in ASHRAE Standard 62.2-2019.

If nonresidential spaces are included in the scope of work, ensure that new HVAC systems have air filtration with a minimum MERV 8 rating, located upstream of all cooling coils or other devices with wetted surfaces, as stated in ASHRAE Standard 62.1-2019.

For existing HVAC systems, check with the manufacturers to determine whether filters with these MERV ratings can be accommodated by the equipment, and if not, install filters with the highest MERV rating that can be accommodated.

There should be no air bypass around filters. No air cleaners designed to intentionally produce ozone should be installed.

MA 17.4 Control Mold and Bacterial Growth in HVAC Systems and Mechanical Equipment

Ensure that existing HVAC equipment is free of mold growth in ducts, drain pans and coils, and if any mold exists, correct the cause of the condition.

Follow ASHRAE Standard 188-2015 or OSHA Technical Manual, Section III, Chapter 7: Legionnaires' Disease to protect against bacterial growth in building water systems (e.g., cooling towers, evaporative condensers, humidifiers, hot- and cold-water systems, fire sprinkler systems, ice machines, eyewash stations, safety showers).

MA 17.5 Train Building Staff on HVAC Operations and Maintenance

After the upgrade, building staff should be trained on the operations and maintenance of the HVAC systems, including the outdoor air ventilation strategy (see Priority Issues [17.0](#), [18.0](#), [19.0](#), and [20.0](#), as applicable); temperature, humidity and other HVAC controls; measuring and adjusting airflows; preventive maintenance; and troubleshooting problems. The training should include any needed seasonal adjustments, air filter change-out schedules, control system set-point adjustments, and other maintenance and operational requirements for mechanical equipment. An operations and maintenance manual should be provided to the building staff.



Discuss with the building owner or property manager the need to educate occupants about the basic operation of ventilation, heating and cooling systems in dwelling units. This should include any maintenance activities (e.g., air filter change-out) and adjustments that are the occupants' responsibility.

EXPANDED ACTIONS

EA 17.1 Consider Upgrading HVAC Equipment

Replace functioning HVAC equipment that is near the end of its service life or can be upgraded to improve operating and ventilation efficiency with new energy-efficient HVAC equipment and base sizing calculations on post-retrofit conditions. Refer to Sections 4.1 and 4.2 of EPA Indoor airPLUS Construction Specifications.

Follow ANSI/ACCA Standard 5 (HVAC Quality Installation Specification), Standard 9 (HVAC Quality Installation Verification Protocols), the ASHRAE Handbook, or equivalent standards and guidelines.

EA 17.2 Install Higher-Efficiency Filters in HVAC Systems

Higher filtration can both improve IAQ and protect HVAC equipment. For new HVAC systems, install filters with the highest MERV rating that the equipment is capable of physically accommodating and for which there is adequate fan capacity to overcome the filters' pressure drop.

For existing systems, check with the manufacturer to determine whether filters with higher MERV ratings can be installed. Install filters with the highest MERV rating that can be accommodated by the equipment.

EA 17.3 Provide Additional HVAC Training to Building Operations and Maintenance Staff

Conduct follow-up training (e.g., 6 months or 1 year after the initial training). This will reinforce staff skills and knowledge and provide an opportunity for staff to ask questions after they become familiar with the upgraded building and systems.

Recommend that building operations and maintenance staff attend a Building Operator Certification (BOC) course or other comparable training regarding HVAC, IAQ and energy use.

Relevant Standards or Guidance

- [ACCA: Manual J Residential Load Calculation](#)
- [ACCA: Manual N Commercial Load Calculation](#)
- [ACCA: Manual S Residential Equipment Selection](#)
- [ANSI/ACCA 4 QM-2019, Maintenance of Residential HVAC Systems](#)
- [ACCA: Standard 5 QI-2010, HVAC Quality Installation Specification](#)
- [ANSI/ACCA: Standard 6-2015, Restoring the Cleanliness of HVAC Systems](#)
- [ACCA: Standard 9 QIvp-2016, HVAC Quality Installation Verification Protocols](#)
- [American Technical Publishers and the International Union of Operating Engineers: Indoor Air Quality Solutions for Stationary Engineers](#)
- [ASHRAE/ACCA Standard 180-2012, Standard Practice for Inspection and Maintenance of Commercial Building HVAC Systems](#)
- [ASHRAE Standard 188-2018, Legionellosis: Risk Management for Building Water Systems](#)
- [ASHRAE/ACCA Standard 183-2007 \(RA 2014\), Peak Cooling and Heating Load Calculations in Buildings Except Low-Rise Residential Buildings](#)
- [ASHRAE: Handbook—Fundamentals](#)
- [ASHRAE: Handbook—HVAC Systems and Equipment](#)
- [ASHRAE: Load Calculation Applications Manual](#)
- [ASHRAE Standard 62.1-2019, Ventilation for Acceptable Indoor Air Quality, Section 5.8](#)
- [ASHRAE Standard 62.2-2019, Ventilation and Acceptable Indoor Air Quality in Residential Buildings, Section 6.7](#)
- [EPA: Air Cleaners and Air Filters in the Home](#)
- [NREL Section 2: Health & Safety](#)
- [NREL Section 5: Heating and Cooling](#)
- [OSHA: OSHA Technical Manual, Section III: Chapter 7 Legionnaires' Disease](#)

PRIORITY ISSUE 18.0: MECHANICAL VENTILATION FOR INDIVIDUAL DWELLING UNITS

Ventilation can help to remove moisture and other contaminants generated by resident activity, as well as increase air flows.

ASSESSMENT PROTOCOLS

AP 18.1 Determine Whether Dwelling Units Have Individual Mechanical Ventilation Systems

Determine if individual mechanical ventilation systems in dwelling units exist, including the following configurations, which can also include—but not rely on—operable windows:

- Occupant-controlled bath and/or kitchen exhaust fans in a dwelling unit
- Continuously operating bath and/or kitchen exhaust fans in a dwelling unit, or other exhaust fan(s) provided in a dwelling unit for mechanical ventilation
- Outdoor air ventilation supplied via a dwelling unit's space conditioning air handler

Note

Evaluate whether local and/or continuous exhaust ventilation exacerbates radon levels in homes with potential radon problems (see [Priority Issue 11.0: Radon](#)) or conflicts with proper venting of combustion appliances or pressure control of pollutant migration in adjoining spaces.

For other dwelling unit ventilation configurations, refer to [Priority Issue 19.0: Mechanical Ventilation for Multiple Dwelling Units Using Central Exhaust](#) or [Priority Issue 20.0: Natural \(Not Fan-Powered\) Ventilation](#).

AP 18.2 Determine Whether Dwelling Unit Mechanical Ventilation Systems Meet ASHRAE Standard 62.2-2019 Requirements

Determine whether the mechanical ventilation systems in dwelling units meet ASHRAE Standard 62.2-2019 requirements (including Appendix A for existing buildings).

This includes—

- Dwelling unit ventilation rate
- Bath and kitchen exhaust fan airflow rates
- Proper location of exhaust discharges

Conduct the assessment in as many dwelling units as possible. If a sample of dwelling units is assessed, be sure to include any units for which there are indoor air quality complaints or complaints of drafts caused by high supply-air discharge velocities.

AP 18.3 Determine Whether Common Corridors and Nonresidential Spaces Meet Ventilation Requirements

Determine the amount of outdoor air ventilation provided to common corridors and whether this meets the ASHRAE Standard 62.1-2019 minimum requirement of 0.06 cfm/ft² of floor area.

If nonresidential spaces (e.g., exercise rooms, lobbies, mailrooms, commercial/retail spaces) are included in the scope of service, determine whether the ventilation in these spaces meets the requirements of ASHRAE Standard 62.1-2019.

AP 18.4 Identify and Assess Outdoor Air Intakes

Identify the location of outdoor air intakes for all ventilation systems and assess their distances from outdoor pollutant sources (e.g., vehicle exhaust, plumbing vents, exhaust discharges, streets or highways with large traffic volumes).

MINIMUM ACTIONS**MA 18.1 Repair and Upgrade Dwelling Unit Mechanical Ventilation Systems as Needed**

If dwelling units are served by individual mechanical ventilation systems—

- Ensure a continuous or intermittent operating schedule in the dwelling unit to meet ASHRAE Standard 62.2-2019 ventilation requirements.
- If ventilation air is integral to the space conditioning system, the system shall be configured to provide the required ventilation regardless of the heating or cooling demand in the dwelling unit.
- If each dwelling unit has dedicated mechanical exhaust for outdoor air ventilation—

- Adjust, repair, or replace existing exhaust ducts and fans serving the dwelling unit as needed to meet ASHRAE Standard 62.2-2019 requirements (including Sections 4 and 5 for ventilation and local exhaust and Appendix A for existing units). If it is not possible to achieve the ASHRAE Standard 62.2-2019 minimum outdoor air ventilation rates, adjust systems to provide the maximum amount of outdoor air ventilation possible.
 - Remove blockages in exhaust grilles, ductwork and components (e.g., constant airflow regulators).
 - Ensure that ducts for all exhaust fans terminate outside the building.
 - Air seal exhaust ventilation ductwork with approved materials to prevent duct leakage within building cavities.
 - Advise the building owner or property manager to implement a preventive maintenance plan to inspect exhaust grilles in all dwelling units at least once per year.
- Ensure that outdoor air intakes that are part of ventilation systems for dwelling units are located a minimum distance of 10 feet from contaminant sources, including plumbing stacks, vents, exhaust hood discharges or vehicle exhaust (see ASHRAE Standard 62.2-2019).

MA 18.2 Repair, Adjust and Upgrade Ventilation Systems in Common Corridors and Nonresidential Spaces as Needed

Ensure that common corridors and nonresidential areas meet the ASHRAE Standard 62.1-2019 minimum outdoor air ventilation rate requirement.

If it is not possible to achieve the 2016 minimum outdoor air ventilation rates, adjust systems to provide the maximum amount of outdoor air ventilation possible.

EXPANDED ACTIONS

EA 18.1 Install Balanced Ventilation Systems With Energy Recovery in Dwelling Units

In appropriate climate zones and where exhaust airflows from the dwelling unit can be combined, consider providing balanced ventilation with energy recovery equipment to (1) supply outdoor air ventilation, (2) reduce the heating and cooling costs associated with outdoor air ventilation, and (3) precondition the incoming outdoor ventilation air.

EA 18.2 Meet Outdoor Air Filtration and Air-Cleaning Requirements

In geographic locations where the outdoor air exceeds the national standards for particulate matter ($PM_{2.5}$, PM_{10}) or ozone, ensure that the outdoor air filtration and air-cleaning requirements in 2018 IgCC Section 801.3.1.3 Filtration and Air Cleaner Requirements are met for mechanical ventilation systems. Also provide enhanced filtration within 500 feet of busy streets and highways.

Requirements include—

- Particulate-matter filters or air-cleaning devices with a MERV rating of at least 8 shall be provided upstream of all cooling coils or other devices with wetted surfaces through which air is supplied to occupied space.
- Particulate-matter filters or air-cleaning devices with a MERV of at least 8 shall be used in areas where the National Ambient Air Quality Standard for PM_{10} is exceeded.
- Particulate-matter filters or air-cleaning devices with a MERV of at least 13 shall be used in areas where the National Ambient Air Quality Standard for $PM_{2.5}$ is exceeded, or within 500 feet of busy streets and highways (those with annual average daily traffic greater than 100,000 vehicles).
- Air-cleaning devices to remove ozone must be provided and used in areas that are in “nonattainment” with the National Ambient Air Quality Standard for ozone. Such air-cleaning devices shall have an ozone removal efficiency of no less than 40 percent where installed, operated, and maintained in accordance with the manufacturer’s recommendations.

Note

Other proprietary test metrics for in-duct air filters include the Microparticle Performance Rating (MPR) and Filter Performance Rating (FPR). In general, the higher the filter rating, the higher a filter’s removal efficiency for at least one particle size range. Use the highest MPR or FPR if MERV rating is not available.

Relevant Standards or Guidance

- [ASHRAE Standard 62.1-2019, Ventilation for Acceptable Indoor Air Quality](#)
- [ASHRAE Standard 62.2-2019, Ventilation and Acceptable Indoor Air Quality in Residential Buildings](#)
- [ASHRAE Standard 189.1-2017, Standard for the Design of High-Performance Green Buildings, Section 8.3.1.3 Filtration and Air Cleaner Requirement](#)
- [2018 International Green Construction Code](#)
- [NCHH: Improving Ventilation in New and Existing Multi-Family Buildings With Individual Unit Ventilation Systems](#)

PRIORITY ISSUE 19.0: MECHANICAL VENTILATION FOR MULTIPLE DWELLING UNITS USING CENTRAL EXHAUST

Ventilation can help to remove moisture and other contaminants generated by resident activity, as well as increase air flows.

ASSESSMENT PROTOCOLS

AP 19.1 Determine Whether Dwelling Units Are Served by Central Mechanical Exhaust Ventilation Systems

Central exhaust ventilation systems serving multiple dwelling units are configurations where the building has one or more central exhaust fans, each of which serves multiple dwelling units. Determine whether the system is intended to provide dwelling unit ventilation (run continuously or scheduled), local exhaust for bathrooms or kitchens (run intermittently), or both. Ventilation is provided to dwelling units via outdoor make-up air induced by the central exhaust fans.

Note

Although a central HVAC air handler supplying outdoor air directly to multiple dwelling units is a reliable strategy for providing ventilation, it is uncommon in existing multifamily buildings. This document does not include guidance for this configuration.

For other dwelling unit ventilation configurations, refer to [Priority Issue 19.0 Mechanical Ventilation for Individual Dwelling Units](#) or [20.0 Natural \(Not Fan-Powered\) Ventilation](#).

AP 19.2 Determine Whether Central Mechanical Exhaust Ventilation Systems Meet ASHRAE Standard 62.2-2019 Requirements

Determine whether the ventilation in each dwelling unit meets ASHRAE Standard 62.2-2019 Appendix A requirements for existing buildings). This includes (depending on whether the system provides exhaust, dwelling unit ventilation or both)—

- Dwelling unit ventilation rate
- Bath and kitchen exhaust fan airflow rates
- Proper location of exhaust discharges

Conduct the assessment in as many dwelling units as possible. If the assessment will be based on a sample of dwelling units, be sure to include any units for which there are indoor air quality complaints or complaints of drafts.

AP 19.3 Determine Whether Common Corridors and Nonresidential Spaces Meet Ventilation Requirements

Determine whether the amount of outdoor air ventilation provided to common corridors and nonresidential spaces meets the ASHRAE Standard 62.1-2019 requirements, as described in MA 19.2.

AP 19.4 Identify and Assess Outdoor Air Intakes

Identify the location of outdoor air intakes and assess their distances from outdoor pollutant sources (e.g., vehicle exhaust, plumbing vents, exhaust discharges).

Note

When assessing central exhaust systems, confirm that local or continuous exhaust ventilation does not exacerbate radon levels in homes with potential radon problems (see [Priority Issue 11.0: Radon](#)) or conflict with proper venting of combustion appliances or pressure control of pollutant migration in adjoining spaces.

MINIMUM ACTIONS



MA 19.1 Repair and Upgrade Central Mechanical Exhaust Ventilation Systems as Needed

If dwelling units are served by central mechanical exhaust systems—

- Adjust, repair or replace the ventilation systems so that each dwelling unit served by the central exhaust system meets its intended use (dwelling unit ventilation, local exhaust or both) and the requirements of ASHRAE Standard 62.2-2019, including Appendices A3 (Local Exhaust in Existing Buildings) and A2 (Dwelling Unit Ventilation), including—
 - Adjust, repair or replace the central fans, ductwork and fittings.
 - Ensure that each dwelling unit receives the required airflow:
 - Remove blockages in exhaust ductwork.
 - Air seal exhaust air ductwork using approved materials. Ensure that the roof curb connection, the lateral connections and the sheetrock/plaster connections behind the exhaust grilles are sealed.

- o Install air-regulating exhaust dampers at each exhaust grille (typically proprietary flow-limiting devices or orifice plates).
 - o For central exhaust used in intermittent operation, ensure that there is an operable backdraft damper or motorized damper at each exhaust point.
- If it is not possible to achieve the ASHRAE Standard 62.2-2019 minimum outdoor air ventilation rates, adjust systems to provide the maximum amount of outdoor air ventilation possible.
- If the system is designed to provide local exhaust only intermittently, adjust the exhaust system to provide continuous operation and meet the ASHRAE Standard 62.2-2019 whole-building ventilation rate requirement for each dwelling unit.
- Compartmentalize to reduce make-up air coming from adjacent units. Refer to [Priority Issue 16.0: Compartmentalization to Prevent Odor or Unwanted Air Transfer](#) and [Appendix A: Compartmentalization—Additional Information](#).
 - Advise the building owner or property manager to implement a preventive maintenance plan to inspect exhaust grilles in all dwelling units at least once per year.
- Ensure that outdoor air intakes that are part of ventilation systems for dwelling units are located a minimum distance of 10 feet from contaminant sources, including plumbing stacks, vents, exhaust hood discharges or vehicle exhaust.
- If mechanical exhaust systems serve several areas, ensure that the backdraft dampers are installed as required by local codes.

MA 19.2 Repair, Adjust and Upgrade Ventilation Systems in Common Corridors and Nonresidential Spaces as Needed

Ensure that common corridors in the building meet the ASHRAE Standard 62.1-2019 minimum outdoor air ventilation rate requirement of 0.06 cfm/ft² of floor area.

If included in the scope of service, ensure that nonresidential spaces in the building meet the ventilation requirements of ASHRAE Standard 62.1-2019.

If it is not possible to achieve the ASHRAE Standard 62.1-2019 minimum outdoor air ventilation rates, adjust systems to provide the maximum amount of outdoor air ventilation possible.

EXPANDED ACTIONS

EA 19.1 Air Seal Exhaust Ventilation Shaft

Air seal the central exhaust system's ventilation shaft with a spray seal system (aerosol or fluid applied). This allows sealing the leakage area associated with inaccessible duct joints to provide pressure control and improve the capability to balance exhaust airflows among dwelling units. Ensure that the ductwork sealing required under Minimum Actions (roof curb connections, lateral connections and connections behind exhaust grilles) has been completed before air sealing the ventilation shaft.

EA 19.2 Meet Outdoor Air Filtration and Air-Cleaning Requirements of ASHRAE Standard 189.1

Higher filtration can both improve IAQ and protect HVAC equipment. For new HVAC systems, install filters with the highest MERV rating that the equipment is capable of physically accommodating and for which there is adequate fan capacity to overcome the filters' pressure drop.

For existing systems, check with the manufacturer to determine whether filters with higher MERV ratings can be installed. Install filters with the highest MERV rating that can be accommodated by the equipment.

Relevant Standards or Guidance

- [ASHRAE Standard 62.1-2019, Ventilation for Acceptable Indoor Air Quality](#)
- [ASHRAE Standard 62.2-2019, Ventilation and Acceptable Indoor Air Quality in Residential Buildings](#)
- [ASHRAE Standard 189.1-2017, Standard for the Design of High-Performance Green Buildings](#), Section 8.3.1.3 Filtration and Air Cleaner Requirement
- [NCHH: Improving Ventilation in Existing or New Buildings With Central Roof Exhaust](#)
- [New York State Energy Research and Development Authority \(NYSERDA\): Improving Central Exhaust Systems for Multifamily Building](#)

PRIORITY ISSUE 20.0: NATURAL (NOT FAN-POWERED) VENTILATION

Ventilation can help remove moisture and other contaminants generated by resident activity and increase air flows.

ASSESSMENT PROTOCOLS

AP 20.1 Determine Whether Dwelling Units Are Served by Natural Ventilation (Not Fan-Powered) Systems

Natural ventilation is a configuration in which outdoor air ventilation is provided to dwelling units without using mechanical fans; such ventilation includes passive rooftop hoods, passive exhaust shafts, and exhaust grilles that serve one or more dwelling units.

For other dwelling unit ventilation configurations, refer to [Priority Issue 18.0: Mechanical Ventilation for Individual Dwelling Units](#) or [Priority Issue 19.0: Mechanical Ventilation for Multiple Dwelling Units Using Central Exhaust](#).

Note

Operable windows on their own are not considered in this issue, because additional strategies must be used to induce drafts through the building.

AP 20.2 Determine Whether ASHRAE Standard 62.2-2019 Mechanical Ventilation Exceptions Are Met

Determine whether the dwelling units and building meet the exceptions to the whole-building mechanical ventilation requirement in ASHRAE Standard 62.2-2019, Section 4.1.1.

AP 20.3 Determine Whether Common Corridors and Nonresidential Spaces Meet Ventilation Requirements

Determine the amount of outdoor air ventilation provided to common corridors and whether this meets the ASHRAE Standard 62.1-2019 minimum requirement of 0.06 cfm/ft² of floor area.

If nonresidential spaces (e.g., exercise rooms, lobbies, mailrooms, commercial/retail spaces) are included in the scope of service, determine whether the ventilation in these spaces meets the requirements of ASHRAE Standard 62.1-2019.

AP 20.4 Identify and Assess Openings for Outdoor Air Ventilation

Identify the location of openings for outdoor air ventilation, and assess their distances from outdoor pollutant sources (e.g., vehicle exhaust, plumbing vents, exhaust discharges).

MINIMUM ACTIONS

MA 20.1 Repair and Upgrade Natural Ventilation Systems as Needed

If the dwelling unit is served by natural ventilation and does not meet the exceptions to the whole-building mechanical ventilation requirement in ASHRAE Standard 62.2-2019, Section 4.1.1, or does not perform as intended, convert the natural ventilation system to a fan-powered system:



- In dwelling units that have no fan-powered space conditioning systems, install a low-noise (maximum of 1 sone for bathrooms, 3 sones for kitchens) exhaust fan ducted directly to the outdoors in each bathroom and kitchen. Ensure that each exhaust fan meets the local exhaust (e.g., kitchen or bath) requirements of ASHRAE Standard 62.2-2019 and at least one exhaust fan (or a system including multiple fans) meets ASHRAE Standard 62.2-2019 for whole-building ventilation, as well as Section 4 for existing buildings.
- In dwelling units equipped with fan-powered air handlers for space conditioning equipment, where possible—
 - Provide ducted, filtered outdoor air to the return side of the HVAC unit and install a timer to ensure that the operating schedule and outdoor air ventilation rate meet ASHRAE Standard 62.2-2019 intermittent ventilation requirements. The system shall be capable of providing the required ventilation regardless of the heating or cooling demand in the dwelling unit. Alternatively, install a variable-speed fan to reduce energy use when the system operates in ventilation-only mode, or operate local exhaust fans (e.g., bath fans) continuously.
 - Install a low-noise (maximum of 1 sone for bathrooms, 3 sones for kitchens) exhaust fan ducted directly to the outdoors in each bathroom and kitchen, meeting the requirements of 62.2-2019 Section 5. If providing central fan-powered mechanical exhaust ventilation systems as part of the building upgrade, refer to [Priority Issue 19.0: Mechanical Ventilation for Multiple Dwelling Units Using Central Exhaust](#).

- Ensure that ventilation openings for introducing outdoor air into dwelling units are located a minimum distance of 10 feet from contaminant sources, including plumbing stacks, vents, exhaust hood discharges or vehicle exhaust (see ASHRAE Standard 62.2-2019).

Note

Confirm that local or continuous exhaust ventilation does not exacerbate radon levels in homes with potential radon problems (see [Priority Issue 11.0: Radon](#)) or conflict with proper venting of combustion appliances or pressure control of pollutant migration in adjoining spaces.

MA 20.2 Repair, Adjust and Upgrade Ventilation Systems in Common Corridors and Nonresidential Spaces as Needed

Ensure that the building's common corridors meet the ASHRAE Standard 62.1-2019 minimum outdoor air ventilation rate requirements.

If that is not possible, adjust systems to provide the maximum amount of outdoor air ventilation possible.

EXPANDED ACTIONS

EA 20.1 Include Requirements for Advanced Passive Ventilation Systems

If a passive ventilation system is desired in lieu of a mechanical system, the passive system must be designed and approved by a licensed engineer, taking into account expected stack effect, wind, local terrain and shielding.

The ventilation rate for each dwelling unit must be sufficient to achieve the goal of an ASHRAE Standard 62.2-2019 mechanical ventilation rate; specifically, the annual average ventilation rate shall not be less than if a mechanical system had been installed in accordance with 62.2-2019.

EA 20.2 Meet Outdoor Air Filtration and Air-Cleaning Requirements of ASHRAE Standard 189.1, as Applicable to Nonresidential Spaces

Natural ventilation systems cannot provide outdoor air filtration of nonresidential spaces in geographic locations where the outdoor air exceeds the national standards for particulate matter (PM_{2.5}, PM₁₀) or ozone. Mechanical ventilation with adequate filtration (see [Priority Issue 18.0 Mechanical Ventilation for Individual Dwelling Units](#), EA 18.2) should be used.

Relevant Standards or Guidance

- [ASHRAE Standard 62.1-2019, Ventilation for Acceptable Indoor Air Quality](#)
- [ASHRAE Standard 62.2-2019, Ventilation and Acceptable Indoor Air Quality in Residential Buildings](#)
- [ASHRAE Standard 189.1-2017, Standard for the Design of High-Performance Green Buildings, Section 8.3.1.3 Filtration and Air Cleaner Requirement](#)
- [NCHH: Improving Ventilation in Existing or New Buildings With Central Roof Exhaust](#)
- [NCHH: Improving Ventilation in Multi-Family Buildings That Do Not Have Fan-Powered Ventilation](#)
- [NYSERDA: Improving Central Exhaust Systems for Multifamily Buildings](#)

PRIORITY ISSUE 21.0: SOURCE VENTILATION/LOCAL EXHAUST VENTILATION

Ventilation can help to remove moisture and other contaminants generated by resident activity, as well as increase air flow. Local ventilation can help reduce moisture and contaminants at localized sources, such as in kitchens and bathrooms.

ASSESSMENT PROTOCOLS

AP 21.1 Identify Contaminant Sources That Require Exhaust Ventilation

Identify rooms or areas with local contaminant sources that require exhaust ventilation, such as bathrooms, kitchens, laundry rooms, garages and other spaces with strong pollutant sources. To the extent possible, include nonresidential spaces in the building (e.g., retail spaces, fitness facilities, beauty and nail salons), which may require collaboration with the building owner, property manager, and other tenants and occupants within the building.

AP 21.2 Assess Dwelling Units for Local Exhaust and Compliance with ASHRAE Standard 62.2-2019

Determine whether dwelling units in the building have local exhaust ventilation, particularly in kitchens and bathrooms.

Determine whether the dwelling units comply with the local exhaust requirements for kitchens and bathrooms of ASHRAE Standard 62.2-2019, including the standard's Appendix A for existing buildings, as applicable. Determine kitchen and bathroom exhaust flow rates and whether exhaust is vented directly to the outdoors.

AP 21.3 Assess Clothes Dryer Exhausts

Determine whether clothes dryers exhaust directly to the outdoors. Condensing dryers piped to a drain are exempt. Inspect or verify that clothes dryer exhaust ducts do not discharge into crawlspaces or attics or within walls. Inspect clothes dryer vents for restrictions and lint buildup.

AP 21.4 Determine Whether Spaces Outside Dwelling Units Comply With Applicable Local Exhaust Requirements

Determine whether spaces outside dwelling units in the building comply with the exhaust requirements of ASHRAE Standard 62.1-2019, Table 6.5, as applicable. To the extent possible, include nonresidential spaces in the building (e.g., retail spaces,

fitness facilities, beauty and nail salons, parking garages), which may require collaboration with the building owner, property manager and other tenants.

AP 21.5 Occupant Complaints

Inquire about occupant complaints of odors or moisture or mold that might be caused by lack of adequate local exhaust ventilation.

MINIMUM ACTIONS

MA 21.1 Install, Repair or Replace Local Exhaust Ventilation in Dwelling Units

If ASHRAE Standard 62.2-2019 requirements for kitchen and bathroom exhausts are not met, install, repair or replace local exhaust ventilation in dwelling units to meet the requirements. Ensure that ducts are sized and installed properly and exhausted directly to the outdoors.

In dwelling units where local exhaust ventilation is deficient and cannot be corrected with exhaust fans, increase the whole-building ventilation airflow that applies to the dwelling unit to compensate, using the alternative compliance method (Appendix A of Standard 62.2-2019).

Ensure that, if provided, kitchen and bath exhaust fans are operational, vented directly to the outdoors, and meet the continuous or intermittent exhaust rate requirements of ASHRAE Standard 62.2-2019.

Advise building management and occupants about the need to use exhaust fans in kitchens and bathrooms during activities that generate pollutants and moisture (e.g., cooking, showering).



MA 21.2 Ensure Proper Venting of Clothes Dryers

Ensure that all clothes dryers exhaust directly to the outdoors and cannot be readily diverted indoors by occupants. Condensing dryers piped to a drain are exempt.

MA 21.3 Meet Exhaust Requirements for Spaces Outside Dwelling Units

Install, repair or replace exhaust ventilation in spaces outside dwelling units to meet the minimum exhaust rates specified in ASHRAE Standard 62.1-2019, Table 6.5. This may include, for example, janitor closets, trash storage areas, laundry facilities and parking garages.

To the extent possible, work with the building owner, property manager and other building tenants to ensure that retail and other nonresidential spaces have exhaust

ventilation that meets the applicable requirements of ASHRAE Standard 62.1-2019, Table 6.5.

MA 21.4 Implement Minimum Actions for Compartmentalization to Supplement Exhaust Ventilation

Follow the Minimum Actions under [Priority Issue 16.0: Compartmentalization to Prevent Odor or Unwanted Air Transfer](#) to enhance the effectiveness of exhaust ventilation and reduce odor migration and unwanted airflow from adjacent spaces.

EXPANDED ACTIONS

EA 21.1 Kitchen and Bathroom Exhaust Full-Compliance

Ensure that kitchen and bath exhausts meet requirements of ASHRAE Standard 62.2-2019, without the need to use the alternative compliance path (Appendix A of ASHRAE Standard 62.2-2019).

EA 21.2 Use Strategies in Bathrooms to Control Local Exhaust Fan

Use one or more of the following strategies in bathrooms to control the use of the local exhaust fan:

- An occupancy/motion sensor
- An automatic humidistat controller
- An automatic timer to operate the fan for 20 minutes or more after an occupant leaves the room
- A continuously operating exhaust fan

EA 21.3 Install Additional Local Exhaust Ventilation

For spaces outside dwelling units with strong, localized pollutant sources (e.g., arts and crafts rooms, exercise rooms, cleaning supply closets), consider installing dedicated local exhaust ventilation.

EA 21.4 Implement Expanded Actions for Compartmentalization to Supplement Exhaust Ventilation

Follow the Expanded Actions under [Priority Issue 17.0: HVAC Equipment](#) to further enhance the effectiveness of exhaust ventilation and reduce odor migration and unwanted airflow from adjacent spaces.

Note

Evaluate whether local or continuous exhaust ventilation has the potential to conflict with proper venting of combustion appliances or exacerbate pressure-driven migration and entry of pollutants from other spaces or from the soil (e.g., radon).

Relevant Standards or Guidance

- [ASHRAE Standard 62.1-2019, Ventilation for Acceptable Indoor Air Quality](#)
- [ASHRAE Standard 62.2-2019, Ventilation and Acceptable Indoor Air Quality in Residential Buildings](#)

SAFETY

PRIORITY ISSUE 22.0: BUILDING SAFETY FOR OCCUPANTS

ASSESSMENT PROTOCOLS

AP 22.1 Assess Building Safety

Document safety hazards that are observed during the building IAQ walkthrough, energy audit or other inspections. **Immediately inform the building owner and property manager of any urgent and life-threatening conditions.**

AP 22.2 Assess Smoke and CO Alarms

Determine whether there are working smoke alarms and CO alarms installed in dwelling units and other locations in the building.

AP 22.3 Identify Prevalence and Storage of Harmful Chemicals

Identify products containing hazardous chemicals (e.g., strong cleaners, hazardous materials, pesticides) that are stored in accessible locations.

AP 22.4 Identify Fire Extinguisher Locations

Check whether there are working fire extinguishers in dwelling units and appropriate common areas. Work with the building owner or property manager to assess whether fire extinguisher placement meets applicable codes.

AP 22.5 Assess Water Heater Temperature Settings

Determine whether water heater temperature settings are within the allowable limits of the local and state codes.

AP 22.6 Assess Whether Knob-and-Tube Electrical Wiring Is Present

Assess whether knob-and-tube electrical wiring is present in the building and whether it is located in areas affected by the building upgrades.

MINIMUM ACTIONS

MA 22.1 Correct Safety Hazards Identified During Assessments

Immediately correct urgent and life-threatening safety risks. Correct other safety hazards during the building upgrade activities.

MA 22.2 Correct Deficiencies in Smoke and CO Alarms

Replace nonfunctioning smoke and CO alarms. If smoke alarms or CO alarms are not present, install new alarms consistent with local code requirements; if local code requirements do not exist, install smoke alarms and CO alarms in every dwelling unit consistent with CPSC guidance and located according to NFPA 72 (NFPA 720). If new batteries are used, consider installing 10-year lithium batteries. Provide client education on appropriate response to alarm activation.

Note

It is recommended that CO alarms have a digital display and provide peak level readings.

MA 22.3 Recommend Appropriate Storage of Hazardous Chemicals

Recommend appropriate and controlled storage of products containing hazardous chemicals (e.g., strong cleaners, hazardous materials, pesticides).

**MA 22.4 Provide Adequate Fire Extinguishers**

Work with the building owner or property manager to ensure that there are fire extinguishers installed according to applicable code requirements.

MA 22.5 Adjust Water Heater Temperatures

Ensure that water heater set points do not exceed either local and state codes or 140°F, which can still lead to scalding within 3 seconds of human exposure.

MA 22.6 Follow Precautions When Knob-and-Tube Electrical Wiring Is Present

Follow the precautions outlined in [DOE Standard Work Specifications for Single-Family Home Energy Upgrades](#), Section 2.0601.1, for knob-and-tube electrical wiring. This includes requirements that live knob-and-tube wiring shall not be covered or surrounded, and that exposed knob-and-tube wiring shall be replaced with new appropriate wiring, as required by the National Electrical Code or authority having jurisdiction.

EXPANDED ACTIONS

EA 22.1 Install CO Alarms Capable of Detecting and Storing Low Levels

Install CO alarms that can detect and store peak CO levels of less than 30 parts per million in dwelling units.

EA 22.2 Install Fall Prevention Measures

Install grab bars and handrails for fall prevention. Install guards to prevent falls as stated in the NCHH–American Public Health Association (APHA) National Healthy Housing Standard, Section 3.7. For housing with small children, recommend that occupants install child safety gates at the tops of stairs.

EA 22.3 Install Light Switches in Stairwells

Recommend installation of light switches at the top and bottom of all stairwells.

EA 22.4 Consider Step Lighting

Consider installation of safety lighting on or near steps. Consider energy-efficient LED lighting.

EA 22.5 Repair Malfunctioning Doors, Windows, Roofs and Floors

Repair malfunctioning doors, windows, roofs and floors.

EA 22.6 Ensure the Safety of Electrical Systems

Have qualified personnel ensure that electrical systems are in accordance with applicable codes.

Relevant Standards or Guidance

- [CDC: Check for Safety: A Home Fall Prevention Checklist for Older Adults](#)
- [CPSC: Carbon Monoxide Questions and Answers](#)
- [DOE: Standard Work Specifications for Single-Family Home Energy Upgrades, Section 2.0601.1](#)
- [EPA: Safer Choice](#)
- [NCHH-APHA: National Healthy Housing Standard, Section 3.7](#)
- [NFPA 720: Standard for the Installation of Carbon Monoxide \(CO\) Detection and Warning Equipment](#)
- [UL 2034: Standard for Single and Multiple Station Carbon Monoxide Alarms](#)

PRIORITY ISSUE 23.0: PROTECTING INDOOR AIR QUALITY DURING CONSTRUCTION



Precautions can help minimize worker and occupant exposure to air contaminants during construction and prevent IAQ problems after construction is complete.

ASSESSMENT PROTOCOLS

AP 23.1 Assess Occupancy During Construction Periods

Determine the nature of building occupancy during the construction periods. Identify areas of the building that will be occupied. Identify any special needs of the building occupants (e.g., children, elderly people, disabled people). Identify occupant complaints or concerns.

AP 23.2 Identify Construction Contaminants and Pathways

Identify potential IAQ contaminant sources from building upgrades (e.g., activities, materials and equipment that have the potential to cause IAQ problems) and pathways through which contaminants could affect the air quality for the building occupants (e.g., adjacent areas, return ducts, stairwells).

AP 23.3 Identify Risk of Mercury Exposure

Identify the potential risk for mercury exposure during the building upgrade.

Mercury exposure can occur when mercury-containing products and devices—such as thermometers, thermostats, compact fluorescent lamp (CFL) bulbs, and fluorescent lamps—are broken and mercury is released into the building.

Mercury exposure is a risk in a building where broken mercury-containing products and devices are identified—especially when a designated place for proper disposal of such material is not available. If the upgrade involves installing or replacing mercury-containing products, mercury is a potential risk as part of the upgrade.

MINIMUM ACTIONS

MA 23.1 Minimize Occupant and Worker Exposures During Construction

When conducting activities that may result in exposure to airborne contaminants (e.g., cutting or grinding materials, painting, installing insulation), comply with local laws and adhere to the Sheet Metal and Air Conditioning Contractors' National



Association (SMACNA) Indoor Air Quality Guidelines for Occupied Buildings Under Construction. Minimize occupant and worker exposure to VOCs, particles and other airborne contaminants using the following procedures:

- Restrict from construction areas any building occupants and workers not wearing the PPE needed for the work being performed.
- Separate construction areas from occupied portions of the building using appropriate containment and ventilation practices. For example, (1) ensure that work areas are properly isolated by erecting an air barrier separating the work area from occupants, and (2) if necessary, ventilate the work area with exhaust to the outdoors to establish negative pressure relative to surrounding spaces. Ensure that construction contaminants exhausted to the outdoors do not re-enter the building.

MA 23.2 Protect HVAC Systems

Protect HVAC systems from contaminants during work activities.

- Seal openings in existing ducts located in work areas to avoid infiltration of dust and debris.
- New HVAC equipment, ducts, diffusers and return registers should be stored in a clean, dry place and should be covered to prevent dust accumulation.
- If operating an HVAC system that interfaces with work areas, ensure that the system does not pull return air from the work areas, and install air filters with a MERV 8 rating or higher during construction activities.
- Visually inspect ductwork after construction activities have been completed, and clean internal surfaces as needed to remove dust and debris.
- Ensure that all filters that were used during work activities have been removed and new filters are properly installed before operating the HVAC system during occupancy.

MA 23.3 Handle Mercury Properly

If mercury is identified, determine whether the building has a mercury spill response plan and provide guidance to the property manager and occupants on how to perform proper cleanup. Refer to EPA guidance on cleanup.

Take particular care not to break any mercury-containing materials during upgrade activities. If an accidental spill occurs, refer to EPA guidance on cleanup. Properly dispose of fluorescent lighting and CFL bulbs that may be part of energy upgrade activities.

MA 23.4 Protect Highly Absorptive Materials

Protect any existing absorptive materials (e.g., fabrics, furnishings, carpets) by fully covering them with plastic sheeting.

Schedule the installation of new absorbent materials after major dust- and pollutant-generating activities have been completed. Ensure that materials have not been exposed to moisture and are dry before installation.

MA 23.5 Safely Install Spray Foam Insulation

Minimize occupant and worker exposure to VOCs or other airborne contaminants: Ensure proper isolation (e.g., containing the work area with plastic sheeting) and exhaust ventilation to the outdoors of work areas during activities that result in VOC emissions (e.g., painting, sealing, finishing), ventilating as close as possible to the source of contaminant emissions.

Onsite Precautions: When spray polyurethane foam (SPF) or poured insulation is used, follow the manufacturer's instructions for (1) vacating building occupants and other unprotected individuals not involved in the application of the products from the premises during and for some period after application, (2) isolating and ventilating the work areas, and (3) using PPE.

Note

The curing time (complete reaction) varies depending on the [type of SPF product](#), product formulation, applicator technique, foam thickness, temperature, humidity and other factors. [Together, these factors will affect reoccupancy time](#). Cutting or trimming foam before it is fully cured may cause exposure to unreacted SPF chemicals. See EPA's Spray Polyurethane Foam Web resources and the [American Chemistry Council's Center for the Polyurethanes Industry Spray Polyurethane Foam Health + Safety website](#) for additional information.

EXPANDED ACTIONS**EA 23.1 Consider Additional Protections as Appropriate**

Consider implementing the following options:

- Require rigid-wall air barriers with sealed, lockable entries between work areas and occupied spaces, and provide negative pressurization to contain contaminants.
- Create a buffer zone around work sites.

- Restrict construction activities to hours of reduced occupancy when feasible.
- Conduct temporary air cleaning.
- Stage construction activities in controllable sizes.
- Control pressurization and the indoor environment with temporary HVAC equipment.
- Vacate the entire building, when feasible.
- If negative pressurization in the work areas is not possible, consider an exhausted double wall buffer zone to separate work areas from surrounding areas.
- Ensure that fire egress requirements from occupied portions of the building are maintained when isolating work areas.
- Do not conduct dry sanding without implementing containment measures for the dust generated.
- Establish vehicle staging areas for loading and unloading materials and equipment at least 100 feet from outdoor air intakes, operable windows and entryways to the building.
- Clean the area thoroughly and frequently and before re-entry of unprotected workers or occupants to ensure the removal of any dust that may contain pollutants. Use sealed HEPA-rated vacuums.
- Follow all manufacturers' printed instructions, which may indicate the need to evacuate building occupants and other unprotected individuals from work areas during and for some period after the use of a product.
- Ensure sufficient ventilation and cure time to protect occupants before re-entry into the work area.
- Create specific plans to contain particulate matter during demolition activities.
- Limit the impact of airborne contaminants released by roofing materials during installation (e.g., hot mop asphalt, seam sealing on ethylene propylene diene monomer (EPDM), polyvinyl chloride or modified bitumen roofing). Establish isolation barriers and keep roofing materials away from outdoor air intakes.
- Promptly respond to any occupant complaints or concerns.

EA 23.2 Replace Mercury-Containing Products and Materials, Where Possible

Encourage replacement of mercury-containing products and devices (excluding fluorescent lights and CFL bulbs) with products that do not contain mercury.

Relevant Standards or Guidance

- [American Chemistry Council: Spray Polyurethane Foam Health + Safety](#)
- [ASHRAE Standard 62.1-2019, Ventilation for Acceptable Indoor Air Quality, Section 7.1.4.2](#)
- [EPA: Building Air Quality Action Plan](#), Step 8: Establish Procedures for Responding to IAQ Complaints
- [EPA: What to Do If You Spill More Mercury Than the Amount in a Thermometer](#)
- [EPA: Ventilation Guidance for Spray Polyurethane Foam Application](#)
- [SMACNA: IAQ Guidelines for Occupied Buildings Under Construction](#)
- [Spray Polyurethane Foam Alliance \(SPFA\)](#)
- [DOL, OSHA, Green Jobs Hazards: Green Jobs Hazards, Weather Insulating/ Sealing](#)



PRIORITY ISSUE 24.0: JOBSITE SAFETY

Taking precautions to provide a safe job site reduces risks for workers and occupants.

ASSESSMENT PROTOCOLS



AP 24.1 Evaluate Risks

Evaluate worker health and safety concerns that could be encountered during the building upgrade. Refer to [Appendix B: Worker Protection](#) for recommended evaluation measures and actions.



MINIMUM ACTIONS

MA 24.1 Ensure Worker Protection

See [Appendix B: Worker Protection](#) for recommended actions to protect worker health and safety, as well as available resources.

EXPANDED ACTIONS

This section is intentionally left blank.

Appendix A: Compartmentalization— Additional Information



To reduce the movement of odors and air pollutants between indoor spaces, three strategies are commonly employed: (1) Source Control, (2) Ventilation and Air Pressure Control, and (3) Air Sealing. Source Control approaches are often specific to the specific problem contaminant (e.g., Priority Issues: [2.0](#), [3.0](#), [4.0](#), [5.0](#), [8.0](#), [13.0](#), [14.0](#), [21.0](#)) and are described in each priority section. Ventilation and air sealing approaches may be more generically applied to different contaminants. These latter approaches are described in more detail below.

VENTILATION AND AIR PRESSURE CONTROL

- If the existing ventilation exhaust system relies on a central exhaust, specify and install a new balancing device at each exhaust point with a minimum operating pressure to help ensure that required airflow and system performance are not significantly affected by stack effect. For dwelling units, balance airflows for each unit by sealing duct/shaft leaks and with air balancing devices (e.g., constant airflow regulators or orifice plates) at the exhaust points. When flows are the same from adjacent dwelling units with similar leakage characteristics, there is less potential for air and odor transfer between units.
- Provide dedicated pathways for make-up ventilation air in dwelling units. If necessary, provide mechanically supplied make-up air to spaces with mechanical exhaust to prevent excess negative pressure. The total net exhaust flow of the two largest exhaust appliances (including kitchen fan and clothes dryer) shall be limited to 15 cfm per 100 ft² of occupiable floor area when in operation at full capacity, or compensating outdoor airflow must be provided.

Note

Effective compartmentalization can be difficult to achieve with a central exhaust ventilation system, because the system experiences significant pressure fluctuations due to seasonal conditions affecting the stack effect pressures within the building.

- If the existing ventilation system relies on make-up air provided from pressurized corridors to each dwelling unit via leaks around entry doors (e.g., door undercuts and doors that are not weather-stripped), then the compartmentalization principle can be compromised by air drawn from neighboring spaces. Prevent unwanted air transfer and cross-contamination from adjacent spaces by implementing compartmentalization air sealing as described below.
- If make-up air is not provided by pressurized corridor systems, provide outdoor make-up air to each unit (e.g., trickle vents) and do not install pressurized corridor make-up air systems.

AIR SEALING

Compartmentalization by sealing is complex and tedious. Air sealing may be performed in spaces/units with sources, noncompliant spaces/units or both. Some air leakage pathways are very difficult to access in existing buildings. The accessible air leaks often are behind furniture, boxes, clothing or carpets. The inaccessible—and often the largest—leaks are behind built-in cabinets, walls and ceilings. Sealing inaccessible leaks usually is very disruptive in occupied units and requires significant effort in unoccupied units. It becomes more practical when it may solve more than one problem (e.g., tobacco smoke transport and roaches). It often takes successive rounds of air sealing to reduce pollutant migration, and it is very difficult to eliminate all leakage between dwelling units.

Air Sealing—General

- Identify potential areas of uncontrolled environmental tobacco smoke leakage from adjacent units via visual inspection, infrared thermography, chemical smoke and/or pressure testing. ASTM E1186-03 (2009) Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems can be used to guide the air sealing assessment work.
- For all accessible areas, reduce the transfer by using sealants or caulking to create a continuous air barrier. Seal all penetrations in the adjoining surfaces, including joints between walls, ceilings and floors; electrical penetrations for lighting, outlets, switches, wiring and smoke alarms; penetrations for plumbing, HVAC piping and sprinkler heads; HVAC penetrations for ducts and fans; and vertical shafts and chase ways that terminate in the attics or crawlspaces.
- Seal the largest openings first—for example, joints around plumbing penetrations, joints around ventilation openings, lighting penetrations, openings behind baseboard heaters, electrical outlets, etc.

- To track progress during sealing, a blower door depressurization test of airflow at a pressure difference of 50 Pascals can be used. Note that exhaust duct systems should be temporarily sealed off during the blower door depressurization test.
- Apply weather-stripping to all doors between dwelling units and common hallways to minimize air leakage into the hallways. If the existing ventilation system relies on make-up air provided to dwelling units by pressurized corridors, do not weather-strip unit entry doors, and restore or repair the make-up air system as needed (see pressurized corridors, above).
- Seal openings between mechanical rooms and occupied spaces.
- Air seal ventilation ductwork.
- Provide tight-fitting windows and self-closing doors fitted with gaskets in the spaces that are likely to be sources of irritating or noxious odors.
- Seal the enclosure at receiving areas or docks.
- Make as airtight a connection as practical between the bottom of the trash chute and the compactor and dumpster assembly. Limit makeup air provided to trash rooms to below exhaust airflows to maintain a negative pressure relative to adjacent spaces, which will reduce odor and pollutant release to upper floors during corridor trash door use.
- Provide all combustion air and makeup air for equipment in the mechanical room from the outdoors.

Air Sealing—Dwelling Units

- For all accessible areas, seal all penetrations between adjoining dwelling units and where fire walls are located with suitable air sealing or fire-stop materials. Where possible, air sealing shall be directed to openings in interior surfaces without tightening the exterior. According to the 2015 International Building Code, walls separating dwelling units in the same building, walls separating sleeping units in the same building, and walls separating dwelling or sleeping units from other occupancies contiguous to them in the same building shall be treated as fire partitions.
- If common hallways are intentionally pressurized with respect to the dwelling units, then doors in the dwelling units leading to the common hallways need not be weather-stripped, provided that dwelling units are at a negative pressure relative to the hallways of 1 Pascal or greater when the doors between the hallway dwelling unit are closed.
- If new ventilation systems are being installed, avoid pressurizing corridors or depressurizing dwelling units more than 5 Pascals below the pressure in adjacent units.

- *Expanded Air Sealing:* If the building is undergoing extensive rehabilitation, extend compartmentalization efforts to all dwelling units. Provide air sealing in all separating walls, floors and ceilings to achieve compartmentalization within each dwelling unit, with an airtightness of 0.3 cfm/ft² of enclosure area (i.e., sum of all wall, ceiling and floor areas) at 50 Pascals pressure difference—or as low a pressure difference as possible—during a blower door test conducted according to either ASTM E779-10 Standard Test Method for Determining Air Leakage Rate by Fan Pressurization or ASTM E1827-11 Standard Test Methods for Determining Airtightness of Buildings Using an Orifice Blower Door. The test shall be conducted as if the dwelling unit were exposed to outdoor air on all sides and on top and bottom by opening doors and windows in adjacent dwelling units.

Notes

- Compartmentalization is intended to reduce odors due to unwanted air transfer, but it does not eliminate them.
- Compartmentalization activities must consider ventilation system design and operating characteristics to reduce driving forces for unintended airflow between dwelling units.
- Install sealing materials according to manufacturer's specifications. Fire-rated assemblies must be sealed using approved fire-rated materials.

Relevant Standards or Guidance

- [ASTM E779-19: Standard Test Method for Determining Air Leakage Rate by Fan Pressurization](#)
- [ASTM E1186-17: Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems](#)
- [ASTM E1827-11\(2017\): Standard Test Methods for Determining Airtightness of Buildings Using an Orifice Blower Door](#)
- [EPA: Building Air Quality Action Plan](#), Step 2: Develop an IAQ Profile of Your Building, Part 2: Conduct a Walkthrough
- [International Code Council: International Building Code, 2018 Edition](#)
- [NREL Section 3: Air Sealing](#)
- [UL: Fire-Resistance and Smoke Protection](#)

Appendix B: Worker Protection



This appendix contains information to help those performing and supervising the building upgrade assess the risks to workers; it recommends actions to minimize risks to workers' health and safety and identifies resources for additional information. Worker protection is especially important in older buildings. Areas undergoing construction may contain remnants of legacy contaminants, such as lead and asbestos. Although these materials often are not considered harmful if left undisturbed or covered, they can become a concern when disturbed. Therefore, it is essential that the contractors review available information about the existence of such materials before beginning any modifications to the building. In some situations, only certified personnel can perform certain activities outlined in this Guide.

By law, employers and supervisors are required to provide workers with a workplace that is free from recognized hazards that can cause or are likely to cause death or serious physical harm, as required in Section 5(a)(1) of the Occupational Safety and Health Act of 1970. Employers and supervisors must ensure the following:

1. Work site operations are conducted in compliance with Occupational Safety and Health Administration (OSHA) regulatory requirements. OSHA regulatory requirements identify the following construction hazards to be addressed:
 - Asbestos-Containing Materials: 29 CFR Part 1926.1101
 - Chemical Hazards: 29 CFR Part 1910.1200 and 29 CFR Part 1926.59
 - Confined Spaces: 29 CFR Part 1926.21 (b)(6)(i)
 - Electrical: 29 CFR Part 1926, Subpart K
 - Falls: 29 CFR Part 1926.501
 - Ladders: 29 CFR Part 1926.1053
 - Lead: 29 CFR Part 1926.62 and 40 CFR 745
 - Personal Protective Equipment: 29 CFR Part 1926.28
2. Workers are trained in the hazards of their job and the methods to protect themselves.
3. Workers are provided the protective equipment needed to reduce site exposures. Employers are required to perform a Personal Protective Equipment Hazard Assessment for each employee.

The section Recommended Assessments and Actions for Worker Safety Concerns below provides a list of recommended assessments and actions for worker safety concerns. Project contract documents (drawings or specifications) and site plans should include precautions to address these issues. This section also includes measures an employer needs to take to evaluate existing and potential health concerns and recommended actions to ensure worker safety. Assistance with developing these worker protection plans often is available from state or federal training programs. OSHA

offers training courses and educational programs to help broaden worker and employer knowledge on the recognition, avoidance, and prevention of safety and health hazards in their workplaces. OSHA also offers training and educational materials that help businesses train their workers and comply with the [Occupational Safety and Health Act](#).

When known pollutants are being produced or disturbed during retrofit activities, follow appropriate standards—including OSHA, National Institute for Occupational Safety and Health (NIOSH) and U.S. Environmental Protection Agency (EPA) standards—to minimize worker and occupant exposure. The document *IAQ Guidelines for Occupied Buildings Under Construction*, published by the Sheet Metal and Air Conditioning Contractors' National Association (SMACNA), also can be used as a best-practices manual for maintaining indoor air quality (IAQ) in occupied buildings undergoing renovation or construction. The SMACNA document covers how to manage sources of air pollutants, control measures, quality control and documentation, and communication with occupants.

RECOMMENDED ASSESSMENTS AND ACTIONS FOR WORKER SAFETY CONCERNS

ASBESTOS

Assessment

Determine whether workers will be exposed to asbestos-containing material (ACM). Because of the widespread prior use of ACM, construction and renovation activities in older buildings may expose workers to this hazard.

Actions

- Building upgrade activities may expose workers to ACM and require compliance with the OSHA rule at 29 CFR Part 1926.1101, which specifies the required protection measures.
- See OSHA's website on [asbestos](#) for additional information and resources.

CHEMICAL HAZARDS

Assessment

Determine whether workers will be exposed to chemical hazards. Based on 29 CFR Part 1926.59, a chemical hazard is a chemical that is either a physical hazard (e.g., explosive, flammable) or a health hazard (e.g., acute or chronic health effects may occur).

Actions

- Comply with the OSHA rule at 29 CFR Part 1910.1200, which includes the following requirements (not an exhaustive list):
 - Chemical content information must be made available for all chemicals in use.
 - Containers must be properly labeled.
 - Workers handling chemicals must be properly trained.
- Use chemicals that are best in class for the particular application in terms of having low toxic content and low contaminant emissions. Examples include paints, adhesives, sealants and coatings that meet the emissions criteria of California Department of Public Health Specification 01350.
- Proper health and safety precautions should be employed by workers who use or may come in contact with pesticides or chemical contaminants in building materials, subsoils or vapors.
- For pesticides, comply with EPA's [40 CFR Part 170—Current Agricultural Worker Protection Standard](#) (includes all amendments as of October 3, 1997).
- See OSHA's website on [hazard communication](#) for additional information and resources.

CONFINED SPACES

Assessment

Determine whether workers will be exposed to confined-space hazards.

Actions

- Ensure that the workspace is cleaned regularly and has adequate ventilation and exhaust and that construction is phased properly to protect workers and occupants from construction activities that are considered high risk, as outlined in *SMACNA IAQ Guidelines for Occupied Buildings Under Construction, Second Edition*.
- Under the OSHA rule at 29 CFR Part 1926.21 (b)(6)(i), inform all employees required to enter confined or enclosed spaces about the following:
 - The nature of the hazards involved
 - The necessary precautions to be taken
 - The use of required protective and emergency equipment

- See OSHA's website on [confined spaces](#) for additional resources on confined space hazards in general industry.
- See OSHA's [Protect Yourself: Carbon Monoxide Poisoning](#) Quick Card for additional information on sources of carbon monoxide (CO) and recommended actions for preventing CO exposure.
- See [Priority Issue 3.0: Building Products/Materials Emissions](#) and EPA's [Safer Choice](#) website for more information on selecting less-toxic products and materials that can be used in confined spaces.

DUST

Assessment

Determine whether the work will generate dust. Use best-practice measures to manage and control air contaminants in areas of work.

Actions

- Educate workers about dust containment procedures and how to control dust and debris created by equipment used in construction activities.
- Use work methods that minimize dust and prevent dust from spreading to other areas of the building.
- Isolate areas where work is being performed (e.g., sealed with plastic sheeting) to contain any dust that is generated during construction activities.
- Turn off forced-air, central heating and air conditioning systems (including local, window air conditioning units) while work that generates dust is underway.
- Collect and remove all construction dust and debris.
- Conduct careful cleanups routinely and at the end of the project.
- See OSHA's websites on [wood dust](#) and [combustible dust](#) for additional information and resources.
- See EPA's Renovation, Repair and Painting (RRP) Program Rule requirements at [40 CFR Part 745](#) for recommended actions to prevent, contain and clean up lead dust.

ELECTRICAL

Assessment

Determine whether workers will be exposed to electrical hazards.

Actions

- Follow OSHA rule 29 CFR Part 1926 Subpart K requirements for protecting workers from electrical hazards (not an exhaustive list):
 - Employers must make sure that all non-double-insulated electric equipment is equipped with a grounding conductor (three-wire type).
 - Worn or frayed electric cords must not be used.
 - Employers must provide either ground-fault circuit interrupters or an assured equipment grounding conductor program (which includes the regular testing of all equipment grounding conductors) to protect employees from ground faults.
- See OSHA's [Electrical Incidents E-Tool](#) for additional information on electrical safety.

FALLS

Assessment

Determine whether workers will be required to work at heights of 6 feet or more.

Actions

- If work is required at heights of 6 feet or more, protect workers with guardrails or by properly securing to prevent falls.
- See OSHA rule at 29 CFR Part 1926.501 for additional information on requirements.
- See OSHA's web page on [fall protection](#) and OSHA's [Falls E-Tool](#) for additional information on protecting workers from fall hazards.

LADDERS

Assessment

Determine whether workers will be using ladders.

Actions

- Follow OSHA rule at 29 CFR Part 1926.1053, which includes the following requirements (not an exhaustive list):
 - Portable ladders must be able to support at least four times the maximum intended load.
 - Ladders that must lean against a wall are to be positioned at a 4:1 angle.
 - Ladders are to be kept free of oil, grease, wet paint and other slipping hazards.
 - The areas around the top and bottom of a ladder must be kept clear.
 - Ladders must not be tied or fastened together to provide longer sections.
 - Metal ladders must not be used while working on electrical equipment or electrical wiring.
- See the OSHA rule at [29 CFR Part 1926.1053](#) for additional information on requirements.
- See OSHA's publication [Stairways and Ladders: A Guide to OSHA Rules](#) for additional resources on ladder safety.

LEAD

Assessment

Determine whether building upgrade activities will expose workers to lead dust (for example, from lead paint used in buildings constructed before 1978), according to the Assessment Protocols outlined in Priority Issue 3.0: Lead.

Actions

- If the facility was built before 1978, the existing paint is assumed to contain lead, unless EPA-approved testing methods show otherwise, and building upgrade activities must comply with EPA's RRP Program Rule requirements at [40 CFR Part 745](#) and the OSHA rule at 29 CFR Part 1926.62.
- See OSHA's publication [Lead in Construction](#) for information on OSHA requirements to protect construction workers from lead hazards.

MOLD—SUSPECTED

Assessment

Determine whether workers will be exposed to mold.

Actions

- All suspected moldy areas should be remediated by properly trained individuals. Moisture problems need to be identified and fixed, or mold will return. If mold is expected to be disturbed during activities, immediately bring this to the attention of the site manager. Refer to OSHA's [A Brief Guide to Mold in the Workplace](#); NIOSH's [Recommendations for the Cleaning and Remediation of Flood-Contaminated HVAC Systems](#); EPA's [Mold Remediation in Schools and Commercial Buildings](#); the American Conference of Government Industrial Hygienists' [Bioaerosols: Assessment and Control](#); the American Industrial Hygiene Association's [Recognition, Evaluation, and Control of Indoor Mold](#); or the Institute of Inspection, Cleaning and Restoration Certification's [S520 Standard and Reference Guide for Professional Mold Remediation](#).
- See EPA's [Mold and Moisture](#) website for additional information on mold remediation.

POLYCHLORINATED BIPHENYLS (PCBs)

Assessment

Determine whether workers may be handling PCB-containing or PCB-contaminated building materials, including fluorescent light ballasts and caulk.

Actions

- See EPA's [PCB-Containing Fluorescent Light Ballasts](#) web page for information on proper maintenance, removal and disposal of PCB-containing fluorescent light ballasts. If leaking ballasts are discovered, wear protective clothing, including chemical-resistant (nitrile) gloves, boots and disposable overalls.
- See EPA's [Steps to Safe Renovation and Abatement of Buildings That Have PCB-Containing Caulk](#) website for information on this topic. Work practices to help ensure worker and occupant safety include employing protective measures (both interior and exterior), complying with occupational protective regulations, communicating with building occupants/third parties, setting up the work area to prevent the spread of dust, using appropriate tools that minimize the generation of dust/heat, and leaving the work area clean.

SPRAY POLYURETHANE FOAM (SPF)

Assessment

Determine whether workers will be using SPF. There are three main types of SPF products (two-component high pressure, two-component low pressure and one-component foam), each of which has different applications. Determine which of the three main types of SPF products will be used.

Actions

- Minimize occupant and worker exposure to volatile organic compounds (VOCs) or other airborne contaminants. Ensure proper isolation (e.g., containing the work area with plastic sheeting) and exhaust ventilation to the outdoors of work areas during activities that result in VOC emissions (e.g., painting, sealing, finishing), ventilating as close as possible to the source of contaminant emissions.
- When SPF or poured polyurethane foam insulation is used, follow the manufacturer's instructions for (1) vacating building occupants and other unprotected individuals not involved in the application of the products from the premises during and for some period after application, (2) isolating and ventilating the work areas, and (3) using personal protective equipment.

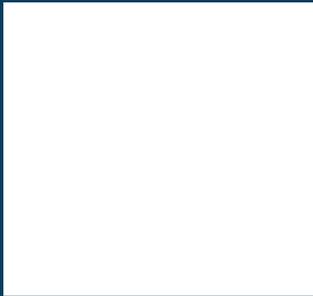
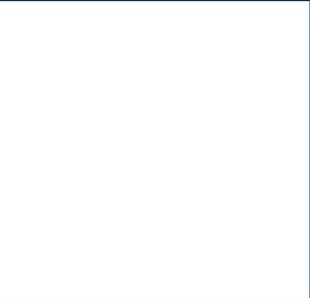
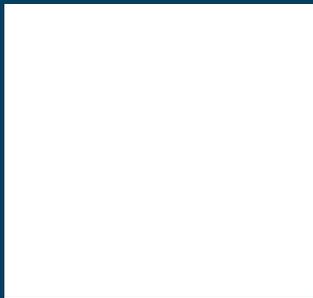
Note

The curing time (complete reaction) varies depending on the type of SPF product, product formulation, applicator technique, foam thickness, temperature, humidity and other factors. [Together, these factors will affect reoccupancy time.](#) While the SPF is curing, it still contains unreacted chemicals, which include isocyanates and proprietary chemicals. Exposure to isocyanates may cause skin, eye and lung irritation, as well as respiratory tract sensitization during the installation and cure period. Exposures to isocyanates should be minimized. Cutting or trimming foam before it is fully cured may cause exposure to unreacted SPF chemicals. See EPA's Spray Polyurethane Foam Web resources and the [American Chemistry Council's Center for the Polyurethanes Industry Spray Polyurethane Foam Health + Safety website](#) for additional information.

- Ensure that health and safety training is completed and safe work practices are followed to prevent eye, skin and inhalation exposures during and after SPF installation.
- If occupants or workers experience breathing problems or other adverse health effects from SPF application, seek immediate medical attention.
- Urea formaldehyde foam insulation (UFFI): This type of sprayed foam insulation contains formaldehyde. Because of concerns over potential formaldehyde exposures, it is banned in Canada and Massachusetts.

See OSHA's [Green Job Hazards](#) website for additional information on the hazards associated with SPF.

Appendix C: Property Management and Occupant Education



Building upgrade activities provide valuable opportunities for building owners, property managers and contractors to educate building occupants on IAQ and safety, which will help occupants maintain healthy indoor environments after the upgrades are complete. Building owners, property managers and contractors are encouraged to provide occupants with training that reinforces the health protections identified in this Guide.

Building occupants play a critical role in helping building owners and property managers maintain healthy living environments, for example, by reporting moisture and pest problems, cooperating with pest management professionals in implementing an integrated pest management policy, and following any smoke-free housing policies that exist.

Property managers play a critical role in maintaining multifamily residential properties, making them healthier living environments for occupants and property maintenance staff. After the building upgrade is completed, property managers, maintenance staff, and contractors hired by the building owner or property manager can take actions to support the health protections incorporated by the building upgrades.

The following priority areas are discussed in this appendix:

- Carbon Monoxide (CO) and Combustion Safety
- Cleaning and Building Products
- Home Safety
- Lead
- Moisture Control
- Pest Control
- Portable Home Air-Cleaning Equipment
- Smoke-Free Housing
- Ventilation

CARBON MONOXIDE AND COMBUSTION SAFETY

Goal

Ensure that vented and unvented combustion appliances are installed, maintained and operated properly so as not to pose a fire hazard or emit moisture and dangerous combustion gases, including CO, into the living spaces.

Actions

Conduct regular inspections and preventive maintenance on all combustion appliances. Ensure proper venting of combustion byproducts to the outdoors. Regularly inspect CO alarms for proper operation.

- Replace gas-fired unvented space heaters not listed to ANSI Z21.11.2 with vented appliances or, at a minimum, consider upgrading such heaters to new models consistent with ANSI Z21.11.2.
- Ensure that unvented combustion space heaters or vent-free gas fireplaces are not oversized for their application. The proper size of a space heater depends on a room's dimensions and its heat loss characteristics. For example, a 5,000 BTU/hour space heater often can be a suitable size for a room with a floor area of 150 ft².
- **Occupant Education:** Ensure that building occupants are provided with information on the hazards of combustion pollutants, including CO.

Note

Be familiar with the hazards of improperly operating unvented space heaters or vent-free appliances—review, for example the manufacturers' written instructions, the Consumer Product Safety Commission (CPSC) Carbon Monoxide Questions and Answers; and EPA's An Introduction to Indoor Air Quality, Carbon Monoxide. The manufacturers' instructions may specify open windows during operation because use of the device requires adequate or additional ventilation to remove products of combustion, such as CO, nitrogen oxides, carbon dioxide, particulate matter and water vapor.

Unvented space heaters should not be used in a manner that influences the thermostat controlling the primary heat source, thereby causing the space heater to operate in place of the primary heat source.

Resources for CO

- CPSC: [Carbon Monoxide Questions and Answers](#)
- EPA: [Carbon Monoxide's Impact on Indoor Air Quality](#)
- EPA: [Protect Your Family and Yourself from Carbon Monoxide Poisoning](#)

CLEANING AND BUILDING PRODUCTS

Goal

Use housekeeping practices, maintenance practices and related products that minimize the use of harmful or toxic chemicals wherever possible.

Actions

- Follow a cleaning plan. For every area in the building that needs to be cleaned, staff should identify—
 - Items to be cleaned (e.g., floors, walls, windows, carpets)
 - Individual(s) responsible for cleaning each item
 - Frequency with which each item must be cleaned
 - Specific cleaning methods that must be used (e.g., microfiber dust mop [no brooms], warm water and mild detergent in a damp wipe [no sprays], HEPA-filtration vacuums)
 - Cleaning materials to be used for each surface

Where possible, require staff and contractors to specify products that meet independent testing and certification protocols. Examples are provided in Table 1; this is not an exhaustive list.

Table 1. Example Products by Category	
Cleaning Supplies	
Cleaners	Use products that meet Green Seal, EPA Safer Choice Label or ECOLOGO Certified standards.
New Flooring and Cabinets	
Carpet, Carpet Cushion and Entry Mats	<p>Use products that meet the California Department of Public Health (CDPH) Standard Method for the Testing and Evaluation of Volatile Organic Chemical (VOC) Emissions from Indoor Sources Using Environmental Chambers, the VOC emission testing method for California Specification 01350. Examples of green label programs consistent with the standard method include Green Label Plus Certified by Carpet and Rug Institute or GreenGuard.</p> <p>Recycle removed carpet: vendor to supply price quote to recycle removed carpet and components (e.g., 100%, 50% or 30% recycled).</p>

Table 1. Example Products by Category (continued)

New Flooring and Cabinets	
Resilient Flooring	Use products that meet the CDPH Standard Method for the Testing and Evaluation of VOC Emissions from Indoor Sources Using Environmental Chambers, the VOC emission testing method for California Specification 01350. Examples of green label programs consistent with the standard method include FloorScore® Certified by Resilient Flooring Covering Association, GreenGuard Gold or SCS Indoor Air Advantage.
Flooring Adhesives	Use mechanical or stick-and-peel products. Other products should meet South Coast Air Quality Management District (SCAQMD) Rule 1168 VOC content limits.
Cabinets	<p>Look for urea formaldehyde-free cabinets, certified to be compliant with California Title 17 for Formaldehyde—Phase 2 or federal Toxic Substances Control Act Title VI.</p> <p>Examples include products produced in registered plants certified under the Kitchen Cabinet Manufacturers Association Environmental Stewardship Certification Program (ESP 05-12).</p>
Paint	
Interior Paint	Use products that meet SCAQMD Rule 1113 for VOC content Master Painters Institute-MPI- GS-2, Extreme Green; Greenwise Gold; and GreenSeal (GS) 11 v 3.2 meet some of the SCAQMD thresholds.

Resources for Cleaning and Building Products

- EPA: [Safer Choice](#)
- California Department of Public Health Standard Method V1.1–2010, using CA Section 01350
- ECOLOGO: [ECOLOGO Product Certification](#)
- Enterprise Green Communities: [Green Operations & Maintenance Training in a Box](#)
- Resilient Flooring Covering Association: [FloorScore®](#)

- Carpet and Rug Institute: [Green Label Plus](#)
- Green Seal: [Green Seal Standard for Paints and Coatings, GS-11](#)
- [GreenGuard](#)
- Health Product Declarations (HPDs)
- Kitchen Cabinet Manufacturers Association: [Environmental Stewardship Certification Program \(ESP 05-12\)](#)
- Master Painters Institute: [Green Performance Standards GPS-1 or GPS-2, X-Green](#)
- [SCS Indoor Advantage](#)
- South Coast Air Quality Management District
- Rule 1113 and 1168

HOME SAFETY

Goal

Ensure that building conditions reduce the risks of injuries and alert residents to potential safety hazards.

Actions

Conduct regular inspections of the building and surrounding areas to identify conditions that would expose occupants to risk of injury.

- Smoke alarms and CO alarms should be installed in all homes and tested regularly. Replace batteries annually. Replace smoke alarms every 10 years and CO alarms every 5–7 years.
- Ensure that water heater set points do not exceed either local and state codes or 140°F, which can still lead to scalding within 3 seconds of human exposure.
- In dwelling units where elderly persons live, reduce trip hazards, provide sufficient lighting on stairs, ensure that handrails and grab bars are in key locations, and follow CDC's guide Check for Safety: A Home Fall Prevention Checklist for Older Adults.
- In dwelling units with young children, install gates at the tops of stairs, securely store chemicals and pesticides, minimize risk of contact with hot surfaces, ensure a safe outdoor play area (including playground equipment, pools, open pits and wells), and ensure that interior doors can be opened from inside and outside.

LEAD

Goal

Ensure that lead-based paint does not pose a hazard in building operations and maintenance activities.

Actions

If maintenance staff will be disturbing lead paint, they shall be trained and certified under EPA's Lead Renovation, Repair and Painting Program for lead-safe work practices.

- **Occupant Education:** Ensure that building occupants are provided with information on lead and renovations as required under EPA's Lead Renovation, Repair and Painting Program.

Resources for Lead

- EPA: [Lead](#) website
- EPA: [The Lead-Safe Certified Guide to Renovate Right](#)
- EPA: [Renovation, Repair and Painting Program](#)

MOISTURE CONTROL

Goal

Incorporate regular checks for moisture problems into ongoing property inspections and work order responses and at unit turnover to minimize moisture and mold problems. Moisture and mold have been associated with asthma and other respiratory problems. Excessive moisture also can contribute to pest problems and deteriorate lead-based paint.

Actions

Perform the following during annual inspections, at unit turnover (as appropriate) and during work order responses:

Plumbing

- Inspect under sinks for leaks.
- Check toilets for leaks with dye test and replace flapper as needed.
- Inspect shower stall, shower faucets and shower diverter valve for leaks. Recommend installation of showerheads with WaterSense label, rated for less than 2 gallons per minute (gpm).
- Inspect faucets and aerators for leaks. As needed, install new faucets with WaterSense label—kitchen faucets rated for less than 1.5 gpm, bath faucets rated for less than 1.0 gpm.

- Inspect under dishwashers and washing machines for leaks.
- Repair all leaks identified.

Exhaust Ventilation

- Check for proper operation of kitchen and bathroom exhaust fans, and confirm exterior venting and fan flows.
- Verify that the clothes dryer exhaust vent is intact and vented to the outdoors.

Exterior Moisture

- Inspect outside gutters and downspouts to be sure water is moved away from the building and property.
- Check for standing water near the building, and correct grade and drainage as needed.

Interior Moisture

- Inspect for moisture stains, mold or musty odor.
- Inspect for standing water.
- Inspect for signs of mold or moisture damage.

Occupant Education

- Advise occupants to report immediately any plumbing leaks; window, wall or roof leaks; standing water; or condensation problems.
- Advise occupants about the need to use exhaust fans in kitchens and bathrooms during activities that generate pollutants and moisture (e.g., cooking, showering).
- Refer occupants to EPA's [A Brief Guide to Mold, Moisture, and Your Home](#).

Resources for Moisture Control

- CDC-NIOSH: [Dampness and Mold Assessment Tool](#)
- EPA: [A Brief Guide to Mold, Moisture, and Your Home](#)
- NCHH: [Healthy Homes Maintenance Checklist](#)

PEST CONTROL

Goal

Minimize pest problems using integrated pest management (IPM) strategies. These cost-effective strategies prevent and address pest problems while minimizing harm to people, property and the environment. IPM methods rely on a range of strategies to prevent and control pest issues. IPM strategies generally are more effective than traditional pest control approaches.

Actions

Ensure that contracts with pest professionals require these IPM elements:

- **IPM Certification:** Require all pest professionals to provide proof of IPM certification from a state agency or third party (e.g., GreenPro, Green Shield or equivalent IPM certification).
- **IPM Policy:** Pest professionals should be required to include an IPM policy in pest control contract documentation. The IPM policy must include a clear plan of action consistent with the IPM requirements outlined below.
- **Inspections:** Pest professionals should conduct initial and periodic inspections of the building's exterior and interior spaces to identify pest entry points and evidence of pests. A written evaluation of pest control needs should be provided for approval by the building owner or property manager. The evaluation should identify problem areas and recommend structural, sanitary or procedural modifications that will reduce pest access to food, water and shelter (e.g., seal entry points, such as openings, cracks and crevices; cover and control pest access to trash cans, dumpsters and trash chutes).
- **Implementation:** Pest professionals will work with building owners and property managers to determine when, how, and by whom the actions identified in the inspections will be undertaken (e.g., safely remove pests, nests, accumulated excrement and allergens; secure trash storage; effectively seal pest entry and migration openings; and plan pesticide use [if any]). Pest professionals will implement their portion of the agreed-upon actions.
- **Pesticide Use:** Pesticide application should be considered only after all other options have been attempted in response to observed pest problems.
 - Approved Products: The IPM contract or IPM policy must include a list of approved products. Only least hazardous or least toxic pesticide products should be specified in an IPM contract. Do not apply any pesticide product that has not been included in the IPM policy or approved in writing by the building owner or property manager.
 - Application by Need: Whenever possible, spot treatments should be used rather than area-wide applications. Applied pesticides must be beyond the reach of children and pets (e.g., inside sealed cracks and cavities; in approved, secured bait stations). Employ the least hazardous material, most precise application technique and minimum quantity of pesticide necessary to achieve control. Ensure that the application of products containing pesticides renders the pesticides inaccessible to occupants, visitors, pets (if allowed) and staff.
 - Specificity: Employ pesticides that are specific to the targeted pests.

- **Prohibited Products:** Pesticide sprays (unless an insect growth regulator or needed to address bedbug infestations), foggers or bombs, and organophosphate or chlorinated hydrocarbons pesticides are not permitted.
 - **Pesticide Storage:** The pest control contractor should not store any pesticide product in the building.
 - **Notification:** Pest control contractors should be required to provide written notice to the property management and occupants of the intention to apply any pesticide, and post signage in the areas to be treated, all at least 24 hours prior to application. It is recommended that this notice be given 72 hours in advance of the pesticide application so that occupants can prepare their dwelling units for the application and arrange to be away from the property, if necessary. Rooms of dwelling units and other areas to be sprayed with insecticides must have signage posted at conspicuous locations and entries at least 24 hours prior to application.
 - **Compliance and Enforcement:** Individuals applying pesticides must do so in a manner not only consistent with federal laws but also consistent with state and local laws. In general, states have primary authority for compliance monitoring and enforcing against use of pesticides in violation of the labeling requirements. Additionally, the agency with primary responsibility for pesticides differs from state to state—usually it is a state’s department of agriculture, but it may be a state’s environmental agency or other agency.
- **Insect Control:** Insecticides are to be applied as “crack and crevice” treatments (i.e., the insecticide is not visible to a bystander during or after the application process). For cockroaches, baits, gels, growth regulators and boric acid are preferred.
 - **Rodent Control:** As a rule, rodent control inside and around buildings shall be accomplished with trapping devices only.
 - **Trapping Devices:** Trapping devices shall be out of public view to avoid being disturbed by routine cleaning. Devices shall be checked on a defined schedule, and the pest management contractor shall be responsible for disposing of all trapped rodents.
 - **Bait Boxes:** All bait boxes shall be placed out of general view, in locations where they will not be disturbed by routine operations. Bait boxes shall have lids securely locked or fastened and shall be secured so they cannot be picked up or moved. Bait boxes shall be labeled with the contractor’s

business name and address and dated by the contractor's technician at the time of installation and each servicing.

- **Rodenticides:** In exceptional circumstances, when rodenticides are deemed essential, the contractor shall obtain approval from the building owner or property manager. All rodenticides, regardless of packaging, shall be placed in locations not accessible to children, pets, wildlife or domestic animals, or the rodenticides shall be in EPA-approved, tamper-resistant bait boxes.
- **Occupant Education:** Contract documents should include provisions for the pest control professional to provide on-site occupant education, in conjunction with building owner or property manager.

Ensure that the building owner, property manager and maintenance staff undertake the following activities:

- **Preventive Measures:** Maintenance staff will help prevent pest issues by—
 - Providing regular housekeeping in common areas, hallways, stairwells, laundry rooms and maintenance/utility areas
 - Sealing cracks, holes and crevices to prevent pest entry
 - Providing an enclosed area for the storage of trash and prompt trash removal service
 - Integrating pest exclusion (e.g., sealing holes, cracks and crevices) with energy efficiency and air sealing activities
- **Review and Approve Contractor IPM Plan:** Building owners/property managers review and approve the IPM plan submitted by the pest control contractor and work with occupants to undertake appropriate actions.
- **Occupant Complaints:** Maintenance staff respond promptly to pest complaints from occupants. Approximately 10–14 days after any action has been taken, the building owner/property manager should follow up to evaluate the conditions.
- **Written Notice:** Building owners/property managers shall provide advance written notice to occupants, preferably 72 hours, but not less than 24 hours, prior to pesticide application.
- **Unit Turnover:** Building owners/property managers shall inspect for pest problems at unit turnover and identify any needed pest control work by maintenance staff or pest control professionals to prevent and address pest issues.
- **Occupant Education:** Building owners/property managers should develop—in conjunction with the IPM contractor—education and outreach materials to

occupants for lease signing, periodic occupant education sessions, and during pest infestations. To the extent feasible, incorporate the following elements into occupant leases, and work to ensure that occupants understand their responsibilities:

- Report to management pest sightings and conditions that may attract pests.
- Do not use foggers, bombs or sprays. A pesticide use policy must be prepared, including what, if any, over-the-counter products are acceptable for use in the building. Illegal pesticides shall be strictly prohibited (e.g., Miraculous Insecticide Chalk, Tres Pacitos).
- Keep dwelling units clean, clutter-free and in sanitary condition according to lease requirements.
- Prepare dwelling units for pest management service visits according to instructions provided in advance.
- Participate in monitoring their dwelling unit with traps provided by management, when needed.

Resources for Pest Control

- ASHRAE: [Indoor Air Quality Guide: Best Practices for Design, Construction and Commissioning](#)
- Boston Public Health Commission: [Integrated Pest Management: A Guide for Managers and Owners of Affordable Housing](#)
- Enterprise Green Communities: [Green Operations & Maintenance Training in a Box](#)
- EPA: [Integrated Pest Management \(IPM\) Principles](#)
- EPA: [Safer Pest Control and Pesticide Safety for Consumers](#)
- Green Shield: [Green Shield Certified](#)
- NCHH: [Integrated Pest Management in Multifamily Housing](#)
- National Pest Management Association: [GreenPro Certified](#)
- New York City: [Integrated Pest Management Tool Kit for Building Owners, Managers, and Staff](#)
- Northeastern IPM Center at Cornell University: [Integrated Pest Management: A Guide for Affordable Housing](#)

PORTABLE HOME AIR-CLEANING EQUIPMENT

Goal

Reduce the use of household air-cleaning equipment that can produce ozone, which can increase respiratory risks—including asthma—and decrease lung function.

Actions

- **Recommend removal of existing portable air-cleaning equipment designed to intentionally produce ozone in excess of 50 parts per billion.** Consult the California Air Resources Board (CARB) for a list of equipment that meets its certification program. Information on appropriate air flow for home air-cleaning equipment and device performance in reducing tobacco smoke, dust, and allergens is available through the American Home Appliance Manufacturers, which tests such equipment.
- **If new portable air cleaners are installed, use of those with mechanical filtration rather than those producing ozone. Only install equipment that meets CARB standards or does not produce ozone.**

SMOKE-FREE HOUSING

Goal

Explore establishing a smoke-free housing policy as part of the building upgrade. Smoking is the single greatest cause of disease and premature death in the United States, affecting smokers and, through secondhand smoke, nonsmokers. It also contributes to occupant complaints related to odor and increases the operational cost of the property.

Actions

A detailed list of actions to implement smoke-free housing policies is provided in HUD's [Change is in the Air: An Action Guide for Establishing Smoke-Free Public Housing and Multifamily Properties](#) and [Smoke Free Housing: A Tool Kit for Owners/Management Agents of Federally Assisted Public and Multi-family Housing](#), and the National Center for Healthy Housing's [Reasons to Explore Smoke-Free Housing](#). Several key steps are summarized here:

- Work with the building owner or property manager to establish a smoke-free housing policy:
 - Conduct an occupant survey of interest in smoke-free housing.
 - Pending results of the survey, develop a plan to implement a smoke-free housing policy and establish suitable areas outside of the building that

can be used for smoking. Amend tenant leases to be consistent with smoke-free policy.

- **Occupant Education:** Educate occupants on smoking policy in the building. Install signage and provide printed material for visitors at the main entrances of the building with information about the smoke-free housing policy.
- **Enforce any smoke-free housing policy** and related lease restrictions (see text box below).

Sample Smoke-Free Housing Policy

Effective [DATE], the use of all smoking products (cigarettes, cigars, pipes and electronic smoking devices) is prohibited on [Property Name] property and within 25 feet of the building. This prohibition applies to all indoor and outdoor areas (dwelling units, entry areas, walkways, grassed areas, picnic areas and parking lots at [Property Name] property). This policy applies to all employees, visitors, residents, subcontractors, volunteers and vendors.

Sample Lease Addendum Language

Include in the “Definitions” section of the lease

Smoking: “Smoking” shall include the inhaling, exhaling, burning or carrying of any lighted cigarette, cigar or other tobacco product; the emissions produced by electronic smoking devices; and the burning of cannabis or illegal substances.

Include in the “Restrictions” section of the lease

Smoking: Due to the increased risk of fire and the known health effects of secondhand smoke, smoking is prohibited indoors and within 25 feet of the residential building. This restriction applies to both private and common areas and applies to all owners, tenants, guests and service persons.

Resources for Smoke-Free Housing

National

- EPA: [Secondhand Tobacco Smoke and the Health of Your Family](#)
- EPA: [Secondhand Smoke and Smoke-Free Homes](#)
- HUD: [Change is in the Air: An Action Guide for Establishing Smoke-Free Public Housing and Multifamily Properties](#)
- HUD: [Optional Smoke-Free Housing Policy Implementation, Notice H 2010-21](#)
- HUD: [Smoke Free Housing: A Tool Kit for Owners/Management Agents of Federally Assisted Public and Multi-family Housing](#)
- HUD: [Smoke Free Housing: A Toolkit for Residents of Federally Assisted Public and Multi-family Housing](#)
- NCHH: [Reasons to Explore Smoke-Free Housing](#)
- TTAC: [Tobacco Technical Assistance Consortium](#)

State and Local

- [Boston Smoke-Free Homes](#)
- [Capital District \(New York\) Tobacco-Free Coalition](#)
- [Michigan Smoke-Free Apartment](#)
- [Minnesota Smoke-Free Housing](#)
- [Smoke-Free Housing Coalition of Maine](#)

VENTILATION

Goal

Confirm that ventilation systems are functioning as intended to reduce buildup of moisture and contaminants in dwelling units and common areas. Moisture can contribute to mold growth and breathing problems, such as asthma. Contaminants from kitchen cooking can contain small particles and nitrogen oxides that also can adversely affect health.

Actions

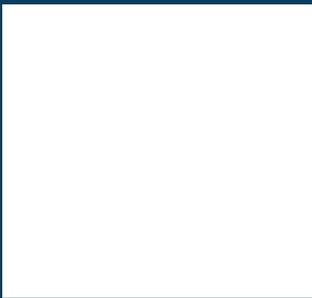
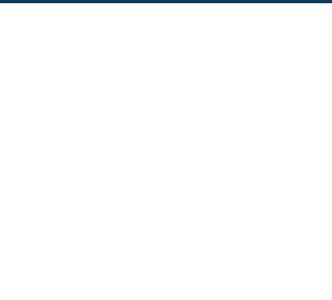
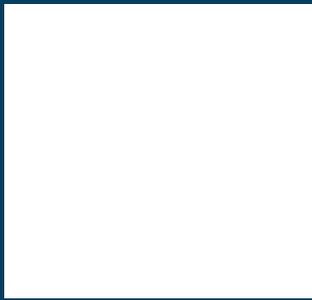
Perform the following during annual inspections and at unit turnover:

- Inspect bath and kitchen fans to determine whether they are clear of obstructions, operational and moving air at the correct airflow rates. Ensure that fans are operating as intended (e.g., manually or automatically controlled intermittent operation, continuous operation).
- Remove any items put up by occupants to block airflows at supply or exhaust grilles. Identify the source(s) of occupant dissatisfaction that prompted blocking the airflows and take corrective action.
- Replace filters in HVAC systems with new filters at unit turnover, semiannually or as often as recommended by manufacturer. Use a MERV 8 filter, if compatible with equipment.
- Conduct a ventilation system assessment to determine whether adequate ventilation rates are being provided to dwelling units.
- Assess ventilation rates in common areas.
- **Occupant Education:** Advise occupants about the need to use exhaust fans in kitchens and bathrooms during activities that generate pollutants and moisture (e.g., cooking, showering). Educate occupants about the basic operation of ventilation, heating and cooling systems. This should include any maintenance (e.g., air filter change-out) and adjustments that are the occupants' responsibility.

Resources for Ventilation

- NCHH: [Improving Ventilation in Existing or New Buildings With Central Roof Exhaust](#)
- NCHH: [Improving Ventilation in Multi-Family Buildings That Do Not Have Fan-Powered Ventilation](#)
- NCHH: [Improving Ventilation in New and Existing Multi-Family Buildings With Individual Unit Ventilation Systems](#)
- NYSERDA: [Improving Central Exhaust Systems for Multifamily Buildings](#)

Appendix D: References



STANDARDS AND OTHER REQUIREMENTS

AARST MAMF-2017

Protocol for Conducting Radon and Radon Decay Product Measurements in Multifamily Buildings, MAMF-2017. 2017. American Association of Radon Scientists and Technologists, Inc. standards.aarst.org/MAMF-2017/. Last Accessed November 2020.

AARST RMS-MF 2018

Radon Mitigation Standards for Multifamily Buildings, RMS-MF 2018. 2018. American Association of Radon Scientists and Technologists, Inc. standards.aarst.org/RMS-MF-2018/5/. Last Accessed November 2020.

ABAA

Air Barrier Materials, Components, Assemblies & Systems. 2011. Air Barrier Association of America. www.airbarrier.org/technical-information/evaluated-assemblies-2/. Last Accessed November 2020.

ACCA 2 Manual J

ANSI/ACCA 2 Manual J—Residential Load Calculation. 2016. Air Conditioning Contractors of America. www.acca.org/store#/productDetail/DB68FDFC-BB20-E511-80F5-C4346BAC9A78/. Last Accessed February 2021.

ACCA 3 Manual S

ANSI/ACCA 3 Manual S—Residential Equipment Selection. 2014. Air Conditioning Contractors of America. www.acca.org/store#/productDetail/18B6715F-BC20-E511-80F5-C4346BAC9A78/. Last Accessed February 2021.

ACCA 5 QI-2010

ANSI/ACCA Standard 5: HVAC Quality Installation Specification. Standard Number ANSI/ACCA 5 QI-2010. 2010. Air Conditioning Contractors of America.

ACCA 6 QR-2007

ANSI/ACCA Standard 6: Restoring the Cleanliness of HVAC Systems. Standard Number ANSI/ACCA 6 QR-2007. 2007. Air Conditioning Contractors of America.

ACCA 9 QIVP-2008

ANSI/ACCA Standard 9: HVAC Quality Installation Verification Protocols. Standard Number 9 QIVP-2008. 2008. Air Conditioning Contractors of America.

ANSI Z21

Z21 Series Standards for Residential Gas-Fired Appliances. 2020. American National Standards Institute webstore.ansi.org/standards/csa/ansiz21112016. Last Accessed November 2020.

ANSI Z21.11.2

ANSI Standard Z21.11.2-2016: Gas-Fired Room Heaters—Volume II, Unvented Room Heaters. 2013. American National Standards Institute. webstore.ansi.org/RecordDetail.aspx?sku=ANSI+Z21.11.2-2013. Last Accessed November 2020.

ANSI/ASHRAE Standard 188-2018

ANSI/ASHRAE Standard 188-2018: Legionellosis: Risk Management for Building Water Systems. 2018. American Society of Heating, Refrigerating and Air Conditioning Engineers. www.ashrae.org/technical-resources/bookstore/ansi-ashrae-standard-188-2018-legionellosis-risk-management-for-building-water-systems. Last Accessed November 2020.

ANSI Z223.1/NFPA 54

ANSI Standard Z223.1/NFPA 54: National Fuel Gas Code. 2018. American National Standards Institute. www.nfpa.org/codes-and-standards/document-information-pages?mode=code&code=54. Last Accessed November 2020.

ASHRAE

2017 ASHRAE Handbook—Fundamentals. 2017. American Society of Heating, Refrigerating and Air Conditioning Engineers. www.ashrae.org/technical-resources/ashrae-handbook/description-2017-ashrae-handbook-fundamentals. Last Accessed September 2020.

ASHRAE

ASHRAE Handbook—HVAC Systems and Equipment. 2016. American Society of Heating, Refrigerating and Air Conditioning Engineers. www.ashrae.org/technical-resources/ashrae-handbook/description-2016-ashrae-handbook-hvac-systems-and-equipment. Last Accessed September 2020.

ASHRAE

ASHRAE Indoor Air Quality Guide. 2009. American Society of Heating, Refrigerating and Air Conditioning Engineers. www.ashrae.org/technical-resources/bookstore/indoor-air-quality-guide. Last Accessed September 2020.

ASHRAE

Load Calculation Applications Manual, 2nd Edition. 2014. American Society of Heating, Refrigerating and Air Conditioning Engineers. www.techstreet.com/ashrae/searches/7857005. Last Accessed November 2020.

ASHRAE Standard 62.1-2019

ANSI/ASHRAE Standard 62.1-2019: Ventilation for Acceptable Indoor Air Quality. 2019. American Society of Heating, Refrigerating and Air Conditioning Engineers. Also includes published addenda. www.ashrae.org/resources--publications/bookstore/standards-62-1--62-2, and www.ashrae.org/standards-research--technology/standards-addenda. Last Accessed November 2020.

ASHRAE Standard 62.2-2019

ANSI/ASHRAE Standard 62.2-2019: Ventilation and Acceptable Indoor Air Quality in Residential Buildings. 2019. Also includes published addenda. www.ashrae.org/resources--publications/bookstore/standards-62-1--62-2, and www.ashrae.org/standards-research--technology/standards-addenda. Last Accessed November 2020.

ASHRAE Standard 180-2012

ANSI/ASHRAE/ACCA Standard 180-2012: Standard Practice for Inspection and Maintenance of Commercial Building HVAC Systems. 2012. American Society of Heating, Refrigerating and Air Conditioning Engineers. www.techstreet.com/products/1832333. Last Accessed November 2020.

ASHRAE Standard 183-2007 (RA 2017)

ANSI/ASHRAE/ACCA Standard 183-2007 (RA 2017): Peak Cooling and Heating Load Calculations in Buildings Except Low-Rise Residential Buildings. 2014. American Society of Heating, Refrigerating and Air Conditioning Engineers. webstore.ansi.org/standards/ashrae/ansiashraeaccastandard1832007. Last Accessed November 2020.

ASHRAE Standard 189.1-2017

ANSI/ASHRAE/ICC/USGBC/IES Standard 189.1-2017: Standard for the Design of High-Performance Green Buildings. 2017. American Society of Heating, Refrigerating and Air Conditioning Engineers. www.ashrae.org/resources--publications/bookstore/standard-189-1. Last Accessed November 2020.

ASTM C920

ASTM Standard C920: Standard Specification for Elastomeric Joint Sealants, Class 25. 2018. ASTM International. www.astm.org/Standards/C920.htm. Last Accessed November 2020.

ASTM International E779-19

ASTM Standard E779-19: Standard Test Method for Determining Air Leakage Rate by Fan Pressurization. 2019. ASTM International. www.astm.org/Standards/E779.htm. Last Accessed November 2020.

ASTM International E1186-17

ASTM Standard E1186-17. Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems. 2017. ASTM International. www.astm.org/Standards/E1186.htm. Last Accessed November 2020.

ASTM International E1827-11

ASTM Standard E1827-11. Standard Test Methods for Determining Airtightness of Buildings Using an Orifice Blower Door. 2011. ASTM International. www.astm.org/Standards/E1827.htm. Last Accessed November 2020.

ASTM E2600-15

ASTM Standard E2600-15: Standard Guide for Vapor Encroachment Screening on Property Involved in Real Estate Transactions. 2015. ASTM International. www.astm.org/Standards/E2600.htm. Last Accessed November 2020.

BPI Technical Standards

Technical Standards for the Heating Professional, Blower Door Testing. 2007. Building Performance Institute. www.bpi.org/sites/default/files/Technical%20Standards%20for%20the%20Heating%20Professional.pdf. Last Accessed September 2020.

California Department of Public Health

Standard Method for Testing and Evaluation of VOC Emissions from Indoor Sources. Emission Testing Method for California Specification 01350: Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions From Indoor Sources Using Environmental Chambers Version V1.2–2017. California Department of Public Health. www.cdph.ca.gov/Programs/CCDPHP/DEODC/EHLB/IAQ/Pages/VOC.aspx. Last Accessed September 2020.

California Title 17

California Code of Regulations, Title 17, sections 93120–93120.12. 2008. State of California. www.arb.ca.gov/regact/2007/compwood07/fro-final.pdf. Last Accessed September 2020.

CARB (California Air Resources Board)

Composite Wood Products Airborne Toxic Control Measure (ATCM) Phase 2. California Air Resources Board. ww2.arb.ca.gov/our-work/programs/composite-wood-products-program. Last Accessed September 2020.

Carpet and Rug Institute

Green Label Plus. Carpet and Rug Institute. carpet-rug.org/testing/green-label-plus/. Last Accessed September 2020.

DOE (U.S. Department of Energy)

Standard Work Specifications for Multi-Family Home Energy Upgrades. 2013. U.S. Department of Energy. sws.nrel.gov/. Last accessed February 2021.

DOE

Standard Work Specifications for Single-Family Home Energy Upgrades. 2013. U.S. Department of Energy. www.energy.gov/sites/prod/files/2014/01/f7/sws_singlefamily.pdf. Last Accessed November 2020.

ECOLOGO

ECOLOGO Product Certification. 2020. ECOLOGO. industries.ul.com/environment/certificationvalidation-marks/ecologo-product-certification. Last Accessed November 2020.

EPA (U.S. Environmental Protection Agency) Asbestos

Asbestos. 2020. U.S. Environmental Protection Agency. www.epa.gov/asbestos. Last updated August 27, 2020. Last Accessed November 2020.

EPA Asbestos

Overview of the Asbestos National Emission Standards for Hazardous Air Pollutants (NESHAP). 2019. U.S. Environmental Protection Agency. www2.epa.gov/asbestos/asbestos-neshap. Last Accessed November 2020.

EPA Asbestos

Protect Your Family from Asbestos-Contaminated Vermiculite Insulation. 2015. U.S. Environmental Protection Agency. www2.epa.gov/asbestos/protect-your-family-asbestos-contaminated-vermiculite-insulation. Last Accessed November 2020.

EPA Chemical Hazards

Current Agricultural Worker Protection Standard (WPS). 40 CFR Part 170. U.S. Environmental Protection Agency. www.epa.gov/pesticide-worker-safety/agricultural-worker-protection-standard-wps. Last Accessed November 2020.

EPA Cleaning and Building Products

Safer Choice. 2020. U.S. Environmental Protection Agency. www.epa.gov/saferchoice. Last updated November 10, 2020. Last Accessed November 2020.

EPA Formaldehyde

EPA Formaldehyde Emission Standards for Composite Wood Products TSCA Title VI. Background, resources, guidance. U.S. Environmental Protection Agency. www.epa.gov/formaldehyde/formaldehyde-emission-standards-composite-wood-products. Last Accessed September 2020.

EPA Lead

40 CFR Part 745. Lead; Clearance and Clearance Testing Requirements for the Renovation, Repair, and Painting Program; Proposed Rule. 2010. U.S. Environmental Protection Agency. www.gpo.gov/fdsys/pkg/FR-2010-05-06/pdf/2010-10102.pdf. Last Accessed November 2020.

EPA Lead

Hazard Standards and Clearance for Lead in Paint, Dust and Soil (TSCA Sections 402 and 403). 2021. U.S. Environmental Protection Agency. www.epa.gov/lead/hazard-standards-and-clearance-levels-lead-paint-dust-and-soil-tsca-sections-402-and-403. Last Accessed April 2021.

EPA Indoor airPLUS

Indoor airPLUS Construction Specifications. 2018. U.S. Environmental Protection Agency. www.epa.gov/indoorairplus/indoor-airplus-program-documents. Last Accessed September 2020.

EPA IPM

Integrated Pest Management Principles. 2011. U.S. Environmental Protection Agency, Integrated Pest Management. www.epa.gov/safepestcontrol/integrated-pest-management-ipm-principles. Last updated April 11, 2019. Last Accessed September 2020.

EPA Mold and Moisture

Moisture Control Guidance for Building Design, Construction and Maintenance. 2013. U.S. Environmental Protection Agency. www.epa.gov/indoor-air-quality-iaq/moisture-control-guidance-building-design-construction-and-maintenance. Last Accessed September 2020.

EPA Mold and Moisture

Mold Remediation in Schools and Commercial Buildings. 2008. U.S. Environmental Protection Agency. www.epa.gov/mold/printable-version-mold-remediation-schools-and-commercial-buildings. Last Accessed November 2020.

EPA PCBs

Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions, 40 CFR Part 761 Subpart D—Storage and Disposal. 2007. U.S. Environmental Protection Agency. www.govinfo.gov/content/pkg/CFR-2007-title40-vol30/pdf/CFR-2007-title40-vol30-part761.pdf. Last Accessed November 2020.

Green Seal Standard GS-11

GS-11: Paints, Coatings, Stains, and Sealers. 2008. Green Seal, Inc. www.greenseal.org/green-seal-standards/gs-11. Last Accessed September 2020.

HUD

Lead-Safe Housing Rule. 2004. U.S. Department of Housing and Urban Development. www.hud.gov/program_offices/healthy_homes/enforcement/lshr. Last Accessed November 2020.

HUD

Optional Smoke-Free Housing Policy Implementation, Notice H 2010-21. 2010. U.S. Department of Housing and Urban Development. www.tcsg.org/sfelp/HUD-SFHsgImplemt091510.pdf. Last Accessed November 2020.

IICRC

IICRC S520-2015. Standard and Reference Guide for Professional Mold Remediation. 2015. Institute of Inspection, Cleaning and Restoration Certification. webstore.iicrc.org/index.php/new-ansi-iicrc-s520-reference-guide-for-professional-mold-remediation-third-edition-2015-print-version.html. Last Accessed November 2020.

International Code Council

2018 International Building Code. 2017. International Code Council, Inc. codes.iccsafe.org/content/IBC2018?site_type=public. Last Accessed September 2020.

International Code Council

2018 International Fuel Gas Code. 2018. International Code Council, Inc. codes.iccsafe.org/content/IFGC2018P3. Last Accessed November 2020.

International Code Council

International Mechanical Code, 2018. International Code Council, Inc. codes.iccsafe.org/content/IMC2015. Last Accessed December 2020.

International Code Council

International Residential Code for One- and Two-Family Dwellings. 2018. International Code Council, Inc. codes.iccsafe.org/content/IRC2018. Last Accessed November 2020.

Master Painters Institute

MPI Green Vision. MPI Green Performance Standard/MPI-GS-2, MPI Extreme Green, Greenwise Gold 2018. specifygreen.com/. Last Accessed November 2020.

NFPA 31

Standard for the Installation of Oil-Burning Equipment. 2011. National Fire Protection Association. www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=31. Last Accessed November 2020.

NFPA 211

Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances. 2013. National Fire Protection Association. www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=211. Last Accessed November 2020.

NFPA 72

National Fire Alarm and Signaling Code. 2019. National Fire Protection Association. www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=72. Last Accessed November 2020.

DOL (U.S. Department of Labor), OSHA (Occupational Safety and Health Administration)

U.S. Department of Labor, Occupational Safety and Health Administration. www.osha.gov. Last Accessed November 2020.

DOL, OSHA, 29 CFR Part 1926.1101, Subpart Z

Hazard Communication. Occupational Safety and Health Standards: Toxic and Hazardous Substances. U.S. Department of Labor, Occupational Safety and Health Administration. www.osha.gov/pls/oshaweb/owadisp.show_document?p_id=10862&p_table=STANDARDS. Last Accessed September 2020.

DOL, OSHA, 29 CFR Part 1926, Subpart K

Electrical Standards for Construction. 2001. U.S. Department of Labor, Occupational Safety and Health Administration. www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=FEDERAL_REGISTER&p_id=16956. Last Accessed September 2020.

DOL, OSHA, 29 CFR Part 1926.21, Subpart C

Safety and Health Regulations for Construction: General Safety and Health Provisions: Safety Training and Education. U.S. Department of Labor, Occupational Safety and Health Administration. www.osha.gov/laws-regs/regulations/standardnumber/1926/1926.21. Last Accessed September 2020.

DOL, OSHA, 29 CFR Part 1926.28(a), Subpart C

Personal Protective Equipment. Safety and Health Regulations for Construction: Occupational Health and Environmental Controls. U.S. Department of Labor, Occupational Safety and Health Administration. www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10614. Last Accessed September 2020.

OSHA, 29 CFR Part 1926.21 (b)(6)(i): Subpart C

Safety Training and Education. Safety and Health Regulations for Construction: General Safety and Health Provisions. www.osha.gov/pls/oshaweb/owadisp.show_document?p_id=10607&p_table=STANDARDS. Last Accessed November 2020.

DOL, OSHA, 29 CFR Part 1926.59, Subpart D

Hazard Communication. Safety and Health Regulations for Construction: Occupational Health and Environmental Controls: Hazard Communication. U.S. Department of Labor, Occupational Safety and Health Administration. www.osha.gov/pls/oshaweb/owadisp.show_document?p_id=10633&p_table=STANDARDS. Last Accessed September 2020.

DOL, OSHA, 29 CFR Part 1926.62, Subpart D

Lead. Safety and Health Regulations for Construction: Occupational Health and Environmental Controls. U.S. Department of Labor, Occupational Safety and Health Administration. www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10641. Last Accessed September 2020.

DOL, OSHA, 29 CFR Part 1926.501, Subpart M

Fall Protection. Safety and Health Regulations for Construction. U.S. Department of Labor, Occupational Safety and Health Administration. www.osha.gov/pls/oshaweb/owadisp.show_document?p_id=10757&p_table=STANDARDS. Last Accessed September 2020.

DOL, OSHA, 29 CFR Part 1926.1053, Subpart X

Ladders. Safety and Health Regulations for Construction. U.S. Department of Labor, Occupational Safety and Health Administration. www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=standards&p_id=10839. Last Accessed September 2020.

DOL, OSHA, 29 CFR Part 1926.1101, Subpart Z

Asbestos. Safety and Health Regulations for Construction: Toxic and Hazardous Substances; Sampling and Analysis: Non-mandatory. U.S. Department of Labor, Occupational Safety and Health Administration. www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10864. Last Accessed September 2020.

DOL, OSHA

Occupational Safety and Health Act of 1970. Section 5(a)(1). 1970. U.S. Department of Labor, Occupational Safety and Health Administration. www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=OSHACT&p_id=3359. Last Accessed November 2020.

Toxic Substances Control Act Title VI

Formaldehyde Standards for Composite Wood Products. 2010. U.S. Congress. www.gpo.gov/fdsys/pkg/BILLS-111s1660enr/pdf/BILLS-111s1660enr.pdf. Last Accessed November 2020.

UL 181A

UL 181A Standard for Closure Systems for Use With Rigid Air Ducts. 2013. Underwriters Laboratories. ulstandards.ul.com/standard/?id=181A. Last Accessed November 2020.

UL 181B

UL 181B Standard for Closure Systems for Use With Flexible Air Ducts and Air Connectors. 2013. Underwriters Laboratories. standardscatalog.ul.com/ProductDetail.aspx?productId=UL181B. Last Accessed November 2020.

UL 2034

UL 2034 Standard for Single and Multiple Station Carbon Monoxide Alarms. 2008. Underwriters Laboratories. standardscatalog.ul.com/ProductDetail.aspx?productId=UL2034. Last Accessed November 2020.

GUIDANCE

ABAA

Air Barrier Materials, Components, Assemblies & Systems. 2011. Air Barrier Association of America. www.airbarrier.org/technical-information/evaluated-assemblies-2/. Last Accessed November 2020.

ACCA Manual N

ACCA Manual N. Commercial Load Calculation. 5th edition. 2008. Air Conditioning Contractors of America. www.acca.org/store#/productDetail/5A744C03-BC20-E511-80FA-C4346BACEBF4. Last Accessed November 2020.

AHRI

AHRI (Air Conditioning, Heating and Refrigeration Institute). www.ahrinet.org/default.aspx. Last Accessed November 2020.

AIHA

Recognition, Evaluation, and Control of Indoor Mold. 2008. American Industrial Hygiene Association. www.aiha.org/education/marketplace/indoor-mold-book. Last Accessed November 2020.

American Chemistry Council

Spray Polyurethane Foam Health and Safety. 2020. American Chemistry Council. www.spraypolyurethane.org. Last Accessed September 2020.

American Conference of Governmental Industrial Hygienists

Bioaerosols Assessment and Control. 1999. American Conference of Governmental Industrial Hygienists. www.acgih.org/forms/store/ProductFormPublic/bioaerosols-assessment-and-control. Last Accessed September 2020.

ATP and IUOE

Indoor Air Quality Solutions for Stationary Engineers. 2009. American Technical Publishers and International Union of Operating Engineers. www.atplearning.com/product/858/indoor-air-quality-solutions-for-stationary-engineers. Last Accessed November 2020.

Boston Public Health Commission

Boston Smoke Free Homes: Landlord Guide. Boston Public Health Commission. www.bphc.org/whatwedo/tobacco-free-living/smoke-free-homes/condo-owners-and-associations/Documents/BostonSmoke-FreeHomesLLGuide.pdf. Last Accessed November 2020.

Boston Public Health Commission

Integrated Pest Management: A Guide for Managers and Owners of Affordable Housing. 2007. Boston Public Health Commission. asthmaregionalcouncil.org/wp-content/uploads/2014/02/2007_IPM-Toolkit-Affordable-Housing.pdf. Last Accessed November 2020.

Capital District Tobacco-Free Coalition

2013. Capital District Tobacco-Free Coalition. www.smokefreecapital.org. Last Accessed November 2020.

CARB

Hazardous Ozone-Generating “Air Purifiers.” 2012. California Air Resources Board. www.arb.ca.gov/research/indoor/ozone.htm. Last Accessed November 2020.

CDC (Centers for Disease Control and Prevention)

Check for Safety: A Home Fall Prevention Checklist for Older Adults. 2015. Centers for Disease Control and Prevention. www.cdc.gov/steady/pdf/check_for_safety_brochure-a.pdf. Last Accessed September 2020.

CDC

Resource on Rodents. 2010. Centers for Disease Control and Prevention. www.cdc.gov/rodents. Last Accessed September 2020.

CDC, NIOSH (National Institute for Occupational Safety and Health)

Indoor Environmental Quality, Dampness and Mold Assessment Tool. 2013. Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. www.cdc.gov/niosh/topics/indoorenv/moldtesting.html. Last Accessed November 2020.

CDC, NIOSH

Workplace Safety & Health Topics, Protective Clothing and Ensembles. 2014. Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. www.cdc.gov/niosh/topics/protclothing. Last Accessed November 2020.

CDC, NIOSH

Storm, Flood, and Hurricane Response, Recommendations for the Cleaning and Remediation of Flood-Contaminated HVAC Systems: A Guide for Building Owners and Managers. 2010. Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. www.cdc.gov/niosh/topics/emres/Cleaning-Flood-HVAC.html. Last Accessed November 2020.

CDC, NIOSH

Workplace Safety & Health Topics, Respirators. 2015. Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. www.cdc.gov/niosh/topics/respirators/default.html. Last Accessed November 2020.

Collaborative for High Performance Schools

High Performance Products Database. 2002 – 2019. Collaborative for High Performance Schools. chps.net/products. Last Accessed November 2020.

CPSC (Consumer Product Safety Commission)

Carbon Monoxide Questions and Answers. Consumer Product Safety Commission. www.cpsc.gov/en/Safety-Education/Safety-Education-Centers/Carbon-Monoxide-Information-Center/Carbon-Monoxide-Questions-and-Answers-/. Last Accessed November 2020.

CPSC

Lead in Paint, Product-Specific FAQs. Consumer Product Safety Commission. www.cpsc.gov/Business--Manufacturing/Business-Education/Lead/Lead-in-Paint. Last Accessed November 2020.

Enterprise Green Communities

Green Operations & Maintenance Training in a Box. 2012. Enterprise Green Communities. www.enterprisecommunity.com/solutions-and-innovation/enterprise-green-communities/resources/operations-and-maintenance-toolkit. Last Accessed November 2020.

EPA Asbestos

Asbestos in Your Home. 1990. U.S. Environmental Protection Agency. nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=20001EVF.txt. Last Accessed September 2020.

EPA Asbestos

Asbestos' Impact on Indoor Air Quality. 2018. U.S. Environmental Protection Agency. www.epa.gov/indoor-air-quality-iaq/asbestos-impact-indoor-air-quality. Last Accessed November 2020.

EPA Asbestos

Monitoring Asbestos-Containing Material (ACM). 2018. U.S. Environmental Protection Agency. www2.epa.gov/asbestos/monitoring-asbestos-containing-material-acm. Last Accessed November 2020.

EPA Asbestos

State Asbestos Contacts. 2011. U.S. Environmental Protection Agency. www.epa.gov/asbestos/state-asbestos-contacts. Last Accessed September 2020.

EPA Burn Wise

Best Wood-Burning Practices. 2019. U.S. Environmental Protection Agency. www.epa.gov/burnwise/best-wood-burning-practices. Last updated March 25, 2020. Last Accessed September 2020.

EPA Burn Wise

Burn Wise Tips. 2010. U.S. Environmental Protection Agency. www.epa.gov/sites/production/files/documents/burnwisetips.pdf.

EPA Burn Wise

Burn Wise, Consumers—Choosing Appliances. 2015. U.S. Environmental Protection Agency. www.epa.gov/burnwise/choosing-wood-burning-appliances. Last Accessed November 2020.

EPA Burn Wise

Burn Wise, Consumers—Frequent Questions. 2015. U.S. Environmental Protection Agency. www.epa.gov/burnwise/frequent-questions-about-wood-burning-appliances. Last Accessed November 2020.

EPA Burn Wise

EPA Certified Wood Stoves. 2015. U.S. Environmental Protection Agency. www.epa.gov/burnwise/epa-certified-wood-stoves. Last Accessed November 2020.

EPA Burn Wise

Voluntary Programs for More Efficient Wood-Burning Appliances, Hydronic Heaters Program (terminated). 2021. U.S. Environmental Protection Agency. www.epa.gov/burnwise/voluntary-programs-more-efficient-wood-burning-appliances#hheaters. Last Accessed February 2021.

EPA Carbon Monoxide

Carbon Monoxide's Impact on Indoor Air Quality. 2011. U.S. Environmental Protection Agency. www.epa.gov/indoor-air-quality-iaq/carbon-monoxides-impact-indoor-air-quality. Last Accessed September 2020.

EPA Chemical Hazards

Pest Control and Pesticide Safety for Consumers. 2020. U.S. Environmental Protection Agency. www.epa.gov/safepestcontrol. Last Accessed November 2020.

EPA Environmental Tobacco Smoke

Secondhand Smoke and Smoke-Free Homes. 2010. U.S. Environmental Protection Agency. www.epa.gov/indoor-air-quality-iaq/secondhand-smoke-and-smoke-free-homes. Last updated July 15, 2020. Last Accessed September 2020.

EPA Environmental Tobacco Smoke

Secondhand Tobacco Smoke and the Health of Your Family Brochure (Bilingual). 2009. U.S. Environmental Protection Agency. www.epa.gov/indoor-air-quality-iaq/secondhand-tobacco-smoke-and-health-your-family-brochure-bilingual. Last Accessed November 2020.

EPA IAQ

Building Air Quality Action Plan. 1998. U.S. Environmental Protection Agency. www.epa.gov/indoor-air-quality-iaq/building-air-quality-action-plan-june-1998. Last Accessed November 2020.

EPA IAQ

Engineering Issue. Indoor Air Vapor Intrusion Mitigation Approaches. 2008. U.S. Environmental Protection Agency. www.epa.gov/vaporintrusion/indoor-air-vapor-intrusion-mitigation-approaches. Last Accessed November 2020.

EPA IAQ

Guide to Air Cleaners in the Home, 2nd edition. 2018. U.S. Environmental Protection Agency. www.epa.gov/indoor-air-quality-iaq/air-cleaners-and-air-filters-home. Last updated July 2, 2020. Last Accessed September 2020.

EPA IAQ

Healthy Indoor Environment Protocols for Home Energy Upgrades. 2011. U.S. Environmental Protection Agency. www.epa.gov/indoor-air-quality-iaq/healthy-indoor-environment-protocols-home-energy-upgrades. Last Accessed November 2020.

EPA IAQ

IAQ Design Tools for Schools. Preventing the Entry of Pollutants from Outside the Building. Drain Traps. 2013. U.S. Environmental Protection Agency. www.epa.gov/iaq-schools/controlling-pollutants-and-sources-indoor-air-quality-design-tools-schools#DrainTraps. Last Accessed November 2020.

EPA IAQ

IAQ Design Tools for Schools. Preventing the Entry of Pollutants from Outside the Building. Entry Mat Barriers. 2013. U.S. Environmental Protection Agency. www.epa.gov/iaq-schools/controlling-pollutants-and-sources-indoor-air-quality-design-tools-schools#PreventingtheEntryofPollutants. Last Accessed November 2020.

EPA IAQ

Ozone Generators That Are Sold as Air Cleaners. 2010. U.S. Environmental Protection Agency. www.epa.gov/indoor-air-quality-iaq/ozone-generators-are-sold-air-cleaners. Last updated December 23, 2019. Last Accessed September 2020.

EPA IAQ

Vapor Intrusion. 2019. U.S. Environmental Protection Agency. www.epa.gov/vaporintrusion. Last Accessed November 2020.

EPA Lead

Lead. 2020. U.S. Environmental Protection Agency. www.epa.gov/lead. Last Accessed November 2020.

EPA Lead

Lead Test Kits. 2018. U.S. Environmental Protection Agency. www.epa.gov/lead/lead-test-kits. Last updated July 7, 2020. Last Accessed September 2020.

EPA Lead

Lead-Safe Certified Guide to Renovate Right Brochure. 2010. U.S. Environmental Protection Agency. www.epa.gov/lead/renovate-right-important-lead-hazard-information-families-child-care-providers-and-schools. Last Accessed December 2020.

EPA Lead

Locate an RRP Training Class or Provider in Your Area. 2017. U.S. Environmental Protection Agency. cfpub.epa.gov/flpp/searchrrp_training.htm. Last Accessed November 2020.

EPA Lead

Locate Certified Inspection, Risk Assessment, and Abatement Firms. U.S. Environmental Protection Agency. cfpub.epa.gov/flpp/search.cfm?Applicant_Type=firm. Last Accessed November 2020.

EPA Lead

Small Entity Compliance Guide to Renovate Right: EPA's Lead-Based Paint Renovation, Repair, and Painting Program. 2011. U.S. Environmental Protection Agency. www.epa.gov/lead/small-entity-compliance-guide-renovate-right-epas-lead-based-paint-renovation-repair-and-0. Last Accessed November 2020.

EPA Mercury

Recycling and Disposal of CFLs and Other Bulbs that Contain Mercury. 2020. U.S. Environmental Protection Agency. www.epa.gov/cfl/recycling-and-disposal-cfls-and-other-bulbs-contain-mercury. Last Accessed November 2020.

EPA Mercury

What to Do If You Spill More Mercury Than the Amount in a Thermometer. 2020. U.S. Environmental Protection Agency. www.epa.gov/mercury/what-do-if-you-spill-more-mercury-amount-thermometer. Last Accessed November 2020.

EPA Mold and Moisture

A Brief Guide to Mold, Moisture, and Your Home. 2010. U.S. Environmental Protection Agency. www.epa.gov/mold/brief-guide-mold-moisture-and-your-home. Last Accessed November 2020.

EPA Mold and Moisture

Mold. 2020. U.S. Environmental Protection Agency. www.epa.gov/mold. Last Accessed November 2020.

EPA Mold and Moisture

WaterSense. 2020. U.S. Environmental Protection Agency. www.epa.gov/watersense. Last Accessed November 2020.

EPA PCBs

EPA Regional Polychlorinated Biphenyl (PCB) Programs. 2020. U.S. Environmental Protection Agency. www.epa.gov/pcbs/epa-regional-polychlorinated-biphenyl-pcb-programs. Last Accessed November 2020.

EPA PCBs

Information for Contractors Working in Older Buildings that May Contain PCBs. U.S. Environmental Protection Agency. www.epa.gov/pcbs/polychlorinated-biphenyls-pcbs-building-materials#Information-Contractors. Last Updated June 29, 2020. Last Accessed September 2020.

EPA PCBs

Polychlorinated Biphenyls (PCBs). 2018. U.S. Environmental Protection Agency. www.epa.gov/pcbs. Last updated July 27, 2020. Last Accessed September 2020.

EPA PCBs

Polychlorinated Biphenyls (PCBs) in Building Materials. 2020. U.S. Environmental Protection Agency. www.epa.gov/pcbs/polychlorinated-biphenyls-pcbs-building-materials. Last Accessed November 2020.

EPA PCBs

Polychlorinated Biphenyl (PCB)-Containing Fluorescent Light Ballasts (FLBs) in School Buildings. 2015. U.S. Environmental Protection Agency. www.epa.gov/pcbs/polychlorinated-biphenyl-pcb-containing-fluorescent-light-ballasts-flbs-school-buildings. Last Accessed November 2020.

EPA PCBs

Steps to Safe Renovation and Repair Activities. 2011. U.S. Environmental Protection Agency. www.epa.gov/pcbs/steps-safe-renovation-and-repair-activities. Last updated January 17, 2017. Last Accessed September 2020.

EPA Radon

A Citizen's Guide to Radon. 2016. U.S. Environmental Protection Agency. www.epa.gov/sites/production/files/2016-12/documents/2016_a_citizens_guide_to_radon.pdf. Last Accessed September 2020.

EPA Radon

Consumer's Guide to Radon Reduction. 2016. U.S. Environmental Protection Agency. www.epa.gov/radon/consumers-guide-radon-reduction-how-fix-your-home. Last Accessed November 2020.

EPA Radon

Find Information about Local Radon Zones and State Contact Information. 2020. U.S. Environmental Protection Agency. www.epa.gov/radon/find-information-about-local-radon-zones-and-state-contact-information. Last Accessed November 2020.

EPA VOCs

Volatile Organic Compounds' Impact on Indoor Air Quality. 2015. U.S. Environmental Protection Agency. www.epa.gov/indoor-air-quality-iaq/volatile-organic-compounds-impact-indoor-air-quality. Last Accessed February 2021.

Green Shield

Green Shield Certified. www.greenshieldcertified.org/. Last Accessed November 2020.

GREENGUARD Environmental Institute

GREENGUARD Gold Certification. GREENGUARD Environmental Institute. spot.ul.com/greenguard/. Last Accessed November 2020.

HUD (U.S. Department of Housing and Urban Development)

Change is in the Air: An Action Guide for Establishing Smoke-Free Public Housing and Multifamily Properties. 2014. U.S. Department of Housing and Urban Development. portal.hud.gov/hudportal/documents/huddoc?id=smokefreeactionguide.pdf. Last Accessed November 2020.

HUD

HUD's Guidance on Integrated Pest Management. 2008. U.S. Department of Housing and Urban Development. www.hud.gov/program_offices/healthy_homes/healthyhomes/ipm. Last Accessed February 2021.

HUD

Lead-Safe Work Practices for Instructors and Accredited Training Providers. U.S. Department of Housing and Urban Development. www.hud.gov/program_offices/healthy_homes/enforcement/lshr_rrp_changes. Last Accessed February 2021.

HUD

Smoke Free Housing. A Toolkit for Owners/Management Agents of Federally Assisted Public and Multi-family Housing. 2012. U.S. Department of Housing and Urban Development. portal.hud.gov/hudportal/documents/huddoc?id=pdfowners.pdf. Last Accessed November 2020.

HUD

Smoke Free Housing. A Toolkit for Residents of Federally Assisted Public and Multi-family Housing. 2012. U.S. Department of Housing and Urban Development. portal.hud.gov/hudportal/documents/huddoc?id=pdfresidents.pdf. Last Accessed November 2020.

Kitchen Cabinet Manufacturers Association

Environmental Stewardship Certification Program (ESP 05-12). 2012. Kitchen Cabinet Manufacturers Association. [www.kcma.org/Professionals/Environmental Stewardship Program](http://www.kcma.org/Professionals/Environmental_Stewardship_Program). Last Accessed November 2020.

LISC

Green & Healthy Property Management. A Guide for Multifamily Buildings. 2013. Local Initiatives Support Corporation. www.lisc.org/media/filer_public/a6/17/a61783a6-6d04-4ae2-89f2-ff763642d0d9/green_and_healthy_property_management.pdf. Last Accessed November 2020.

Michigan Smoke-Free Apartment

Michigan Smoke-Free Apartment. mismokefreeapartment.org/. Last Accessed November 2020.

Minnesota Smoke-Free Housing

Minnesota Smoke-Free Housing. www.mnsmokefreehousing.org/. 2020. Live Smoke Free. Last Accessed November 2020.

MNCEE

Reduction of Environmental Tobacco Smoke Transfer in Minnesota Multifamily Buildings Using Air Sealing and Ventilation Treatments. 2004. Minnesota Center for Energy and Environment. www.mncee.org/getattachment/Resources/Projects/Secondhand-Smoke-Research/Reduction-of-Environmental-Tobacco-Smoke-Transfer-in-Minnesota-Multifamily-Buildings-Using-Air-Sealing-and-Ventilation-Treatments.pdf.aspx. Last Accessed November 2020.

National Pest Management Association

GreenPro Certified. www.npmaqualitypro.org/available-credentials/greenpro/. Last Accessed November 2020.

National Renewable Energy Laboratory (NREL)

Standard Work Specifications, Section 2: Health & Safety. NREL. sws.nrel.gov/spec/2. Last Accessed February 2021.

NREL

Standard Work Specifications, Section 3: Air Sealing. NREL. sws.nrel.gov/spec/3. Last Accessed February 2021.

NREL

Standard Work Specifications, Section 5: Heating & Cooling. NREL. sws.nrel.gov/spec/5. Last Accessed February 2021.

NREL

Standard Work Specifications, Section 6: Ventilation. NREL. sws.nrel.gov/spec/6. Last Accessed February 2021.

NCHH (National Center for Healthy Housing) IPM

Integrated Pest Management: A Guide for Affordable Housing. National Center for Healthy Housing. www.stoppests.org/what-is-ipm/guide/. Last Accessed September 2020.

NCHH

Healthy Homes Maintenance Checklist. National Center for Healthy Housing. nchh.org/resource-library/healthy-homes-maintenance-checklist_english.pdf. Last Accessed November 2020.

NCHH

Improving Ventilation in Existing or New Buildings With Central Roof Exhaust. 2009. National Center for Healthy Housing. nchh.org/resource-library/fact-sheet_g&hh_improving-ventilation_central-roof-exhaust.pdf. Last Accessed November 2020.

NCHH

Improving Ventilation in Multi-Family Buildings That Do Not Have Fan-Powered Ventilation. 2009. National Center for Healthy Housing. nchh.org/resource-library/fact-sheet_g&hh_improving-ventilation_multifamily-buildings_non-fan-powered.pdf. Last Accessed November 2020.

NCHH

Improving Ventilation in New and Existing Multi-Family Buildings With Individual Unit Ventilation Systems. 2009. [nchh.org/resource-library/fact-sheet_g&hh_improving-ventilation_multifamily-buildings_individual-unit-ventilation.pdf](https://www.nchh.org/resource-library/fact-sheet_g&hh_improving-ventilation_multifamily-buildings_individual-unit-ventilation.pdf). Last Accessed November 2020.

NCHH

Integrated Pest Management: A Guide for Affordable Housing. www.stoppests.org/what-is-ipm/guide/. Last Accessed September 2020.

NCHH

Reasons to Explore Smoke-Free Housing. 2009. National Center for Healthy Housing. [nchh.org/resource-library/fact-sheet_g&hh_reasons-to-explore-smoke-free-housing.pdf](https://www.nchh.org/resource-library/fact-sheet_g&hh_reasons-to-explore-smoke-free-housing.pdf). Last Accessed November 2020.

NCHH-APHA

National Healthy Housing Standard. 2014. National Center for Healthy Housing and American Public Health Association. [nchh.org/tools-and-data/housing-code-tools/national-healthy-housing-standard/](https://www.nchh.org/tools-and-data/housing-code-tools/national-healthy-housing-standard/). Last Accessed November 2020.

NIST (National Institute of Standards and Technology)

NVLAP (National Voluntary Laboratory Accreditation Program) Asbestos Fiber Analysis LAP. 2015. National Institute of Standards and Technology. www.nist.gov/nvlap/asb-lap.cfm. Last Accessed November 2020.

NIST

NVLAP Asbestos Fiber Analysis Directory. 2015. National Institute of Standards and Technology. www.nist.gov/nvlap/asbestos-fiber-analysis-lap. Last Accessed February 2021.

NYSERDA

Improving Central Exhaust Systems for Multifamily Buildings. 2011. New York State Energy Research and Development Authority. www.nyserda.ny.gov/-/media/Files/Publications/Research/Other-Technical-Reports/Improving-Central-Exhaust-Systems-Multifamily-Buildings.pdf. Last Accessed November 2020.

DOL, OSHA

A Brief Guide to Mold in the Workplace. 2013. U.S. Department of Labor, Occupational Safety and Health Administration. www.osha.gov/dts/shib/shib101003.html. Last Accessed November 2020.

DOL, OSHA

Asbestos. U.S. Department of Labor, Occupational Safety and Health Administration. www.osha.gov/SLTC/asbestos/. Last Accessed November 2020.

DOL, OSHA

Asbestos, Construction. U.S. Department of Labor, Occupational Safety and Health Administration. www.osha.gov/asbestos/construction. Last Accessed November 2020.

DOL, OSHA

Combustible Dust. An Explosion Hazard. U.S. Department of Labor, Occupational Safety and Health Administration. www.osha.gov/dsg/combustibledust/index.html. Last Accessed November 2020.

DOL, OSHA

Confined Spaces. U.S. Department of Labor, Occupational Safety and Health Administration. www.osha.gov/SLTC/confinedspaces/index.html. Last Accessed November 2020.

DOL, OSHA

Electrical Incidents E-Tool. U.S. Department of Labor, Occupational Safety and Health Administration. www.osha.gov/SLTC/etools/construction/electrical_incidents/mainpage.html. Last Accessed November 2020.

DOL, OSHA

Fall Protection. U.S. Department of Labor, Occupational Safety and Health Administration www.osha.gov/SLTC/fallprotection/index.html. Last Accessed November 2020.

DOL, OSHA

Falls E-Tool. U.S. Department of Labor, Occupational Safety and Health Administration. www.osha.gov/SLTC/etools/construction/falls/mainpage.html. Last Accessed November 2020.

DOL, OSHA

Green Job Hazards: Weather Insulating/Sealing. U.S. Department of Labor, Occupational Safety and Health Administration. www.osha.gov/dep/greenjobs/weather_spf.html. Last Accessed November 2020.

DOL, OSHA

Hazard Communication. U.S. Department of Labor, Occupational Safety and Health Administration. www.osha.gov/dsg/hazcom/index.html. Last Accessed November 2020.

DOL, OSHA

Lead. U.S. Department of Labor, Occupational Safety and Health Administration. www.osha.gov/SLTC/lead/index.html. Last Accessed November 2020.

DOL, OSHA

Lead in Construction. 2004. U.S. Department of Labor, Occupational Safety and Health Administration. www.osha.gov/Publications/osha3142.pdf. Last Accessed November 2020.

DOL, OSHA

OSHA Technical Manual (OTM), Section III: Chapter 7 Legionnaires' Disease. 1999. U.S. Department of Labor, Occupational Safety and Health Administration. www.osha.gov/dts/osta/otm/otm_iii/otm_iii_7.html. Last Accessed November 2020.

DOL, OSHA

OSHA Training Courses, Materials, and Resources. U.S. Department of Labor, Occupational Safety and Health Administration. www.osha.gov/dte/index.html. Last Accessed November 2020.

DOL, OSHA

Permissible Exposure Limits—Annotated Tables. U.S. Department of Labor, Occupational Safety and Health Administration. www.osha.gov/dsg/annotated-pels/. Last Accessed November 2020.

DOL, OSHA

Quick Card. Protect Yourself. Carbon Monoxide Poisoning. 2007. U.S. Department of Labor, Occupational Safety and Health Administration. www.osha.gov/Publications/3282-10N-05-English-07-18-2007.html. Last Accessed November 2020.

DOL, OSHA

Stairways and Ladders: A Guide to OSHA Rules. 2003. U.S. Department of Labor, Occupational Safety and Health Administration. www.osha.gov/Publications/osha3124.pdf. Last Accessed November 2020.

DOL, OSHA

Wood Dust. U.S. Department of Labor, Occupational Safety and Health Administration. www.osha.gov/SLTC/wooddust/index.html. Last Accessed November 2020.

Resilient Floor Covering Institute

FloorScore®. Resilient Floor Covering Institute. www.rfci.com/knowledge-center/floorscore/. Last Accessed November 2020.

San Francisco Department of the Environment

Guide to the City of San Francisco's Reduced-Risk Pesticide List. 2007. San Francisco Department of the Environment. sfenvironment.org/sites/default/files/fliers/files/sfe_th_pesticidetierprotocol.pdf. Last Accessed November 2020.

San Francisco Department of the Environment

Pest Prevention by Design: Authoritative Guidelines for Designing Pests Out of Structures. 2012. San Francisco Department of the Environment. sfenvironment.org/download/pest-prevention-by-design-guidelines. Last Accessed November 2020.

Scientific Certification Systems

Indoor Air Quality Certification: For Furniture and Building Materials. 2020. Scientific Certification Systems. www.scsglobalservices.com/services/indoor-air-quality-certification. Last Accessed November 2020.

SMACNA (Sheet Metal & Air Conditioning Contractors' National Association)

IAQ Guidelines for Occupied Buildings Under Construction, Second Edition. 2008. Sheet Metal & Air Conditioning Contractors' National Association. www.smacna.org/store/product/iaq-guidelines-for-occupied-buildings-under-construction. Last Accessed November 2020.

Smoke-Free Housing Coalition of Maine

breatheeasymaine.org/. Last Accessed November 2020.

Tobacco Technical Assistance Consortium

Tobacco Technical Assistance Consortium (TTAC). 2020. Tobacco Technical Assistance Consortium. tacenters.emory.edu/focus_areas/tobacco/index.html. Last Accessed November 2020.

UL (Underwriters Laboratories)

Fire-Resistance and Smoke Protection. Underwriters Laboratories. www.ul.com/services/fire-resistance-products-systems-and-designs. Last Accessed November 2020.

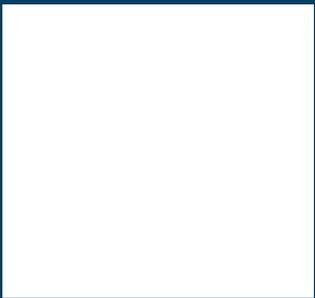
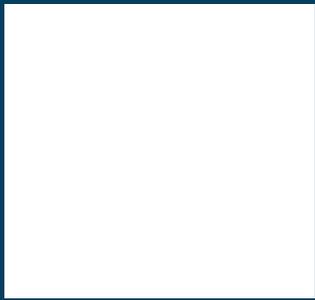
USDA

Cooperative Extension System Offices. 2014. U.S. Department of Agriculture. www.usda.gov/topics/rural/cooperative-research-and-extension-services. Last Accessed November 2020.

Weatherization Assistance Program Technical Assistance Center

Multifamily Audits. 2015. Weatherization Assistance Program Technical Assistance Center. nascsp.org/wp-content/uploads/2018/02/waptac_multifamilyfact_091812_web.pdf. Last Accessed November 2020.

Appendix E: Abbreviations and Acronyms



AARST—American Association of Radon Scientists and Technologists, Inc.
ABAA—Air Barrier Association of America
ACCA—Air Conditioning Contractors of America
ACM—asbestos-containing material
AHRI—Air-Conditioning, Heating, and Refrigeration Institute
ANSI—American National Standards Institute
APHA—American Public Health Association
ASHRAE—American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASPE—American Society of Plumbing Engineers
ASTM—American Society for Testing and Materials
ATCM—Airborne Toxic Control Measures
AWWA—American Water Works Association
BOC—Building Operators Certification
BPI—Building Performance Institute
CARB—California Air Resources Board
CAZ—Combustion Appliance Zone
CDC—Centers for Disease Control and Prevention
CDPH—California Department of Public Health
cfm—cubic feet per minute
CFL—compact fluorescent lamp
CFR—Code of Federal Regulations
CO—carbon monoxide
CPSC—Consumer Product Safety Commission
CRI—Carpet and Rug Institute
CSA—Canadian Standards Association
CSIA—Chimney Safety Institute of America
DOE—U.S. Department of Energy
DOL—U.S. Department of Labor
EPA—U.S. Environmental Protection Agency
EPDM—ethylene propylene diene monomer
ETS—environmental tobacco smoke
FPR—Filter Performance Rating
gpm—gallons per minute
HEPA—high-efficiency particulate air
HPD—Health Product Declaration
HUD—U.S. Department of Housing and Urban Development
HVAC—heating, ventilation and air conditioning
IAQ—indoor air quality
IBC—International Building Code
IFGC—International Fuel Gas Code
IICRC—Institute of Inspection, Cleaning and Restoration Certification
IPM—integrated pest management

IRC—International Residential Code
IUOE—International Union of Operating Engineers
LED—light-emitting diode
LISC—Local Initiatives Support Corporation
LSL—lead service line
MDI—methylene diphenyl diisocyanate
MERV—minimum efficiency reporting value
MNCEE—Minnesota Center for Energy and Environment
MPI—Master Painters Institute
MPI GPS—Master Painters Institute Green Performance Standard
MPR—Microparticle Performance Rating
MSDS—Material Safety Data Sheet
NCHH—National Center for Healthy Housing
NFGC—National Fuel Gas Code
NFI—National Fireplace Institute
NFPA—National Fire Protection Association
NIOSH—National Institute for Occupational Safety and Health
NIST—National Institute of Standards and Technology
NPE—nonylphenol ethoxylate
NVLAP—National Voluntary Laboratory Accreditation Program
NYSERDA—New York State Energy Research and Development Authority
OSHA—Occupational Safety and Health Administration
OSWER—Office of Solid Waste and Emergency Response (EPA)
PCBs—polychlorinated biphenyls
pCi/L—picocuries per liter of air
PHAI—Public Health Advocacy Institute
PLM—polarized light microscopy
PPE—personal protective equipment
RRP—renovation, repair and painting
SCAQMD—South Coast Air Quality Management District
SCS—Scientific Certification Systems
SIP—shelter-in-place
SMACNA—Sheet Metal and Air Conditioning Contractors’ National Association
SPF—spray polyurethane foam
SPFA—Spray Polyurethane Foam Alliance
SVOC—semi-volatile organic compounds
TEM—transmission electron microscopy
TSCA—Toxic Substances Control Act
UFFI—urea formaldehyde foam insulation
UL—Underwriters Laboratories
VOC—volatile organic compound

