



Home Upgrade

INSTALLATION STANDARDS

**For Energy Upgrade California®
Advanced Home Upgrade, Eligible Measures**

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SUMMARY of INSTALLATION STANDARDS UPDATES

<u>DATE</u>	<u>Page Number</u>	<u>SECTION(S)</u>	<u>UPDATE</u>
March 2012	N/A	Creation of Document	
July 2014	N/A	Document update	
June 2015	N/A	Document update	
December 2015	137	2	SEER minimum value increased to 15
December 2015	71-72	4.2	Update to Recessed light non IC rated light enclosures section
December 2015	6	Table 1	Updated duct sealing language
December 2015	138	17.2	Updated duct sealing language
February 2016	6	Table 1	Update Duct Replacement language to Duct Seal
May 2017	All	All	<p>Removed Installation procedures currently described in the Inspection Guidelines document.</p> <p>Removed section on Mechanical Ventilation to a stand-alone document.</p> <p>Removed measure minimums.</p> <p>Consolidated text where possible.</p> <p>Reformatted entire document to consistent and more legible formatting.</p>
January 2019	All	All	<p>Removed all language pertaining to the prescriptive path of the program.</p> <p>Updated all necessary sections pertaining to Home Upgrade and Multi-family program</p>
January 2020	All	All	Updated document to remove test-in diagnostic testing requirements

1. Introduction

The Energy Upgrade California – Advanced Home Upgrade installation specifications serve the primary purpose of providing consistent documentation regarding minimum material requirements, installation best practices, and additional considerations in the implementation of high-quality energy retrofits. The installation specifications are a tool for contractors, program managers, trainers, and quality assurance inspectors and are intended to build consistency and predictability into the Advanced Home Upgrade program. These specifications are a companion document to other Energy Upgrade California Home Upgrade (Home Upgrade) documents.

The specifications have been developed with input and review from many renowned industry experts in their respective fields over a 20-year period. They represent a body of information and research that is ever evolving, as the total body of knowledge around home energy retrofits is also evolving. Due to the in-depth and complex nature of HVAC and mechanical system configurations, design, sizing and installation practices, no specific standard for HVAC retrofits is provided herein. Title 24, California Mechanical Code, Home Upgrade Inspection Guidelines, this document (Home Upgrade Installation Specifications), other Home Upgrade documents and local jurisdictions remain the minimum referenced standards for this measure class.

It is a commonly understood fact that the home performance industry is a diverse field, and that no one solution fits all opportunities. The individual chapters (or measures) in this set of specifications are segmented to allow some measure of flexibility, acknowledging that specific results and conditions may vary.

To that end each measure chapter is divided into four primary sections. This introduction attempts to explain how stakeholders should view these sections.

- **Material Standards:** This section lays out the minimum material requirements for a specific measure, and references the relevant codes and standards for those materials. This section is not comprehensive, and generally refers to commonly installed materials for a specific application. Contractors wishing to substitute materials with items that do not meet these minimum standards are encouraged to contact their Account Manager in advance.
- **Installation Standards:** This is the primary informational section of each standard, and offers more in depth details regarding standard practices for specific measures or testing procedures. This section is designed to offer as much information as possible, but does not cover every possible condition. Where contractor practices are in potential conflict with these standard industry practices, contractors are encouraged to raise the issue with program technical staff.
- **Additional Health and Safety Considerations:** The health and safety considerations are provided to highlight specific areas of concern or consideration regarding a particular measure or topic. They are intended as a set of MINIMUM practices and considerations, and are not a comprehensive list of every possible health or safety concern. Contractors are expected to have all necessary training and licensing regarding their specific scopes of work, and are expected to maintain worker and client safety as the highest priority on any job.
- **Feasibility Considerations:** When applicable, a sidebar is provided offers specific considerations contractors should take into account when determining the feasibility of a measure. There are conditions when additional work may be required to prepare the home for a specific measure. Existing environmentally hazardous materials, impacts of pressure changes on combustion appliances, and degradation of structural elements are examples of items that may impact the feasibility of a measure. This section is provided for contractor reference; however, the final scope of work on a given project remains at the discretion of the participating contractor.

When needed, additional subheadings are used throughout this document to organize the material.

2. Advanced Home Upgrade

The **Advanced Home Upgrade** program maximizes opportunities for deeper retrofits and long-term energy savings. It offers homeowners a more customized path to enhanced home performance as it pertains to energy utilization. The incentive is based on modeled energy-savings and may vary depending on the results of the work performed and housing characteristics. This Advanced Home Upgrade path requires diagnostic “test-in” and “test-out” assessments consistent with ANSI BPI-1200-S-2015 Standard Practice for Basic Analysis of Buildings and Program specific testing and requirements. The Advanced Home Upgrade test-in generates a comprehensive work scope for each job. The test-out assessments are used to document that specified improvements have been properly sized and installed and safety testing has been successfully completed. Energy model values must match the final work scope and a minimum 10 percent modeled energy savings must be calculated by the software.

This document provides a set of installation specifications for measures that are eligible for Advanced Home Upgrade projects. In addition, each upgrade must follow national, state and local laws, as well as Program specific requirements. All permits must be pulled in compliance with state and local requirements. The QA/QC vendor will confirm that the minimum requirements discussed per measure were adequately met in the field.

3. Health and Safety

Requirements

All Participating Contractors must abide by BPI, all applicable federal, state and local health and safety regulations, and Safety standards and have all the necessary personal protective equipment required by all applicable federal, state and local laws, including, but not limited to, the "Occupational Safety and Health Standards" promulgated by the U.S. Secretary of Labor and the California Division of Occupational Safety and Health.

Safety Equipment and Worker Training

1. Required safety equipment includes, but is not limited to:
 - a. Canister-type respirators
 - b. Gloves
 - c. Protective clothing or overalls
 - d. Elbow and knee pads
 - e. Safety glasses
 - f. Hard hats
 - g. First aid kit
2. Technicians and installers must be trained on the proper use and applicability of these safety devices and adhere to all OSHA regulations when performing diagnostics or work at the site.
3. All tools and machinery must be used in a safe manner and be properly maintained and/or calibrated per manufacturer's recommendations.

Safety Data Sheets and Occupant Safety

4. Contractors, installers and auditors must have in their possession all applicable SDSs for all materials brought on site. This includes but is not limited to:
 - a. Diagnostic smoke
 - b. Caulking and adhesives
 - c. Insulation and air-sealing materials
5. If there is known or suspected presence of Potential Asbestos Containing Materials (PACM), Black Organic Matter (BOM), or any other perceived or potentially hazardous materials found at the job site, all care must be taken to ensure occupant and worker safety. All applicable codes, ordinances, and guidelines must be followed.

Hazard Removal

Training and certification in the identification, removal, disposal, abatement and remediation of hazardous materials is outside of the scope of the Program. If any hazardous materials are encountered during a project, only those Participating Contractors that have the necessary training and required license(s) and certification(s) may remove, dispose, abate and/or remediate hazardous materials discovered on a job site. Participating Contractors shall be solely responsible for identification, removal, disposal, abatement and/or remediation of hazardous materials encountered on a job site. Neither RHA, SDG&E nor SoCalGas® shall have any liability arising out of, resulting from or regarding a Participating Contractor's detection, identification, inspection, removal, disposal, abatement, and/or remediation of hazardous material.

4. Permit Requirements

When installing upgrade measures, if a permit is required by the local jurisdiction, one shall be obtained and final inspection shall be passed, before the job can be completed. The Program requires a finalized building permit.

5. Shell Air Sealing

Per BPI, an effective and continuous thermal and pressure boundary shall be established in each home through the installation of appropriate air sealing and insulation measures. Wherever possible, air sealing and insulation strategies shall be designed to align the thermal and pressure boundaries to create a single continuous thermal envelope.

Air sealing strategies shall be determined based on visual inspection of critical by-pass areas, and indoor air quality evaluations for each home and blower door testing (optional).

5.1 General Requirements

1. Completed work must result in measurable air infiltration reduction and meet program minimum requirements for building air leakage reduction and/or target Specific Leakage Area (SLA). See Program Specifications.

5.2 Material Standards

1. Use materials that meet nationally-recognized standards (UL, ASTM, ANSI, etc.), when applicable.
2. Air sealing installations must be installed to be permanent improvements to the structure. Products with an expected lifespan of less than 20 years shall not be used.
3. Material quality must be adequate to last for the expected life of the measure.
4. Foam Products
 - a. Foam board installed in the living space must be covered in conformance with local code.
 - b. Foam sealant may be used indoors to seal gaps in penetrations (e.g., plumbing and electrical), subject to the following limitations:
 - c. Gap size and installation must be in conformance with foam manufacturer's instructions and local code.
 - d. Fire-resistant foam (e.g., orange or red) must be used to seal penetrations in common walls/floors/ceilings between adjacent residences (e.g., multi-unit dwelling).
5. Insulation Use in Air Sealing
 - a. Where leakage paths are identified that cannot be accessed or reasonably sealed using conventional air sealing techniques, high density cellulose or foam insulation shall be installed strategically to reduce airflow through the building shell.

Measure Feasibility

For [All Shell Air Sealing](#), this measure may not be feasible if:

- CAS/CAZ issue(s) cannot be resolved
- Envelope is below the Minimum Building Airflow and mechanical ventilation cannot be installed.
- Dwelling unit is so loose that air sealing is impractical (e.g., envelope is damaged or deteriorated, home is being remodeled and interior work is incomplete, etc.).
- Crawlspace or attic contains hazardous, unsafe, or unsanitary conditions.
- Required lead-safe practices (pre-1978 building) cannot be performed.
- Attic/crawlspace does not have adequate clearance.

- b. If cellulose insulation is to be used as an air barrier in an enclosed cavity, it must be installed at a minimum density of 3.5 pounds per cubic foot or per manufacturer's instructions.
 - c. Fiberglass insulation is not an air barrier and may never be used as an air sealing material.
6. Caulking
- a. Apply/tool sealant properly to fill the joint completely and be free of voids.
 - b. Gaps 3/8" to 5/8": Install filler material (e.g., polyethylene backer rod, fiberglass, rope caulk) so it is covered by at least 1/8" of caulk.
 - c. Gaps >5/8": Patch with appropriate ASTM approved materials.
 - d. Butt Joints: Use bond breaker tape as needed to prevent sealant adhesion to the bottom.
 - e. Dissimilar materials (e.g., brick and drywall): Seal with elastomeric caulk (polyurethane, silicone, etc.).
7. Weather-stripping
- a. Rigid gasket: Solid extruded aluminum carrier with durable gasket (e.g., vinyl, thermoplastic elastomer (TPE), silicone, or equivalent).
 - b. Foam tape: UV-resistant closed-cell in locations subject to sunlight and weather.
 - c. Replacement pile and bulb: Durable material properly sized for the retaining channel.
 - d. Warranty: Minimum 3 years.

5.3 Installation Standards

1. Whole house air sealing to reduce air infiltration shall be done in accordance with Building Performance Institute (BPI) Standards:¹
 - a. Perform CAS testing before building air sealing.
 - b. Perform duct testing and duct sealing before building air sealing.
 - c. All top plane sealing shall be performed before insulation installation.
 - d. Air sealing measures shall be prioritized to reduce the stack effect and inhibit moisture migration into attics or other interstitial spaces.
2. Whole house air sealing to reduce air infiltration shall be done in accordance with the program standards. ASHRAE Standard 62.2². If the measured CFM₅₀ is less than 70% of the Building Airflow Standard as set forth in ASHRAE 62-89, mechanical ventilation must be installed according to the standards.³

¹ Building Performance Institute, ANSI/BPI-1200-S-2015 Standard Practice for Basic Analysis of Buildings, www.bpi.org/standards_approved.aspx

² American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., *Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings*, ANSI/ASHRAE Standard 62.2-2016, www.ashrae.org.

³ American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., *Ventilation for Acceptable Indoor Air Quality*, ANSI/ASHRAE Standard 62-1989, www.ashrae.org.

3. When a mechanical ventilation system is installed in a building where combustion appliances are present, a complete post-installation combustion safety diagnostic test must be conducted and final conditions must meet minimum safety requirements for spillage, ambient carbon monoxide and undiluted carbon monoxide.
4. A blower door test and Combustion Appliance Safety (CAS) test must be performed before and after the installation of air sealing (each day if necessary) to ensure safety.
5. Blower door quick tests should be performed during air sealing to track progress and verify results.
6. Air sealing priority:
 - a. Catastrophic leaks
 - b. High-level leaks:
 - Attic bypasses.
 - Top plates and drop soffits.
 - Exhaust fans and shower inserts.
 - c. Mid-level leaks:
 - Plumbing penetrations.
 - Electrical penetrations
 - d. Low-level leaks:
 - Bypasses in the floor and baseboard area
 - Bypasses between the living space and attached garage
 - Appliance enclosures obtaining combustion air from outdoors
7. Air seal communication between the attic and living space first. Areas to seal include but, are not limited to: by-passes around chimneys, ducts, drop soffits, shower inserts or other large penetrations; interior and exterior wall top-plates; and plumbing and wiring penetrations.
8. Attic ventilation shall not be recommended or installed without first verifying the presence of an effective air barrier and thermal barrier between the attic and the living space or specifying appropriate attic air sealing as part of the work scope.
9. Seal off leakage paths through interstitial building cavities using manual air sealing, high density cellulose cavity insulation (see below), or spray-foam products.
10. Garage to living space connections must be tested for air tightness using a smoke stick or, pressure differential measurements in conjunction with the blower door. Air leaks between the garage and living space must be sealed as part of the work scope.
11. Leakage paths identified between attached or tuck-under garages and the living space must always be sealed.
12. If the house CFM50 is still higher than the Building Airflow Standard after sealing the attic, garage, and basement, interior air-sealing may be performed as needed including: sealing around plumbing penetrations, caulking around window and door casings, caulking around molding and baseboards, or other significant leakage areas identified using the blower door.

13. Attic and Crawlspace Accessibility

a. Attic Clearance

- Clearance should be at least 24" from the top of the ceiling joists to the bottom of the roof rafters at the highest point.
- Any obstruction in the attic, such as cross members of truss systems and ductwork, should provide an opening with a minimum dimension of 18".

b. Under-floor crawlspace clearance

- Clearance should be at least 18" from the ground to the bottom of the floor joist system.
- Any obstruction in the crawl area, such as an HVAC duct, should provide a minimum clearance of 12", to crawl over or under it.

14. Ceiling penetrations within the attic

a. Caulk

- Use high temperature caulk:
 - Near heat producing devices.
 - When sealing recessed lighting at sheet rock.
 - Do not block holes or ventilation openings in recessed light canisters or other heat producing devices.

b. Chimneys and vent pipes

- Seal/block attic penetrations by masonry chimneys with non-combustible barrier (e.g., steel or aluminum sheeting) and sealant (high temperature caulk at the chimney).
- Do not seal:
 - Ventilated thimbles and collars, or fire stop for wall furnace vent pipe inside the wall.
 - Non-conforming single wall vent pipes.

c. Wall openings (No Top Plate)

- Block cavity openings with filler board (e.g., foam board, duct board, foil/bubble radiant barrier).
- Mechanically secure filler board, and seal with elastomeric caulk or foam sealant.

15. Crawlspace bypasses

a. Bathtub Holes

- Block floor opening under the bathtub (e.g., with foil/bubble radiant barrier, foam board, duct board).
- Mechanically attach to the floor, and seal (e.g., with elastomeric caulk or foam sealant).

b. Other plumbing penetrations and floor bypasses

- Seal with elastomeric caulk, foam, or other code-compliant material

16. Ceiling bypass at the furnace vent pipe
 - a. Install a one- or two-piece metal collar (do not cover a vented thimble or support system).
 - b. Mechanically secure and seal the collar against ceiling (use high temperature caulk within 6" of the vent pipe).
17. Fireplace chimney dampers
 - a. Factory-built ("Zero Clearance") fireplaces
 - Repair or replace as feasible malfunctioning dampers with listed parts specified by the manufacturer.
 - b. Masonry fireplaces
 - Repair malfunctioning damper, if feasible, or install a retrofit (e.g., chimney-top) damper.
 - Use only commercially-available damper properly sized to fit the chimney termination.
 - c. Install in accordance with its listing, manufacturer's instructions, and local code regarding permanent free opening (see current CMC).
18. Weather-stripping door openings
 - a. Weather-strip walk-through door and all air leaks between attached or tuck-under garage and living space.
 - b. Make each leg of rigid gasket weather-stripping one continuous piece.
 - c. Trim the gasket on each end to provide an effective air barrier where it meets another leg or the threshold.
 - d. Remove metal burrs and sharp edges on metal components.
 - e. Use shoe and saddle-threshold combination when possible.
 - f. Use stationary or auto sweep only when no other treatment is feasible.
 - g. Do not allow shoe or sweep to drag on the floor.
19. Thresholds
 - a. One-piece full length, with floor sealer on the bottom.
 - b. Cut ends to match contour of the jamb.
 - c. Risers: Factory made, compatible with threshold; use only when no other treatment is feasible.
 - d. Do not exceed 1" height above finished floor (1/2" if any occupant is physically handicapped and uses a wheelchair).
20. Open combustion forced-air furnace closet doors
 - a. Seal closet door with any appropriate weather-stripping material.
 - b. Furnace closet door must have a latch
21. Attic and crawlspace access doors/covers

- a. Weather-strip opening with open or closed cell foam.
 - b. Doors with Fire Rating Greater than 20 Minutes:
 - Do not install standard weather-stripping.
 - Materials must be UL classified fire-rated (e.g., with adhesive backing, per UL 10B/10C and/or NFPA 80).
 - Material and installation must meet specifications and listing requirements of the door and jamb manufacturer.
 - Do not install screws in the door or jamb, unless approved by the manufacturer.
22. Plumbing penetrations
- a. Patch with commercially-available plumbing patches and pipe collars, or field-fabricated metal collars, and caulk gaps 1/16" or larger between patch and pipe.
23. Interior wall patching:
- a. Use factory-made mesh patches or field-fabricated drywall plugs.
 - b. Cover interior wall patches with spackling compound, drywall joint compound, etc.
 - c. Finish patches to match surrounding surfaces, and seal with primer or paint.
24. Exterior wall patching:
- a. Use sealants and patching materials rated for exterior use.
25. Fireplace Glass Doors
- a. General requirements for glass door unit installation
 - All fireplaces: must be installed per manufacturer's instructions.
 - Standard fireplace: must seal against the fireplace surround.
 - Factory-Built ("Zero Clearance") fireplace: must be compatible with fireplace listing.
 - b. Masonry fireplaces
 - The glass door unit must be designed and sized to properly fit the firebox opening and the surface of the surround (smooth or textured).
 - Mechanically secure the top of the door unit to the lintel bar (e.g., with a lintel clamp), and attach the bottom to the firebox floor (e.g., with screws secured in lead anchors).
 - Install the door unit against the surround so insulation or a gasket applied to the back creates a tight seal.

5.4 Additional Health & Safety Considerations

1. Attic and crawlspace area must be free of the following conditions:
 - a. Hazardous insect/rodent infestation.
 - b. Hazardous electrical condition.
 - c. Unsafe structural members.

- d. Excessive ground moisture (standing water or mud).
- e. An unsanitary condition is present, such as:
 - f. Sewage waste on the ground.
 - g. Excessive animal feces or any other unsanitary condition present.
2. Do not access or work in an area that is unsafe.
3. All federal, state, local and program specific health and safety regulations should be followed.
4. Lead-safe practices shall be employed when working with pre-1978 painted materials per state codes T8 Section 1532.1 and T17 Section 36000, et seq.
5. Asbestos Caution: When ductwork may contain or is made of asbestos containing material (ACM), pressure diagnostics (duct testing and blower door testing) are unsafe and unfeasible.

6. Attic Insulation

6.1 General Requirements

1. Must meet program requirements for minimum thermal resistance or greater if required by local code (see Program Specifications).

6.2 Material Standards

1. Materials shall be new, comply with, and be installed in conformance with:
 - a. Applicable building and fire codes⁴
 - b. California insulation quality standards listed in the *Directory of Certified Insulation Materials*.⁵
 - c. Surface burning characteristics of exposed facings:⁶
 - maximum flame spread of 25
 - smoke developed rating of 450.
2. Mineral Fiber
 - a. Flexible (batts/blankets): Conformance to ASTM C665.
 - b. Loose Fill: Conformance to ASTM C764.
3. Cellulose
 - a. Licensed for sale in CA
 - b. in compliance with CPSC 16 CFR, Parts 1209 and 1404
 - c. Conformance to ASTM C739.
4. Polyisocyanurate board
 - a. foil faced on both sides
 - Conformance to FS HH-1-1972.
5. Extruded Polystyrene (e.g., OC Pink Board and Dow Blue Board)
 - a. Conformance to quality standards such as ASTM C578 and/or CAN/ULC-S701).
6. Spray Polyurethane Foam (SPF)

Measure Feasibility

Attic Insulation may not be feasible if:

- An uncorrectable CAS hazard present in the attic.
- Knob-and-tube (K&T) wiring is present:
 - Functioning but can't be certified safe by a C-10.
 - Abandoned but not disconnected and certified as abandoned by a C-10.
 - Insulation over K&T wiring is prohibited by local code.
- The structure is unsound and will not support the weight of the insulation and installer.
- Attic accessibility is inadequate, due to conditions such as:
 - Inspector cannot gain safe access to all treated areas of the attic after insulation is installed.
 - Attic crawl area clearance is inadequate, or an unsafe condition exists, per section 4.3.
- A roof leak is present.
- Adequate attic venting cannot be installed.
- Disconnected or damaged space heating/cooling ducts cannot be repaired.
- Asbestos containing materials are present, including the following:
 - Friable ACM in any location
 - Popcorn ceilings
 - In or on air ducts
 - Appliance vent pipe (e.g., transite pipe)
 - Vermiculite which has been lab tested and shown to contain ACM

⁴ Current California Building Standards Commission, *California Building Standards Code: California Code of Regulations Title 24*

⁵ *CCR, Title 24, Part 12, Chapter 12-13, Standards for Insulating Material*, and current CA Department of Consumer Affairs, *Directory of Certified Insulation Materials*.

⁶ Insulation facings that do not touch a ceiling, wall, or floor surface, and faced batts on the undersides of roofs with an air space between the ceiling and facing, are considered exposed applications, per current California Building Standards Commission, *California Building Standards Code: California Code of Regulations Title 24*

- a. Low Density Open-Cell SPF Insulation: A spray applied polyurethane foam insulation having an open cellular structure resulting in an installed nominal density of 0.4 to 1.5 pounds per cubic foot.
 - b. Medium Density Closed-Cell SPF Insulation: A spray applied polyurethane foam insulation having a closed cellular structure resulting in an installed nominal density of greater than 1.5 to less than 2.5 pounds per cubic foot.
7. Blocking Materials
- a. Batts: Flexible mineral fiber, faced or un-faced.
 - Uses: HPDs, attic accesses, platforms, storage areas, walkways
 - b. Metal: Corrosion-resistant metal, minimum 0.007" thick.
 - Shall not be installed to block attic accesses.
 - c. Structural Wood: Framing members and attached sheathing (e.g., plywood).
 - d. Eave vent chutes and baffles: Commercially available plastic chutes and cardboard baffles, or 0.007" metal acceptable for attic ventilation.
8. Default Insulation R-values as established by BPI are shown in Table 6-1.

Table 6-1: Default Values for Insulation

Insulation Type	R-value per inch	Typical Applications
Cellulose, loose fill	3.7	Attic floor
Cellulose, high density	3.2	Walls, enclosed cavities, framing transitions
Fiberglass, batts & blankets	3.0	Basement ceilings, open stud walls, attic floor (see Table 4-3 for existing batts)
Fiberglass, loose fill	2.8	Attic floor, walls (existing)
Fiberglass, loose fill, fluffed below manufacturer's standards	Uncertain	Do not install, or correct by blowing over with higher density
Rockwool	3.0	Attic floor, walls, basement ceiling (may be loose or batts)
Vermiculite	2.7	Attic floor
Polyisocyanurate, rigid board	7.0	Foundation walls, attic access doors
Polystyrene, expanded rigid board	4.0	Foundation walls, sill plate
Polystyrene, extruded rigid board	5.0	Foundation walls, sub-slab, sill plate
Low Density Urethane, sprayed foam	3.7	Attics, walls (new construction), sill plate, band joist, framing transitions
Urethane, sprayed foam	6.0	Attics, walls (new construction), sill plate, band joist, framing transitions
Urea Formaldehyde Foam	4.0	Attics, walls (existing)

6.3 Attic Insulation – Pre-Installation Standards

1. Thoroughly inspect the interior and exterior of the home in accordance with BPI Technical Standards for the Envelope Professional to identify areas where installation of insulation may be unsafe.
2. Assess the attic, and determine feasibility of insulation installation, with attention to:
 - a. Accessibility (crawl clearances), and the presence of problems and hazardous conditions, as described in subsection 4.3.
 - b. Joist size and spacing.
 - c. Square footage to be insulated.
 - d. Existing insulation type(s), R-value(s), and improper vapor barrier orientation (vapor barrier should face toward conditioned space).
 - e. R-value(s) to be installed (including different R-values in different sections).
 - f. Insulation barrier locations and type(s) to be installed (for HPDs, attic vents, CVA vents, etc.).
 - g. Attic ventilation:
 - existing vent types, locations, and NFVA;
 - presence of obstructed/incorrect/damaged vent screens
 - need for additional vents by type, location, and NFVA required.
 - h. Electrical wiring
 - wires that are not insulated or have frayed or decayed insulation.
 - unprotected wiring connections.
 - Existing and abandon knob and tube wiring
3. Perform duct repair/sealing for ducts in the attic, in accordance with Section 3 (Duct Testing & Sealing).
4. Perform shell sealing for bypasses in the attic floor, including gaps/cracks on the house side adjacent to the attic access cover/door.
5. Attic venting: provide for adequate attic cross-ventilation and NFVA as listed below.
 - a. 1 sq. ft. of Net Free Venting Area (NFVA) required per 150 sq. ft. of ceiling area.
 - b. 1 sq. ft. to 300 sq. ft. ratio is acceptable if: (i) vapor barrier placed toward the winter warm side is present, or (ii) 50% of the venting is upper venting ($\pm 25\%$), with upper vents located at least 3' higher than low vents, and low vents are eave or soffit venting.
 - c. When NFVA is marked on the vent or is stated by the manufacturer, that value may be used.
 - d. When manufacturer's information is not available, NFVA shall be estimated in accordance with Table 6-2:

Table 6-2: Screen and Louver Reduction Factors

1/4" Screen (hardware cloth)	1/8" Mesh (wire mesh)	1/16" Mesh (insect screen)	Metal Louvers <u>or</u> Metal Louvers <u>and</u> 1/4" <u>or</u> 1/8" Mesh	Metal Louvers <u>and</u> 1/16" Mesh	Wood Louvers <u>or</u> Wood Louvers <u>and</u> 1/16" to 1/4" Mesh
0.90 (90%)	0.75 (75%)	0.50 (50%)	0.75 (75%)	0.50 (50%)	0.25 (25%)

- e. Installed vents must be screened with 1/8" or 1/4" wire mesh.
- f. Clean or replace clogged mesh and replace torn or defective mesh.
- g. Vents exposed to precipitation shall be louvered (not required for eave vents).

6. Insulation barriers and blocking - General Requirements

- a. The following must be blocked with insulation barriers:
 - Heat producing devices (HPDs)—including recessed light fixtures, fan motors, doorbell transformers, vent pipes, metal/masonry chimneys, gas and electric appliances.
 - Vents (attic and combustion air)
 - Attic accesses
 - Open-end cavities.
- b. Clearance zone
 - A cleared space free of insulation surrounding a heat producing device, vent, etc.
 - The cleared space must be at least 3" (or as specified for the protected item) but no greater than necessary to provide proper protection.
 - After insulating, the clearance zone must be free of loose fill material.
 - During and after insulation blow-in, verify that none has settled onto HPDs or vents protected by blocking.
 - 3" clearance zone required around HPDs, with non-combustible blocking that extends from the attic floor and exceeds height of loose fill by 4".
 - 24" top clearance required above HPD if covered.
 - Verify safety clearance requirements with a tape measure if needed.
- c. Metal blocking must be permanently attached to the ceiling framing with staples, nails, or screws.
- d. HPDs must have noncombustible insulation barriers.
- e. Flexible mineral fiber blocking (FG batt) shall extend 14-1/2" away from clearance zone.
- f. Metal blocking shall not be installed to block attic accesses.
- g. HPDs must have barriers made from noncombustible materials.

7. Loose fill insulation blocking
 - a. When batt or rolled insulation is being installed over loose fill insulation, blocking/barrier shall prevent loose fill from entering the clearance zone.
 - b. A barrier (blocking and/or structural wood) must extend from the attic floor to the prescribed height above installed loose fill.
8. Eave and soffit vents
 - a. Maintain a minimum 2-1/2" clearance between roof sheathing and insulation or blocking.
 - b. Install blocking (sheet metal, chute, or baffle) that is attached to bottom of rafters and extends down to the top plate but does not obstruct vent screens.
 - Chute shall be attached to bottom of rafter, not to sheathing.
 - c. Baffles and chutes attached to rafters must:
 - Rest on (begin at) the top plate and extend above the loose fill a minimum of 4" and a maximum of 12".
 - Be permanently attached to the bottom of the rafters with a minimum of two mechanical fasteners (staples) per rafter.
 - Be kept 3" away from HPDs, if blocking is non-metal.
 - d. Soffit baffle attached to sheathing:
 - Make sure this restriction leaves enough NFVA.
 - Opening at the end of the baffle may be the smallest opening in the path the air takes through this vent.
 - e. Continuous soffit vents
 - Blocking must protect all vents, individual or continuous.
9. Range hood and bath type exhaust fans
 - a. 3" clearance zone required around HPDs, with non-combustible blocking that extends from the attic floor and exceeds height of loose fill by 4".
 - b. 24" top clearance required above HPD if covered.
 - c. Exhaust system must not terminate in attic.
 - d. Vent hose/duct may be covered by insulation but not obstructed at the termination.
10. Recessed lighting fixtures - Insulation Contact (IC) type
 - a. No blocking, unless required by local code.
11. Recessed lighting fixtures—Non-IC type
 - a. Factory made enclosures shall pass both thermal and flammability tests:
 - UL1598
 - IEC 60598-1

- b. Enclosure shall be installed strictly in accordance with manufacturer's instructions, including type/temperature of bulbs to be used in the fixture.
 - c. The lamp socket in the recessed fixture shall be modified as needed to ensure that only acceptable bulbs can be installed (e.g., by retrofitting a pin-based socket).
 - d. Air seal the enclosure at all gaps, cracks, and penetrations, using appropriate materials per Home Upgrade IS Section 1 (Shell Air Sealing)
 - e. Replace with an IC rated recessed light fixture
 - f. Site-built airtight enclosure details for non-IC recessed fixtures
 - Enclosure material shall be non-combustible (e.g., metal).
 - Minimum 3" clearance between enclosure walls and any part of the fixture.
 - Minimum 24" clearance from top of fixture to enclosure lid.
 - Enclosed lid must be R-0.5 or less, with no insulation installed over it.
 - Air seal the enclosure at all gaps, cracks, and penetrations, using appropriate materials per Home Upgrade IS Section 1 (Shell Air Sealing).
 - Non-airtight fixture not inside an enclosure shall have 3" clearance to blocking that extends 4" above loose fill.
12. Recessed fluorescent light fixture
- a. Gypsum enclosure
 - No blocking, unless required by local code.
 - b. Metal enclosure
 - Protect from loose fill in accordance with manufacturer's specifications and local code.
 - c. Air seal the enclosure at all gaps, cracks, and penetrations, using appropriate materials per Home Upgrade IS Section 1 (Shell Air Sealing)—unless prohibited by manufacturer or local code.
13. Doorbell transformer (located below top of insulation)
- a. 3" clearance zone around transformer
 - b. Non-combustible blocking that extends above height of loose fill by 4".
14. Whole-House Fans: 3" clearance required for fan motor.
- a. Must meet manufacturer's specifications for attic ventilation.
15. Gas and solid fuel appliance vent pipes and metal/masonry chimneys
- a. Must terminate outdoors.
 - b. Non-combustible blocking with 3" clearance zone around HPD.
 - c. Block or remove pipes not currently in use (e.g., abandoned).
16. Furnaces and heat pumps located in attics

- a. If HVAC unit is on a platform, clearance zone must provide: (i) 12" clearance around back, sides, and top, and (ii) 24" clearance in front.
 - b. If HVAC unit is suspended or draws combustion air from the bottom: (i) Provide 12" clearance below unit, or (ii) Install flexible insulation with 6" clearance below, which extends 12" beyond unit on all sides (no exposed loose fill beneath unit).
17. Water heater located in attic
- a. Electric: 3" clearance zone required around unit.
 - b. Gas: Clearance zone around unit must provide:
 - 6" clearance around sides and back
 - 12" clearance in front.
18. Appliance closet openings
- a. Ceiling vents used for combustion air supply must be blocked.
 - b. Ceiling vents not used for combustion air: Seal the opening with 1/2" gypsum or plywood, or with 0.007" metal (not batts or foam board), and cover it with insulation.
19. Attic access blocking
- a. When unblocked loose fill is present at the access opening, block each functional/usable access.
 - b. Blocking must extend from attic floor to 4" above the loose fill.
 - c. Blocking may be achieved with 2-by joists and other wood members, or a combination of wood and mineral fiber/fiberglass batts.
 - d. A dam around the entrance may be created with plywood but not with metal barrier material.
 - e. Flexible fiberglass blocking shall be touching at all the corners, with blocking material extending outward 14-1/2" in all directions from the corners.
20. Folding attic access stairs/ladders: Block same as for attic access cover.
21. Open-end cavities: Install blocking (metal, manufactured pre-cut cardboard chute/barrier material, or flexible insulation) to prevent loose fill from spilling out the open end of the joist cavity.
22. Balloon framing: Install blocking to prevent loose fill from falling down open wall cavities and into crawl space or basement.
23. Attic access door/cover insulation:
- a. Permanently attach rigid or flexible insulation to each attic entry door/cover accessed from conditioned space (whether functional/sealable or not), in accordance with Table 4-2. Insulation must be in complete contact with the door/cover.
 - b. Rigid insulation may be attached with heavy duty construction adhesive.
 - c. Faced flexible insulation shall be stapled to the cover, and
 - Covered by FSK or comparable material that is stapled along the edges to the lid, or

- Secured with netting or at least two (parallel or perpendicular) strands of wire/twine that is securely stapled or otherwise attached to the lid.
- d. Attic access door/cover weather-stripping:
- Weather-strip only functioning attic entry doors/covers accessed from conditioned space.
 - Horizontal access doors/covers:
 - With mounting surface free of dust, dirt, and debris, apply open cell foam (closed cell foam and flanged bulb acceptable, if not too thick).
 - Weather-stripping material should not create more than a 3/16" gap between door and retaining surface.
 - Visible material should blend with paint color (i.e., light-colored gasket with light-colored ceiling/lid/trim).
 - Vertical Access Doors: Use materials approved for entry doors (see Home Upgrade IS Section 1).
24. Folding attic access stairs/ladders: When accessed from conditioned space:
- a. Install a hinged lid, if not already present.
 - b. Use minimum 1/2" plywood and metal hinges.
 - c. Insulate same as for attic access cover.
 - d. Weather-strip same as for attic access cover.
25. Powered attic fans: Must have adequate inlet ventilation in accordance with manufacturer's specifications.
26. Electrical wiring:
- a. Do not install insulation over energized wires that are not insulated or have frayed or deteriorated insulation.
 - b. Do not install loose fill over unprotected wiring connections.
 - *Open junction boxes*: Cover boxes with standard cover plate.
 - *Wire Splices*: All splices must be inside a junction box.
 - *Boxes with wire connections protruding*: Install a box extension and standard cover plate.
 - *Spider web of wires without a junction box*: Protect wiring with mineral fiber blocking which exceeds height of loose fill by 4" and extends away at least 14-1/2" in all directions.
 - c. Knob-and-Tube Wiring:
 - Do not install insulation which encapsulates knob-and-tube wiring when prohibited by local code. Whenever possible, upgrade wiring to current standards before insulating.
 - Do not install insulation in an attic with knob-and-tube wiring unless the wiring has been surveyed by a C-10 electrical contractor and certified to be:

- Live and acceptable for encapsulation, or
- Abandoned and disconnected.
- The C-10 contractor must:
 - Survey all knob-and-tube wiring located in all areas to be insulated
 - Complete a "Notice of Survey by Electrical Contractor" (see page 71), a copy of which is provided to the local jurisdiction and the property owner.
- Post a "Warning Placard" inside the attic near each operable entrance, in a location where it will be observed by persons entering the attic (see below), stating that caution is required when entering insulated areas because of covered electrical wiring,
- Post a copy of the completed "Notice of Survey by Electrical Contractor" (see Inspection Guidelines) at the primary entrance near the "Warning Placard"
- Knob-and-tube wiring must comply with all provisions of the current California Electrical Code (CEC), Article 394 (Concealed Knob-and-Tube Wiring).
- Live Knob-and-Tube wiring
 - Do not install insulation which encapsulates live knob-and-tube wiring when the wiring is found to be in poor condition and will not be upgraded to be acceptable for encapsulation.
 - Installation of new overcurrent protection
 - The devices must be a tamperproof type (e.g., Type "S" fuses or circuit breakers).
 - Prior to installation of such devices, the occupant must sign a statement in the "Notice of Survey by Electrical Contractor" acknowledging that he/she understands that existing usage of electrical appliances may cause nuisance tripping of the new overcurrent protection devices.
 - Install only insulation that is non-combustible., in accordance with current CBC.
 - Install only barriers and supports that are non-combustible and do not contain any electrically-conductive material.
- Abandoned and disconnected Knob-and-Tube wiring
 - Do not install ceiling insulation that encapsulates knob-and-tube wiring, unless the "Notice of Survey by Electrical Contractor" specifies that all knob-and-tube wiring located in all areas to be insulated is not live and has been abandoned and disconnected.
 - The electrical contractor, by severing wires in the attic or by other means, shall ensure that all abandoned and disconnected wiring cannot be energized by reconnecting abandoned feeder conductors to a service panel or other power source.

6.4 Attic Insulation – Installation Standards

1. A permit shall be obtained when required by the local jurisdiction.

2. Insulation should be installed between conditioned living area and unconditioned non-living area.
3. Insulation installed in unconditioned areas of interior walls, garages, porches, or other areas do not qualify.
4. Install insulation in accordance with:
 - a. Insulation manufacturer's recommendations, and
 - b. BPI Standards⁷, and
 - c. California Quality Insulation Installation Standards (QII), as specified in current Title 24 Building Energy Efficiency Standards Reference Appendices.⁸
5. To verify insulation depth, evenly distribute attic rulers appropriate to the material—scaled to read inches of insulation and the R-value installed. Install one ruler for every 250 square feet that is clearly readable from the attic access in all directions.
6. Effective R-values for imperfect existing fiberglass batt Insulation shall be based on the table in the Appendix B. These values should be entered into the energy modeling software per Program guidelines.
7. Vapor barrier
 - a. Vapor barrier criteria apply to flexible mineral fiber batts/blankets installed directly onto the attic floor, knee wall, or skylight well.
 - b. When installed, vapor barrier must be rated no higher than 1 perm (water vapor transmission) and placed toward winter warm side (e.g., directly on attic floor).
 - c. When existing batts are incorrectly installed with vapor barrier on top:
 - Remove vapor barrier from attic, or
 - Turn over batts to place facing against attic floor, or
 - Slash the vapor barrier the entire length of batt or across the width of the batt at 12" intervals.
 - d. Un-faced and faced batt insulation may *rest on top* of other insulation, with vapor barrier facing either up or down.
8. Loose fill insulation
 - a. Blow insulation to a uniform thickness throughout the attic at appropriate air pressure and material quantity (depth and/or weight) to ensure complete coverage and manufacturer's recommended density to achieve the prescribed R-value without voids, gaps, or settling in enclosed cavities. Install insulation all the way to the outer edge of the wall's top plate.
 - b. Provide a signed attic card that states:
 - insulation type,

⁷ Building Performance Institute ANSI/BPI-1200-S-2015 Standard Practice for Basic Analysis of Buildings

⁸ Current California Energy Commission *Reference Appendices for the Building Energy Efficiency Standards for Residential and Nonresidential Buildings*

- installed thickness and settled thickness,
 - R-value installed,
 - coverage area (sq. ft.),
 - number of bags specified by manufacturer, and
 - number of bags actually installed.
- c. Install insulation underneath and on both sides of obstructions, such as cross-bracing, strong backs, wiring, and framing.
- d. If a platform or catwalk is present, insulate underneath, do not install insulation on top of a platform.
- e. Ensure HPDs and vent screens are free of insulation.
9. Knee walls - R-value and protection
- a. Insulate to at least R-13 for 2 x 4 framed walls or R-19 for 2 x 6 framed walls.
- b. Insulation (other than rigid foam) installed in knee walls or other exposed vertical areas within an attic:
- Cover the cold side with an air barrier such as 1/2-inch plywood, 5/8-inch drywall, FSK, or other air-sealing, fire-proof material, to protect the insulation from wind-washing and prevent convection within the insulation.
 - Observe local code regarding any requirement for fireproofing of vertical surfaces on the attic side.
10. Knee walls—Batt Insulation
- a. Top and bottom of cavity
- Top and bottom plates or blockers of rigid material must be in place.
 - Air seals all joints, cracks, and penetrations in each joist cavity before insulating.
- b. Insulation
- Adjust existing batted material to ensure full contact with all sides.
 - Install new batts where none exists.
 - Secure batts in place with wire, nylon cord, netting, etc.
 - Vapor barrier placed toward conditioned space.
11. Knee walls—Dense pack insulation
- a. Top and bottom of cavity
- Top and bottom plates or blockers of rigid material must be in place.
 - Air seals all joints, cracks, and penetrations in each joist cavity before insulating.
- b. If fabric material is used, it must be secured with 1" crown staples every 2", or furring strips every wall stud.

- c. Insulation blown behind fabric or air barrier material must have a minimum density (in pounds per cubic foot) of:
 - Cellulose: 3.5
 - Fiberglass: 2.2
12. Knee walls – Rigid insulation
 - a. Must cover the entire surface of the accessible knee wall area.
 - b. Must be listed for uncovered use in an attic, or
 - c. Covered with an ignition barrier or thermal barrier.
13. Appliance enclosure: Insulate walls of interior closets for open combustion HVAC and/or water heating equipment to the same R-value as the exterior walls.
14. Enclosed cavities (a portion of the attic that is sealed on all sides or the space between floors): Insulation is not installed inside the cavity.
15. Spray foam insulation
 - a. Installation of spray foam insulation will be considered on a case-by-case basis, and must be approved in advance.
 - b. Spray foam insulation (SPF) increases thermal performance and reduces air infiltration significantly.
 - c. Install in accordance with the Title 24 Building Energy Efficiency Standards, Joint Appendix.
 - d. Allow house to air out a minimum of 24 hours after spray foam installation before occupying.
 - e. Ceiling and roof insulation:
 - Spray-apply SPF insulation to fully adhere to the substrate (roof deck or ceiling), the joists, and other framing faces to form a complete air seal around wiring and plumbing and within the construction cavity.
 - f. Recessed light fixtures
 - Do not apply SPF insulation directly to recessed lighting fixtures.
 - Fixtures must be either insulated by methods other than SPF (such as mineral fiber) or enclosed in a box fabricated from ½-inch plywood, 18-gauge sheet metal, 1/4-inch hard board, or 5/8-inch drywall. The exterior of the box may then be insulated with SPF.
 - If the fixtures are not airtight or not rated for insulation contact (IC), the fixtures shall either be replaced or eliminated.
 - g. HVAC platform
 - Install a minimum of 3 inches of SPF insulation below any plywood platform or catwalk installed for HVAC equipment in vented attics. Ensure that the overall assembly meets the required insulation values listed in the compliance documentation.
 - Install SPF insulation in a continuous and fully-adhered manner, to form an air barrier.
 - h. Attic access:

- Insulate hatch to match R-value of surrounding insulation.
- i. Attics and cathedral ceilings
 - Prior to installation, verify that the building official in your area permits SPF insulation directly applied to the underside of the roof.
 - Do not apply SPF insulation closer to a combustion appliance vent pipe than allowed by pipe manufacturer's installation instructions or clearance specified on the pipe label.
 - In unvented conditioned attics, where entry is made for the service of utilities, SPF applied in direct contact with the underside of the roof deck must be protected from ignition in accordance with Title 24 Building Energy Efficiency Standards, Joint Appendix.
 - In cathedral ceilings where restricted spaces do not allow entry, SPF insulation does not require protection from ignition.

6.5 Additional Health & Safety Considerations

1. Do not cut mineral fiber batts for blocking/baffling purposes inside the living space.
2. Do not work in an attic when:
 - a. Functional Knob-and-Tube wiring is energized and has not been certified safe by an electrical contractor.
 - b. Uncorrected bare wires or other electrical hazards are present.
 - c. Attic temperature is excessive.
 - d. Accessibility is inadequate, or a hazardous condition exists, as described below.
3. Accessibility (crawl clearances) must be as follows:
 - a. An inspector must be able to gain safe physical access to all treated areas of the attic after insulation is installed.
 - b. Clearance between top of ceiling joists and bottom of ridge board should be at least 24" at highest point.
 - c. Structural obstructions, such as cross members of truss systems, should provide an opening of at least 18".
 - d. When access requires crawling over/under HVAC ducts, clearance should be at least 18".
4. The attic must be free of hazardous conditions and materials, such as the following:
 - a. Electrical hazards associated with knob-and-tube wiring and recessed light fixtures.
 - b. Structurally unsound building elements (e.g., substandard ceiling joists and/or sheathing, suspended acoustical tile ceilings, wood paneling).
 - c. Hazardous pest infestation.
 - d. Areas where moisture is present or suspected (e.g., roof leaks).
5. Protect the installation crews by providing safety gear (dust masks, respirators and protective clothing), ample light, and fresh air to the space in which they are working.
6. All federal, state, local and program specific health and safety regulations should be followed.

7. Lead-safe practices shall be employed when working with pre-1978 painted materials per state codes T8 Section 1532.1 and T17 Section 36000, et seq.
8. Asbestos Caution: When ductwork contains PACM or is made of asbestos containing material (ACM), pressure diagnostics (duct testing and blower door testing) are unsafe and unfeasible.

7. Cool Roofs and Radiant Barriers

7.1 General Requirements

1. For both cool roofs and radiant barriers, installation shall be in conformance with:
 - a. Current CEC Building Energy Efficiency Standards.
 - b. Current Title 24 Residential Compliance Manual.
 - c. Program requirements (see Program Specifications).
2. Roofing materials must be rated by the Cool Roof Rating Council. See www.coolroofs.org.
3. Specify roofing materials with a minimum 30-year warranty.

Measure Feasibility

This measure may not be feasible if:

- Home does not have a central air conditioning system. (*Note:* Installing central air conditioning where none exists will result in an energy penalty.)

7.2 Installation Standards – Cool Roofs

1. Install all materials per manufacturer's instructions.
2. Installation must be water-tight and securely attached to underlying structure.

7.3 Installation Standards – Radiant Barriers

1. Install radiant barrier per manufacturer's instructions and safety precautions and in conformance with local building and fire codes.
2. Radiant barriers can be installed between the roof sheathing and attic floor insulation, in cavity walls, and around door openings, water heaters, and pipes.
3. When installing a foil-type barrier, allow the material to "droop" between the attachment points to make at least a 1.0-inch (2.5 cm) air space between it and the bottom of the roof.
4. Do not install radiant barrier on top of attic floor insulation. This method is susceptible to dust accumulation and may trap moisture in fiber insulation during cold weather.

7.4 Additional Health & Safety Considerations

1. All federal, state, local and program specific health and safety regulations should be followed.
2. Lead-safe practices shall be employed when working with pre-1978 painted materials per state codes T8 Section 1532.1 and T17 Section 36000, et seq.

8. Wall Insulation

8.1 General Requirements

1. Must meet state code, local code and program requirements for thermal resistance (see Program Specifications).

8.2 Material Standards

1. Mineral Fiber
 - a. Flexible: Conformance to ASTM C665.
 - b. High Density Fiberglass Board: Conformance to ASTM C726.
 - c. Loose Fill: Conformance to ASTM C764.
2. Cellulose: Licensed for sale in California and in compliance with CPSC 16 CFR, Parts 1209 and 1404, and ASTM C739.
3. Rigid Foam—Preformed Foil Faced Polyisocyanurate Board: Conformance to FS HH-I-1972/1.

8.3 Installation Standards - General

1. Insulation certificate shall be completed following installation, and the certificate shall be posted at the electrical panel when indoors; otherwise in the garage.

8.4 Installation Standards - Open Wall Cavities

1. Install installation in conformance with:
 - a. DOE Standard Work Specifications (SWS) for wall insulation, Sec. 4, §4.1101.1 – 4.1102.3 9, and
 - b. Guidelines in the current 2016 Title 24 Building Energy Efficiency Standards, Residential Appendices, §RA3.5.¹⁰
2. Install insulation to full-stud thickness regardless of material used, and uniformly fill the cavity side-to-side, top-to-bottom, and front-to-back, with no gaps or voids around wires, boxes, or obstructions.
3. Insulation should cover at least 90% of total uninsulated accessible (after deducting windows, doors, and unfeasible sections) areas for Advanced Home Upgrade projects.
4. Where accessible, caulk/foam wall stud cavities to provide a substantially airtight envelope to the outdoors, attic, garage, and crawl space.

Measure Feasibility

This measure may not be feasible if:

Entire Home

- Walls contain Knob-and Tube Wiring which cannot be certified safe.
- Homeowner refuses lead-safe work practices.
- It has been verified that lead is present.

Section of Wall

- Wall is between two conditioned or two unconditioned spaces.
- Cavity is insulated or partially insulated.
- Cavity contains any of the following:
 - Gas wall furnace.
 - Electric wall heater or other HPD without full dimensional blocking and 3" clearance or sealed protective pan.
 - Exhaust fan housing that is not a sealed unit.
 - Recessed light fixture without a solid barrier and 3" clearance zone.
 - Metal chimney without a solid barrier and 3" clearance zone.

⁹ DOE SWS is available at https://sws.nrel.gov/sites/default/files/sws_singlefamily_0.pdf

¹⁰ Current California Energy Commission *Reference Appendices for the Building Energy Efficiency Standards for Residential and Nonresidential Buildings*

- a. Pay special attention to plumbing and wiring penetrations through top plates, electrical boxes that penetrate sheathing, and sheathing seal to the bottom plate.
 - b. Caulk all gaps in the air barrier greater than 1/8 inch, or seal with expansive or minimally expansive foam.
5. Batt insulation
- a. Carefully check for all conditions that make wall insulation unfeasible for the entire home or a wall section (see measure feasibility sidebar).
 - b. Insulation should be fitted and cut around pipes, wires, etc. traversing the bay. Split the batt so equal amounts of insulation are behind and in front of those items. Ideally, nothing is visible after insulation is installed except for the insulation product itself.
 - c. Friction fit batts into the cavities, unless another support method is used.
 - d. Fill nonstandard-width cavities with insulation fitted into the space without excessive compression or gaps.
 - e. Vapor barrier on flexible and rigid mineral fiber, when installed, must have a maximum perm rating of one and be placed on the winter warm side.
 - f. Insulate small cavities around windows (except those containing sash weights) and doors with insulation cut to fit snugly without compression.
 - g. Do not isolate pipes from the heated side:
 - In locations without freezing temperatures, pipes may be surrounded with insulation.
 - In locations with freezing temperatures, place insulation between pipes and cold side.
 - Locations with freezing temperatures are those with winter design temperature listed at or below 32°F in the California Energy Commission Residential Manual, or per ASHRAE.
6. Loose-fill insulation
- a. Fiberglass and cellulose loose-fill insulation can be installed behind netting, which is stapled to the fronts of studs. Netting may not be required when moisture is added to cellulose or adhesives are added to fiberglass.
 - b. CAUTION: Moisture levels in insulation must be carefully monitored before installing sheet goods. If the walls are closed-up too soon, moisture could affect interior of walls and cause durability issues.
 - c. Loose-fill wall insulation shall be installed to fit around wiring, plumbing, and other obstructions.

Measure Feasibility (cont'd)

This measure may not be feasible if:

- Wall cavity is:
 - Used as or contains an HVAC duct.
 - Open to a soffit with a recessed light fixture that cannot be properly blocked.
 - Adjacent to a masonry fireplace or chimney with less than 3" clearance between cellulose and masonry.
 - Connected to an unprotected pocket door cavity.
 - Open on the interior (e.g., incomplete sheathing inside cabinet, under sink, etc.).
- Defects prevent safe installation of wall insulation, such as:
 - Interior or exterior repair is needed.
 - Water leak or evidence of leakage.
 - Substandard interior or exterior sheathing.
- Section is solid masonry, concrete, or adobe.

- d. The installer must certify on the Installation Certificate forms that the manufacturer's minimum weight per-square-foot requirement has been met.
7. Spray foam insulation (SPF)
 - a. Spray foam insulation may be used in walls to decrease air infiltration and add thermal performance to the wall assembly. Install in accordance with Building Energy Efficiency Standards, Joint Appendices and the DOE Standard Work Specifications.
 - Allow house to air out a minimum of 24 hours before occupying.
 - b. Install SPF insulation to provide an air-tight envelope to the outdoors, attic, garage, and crawl space. Pay special attention to plumbing and wiring penetrations through the top plates, electrical boxes that penetrate the sheathing, and the sheathing seal to the bottom plate.
 - c. Install SPF insulation uniformly cover the cavity side-to-side and top-to-bottom. An air space may be left between the surface of the Medium-Density SPF insulation and the interior sheathing/drywall, provided the appropriate thickness of SPF insulation has been applied to achieve the specified R-value and the SPF insulation is installed to cover and form an air barrier on the framing at the top, bottom and sides of each cavity.
 - d. Narrow spaces (2" or less):
 - At windows and door jambs, fill with minimally-expansive foam.
 - Between studs at the building corners and at the intersections of partition walls, fill with batt insulation snugly fitted into the space (without excessive compression), loose-fill insulation, or expansive or minimally-expansive foam.
 - e. Spray-apply SPF insulation to fully:
 - Adhere and seal around wiring and plumbing, and
 - Seal between the sheathing and the rear of electrical boxes and phone boxes.
 - f. In cold climates, where water pipes may freeze (Climate Zones 14 and 16):
 - Apply at least two thirds of the insulation between the water pipe and the outside—or as much as possible, when pipe is near the outside.
 - Do not spray insulation between the pipe and the interior wall (minimal amounts of SPF overspray are acceptable).

8.5 Installation Standards - Closed Wall Cavities

1. Wall Cavity Pressure-Fill
 - a. Drilling Restrictions
 - Use a drill stop which prevents the bit from penetrating beyond the inside surface of the exterior sheathing, when drilling cavities containing service entrance, meter base, and/or distribution panel.
 - Do not drill through the following materials:
 - Asbestos shingles and siding; metal and vinyl siding; brick, stone, or adobe.

- Exposed surfaces of wood shingles—although it is acceptable to remove the outermost shingle, drill and patch the weather-protected surface below, and reinstall or replace the outer shingle.
 - Shutters, facing, or trim.
- b. Balloon-framed walls
- Walls without bottom or top plates: Block cavities at both top and bottom (bottom permanently secured) prior to injecting insulation by nozzle or fill tube.
 - Walls with bottom plate only: Block cavities at the top prior to injecting insulation.
- c. Walls open to suspended ceilings
- Walls below suspended ceiling:
 - Insulate the portion of wall below the suspended ceiling with loose fill material.
 - If filled through side holes, block at suspended ceiling level to prevent loose fill from blowing onto the suspended ceiling.
 - Walls above suspended ceiling: Insulate the portion of wall extending above uninsulated suspended ceiling with batts.
- d. Walls open to uninsulated soffits containing recessed light fixtures: Keep loose fill at least 3" away from the HPDs.
- Top fill method: Fill cavities from the top with loose fill up to the soffit, and insulate the remaining distance to the top plate with flexible or rigid material.
 - Top seal method: Securely seal tops of cavities at the soffit/ceiling level, pressure-filled from below, and insulated the remaining distance to the top plate with flexible or rigid material.
- e. Precautions:
- Prior to installing insulation, thoroughly inspect all walls to be insulated on the inside for any areas where insulation might blow into the home. Pay particular attention to potentially weaker wall sheathing, such as:
 - thin/damaged/cracked/bulging drywall,
 - wood paneling, and
 - Lath-and-plaster (which may be thin in some areas).
 - During installation, re-check the interior of the home for wall weakness, breaches in the sheathing, and accidental leakage of insulation material.
 - During and after installation, check a representative sample of switch/outlet boxes.
 - If loose fill insulation is found, check all accessible boxes and remove the insulation.
 - Accessible boxes are those that can be accessed without moving large, heavy furniture or delicate items that may easily be damaged (e.g., a glass hutch containing crystal or antiques).
- f. Pressure-fill procedures

- Fill all portions of all fillable cavities (large enough to drill) to required density, as prescribed by insulation manufacturer.
 - Fill tube method (through hole in siding):
 - Recommended for all cavities over 48" in height.
 - Using holes no more than 1/2" larger than fill tube OD, fill cavities from top to bottom, or bottom to top.
 - Nozzle fill method
 - Nozzle: Use a directional nozzle to direct the flow of insulation, when that produces the densest fill.
 - Insulation Travel: Blow downward 48" maximum and upward 15" maximum.
 - Cavities created by fire blocks and bracing
 - Drill holes shall be above and below all fire blocks and cross braces to fill all cavities.
 - Nozzle method: Minimum two holes for cavities exceeding 63" in height.
 - Fill tube method: A single hole may be drilled at the top or bottom of each cavity.
 - Open cavities: Fill any open cavities with batts or SPF.
2. Interior drill and fill
- a. Walls may be drilled and cavities filled from the interior if it is the only feasible installation method.
 - b. Before beginning an interior installation, take the following precautionary steps:
 - Inform the customer of the inconvenience that may result and the condition in which the home will be left.
 - Cover all appliances, computer equipment, furniture, clothing, and other personal property subject to dust contamination before beginning any interior insulation installation procedures.
3. Post-installation requirements—Pressure fill
- a. Check for loose fill in all accessible electrical outlets and switch boxes in each exterior wall.
 - b. Check for insulation inside the home, including closets and cupboards, remove any insulation found.
 - c. Check the home for pressure fill wall damage indoors and outdoors, and repair all damage.
 - d. Exterior cleanup includes removal of insulating materials and scraps from the premises and returning all things on the jobsite that were changed to their original condition.
4. Fill hole plugs and filler
- a. All walls
 - Use filling and patching materials that are appropriate for the application, exterior grade on the exterior, and compatible with the surrounding material.

- Install in conformance with manufacturer's instructions and finished to blend with the surrounding wall surface.
 - Must provide moisture barrier equal to original material.
- b. Painted walls
- Seal filler/patch or plug with a minimum of one coat of an appropriate primer.
- c. Stucco, plaster, and gypsum walls
- Install backing material (e.g., foam backer rod) in each hole to control patch depth and isolate patch from insulation, and properly patch holes and prime patches.
 - Flush-mount plastic plugs may be used with customer approval to plug holes in interior unpainted gypsum (e.g., garage walls).
- d. Wood walls
- Painted walls: Use plugs made of wood or cork, recessed at least 1/8", covered with filler, and primed.
 - Natural finish walls: Install wooden plugs compatible with siding—installed flush with the siding or sanded flush—permanently secure with exterior grade adhesive, and sealed against water damage.
 - Wood and Cork Plugs: Use non-vented plugs that are resistant to shrinkage.
- e. Fill holes in sheathing
- When siding is removed, patch all breaches in moisture barrier with material having an equivalent perm rating.

8.6 Installation Standards - Unfinished Walls below Grade

1. Vapor barrier must be in conformance with local codes, with placement determined by site-specific analysis of factors governing moisture migration.

8.7 Additional Health & Safety Considerations

1. All federal, state, local and program specific health and safety regulations should be followed.
2. Lead-safe practices shall be employed when working with pre-1978 painted materials per state codes T8 Section 1532.1 and T17 Section 36000, et seq.

9. Windows

9.1 General Requirements

1. Must meet state code and program requirements for U-Factor and SHGC.

9.2 Material Standards

1. Windows shall:
 - a. Comply with local code.
 - b. Bear an NFRC temporary label.
2. Flashing material: Conformance with ASTM D 779 to provide 24- hour minimum protection from water penetration.
3. Nails and screws: Corrosion-resistant and compatible with the materials contacted and penetrated.
4. Caulking materials: Compliance with window manufacturer’s instructions, ASTM E 2112, and Section 5 (Shell Air Sealing).
5. Written warranty
 - a. Insulated Glazing Glass (IGU): Minimum 10-year warranty that (i) covers obstruction of vision resulting from premature failure of glass and organic seal and (ii) provides for the replacement of defective components, including IGU and sash or door panel.
 - b. Components Other Than Glass: Minimum 3-year warranty.
6. Egress requirements for windows in sleeping rooms that have no operable exterior door:
 - a. Retrofit window must be in compliance with local code. If customer refuses required opening modifications, make a notation in the file.
 - b. When local jurisdiction does not specify egress requirements, retrofit sleeping room windows not meeting current CRC egress code may be installed if the new assembly does not reduce the operable dimensions to less than those of the existing assembly.
7. Safety glass: Safety glazing must be permanently labeled and installed in accordance with current CRC.

Measure Feasibility

This measure may not be feasible if:

- A combustion appliance fail or CAS Hazard exists that cannot be repaired.
- Structural weakness or deterioration prevents sound and secure installation of retrofit windows.

9.3 Installation Standards

1. If weather-stripping is needed, prime and paint those surfaces first, ensure they are dry before weather-stripping is installed. Select weather-stripping per Home Upgrade IS Section 5 (Shell Air Sealing).
2. Preparation of opening:
 - a. Existing components associated with the installation must be structurally sound, with all necessary repairs made prior to window installation (e.g., dry rot damage and water penetration points), and
 - b. Mounting surface contact areas must be smooth, clean, and free of protrusions.

3. Ensure clearance between window and rough opening conform to manufacturer's specifications, especially at top to allow for expansion and contraction.
4. General window installation requirements
 - a. Install windows plumb, level, and square, with sash edge parallel to frame edge.
 - b. Install, secure, and seal windows in conformance with window manufacturer's instructions/specifications and the current California Residential Code.
 - c. Special care should be exercised to ensure that flashing provides a water-tight fit around the perimeter.
5. Shims: Install as required to ensure square installation and proper operation of sashes.
 - a. Use doubled, opposing shims to prevent frame rotation.
 - b. Use shims at window anchor locations, penetrated by the anchor and trimmed flush.
 - c. Avoid overdriving fasteners.
6. Vinyl window bottom: Support the sill jamb along the entire bottom to prevent distortion (sagging or rotation), and avoid resting it directly on sharp or uneven surfaces.
7. Vinyl window top: Do not fasten top frame to header, unless per manufacturer's instruction.
8. Flashing and drip cap
9. Install flashing and drip cap per window manufacturer's instructions and industry standard practice.¹¹
 - a. Flashing is needed when the fins are attached directly to sheathing or framing, and when windows are not secured by fins but the existing flashing was damaged.
 - b. Install bottom flashing strip first, then sides (extending over bottom strip), then top (extending over side strips)—or as appropriate for the chosen installation procedure.
10. Installing flush fin (retrofit) windows¹²
 - a. Attachment: Anchor the frame to structural framing with minimum #8 corrosion resistant screws, but do not place screws in the fin, or attach retrofit frame to the old window frame, or install fins overlap siding.
 - b. Sealing: Use elastomeric caulk to seal perimeter of existing frame. Apply a continuous bead of sealant, leaving small gap(s) near center of bottom fin (for drainage).
 - c. Dissimilar materials: Separate from each other with a non-conductive tape, coating, or sealant material.
11. Installing box frame windows (no fins)
 - a. In existing frames: Frame must be structurally sound and free of damage or deterioration, with all sashes, strips, hardware, and other obstructions removed.

¹¹ Reference AAMA 2400-02 and AAMA 2410-03, American Architectural Manufacturers Association, www.aamanet.org

¹² Reference AAMA 2410-03, Standard Practice for Installation of Windows with An Exterior Flush Fin Over An Existing Window Frame, American Architectural Manufacturers Association, www.aamanet.org

- b. In rough opening: Remove existing frame and all obstructions.
 - c. Anchor the new unit in position and seal with elastomeric caulk, using backer rod as needed (see Home Upgrade IS Section 1 (Shell Air Sealing)).
 - d. Stop and casing: Use only exterior wooden stop and casing materials.
 - e. Bottom Gap: Install a step sill, sill extension, or equivalent when gap between existing sill and new sill jamb exceeds 1/4".
 - f. Build-out (Jamb Extension): Install when window frame thickness is less than wall thickness, using material that is compatible with the frame material. Finish wooden build-out to match the window frame.
12. Installing flanged (finned) windows¹³
- a. Expose the fin of the existing window, remove anchors, and remove the window.
 - b. Repair/replace flashing material as need to ensure a water-tight barrier around the entire opening, using standard building practices (e.g., AAMA standards).
 - c. Apply a continuous bead of sealant on the back (interior) side of the mounting flange near the outer edge and in line with any pre-punched holes or slots.
 - d. Shim window as necessary so it is square, level, and plumb.
 - e. Install fasteners per window manufacturer's instructions.
 - f. Apply a continuous bead of sealant on the exterior face of the mounting flange, covering all fasteners and holes/slots in the flange.
 - g. Cover exposed flange with suitable exterior grade "filler" material, secure it, and caulk all exposed edges.
 - h. Prime/paint/stain all exposed filler material.
13. Wooden sashes: Replace if decayed or deteriorated (unless complete window is replaced), ensuring springs and sash weight systems operate properly after replacement.
14. Cavity insulation for wood framing: Insulate open cavities between rough framing and window jamb, except cavities containing sash weights.
15. Exterior sealing: To ensure a water-tight seal, prior to installation caulk the entire window flange or the entire exterior perimeter on block frame windows.
16. Post-installation best practices:
- a. Operation—ensure that:
 - windows operate smoothly,
 - frame is square, so sashes/panels close properly at all corners and edges, and
 - interlocks and latches function properly.
 - b. All new exterior bare wood must be primed minimum of one coat.

¹³ Reference AAMA 2400-02, Standard Practice for Installation of Windows with a Mounting Flange in Stud Frame Construction, American Architectural Manufacturers Association, www.aamanet.org

- c. Safety: Remove all burs, sharp corners and edges, and other such hazards.
- d. Ensure that all work is weathertight and has been completed per manufacturer's instructions and local code requirements.
- e. Instructions: Provide verbal instructions/demonstration of window operation to occupants, and supply written warranty and manufacturer's documents.

9.4 Additional Health & Safety Considerations

1. When shards of broken glass are present, care shall be taken to avoid injury to workers and spreading glass pieces in the residence (in the carpet and on the ground).
2. Masking tape or register film must be applied to broken panes, to stabilize broken pieces and prevent them from falling out of the sash/frame.
3. All broken glass must be removed from the work site.
4. Installation of this measure shall not cause natural draft combustion appliances to backdraft or spill.
5. All federal, state, local and program specific health and safety regulations should be followed.
6. Lead-safe practices shall be employed when working with pre-1978 painted materials per state codes T8 Section 1532.1 and T17 Section 36000, et seq.
7. Protect the area immediately around the window both inside and out. If possible, isolate the construction area from the rest of the house with plastic sheeting.

10. Floor Insulation

10.1 General Requirements

1. Must meet state code, local code and program requirements for thermal resistance (see Program Specifications).
2. When depth of floor joist exceeds depth of required R-value insulation:
 - a. batts must be secured against the floor with wire or twine attached to insides of the joists, **or**
 - b. batts shall be installed that are of sufficient thickness to fill the joist bay (even if a higher R-value batt must be used) and secured with wire, twine or other means installed across the bottoms of the joists.
3. All work must follow local, state, and federal guidelines, especially regarding ventilation and vapor barriers.

10.2 Material Standards

1. Insulation must be certified to comply with the CCR, Title 24, Part 12, Chapters 12-13, and Standards for Insulating Material.
2. Installed materials shall be fire rated and in conformance with all local, state, and federal codes and regulations.
3. Mineral fiber
 - a. Flexible (batts and blankets): conformance to ASTM C665.
 - b. High density fiberglass board: conformance to ASTM C726.
4. Rigid foam
 - a. Preformed polyisocyanurate board foil faced on both sides: conformance to FS HH-I-1972 or ASTM C1289.
 - b. Rigid, cellular polystyrene thermal insulation: conformance to ASTM C578.
5. Cellulose loose-fill: Licensed for sale in California and in compliance with CPSC 16 CFR, Parts 1209 and 1404, and ASTM C739.
6. Insulation supports and anchors
 - a. Staples: Minimum 18-gauge zinc coated, stainless steel, or similar corrosion-resistant material, with 3/8" crown.
 - b. Nails: Galvanized.
 - c. Joist penetration: 5/8" minimum.
7. Wire and twine support for flexible insulation
 - a. Use minimum 20-gauge corrosion-resistant wire (e.g., zinc coated or stainless steel).

Measure Feasibility

This measure may not be feasible if:
Entire Home

- Access is not adequate (clearance less than 18" or obstruction clearance less than 12").
- Crawlspace has hazardous, unsafe, or unsanitary conditions.
- Crawlspace does not separate conditioned space from unconditioned space.
- Knob-and-tube (K&T) wiring is present and:
 - functioning but can't be certified safe by a C-10.
 - abandoned but not disconnected and certified as abandoned by a C-10.
 - insulation over K&T wiring is prohibited by local code.
- Insulation over K&T wiring is prohibited by local code.
- Crawlspace cannot be properly vented.

Section of Floor

- Access is not adequate (less than 18"), or unsafe condition is present.
- Already insulated or partially insulated.

- b. Joists up to 24" OC: Span wire twice in 18", with anchor points maximum 18" apart.
 - c. Joists 25" to 48" or greater OC: Staple facing to subfloor, and span wire four times between anchor points spaced maximum 12" apart (crisscross pattern). Maximum 10% compression of insulation.
8. Woven wire or netting support for flexible insulation
 - a. Use galvanized woven wire or propylene or equivalent netting with a minimum 75 lb. breaking strength.
 - b. Attach wire or plastic mesh to form a basket between joists to support the insulation.
 - c. Anchor support material to joist every 12", with sag of no more than 1" per 24" of span in any direction, and 10% maximum overall compression of insulation.
 9. Wood lath support for flexible insulation
 - a. Size appropriately to prevent sagging between joists.
 - b. Space no greater than 18" on center and attached with galvanized nails or corrosion-resistant staples.
 10. Vent screen: Corrosion-resistant wire mesh.

10.3 Pre-Installation Standards

1. Air sealing:
 - a. Seal all air leaks between the conditioned area of the home and the crawl space in compliance with DOE standards.
 - b. See Section 5 - Shell Air Sealing
 - c. High-priority leaks:
 - Holes around bathtub drains and other drain lines.
 - Leaks around plenums for ductwork.
 - Penetrations for electrical wiring, plumbing, and ductwork (including duct boot connections at the floor).
 - Gaps between rim joist and subfloor sheathing.
 - Bypasses to interior wall or attic.
2. Crawl space venting
 - a. Crawl space venting must conform to local building code and Title 24 requirements.
 - b. Title 24 Requirements: Crawlspace must be vented by means of openings in the foundation walls that meet the following requirements:
 - 1 sq. ft. NFVA for each 150 sq.150-sq. ft. of under-floor area (i.e., 1/150 ratio), or
 - 1 sq. ft. NFVA for each 1500 sq. ft. of under-floor area (i.e., 1/1500 ratio), when approved by the local jurisdiction on the basis that: (i) moisture in the crawlspace is not considered excessive, and (ii) the under-floor ground surface area is covered by an approved vapor retarder (see Item **Error! Reference source not found.** below).

- Vent openings must be:
 - located as close to corners as practical,
 - approximately evenly distributed along the lengths of at least two opposite sides to provide cross-ventilation, and
 - covered with 1/8" or 1/4" wire mesh.
 - NFVA shall be estimated in accordance with Table 10-1:

Table 10-1: Screen and Louver Reduction Factors

(A) Mesh Only	1/4" Mesh (hardware cloth)	1/8" Mesh (wire mesh)	1/16" Mesh (insect screen)
	0.90 (90%)	0.75 (75%)	0.50 (50%)
(B) Louvers & Mesh	Metal Louvers <u>or</u> Metal Louvers <u>and</u> 1/4" <u>or</u> 1/8" Mesh	Metal Louvers, <u>or</u> Metal Louvers <u>and</u> 1/16" Mesh	Wood Louvers <u>or</u> Wood Louvers <u>and</u> 1/16" to 1/4" Mesh
	0.75 (75%)	0.50 (50%)	0.25 (25%)

- Clean or replace clogged mesh and replace torn or defective mesh.
 - Installed vents must be screened with 1/8" or 1/4" wire mesh and louvered.
 - Clearance from Vents:
 - Do not obstruct any vent with insulation and maintain the following setbacks: 12" clearance without barrier, and 3" clearance with minimum 0.007" sheet metal barrier.
3. Ground cover moisture barrier (vapor retarder)
- a. Ground cover is necessary when required by local code or when ground water problem exists.
 - b. Existing undamaged ground cover acceptable if at least 4- mil thick and in good condition after insulation is installed.
 - c. When installation of a ground cover moisture barrier is required:
 - Install minimum 6- mil black polyethylene that covers 100% of the soil.
 - Lap joints 12" and extend 6" up the foundation wall—without contacting any wood members.
 - Secure the barrier in place with tape or fasteners every 8' minimum.
 - If tape is used to secure polyethylene, sheeting must first be wiped clean and tape must be capable of adhering to polyethylene.

- d. Basements with exposed soil floor must have ground cover over soil, unless vented and dry or excluded by local code.

10.4 Installation Standards

1. Installation shall be in harmony with guidelines in the current Title 24 Building Energy Efficiency Standards, Residential Appendices.¹⁴
2. Do not install insulation in floors separating two areas that are either conditioned or unconditioned.
3. Insulation shall not be compressed more than 10%.
4. Regardless of material used, insulation must be installed full-joist thickness, even when that results in use of higher R-value batts.
5. Clearance from HPDs: Minimum 3".
6. Knob-and-Tube wiring: Do not install insulation over knob-and-tube wiring; unless the wiring is certified safe and proper overcurrent protection is in place (see Home Upgrade IS Section 4 (Attic Insulation), Item 6).
7. Batt insulation: The insulation should be fitted and cut around pipes, wires, etc. that may be traversing the bay. The batt should be split so that equal amounts of insulation are behind and in front of those items. Ideally, nothing is viewable after insulation is installed except for the insulation product itself.
 - a. If the batts have a vapor barrier attached to them, this facing should contact the sub-floor above it, touching the warm side of the assembly for best performance and to prevent moisture issues.
 - b. Install raised-floor insulation between floor joists with a means of support that prevents the insulation from falling, sagging or deteriorating.
8. Loose-fill fiberglass insulation: When using loose-fill insulation under floors, it is mandatory that approved netting be used to hold the product securely in place.
9. Spray-foam insulation: All efforts must be made to adhere to local, state, and federal standards and codes as it relates to coverage and flame protection.
 - a. See Home Upgrade IS Section 4 (Attic Insulation), for spray foam insulation installation guidelines.
 - b. Allow house to air out a minimum of 24 hours before occupying.
10. Crawl space access from conditioned space
 - a. Insulate the access cover/door with R 19, if horizontal, or R 13, if vertical.
 - b. Cover insulation with FSK, and secure it to the cover with staples or twine and staples.
 - c. Weather-stripped the access cover/door with appropriate material, per Home Upgrade IS Section 4 (Attic Insulation).

¹⁴ Current California Energy Commission *Reference Appendices for the Building Energy Efficiency Standards for Residential and Nonresidential Buildings*

11. Do not isolate water pipes in crawl space from the heated side by placing batt between pipes and floor.
 - a. In locations without freezing temperatures, pipes may be surrounded with insulation.
 - b. In locations with freezing temperatures, place insulation between pipes and cold side.
 - c. Locations with freezing temperatures are those with winter design temperature listed at or below 32°F in the California Energy Commission Residential Manual, or per ASHRAE.
 - d. Water pipe heaters are not allowed.
12. Water valves: Tag if covered.
13. Exposed floors:
 - a. Insulate with flexible mineral fiber supported with woven wire or minimum 70 perm breathable cover.
 - b. Other options are spray foam or extruded foam board insulation.
 - c. Insulation must be covered, not left exposed to the weather.
14. HPDs: 3" clearance required.
15. HVAC ducts: Surround ducts located within joist cavities with flexible insulation, placing the vapor barrier, when present, on the outside.
16. Finished floor cavities (blind fill)
 - a. Loose Fill
 - Drill and pressure-fill cavities using a directional nozzle or fill tube.
 - Space holes for maximum 2' horizontal insulation travel beyond the injector.
 - b. HPD clearance
 - Minimum 3" clearance required for recessed lights, vent pipes, solid fuel chimneys, and other HPDs.
 - Do not insulate the cavity when 3" clearance cannot be achieved.
 - c. Coverage and finishing
 - Completely fill all portions of all fillable cavities to density prescribed by the insulation manufacturer.
 - Plug and patch holes as prescribed in Home Upgrade IS Section 13 (Wall Insulation).

10.5 Installation Standards – Encapsulated Crawlspace

1. Insulation is installed to perimeter of crawl space walls in lieu of placing it against the floor.
2. Consult local jurisdiction regulations.
3. Crawlspace encapsulation may be done only where the local jurisdiction allows foundation vents to be closed permanently.
4. Crawlspace vents must be permanently closed and vents must be installed to the living space.

10.6 Installation Standards – Crawl Space Perimeter Insulation—Interior

1. Must be allowed by local jurisdiction.
2. R-Value minimum R-13, with ground cover installed in accordance with section 10.3.3 above.
3. Foundation vents:
 - a. Must be operable, so they can be closed during adverse weather, and
 - b. must not be obstructed by insulation.
4. Flexible insulation
 - a. Cover band and header joists, and extend insulation 3' away from the walls over top of the ground cover and tape it to the ground cover.
 - b. Mechanically attach insulation with stick pins.
 - c. Continuously tape or staple seams at up to 6" intervals, with no gaps between batts.
 - d. Facing must meet applicable code requirements for flame spread and smoke density.
5. Rigid insulation
 - a. Install only code-approved fire-rated materials.
 - b. Clean foundation wall, and apply at least one continuous horizontal bead of adhesive on the wall to block insect infestation.
 - c. Install insulation on band and header joists and down the wall.
 - d. Permanently secure insulation to the foundation wall with mechanical fasteners, such as glued-on insulation hangers with press-on spring washers, self-drilling insulation pins with spring washers, etc.
6. Insulation certificate shall be completed following installation, and the certificate shall be posted inside the crawlspace adjacent to the access.

10.7 Additional Health & Safety Considerations

1. All federal, state, local and program specific health and safety regulations should be followed.
2. Lead-safe practices shall be employed when working with pre-1978 painted materials per state codes T8 Section 1532.1 and T17 Section 36000, et seq.
3. Do not work around functional knob-and-tube wiring that is energized, unless the wiring has been certified safe by an electrical (C-10) subcontractor.
4. Correct any unsafe electrical conditions before insulation is installed.

11. Cooling System Installation

11.1 General Requirements

1. Must meet program standards, Title 24 Standards, state codes, local codes and program requirements (see Program Specifications).

11.2 Material Standards

1. Replacement air conditioning systems shall be in compliance with Title 24 efficiency standards, American Standards Testing & Measurements (ASTME) and Rated by the Air-Conditioning and Refrigeration Institute (ARI).
2. All materials shall be in conformance with the California Building Code (CBC) and California Mechanical Code (CMC).
3. Thermostats
 - a. Programmable and smart thermostats
 - Energy Star® qualified.
 - System powered, not battery powered, on 24 volt systems.
 - Digital with anti-short-cycle feature.
 - Minimum setback capability of 10°F.
 - At least two setback periods per 24- hour day, with change cycle increments being no greater than 30 minutes.
 - Programmable for weekdays and weekends.
 - Manual override and standard alkaline battery backup or other program saving backup system.
 - Positive on/off switch that is easily accessible.
 - Compatible with the HVAC equipment.
 - b. Standard wall thermostat
 - Digital with built in anti-short-cycle feature.
 - Compatible with the HVAC equipment.
 - Includes a positive on/off switch.
4. Air filters
 - a. shall conform to AHRI 681 (SI) and UL-900
 - b. shall be rated at MERV 6 or better.
5. Non-metallic Combustion Air and Vent Pipes
 - a. Pipes and fittings shall conform to ASTM D 1785 and D 2665.

Measure Feasibility

This measure may not be feasible if:

- The air conditioner is not accessible.
- For roof-mount unit, roof structure is not adequate to support the installation.
- Electrical service requirements cannot be met.
- Attic or crawlspace access is required and safe entry and clearances are not feasible.
- Customer refuses.

- b. Pipe cement and primer shall conform to ASTM D 2564.
6. Ducts and sealants shall be in conformance with Home Upgrade IS Section 2 (Duct Testing & Sealing).

11.3 Installation Standards

1. A building permit for the installation shall be obtained from and finalized by the local jurisdiction.
2. Installation shall be in compliance with the following:
 - a. Manufacturer's instructions and specifications.
 - b. Current Title 24 Residential Compliance Manual.
 - c. CEC, CMC, and local code.
3. System shall be sized in accordance with current Title 24 Building Efficiency Standards, based on cooling loads, determined using an approved ASHRAE, SMACNA, or ACCA method, such as Manual S.
4. Ratio of sensible to latent heat must be:
 - a. $\geq 70\%$ Sensible Heat
 - b. $\leq 30\%$ Latent Heat
5. Optimize cooling without causing condensation.
6. Evaporator coil and condenser unit
 - a. Split systems
 - Evaporator coil shall be verified to be a rated match with the condenser unit by manufacturer or as listed in the current AHRI Directory.
 - The evaporator coil and condenser unit labels shall be visible.
 - Refrigerant lines shall provide the rated SEER for the combination condenser and evaporator coil match.
 - b. Evaporator coil replacement
 - Prior to charging, vacuum shall be drawn on the refrigerant lines to test for leaks and remove water vapor.
 - Depth of vacuum and length of time shall be as specified by the manufacturer.
7. Operational requirements
 - a. Air flow through the indoor coil shall be adequate to meet manufacturer's specifications.
 - Refrigerant recovery shall be performed in accordance with Federal law by a technician with EPA-approved certification as a Type II or Universal technician.
 - Condenser coil and evaporator coil shall be verified to function properly.
8. Air distribution:

- a. Distribution system shall be in conformance with HVAC manufacturer's specifications, current Title 24 Residential Compliance Manual, and Section 13 below (Duct Testing and Sealing).
 - b. Existing duct system shall be examined for leaks and disconnections and repaired or replaced as needed.
 - c. New/replacement duct systems
 - Return duct sizing shall be adequate, and airflow shall be greater than 350 cfm/ton, in accordance with Title 24.
 - Duct leakage shall not exceed 10% of system airflow.
 - d. System airflow shall be determined in accordance with current Title 24 Residential Appendix.
 - e. Air handler watt draw shall be less than 0.58 watts per cfm.
9. Thermostat:
- a. If a functioning programmable thermostat is not present, one shall be installed (a Title 24 requirement).
 - b. A standard thermostat may be installed only if programmable is refused by the customer and approved by the local jurisdiction.
10. Accessibility of equipment:
- a. The air-conditioning equipment shall be accessible for inspection, service, repair and replacement without removing permanent construction.
 - b. Minimum clearance between air-conditioning equipment and the adjacent structure/wall/obstruction shall be:
 - 5' from clothes dryer moisture exhaust.
 - 48" above unit,
 - 24" on side(s) containing service access panels, and
 - 12" on all other sides, or
 - As specified by manufacturer and local jurisdiction.
11. Electrical requirements
- a. A 120-volt grounded service receptacle shall be located within sight of the equipment up to 25 feet (or attached to it).
 - b. Equipment shall be grounded in conformance with manufacturer's instructions and local code.
 - c. Branch circuit:
 - In accordance with the CEC, provide air conditioning equipment with overcurrent protection and disconnect, branch circuit short circuit and ground fault protection.
 - Branch circuit conductors shall be in conformance with CEC requirements for ampacity and rating of conductors.

- A service disconnect shall be located within sight from, and readily accessible from, the air conditioning equipment or as required by the local jurisdiction.

12. Mounting of equipment

a. Roof mount

- The roof shall be structurally adequate to properly support installed equipment in conformance with CBC and local code.
- Design and installation of support frame or curb and installation of air-conditioning equipment and applicable safety apparatus shall be in conformance with manufacturer's instructions and local code.
- Curb base and exposed roof penetrations shall be properly installed, flashed and sealed watertight.
- The condensate drain line shall be equipped with a trap and painted to resist UV degradation if PVC is used.
- Roofing materials shall be in good condition and not in need of repair or replacement.

b. Ground mount

- Air-conditioning equipment shall be installed in conformance with CMC and local code.
- The unit shall rest on concrete or other approved base extending at least 3" above the adjoining ground level.

c. Protection and Clearance

- Units subject to mechanical damage shall be protected in conformance with CMC and local code.
- Unit shall be attached to base with seismic straps, when required by local code.
- Installed outdoor condenser unit shall be located at least 5' from the outlet of a clothes dryer moisture exhaust.

11.4 Additional Health & Safety Considerations

None

12. Heating System Installation

12.1 General Requirements

1. Must meet current Title 24 Standards, state code, local code and program requirements (see Program Specifications).

12.2 Material Standards

1. Furnaces shall be in conformance with the current CBC, CMC, and Title 24 Residential Compliance Manual.
2. All units and components shall be UL Listed and/or have one of the following certifications: CSA, AGA, AHRI.
3. Thermostats
 - a. Programmable and smart thermostats
 - Energy Star[®] qualified.
 - System powered, not battery powered, on 24 volt systems.
 - Digital with anti-short-cycle feature.
 - Minimum setback capability of 10°F.
 - At least two setback periods per 24 hour24-hour day, with change cycle increments being no greater than 30 minutes.
 - Programmable for weekdays and weekends.
 - Manual override and standard alkaline battery backup or other program saving backup system.
 - Positive on/off switch that is easily accessible.
 - Compatible with the HVAC equipment.
 - b. Standard wall thermostat
 - Digital with built in anti-short-cycle feature.
 - Compatible with the HVAC equipment.
 - Includes a positive on/off switch.
4. Air filters shall conform to AHRI 681 (SI) and UL-900, and shall be rated at MERV 6 or better.
5. Metal vent pipes
 - a. All metal vent connectors, vent pipes, and components shall be UL listed.
 - b. Gas vent pipe shall be Type B or BW.
6. Non-metallic combustion air and vent pipes
 - a. Pipes and fittings shall conform to ASTM D 1785 and D 2665.
 - b. Pipe cement and primer shall conform to ASTM D 2564.

Measure Feasibility

This measure may not be feasible if:

- The FAU is not accessible.
- For roof-mount unit, roof structure is not adequate to support the installation.
- Gas service requirements cannot be met.
- Attic or crawlspace access is required and safe entry and clearances are not feasible.
- Customer refuses.

7. Gas pipes and valves
 - a. Gas valves: UL Listed and AGA or CSA certified.
 - b. Gas flexible connectors: IAPMO Listed epoxy-coated or stainless steel units.
 - c. Pilot tubing shall be aluminum (copper not allowed).
 - d. Fuel-gas piping:
 - Shall be selected, sized and installed per current CMC, Chapter 13.
 - Copper gas lines not allowed.
8. Ducts and sealants shall be in conformance with Section 13 (Duct Testing & Sealing).

12.3 Installation Requirements

1. A building permit for the installation shall be obtained from and finalized by the local jurisdiction.
2. Installation shall comply with the following:
 - a. Manufacturer's instructions and specifications.
 - b. Current Title 24 Residential Compliance Manual.
 - c. CEC, CMC, and local code.
3. Thermostat:
 - a. If a functioning programmable thermostat is not present, one shall be installed (a Title 24 requirement).
 - b. A standard thermostat may be installed only if programmable is refused by the customer and approved by the local jurisdiction.
4. Combustion air
 - a. All units
 - Combustion air shall be supplied in conformance with manufacturer's instructions and local code (see Home Upgrade IS Appendix A and CMC Chapter 7).
 - Existing combustion air vents shall be free of obstructions (e.g., overblown ceiling insulation, duct insulation, etc.).
 - Combustion air shall be isolated from return air.
 - b. Open combustion furnaces inside the living space:
 - Combustion air shall be obtained entirely from either outdoors or inside the living space.
 - Combustion air shall not be drawn from a sleeping space.
 - c. Open combustion furnaces inside an unconditioned garage:
 - Combustion air may be obtained from indoors, outdoors, or a combination of indoors and outdoors, in accordance with CMC Chapter 7.

- Combustion air shall not be drawn from a sleeping space.

12.4 Installation Standards

1. System shall be sized in accordance with current Title 24 Building Efficiency Standards, based on heating and cooling loads, and determined using an approved ASHRAE, SMACNA, or ACCA method.
2. Air distribution system
 - a. Distribution system shall conform to HVAC manufacturer's specifications and Title 24.
 - b. Installations utilizing existing ducts
 - New FAU airflow shall be compatible with existing duct system.
 - Existing duct system shall be examined for leaks and repaired or replaced as needed.
 - c. New/replacement duct systems
 - Return duct sizing shall be adequate, and airflow shall be greater than 350 cfm/ton, in accordance with Title 24.
 - Duct leakage shall not exceed 6% of system airflow (for new duct systems) using duct leakage to outside (LTO) testing (10% of system airflow for altered duct systems). Testing and repairs/sealing shall be performed in accordance with chapter 13 (Duct Testing & Sealing).
3. Appliance venting
 - a. Appliance venting shall be in conformance with manufacturer's installation instructions and local code.
 - b. When an existing furnace sharing a common vent with another appliance is replaced with a new unit, contractor shall ensure that both appliances operate properly.
4. Wall and floor repairs
 - a. Surface of repair shall match plane of adjacent material (e.g. subfloor, wall).
 - b. Patching shall blend with surrounding surfaces.
 - c. Floor openings shall be closed in a workmanlike manner.
 - d. All construction debris shall be removed from the attic, crawl space and the premises.
5. Returns and return plenum
 - a. Return (platform, cabinet, and plenum) shall be free of leaks.
 - b. Platform returns:
 - Platform cavity shall be lined/sealed to prevent infiltration from unconditioned space and furnace enclosure.
 - Uninsulated platform plenums shall be insulated.
 - Additional insulation not required when fiberglass duct board is used to line/seal the plenum.

- Platform return accessed by swinging appliance enclosure door:
 - Door-mounted grille shall not interfere with proper closure of door.
 - Return shall be isolated from furnace enclosure (i.e. with weather-stripping).
6. Gas piping and valves
- a. Installed plumbing/piping parts shall be new; used parts are not allowed.
 - b. Gas flexible connector shall be new (existing shall not be reused).
 - c. All gas piping, fittings, and valves shall be installed in conformance with manufacturer's instructions and local code.
 - d. Existing gas shut-off valve may be used, if it is:
 - in good condition and in conformance with subsection 18.1, Item 9.
 - within 3' of the appliance and in the same room or space where the appliance is located.
 - e. Existing copper components shall be replaced with approved material.
 - f. All new and affected lines and components shall be checked for gas. See Inspection Guidelines, Chapter 2, section B (Gas Leak Testing).
7. Access and service space: Access and service space shall be provided in accordance with manufacturer's instructions and local code, which may include CMC requirements summarized in Table 12-1.

Table 12-1: Furnace Location Requirements	
Location	Requirements
Enclosures	Width: Minimum 24" Height: High enough to accommodate installation and removal
Under-Floor and Roof-Mount Locations	Compliance with local code
Attic Location	Unobstructed passageway: <ul style="list-style-type: none"> • Minimum 30" wide and high • Maximum 20' long Service Space: <ul style="list-style-type: none"> • Minimum 30" wide and deep • Level and located in front of unit Illumination: <ul style="list-style-type: none"> • Switch located near access/entrance • Sufficient illumination for safe access and service Convenience Receptacle: <ul style="list-style-type: none"> • Permanent 120-volt receptacle near appliance
Garage	Open combustion: Pilot and burner located 18" above floor.

8. Central air conditioner combined with furnace
- a. Air conditioning equipment shall be selected and installed as prescribed in Chapter 11 (Cooling System Installation).

9. CO and draft
 - a. The appliance shall be tested and follow manufacturer's specifications and the requirements in Home Upgrade Inspection Guidelines, Chapter 5 (CAS Testing).
10. Thermostat installation
 - a. Location and mounting
 - New thermostat shall be installed at existing location unless affected by drafts, heat from direct sun, or adjacent appliances.
 - Thermostat installed in a new location shall be mounted:
 - 60" above the floor, or
 - As low as 48" above the floor when an occupant uses a wheelchair.
 - Thermostat shall be located away from direct sunlight, doors, windows, return/supply air, appliances, and sources of electrical interference.
 - Mounting bracket shall be securely attached to wall.
 - Any holes or damage to wall from installation or removal of thermostat shall be repaired in a workmanlike manner.
 - b. Wiring
 - All wiring shall be a minimum of 18 gauge and conform to manufacturer's specifications and local code.
 - All wiring shall be installed inside wall cavities when possible.
 - When not inside a wall, exposed wiring shall be enclosed in a raceway.
 - c. Programming and operation
 - Thermostat shall be cycled to insure proper operation of all functions.
 - Setbacks shall be programmed in accordance with customer's wishes.
 - d. Instructions and warranty
 - Customer shall be provided with:
 - A demonstration with verbal instructions for operating the thermostat and installing batteries.
 - The manufacturer's written instructions and warranty.
 - e. Disposal of replaced thermostats
 - Old thermostats containing mercury shall be disposed of in accordance with Universal Waste Regulations, as set forth by DTSC at:
http://www.dtsc.ca.gov/HazardousWaste/Mercury_Therm_Act.cfm

12.5 Post-Installation Standards

1. Appliance operation
 - a. The installed unit shall be tested for proper operation.

- b. Proper operation shall be explained and demonstrated to the customer, including:
 - Operation of all user-accessible controls.
 - Filter replacement.
 - Routine maintenance recommended by manufacturer.
 - c. All manufacturer's written instructions and warranty documents shall be supplied to the customer.
2. Cleanup and disposal
 - a. Paint dust and chips, scraps, and other debris resulting from installation activities shall be cleaned up and removed from the premises—utilizing lead-safe practices when applicable.
 - b. All packing materials and installation debris shall be cleaned up and removed from the premises.
 - c. All replaced equipment and parts shall be removed from the premises and properly disposed of, unless specified otherwise in the home improvement contract.
 - d. Refrigerant shall be recovered and all hazardous waste materials shall be disposed of in conformance with federal, state and local code.

12.6 Additional Health & Safety Considerations

1. All federal, state, local and program specific health and safety regulations should be followed.
2. Lead-safe practices shall be employed when working with pre-1978 painted materials per state codes T8 Section 1532.1 and T17 Section 36000, et seq.

13. Duct Testing and Sealing

13.1 General Requirements

1. Must meet program requirements for maximum allowable duct leakage at test-out. (see Program Specifications).
2. Home Upgrade Eligibility: Home has not participated in duct test and seal program or has not done duct sealing (10 percent or less leakage) in past six years.
3. Home must be served by an existing central air conditioner, furnace, or heat pump; new systems installed when no prior equipment was present will not qualify.
4. Individual cooling systems must be between 1.5- and 5-tons capacity. Air conditioning systems with multiple compressors and economizers are not eligible.

13.2 Material Standards

1. Code-compliant duct sealants
 - a. Use UL 181A and 181B listed sealants, labeled per Table 13-1.

Table 13-1: Required UL 181 Identification

DUCT TYPE	SEALING MATERIAL	UL IDENTIFICATION
<u>Rigid</u> Metal and Fiberglass Ducts and Components [UL 181A Standard]	Pressure Sensitive Tape	Marked "181A-P" or "181A-P/181B-FX"
	Heat Activated Tape	Marked "181A-H"
	Mastic	Labeled "181A-M" or "181A-M/181B-M"
<u>Flexible</u> Ducts [UL 181B Standard]	Pressure Sensitive Tape	Marked "181B-FX" or "181A-P/181B-FX"
	Mastic	Labeled "181B-M" or "181A-M/181B-M"

2. Use only exterior-rated products in outdoor locations.
3. Addendum to Table 13-1 Regarding Tapes
 - a. Flexible non-metallic and flexible metallic ducts
 - "Butyl Tape" (also known as "Foil Mastic"):
 - Aluminum foil tape with minimum 15- mil butyl adhesive.
 - Marked 181B-FX or UL 723 or ASTM E84 or NFPA 255.
 - Do not seal flexible ducts with Butyl tape, unless it is marked "181B-FX".
 - Not for use in high temperature applications.

- Cloth-back butyl-adhesive tapes are acceptable, if CEC-approved for use in California (e.g., indicated by “CA” in the product number).
 - Do not use cloth-back rubber-adhesive tapes.
- b. Rigid metal ducts and components: “Butyl tape” without 181A-P or 181B-FX markings may be used to seal rigid metal-to-metal connections.
 - c. High-temperature applications: Use metallic tapes with non-butyl adhesive (e.g., acrylic) and service temperature rating of at least 265°F.
4. Mesh and backer rod
 - a. Use mesh for gaps greater than 1/4" up to 3/4".
 - b. Use backer rod for gaps greater than 3/8" up to 5/8".
 5. Drawbands and clamps
 - a. Drawbands and clamps used to secure flexible non-metallic ducts must comply with duct manufacturer’s installation instructions.
 - b. Drawband minimum standards:
 - Weather and UV resistant (e.g., black) nylon duct straps/ties rated for outdoor use;
 - 150 pound150-pound loop tensile strength; 165°F service temperature rating.
 - c. Clamps: Stainless steel worm-drive.
 6. Flexible ducts—Conventional Homes
 - a. All flexible ducts
 - Conformance to NFPA 90B and UL 181 Class 1.
 - Vapor barrier (Jacket): UV-resistant material (e.g., silver metalized polyester jacket).
 - Do not install flexible ducts with air-permeable core.
 7. Rigid metal ducts
 - a. Ducts and components
 - Non-corrosive material with conformance to NFPA 90B and UL 181 Class 1 or Class 0.
 - Round metal ducts must conform to minimum thickness requirements of the CMC, some of which are shown in Table 14-1 (next page).

Measure Feasibility

Duct Testing (all homes) may not be feasible if:

- Attic or crawlspace has hazardous, unsafe, or unsanitary conditions.
- A combustion appliance hazard exists that cannot be repaired (includes inadequate CVA room volume).
- Ductwork contains excessive damage or deterioration that precludes proper testing.
- Any portion of the duct system is made of asbestos containing materials (ACM).
- Ductwork is insulated/sealed with ACM, and a disconnection exists that cannot be repaired.
- FAU is abandoned or inaccessible.
- FAU shares ducts with an evaporative cooler, and cooler cannot be isolated by a damper.
- Duct system is inside conditioned space (plenum and short duct system in living space).
- Ductwork is inaccessible, because ducts are located in attic or under floor, and crawl area clearance is inadequate and/or an unsafe condition is present, per Section 2.5, Item 12.
 - *Exception:* When the duct system includes an unlined platform return that can be accessed and lined/sealed, duct testing is feasible prior to platform sealing.
- Another health or safety issue that will impact occupants cannot be mitigated.

Table 14-1: Minimum Gauge of Round Metal Ducts

ROUND METAL DUCTS At Positive Static Pressure up to 2 IWG (500 Pa)		
DIAMETER of Duct	MIN. SHEET GAUGE (Galvanized Steel)	MIN. B. & S. GAUGE (Aluminum)
Up to 14"	26	24
15" to 23"	24	22
24" to 37"	22	20
38" to 51"	20	18

8. Fittings for flexible non-metallic ductwork
 - a. Fittings (starting collars, splicing sleeves/couplings, elbows, wyes, etc.) must be same gauge as the ducts to which they are attached (per Table 2-4).
 - b. New Fittings:
 - Starting Collars: 4" length minimum (6" recommended).
 - Splicing Sleeves: 6" length minimum (8" recommended).
 - All fittings must be beaded at each flexible core connection.
9. Duct board and foam products
 - a. High density fiberglass duct board used in the duct system should conform to ASTM C612, NFPA 90B, or UL Class 1.
10. Do not use foam board or foam sealant anywhere in the duct system (e.g., to line/seal platform returns and other building cavities used as ducts).

13.3 Duct Testing Standards

1. Refer to the Quality Control Inspection Guidelines for duct testing protocol.
2. Use equipment that meets Title 24 requirements specified in the current Title 24 Building Efficiency Standards Reference Appendices.
3. General
 - a. Duct disconnections must be mechanically reattached prior to performing duct testing.
 - b. Perform duct testing (and sealing) before blower door testing.
 - c. Follow manufacturer's instructions for equipment set-up, operation, maintenance, and calibration.
 - d. Pressurize the duct system to a standard test pressure of 25 Pa.
 - e. Record test data.
4. HVAC System Airflow (Fan Flow)

- a. Determine HVAC system airflow (fan flow) per the current Title 24 Residential Appendix, utilizing one of the following methods:
 - Estimate, using Nominal System Airflow defaults.
 - Measure, using a Flow Grid, Plenum Pressure Matching method, or Flow Capture Hood.
5. Estimating Nominal System Airflow (Fan Flow)
- a. Utilize procedures specified in the current Title 24 Residential ACM Manual.
 - b. Determine air conditioner cooling capacity in tons, and furnace heating capacity (output) in KBtuh, in accordance with the current Title 24 Residential Appendix.
 - c. See Table 13-2 below for a summary of system airflow defaults.

Table 13-2: System Airflow Defaults

HVAC System Type	System Airflow Defaults
Combined Heating and Air Conditioning	400 CFM per ton Fan flow CFM shall be the <i>greater</i> of cooling capacity CFM or heating capacity cfm.
Air Conditioning only	400 CFM per ton
Gas Heating only	21.7 CFM per KBtuh heating output
Electric Heating only	If Btuh is known: (kBtuh) x (21.7) = CFM If Btuh is <u>not</u> known: (___ kW) x (74.1) = CFM

13.4 Duct Installation Standards

1. General Requirements
 - a. Ducts must be sealed, repaired or replaced in accordance with the requirements contained in the current Building Energy Efficiency Standards, Subchapter 9, "Additions and Alterations in Low-Rise Residential Buildings."
 - b. When duct sealing is recommended, the work scope must include duct leakage testing and system airflow estimate or testing. The results of these tests must be documented and used to verify the effectiveness of the installation. When quantifying duct leakage, an appropriate type of measurement system shall be used that includes a metered and calibrated duct pressurization device. Duct leakage shall be measured and documented any time that duct sealing is part of the work scope to verify the success of the installation.
 - c. Do not install rigid fiberglass duct as air ducts. Fiberglass duct board may be used to line stud cavities in platform returns.
 - d. Duct connections and joints must be mechanically secured with draw bands, clamps, or 3 or 4 evenly spaced screws.
 - e. Duct systems are to be sealed with duct mastic (not tape) down to a minimum of 10 percent of nominal air flow of the heating/cooling system as calculated utilizing cooling

capacity first when present or using the BTU output of the furnace as defined in Building Energy Efficiency Standards Residential Appendices.¹⁵

- f. Sheet metal and flexible ductwork shall be sealed at all duct connections using duct mastic or similar product designed for sealing ducts. Duct tape is not an allowable duct sealing material. Aluminum FSK tape may be used on duct board systems and at the connections to the air handler cabinet.
- g. Blower door and CAS testing shall be performed whenever insulation, air sealing of shell or the ducts, or ventilation is installed to confirm safe conditions for the occupants.

13.5 Duct Sealing Standards

1. Duct sealing protocol
 - a. Reference industry standards, including:
 - Current California Mechanical Code (CMC), Chapter 6, Duct Systems.
 - Current Title 24 Residential Compliance Manual
2. Duct sealing priority
 - a. Seal largest leaks first (e.g., disconnections, missing end caps, platform return, other catastrophic holes).
 - b. Seal areas of highest pressure (e.g., leaks near the air handler and supply and return plenums, flexible canvas plenum connectors, and filter slot covers).
 - c. If necessary, cut onto plenum or remove squirrel cage to seal connection to furnace cabinet.
 - d. Seal return leaks that can exert negative pressure in the combustion appliance zone (CAZ).
 - e. Seal accessible connections between duct sections, at start collars, and fittings/wyes/elbows.
 - f. Seal connections to register boots, and boot connections to the floor/wall/ceiling.
3. Duct closure systems
 - a. Apply sealants per manufacturer's instructions to achieve a complete, durable seal—with attention paid to surface preparation/cleaning, temperature and moisture limitations, thickness of mastic, and pressure/rubbing of tape.
 - b. All duct connections/joints must be mechanically secured.
 - Flexible duct/component connections: Secure with a drawband (or clamp).
 - Rigid metal duct/component connections: Secure with at least three evenly-spaced sheet metal screws (4 screws on diameters 15" to 19").
 - c. Repairs

¹⁵ Current California Energy Commission *Reference Appendices for the Building Energy Efficiency Standards Title 24, Part 6*.

- Flexible duct connections with gaps 1/4" or wider should be replaced with properly-sized duct and/or fitting.
 - Rigid metal ducts with gaps wider than 3/4" should be repaired with a sheet metal patch or sleeve (per Item 8 below).
4. Sealing with mastic
- a. Mastic alone
 - Apply on gaps less than 1/4" wide that are more than 10' from the air handler.
 - b. Mastic with fiberglass mesh tape:
 - Apply mastic on metal gaps that are:
 - Over 1/4" and $\leq 3/4$ " wide, or
 - Less than 1/4" wide and less than 10' from the air handler.
 - First cover the gap with duct tape, and then cover with a mastic closure system (mesh fabric imbedded between two layers of duct mastic).
 - Center the first mastic layer over the joint to be sealed, and extend it at least 1" onto each of the joined surfaces and beyond the width of the mesh.
 - After imbedding the mesh in the first layer of mastic, apply another thick layer over the entire joint, filling the scrim pattern and completely covering the mesh.
 - c. Flexible non-metallic duct connections on beaded fittings:
 - Apply mastic to the outside of the fitting, and pull the duct core at least 2" onto the fitting (1" beyond the bead).
 - Install a drawband over the core behind the bead.
5. Sealing with pressure sensitive tape
- a. All duct types: Apply at least two wraps of UL 181 tape centered over the joint, staggering successive wraps to overlap by 50% to 75% of the tape width.
 - b. Rigid metal connections: Use metallic tape, not plastic.
 - c. Nonmetallic flexible duct on beaded fitting:
 - Pull the duct core at least 2" onto the fitting (1" beyond the bead)
 - install a drawband behind the bead
 - seal with at least 2 wraps of "181B-FX" tape.
 - d. Gaps over 1/4" up to 3/4":
 - Apply 2 wraps of tape
 - cover the tape with duct mastic that is at least 1/8" thick and extends beyond the width of the tape.
 - e. Gaps wider than 3/4": Repair first, and then seal.

- f. High temperature applications: Use metallic tape with a service temperature rating of at least 265°F, when located within:
 - 1" of a double-wall gas vent pipe.
 - 6" of a single-wall gas vent pipe.
6. Nonmetallic flexible duct on non-beaded fitting
 - a. Sealing with "181B-M" duct mastic:
 - Apply mastic to the outside of the fitting, pull the duct core at least 2" onto the fitting.
 - Install a drawband over the core, and install a screw on the exterior side of the drawband through the flexible core.
 - b. Sealing with "181B-FX" duct tape:
 - Pull duct core at least 2" onto the fitting, and apply one wrap of duct tape over duct core.
 - Secure the core with at least 3 #8 sheet metal screws that penetrate the tape and capture the wire coil of the core.
 - Seal the connection with at least 2 wraps of tape.
7. Flexible Metallic Duct
 - a. Factory-installed sleeve present: Pull at least 1" of core over the fitting, mechanically secure the connection with at least 3 evenly-spaced sheet metal screws, and seal with tape or mastic (no drawband).
 - b. When a factory-installed sleeve is not present, trim the end of the core squarely.
 - Sealing with duct mastic: Coat the fitting with mastic, pull at least 1" of core over the fitting, mechanically secure the connection with at least 3 evenly-spaced sheet metal screws, and apply mastic externally as needed to ensure a complete seal.
 - Sealing with duct tape: Pull at least 1" of core over the fitting, mechanically secure the core with at least 3 evenly-spaced sheet metal screws, and seal the connection with at least 2 staggered wraps of tape.
8. Core Repairs: Repair holes/damage in the flexible duct core by removing the damaged section, inserting a sleeve/coupling, and securing/sealing as described above.
 - a. All ducts: After sealing/securing the connection, pull insulation back over it.
 - b. Flexible ducts:
 - Pull the jacket back over the insulation, and overlap jacket ends at least 2".
 - Secure the joint with at least 2 staggered wraps of "181B-FX" tape, or install a drawband that secures the jackets without excessive compression of the insulation.
9. Sheet metal patches to repair ducts
 - a. Use material that matches the existing duct material (i.e., galvanized patch for galvanized duct, or aluminum patch for aluminum duct).
 - b. Gauge of the patch should equal or exceed gauge of the duct being repaired.

- c. The patch should extend at least 1" beyond each edge of the gap, overlap itself by at least 1", and be secured with at least 3 evenly-spaced sheet metal screws on each end of the patch.
 - d. Seal the seam and ends appropriately with mastic or pressure sensitive tape.
10. Plenum connections
- a. Fiberglass duct board: Replace with metal plenum.
 - b. Rectangular metal plenum: Secure to FAU housing with sheet metal screws—at least 1 screw per side.
 - c. Duct board plenum: Replace with metal plenum.
 - d. Air handler and filter slot
 - At the air handler, close off all joints, cracks, and holes not needed for proper function of the unit using removable sealant (e.g., duct tape).
 - If an open filter slot is present, install a factory-made or field-fabricated durable filter slot cover.
11. Register boots
- a. Boot support
 - Boot must be mechanically secured to the structure (e.g., with nails or screws)
 - Boot must not rely on the duct for support or stability.
 - b. Boot sealing—gaps around the boot
 - Seal gaps between boot and surrounding material appropriately, with:
 - Elastomeric caulk for gaps up to 3/8"
 - Elastomeric caulk supported by backer rod for gaps 7/16" to 5/8".
 - Duct mastic or metallic pressure sensitive tape for gaps up to 1/4".
 - Duct mastic reinforced with fiberglass mesh, or metallic tape covered with mastic, for gaps over 1/4" up to 3/4"
 - When sealing with duct mastic, wet the edge of the gypsum before applying mastic.
 - Make sure sealing material does not impede removal/replacement of the register.
 - c. Boot sealing—inside the boot
 - Seams/gaps inside the boot: Seal with appropriate material, such as duct mastic, mastic and mesh, or metallic tape.
12. Building cavities
- a. Seal accessible leaks
 - When accessible, seal building cavities being used as ducts (e.g., platform return, panned joists, building cavity/chase, cabinet toe-kick supply terminal, etc.).
 - Prioritize the top and bottom of any cavity used as a duct or as a chase for a duct.

- Do not use foam board, foam sealants, or gypsum wallboard for duct/cavity repair/sealing.
- b. Unlined platform returns
 - When uninsulated platforms are sealed, the walls outside of conditioned space should also be insulated.
 - When using sheet metal or duct board to line/seal the platform, fill stud cavities inside the plenum with flexible insulation.
 - When fiberglass duct board is used to line/seal the platform, additional insulation in the wall cavities is not necessary.
 - An alternative to lining the platform is to install a return duct between the filter grille and the FAU return intake.
 - c. Staircase returns
 - Line and seal the staircase cavity when feasible, or
 - Install ducting from the return grille to the HVAC intake.
13. Evaporative coolers
- a. When the FAU shares the duct system with an evaporative cooler, a damper should be in place that makes it possible to isolate the cooler from the HVAC ducts (preferably a positive damper controlled from inside the home).
14. Attic and crawlspace accessibility
- a. Attic clearance
 - Clearance should be at least 24" from the top of the ceiling joists to the bottom of the roof rafters at the highest point.
 - Any obstruction in the attic, such as cross members of truss systems and ductwork, should provide an opening with a minimum dimension of 18".
 - b. Under-floor crawlspace clearance
 - Clearance should be at least 18" from the ground to the bottom of the floor joist system.
 - Any obstruction in the crawl area, such as an HVAC duct, should provide a minimum clearance of 12", to crawl over or under it.

13.6 Additional Health & Safety Considerations

1. General Safety
 - a. Attic and under-floor crawl area must be free of the following conditions:
 - Hazardous insect or rodent infestation.
 - Hazardous electrical condition.
 - Unsafe structural members.

- Excessive ground moisture (standing water or mud).
 - An unsanitary condition, such as: (i) sewage waste on the ground, and (ii) excessive animal feces or any other unsanitary condition.
 - Do not access or work in an area that is unsafe.
2. All federal, state, local and program specific health and safety regulations should be followed.
 3. Asbestos Caution: When ductwork contains PACM or is made of asbestos containing material (ACM), pressure diagnostics (duct testing and blower door testing) are unsafe and unfeasible.

14. Duct Insulation

14.1 General Requirements

1. Must meet program requirements for minimum thermal resistance or greater if required by local code (see Program Specifications).
2. Home must be served by an existing ducted HVAC system; new systems installed when no prior equipment was present will not qualify.

14.2 Material Standards

1. All Materials
 - a. Maximum flame-spread index of 25 and smoke-developed index of 50, per ASTM E84, UL 723, OR NFPA 255.
2. Insulation
 - a. Flexible or rigid fiberglass.
 - b. Facing shall be FSK foil or vinyl (on rigid ducts; not on heat-only ducts).
3. Duct tape
 - a. Metallic or FSK duct tape only; cloth tape not allowed.
 - b. FSK tape on FSK-faced ducts.
 - c. For rigid fiberglass:
 - UL labeled "181A-P"
 - Minimum width 2".
4. Drawbands
 - a. Weather- and UV-resistant (e.g., black) nylon duct straps/ties rated for outdoor use.
 - b. Service temperature rating of 165°F minimum.
 - c. Loop tensile strength rating of 50 pounds minimum.
 - d. Listed for exterior applications when installed outdoors or in sun struck locations in attics.
5. Vapor barrier/retarder
 - a. Maximum perm rating (permeance) of 0.5.
 - b. Vapor retarder required for all refrigerated air conditioning ducts.
 - c. Vapor retarder shall be placed on outermost side of insulation (not allowed for rigid metal heating duct).

Measure Feasibility

This measure may not be feasible if:

- Existing ducts are made of asbestos-containing materials (ACM).
- Metal ducts and/or components are insulated with ACM, and work on the duct system would cause asbestos to become friable or discharged into the air.
- The existing duct insulation is functioning properly, and it is installed in accordance with current standards.
- Ductwork is inaccessible.
- Duct system has been abandoned.
- Duct system is damaged or deteriorated beyond repair (cannot be brought into conformance with Section 2).
- Ducts are located in conditioned space.
- Ducts are exposed to weather.
- Do not insulate the following:
 - Ducts in conditioned space.
 - Leaking ducts.
 - Ducts with broken or missing supports.
 - Ducts made or insulated with asbestos.
- No action shall be taken which will cause asbestos to be friable or discharged into the air.
- Customer refuses.

14.3 Installation Standards

1. Duct leaks must be sealed first.
2. Broken or missing duct supports must be repaired.
3. All air ducts, air connectors, plenums, distribution boxes and system components shall be insulated.
 - a. Insulation is to be installed on uninsulated portions of the duct system located outside of conditioned space.
 - b. Rigid air conditioning metal ducts located entirely within conditioned space may be insulated to prevent condensation.
4. 100% coverage required without gaps or openings.
5. Compression:
 - a. Maximum 20% overall compression by attachments.
 - b. Maximum 50% compression in corners/bends.
6. Duct wrap shall not obstruct CVA vents.
7. Required clearance between faced duct insulation and HPDs:
 - a. 6" clearance required from single-wall vent pipe.
 - b. 1" clearance from Type "B" double-wall gas vent pipe.
 - c. 3" clearance from all other heat producing devices.
 - d. Follow insulation and pipe manufacturer's instructions, and local code, if more stringent.
8. Attachment requirements
 - a. Flexible insulation
 - Insulation shall be permanently secured, at maximum 18" intervals, with any of the following:
 - Drawbands
 - Non-corrosive wire, 20-gauge minimum.
 - Pressure-sensitive tape (e.g., metallic or FSK) wrapped a minimum of 3 time around the circumference.
 - Rust-resistant nails: Nails penetrate and extend through both layers of insulation.
 - b. Spirally wrapped insulation
 - Wraps of un-faced insulation shall overlap each other at least 2".
 - Insulation shall be mechanically secured as needed to prevent gaps or openings, e.g., spiral wrap wiring.
 - c. Parallel wrapped insulation
 - Faced wraps shall overlap at least 1" and be secured and sealed with pressure-sensitive tape or as prescribed by manufacturer.

- Un-faced wraps shall:
 - Overlap each other at least 1".
 - Be mechanically secured with fasteners (draw bands, wire, nails, or staples) installed maximum 18" apart along the lengthwise seam (overlap) of the insulation.
9. Vapor barrier/retarder (Jacket)
- a. Jacket splices
 - When two jacket ends are joined together, they shall overlap at least 2".
 - Overlap shall be secured/sealed with a drawband and/or 3 staggered wraps of pressure sensitive tape.
 - b. Duct termination
 - Jacket shall be pulled over insulation and secured/sealed to fitting with one or more of the following:
 - A drawband.
 - 3 staggered wraps of pressure sensitive tape.
 - Mastic and mesh tape.
10. Duct supports—reference standards
- a. Current California Mechanical Code (CMC), Chapter 6, Duct Systems.
 - b. Current California Energy Commission (CEC) Building Energy Efficiency Standards Residential Compliance Manual.
11. Duct supports—Abbreviated Guidelines Based on the CMC and Title 24
- a. Flexible ducts
 - Where feasible, do not hang flexible ducts.
 - Supports must not constrict inner diameter of duct nor cut the jacket.
 - Sheet metal support straps and saddles: Minimum 26-gauge and 1.5" wide.
 - Horizontal Flexible Ducts:
 - Ducts must be at least 4" above earth and protected from physical damage.
 - When 4" clearance cannot be achieved, minimum 2" thick rigid foam board insulation must be placed under the duct.
 - Maximum 4' spacing between supports; maximum 2" sag between supports.
 - Ducts resting on ceiling joists and truss members must meet sag limitation, and must not be wedged between truss members that restrict inner diameter.
 - Vertical Flexible Ducts:
 - Maximum 6' spacing between supports.
 - b. Rigid round metal ducts—Horizontal

- Ducts up to 10" diameter: Galvanized steel straps, same gauge as duct, minimum 1" wide, or 18-gauge galvanized steel wire.
 - Ducts 11" to 40" diameter: Galvanized steel straps, same gauge as duct, minimum 1" wide, or 8-gauge galvanized wire tied to 1" galvanized steel band surrounding the duct.
 - Maximum 10' spacing between supports.
- c. Rigid round metal ducts—Vertical
- Ducts up to 10" diameter: 18-gauge galvanized steel straps, minimum 2" wide.
 - Ducts 11" to 20" diameter: 16-gauge galvanized steel straps, minimum 2" wide.
 - Maximum 12' spacing between supports.
- d. Rigid rectangular metal ducts
- Horizontal: Maximum 10' between supports, secured to sides of duct with sheet metal screws, rivets, or bolts.
 - Vertical: Maximum 12' spacing between supports.
- e. Horizontal plenums (metal and duct board)
- May not rely on FAU for support.
 - Must be independently supported at each end, and intermediately if over 10' in length.
12. Exposed Ducts - CMC Chapter 6 and Appendix A. Installation Standards
- a. Uninsulated ducts located outdoors
- When external insulation is installed, materials shall be:
 - Listed for exterior applications.
 - Selected and installed in conformance with manufacturer's instructions and local code.
- b. Ducts located in areas Subject to human contact
- When fiberglass insulation is installed, it shall be covered with Tyvek or other vapor permeable material.
 - Fiberglass edges shall not be left exposed in the living space.

14.4 Additional Health & Safety Considerations

1. No attempt shall be made to patch, repair, or re-tape old ducts that are:
 - a. Made of PACM or asbestos-containing materials (ACM), or
 - b. Sealed and/or insulated with PACM or ACM.

15. Water Heater Replacement—Gas

15.1 General Requirements

1. Must meet current Title 24 Standards, state code, local code and program requirements (see Program Specifications).

15.2 Material Standards

1. Replacement of domestic hot water systems shall comply with current Title 24 Building Energy Efficiency Standards, meet or exceed Energy Star[®] standards when applicable¹⁶ and meet program requirements for Energy Factor (see Program Specifications).
2. When specifying a combination water and space heating system, specify a combined appliance efficiency (CAE) rating of 0.85 or higher.
3. Insulate all accessible pipes per standards specified in Section 17 (Water Heater Pipe Insulation)
4. Materials
 - a. Storage water heaters:
 - Minimum capacity 30 gallons
 - Flammable Vapor Ignition Resistant (FVIR) unit or closed combustion.
 - First Hour Rating shall comply with the greater of:
 - Manufacturer’s sizing recommendations, or
 - Local code requirements.
 - Storage units First Hour Rating shall be no less than the California Plumbing Code (CPC) minimum guidelines, as shown in Table 15-1.

Table 15-1: Storage Water Heater Minimum Capacity (First Hour Rating)

Number of Bathrooms	1 to 1.5			2 to 2.5				3 to 3.5			
	1	2	3	2	3	4	5	3	4	5	6
First Hour Rating ¹⁷	42	54	54	54	67	67	80	67	80	80	80

- b. Tankless water heaters:
 - Unit capacity (Btuh Rating) shall be:
 - Based on hot water usage in the residence, and

¹⁶ Current California Energy Commission *Reference Appendices, Building Energy Efficiency Standards, Title 24.*

¹⁷ First Hour Rating, the water heating capacity expressed in gallons, is the amount of hot water the heater can supply per hour (starting with a tank full of hot water). The First Hour Rating is shown on the yellow Energy Guide label.

- In accord with manufacturer's guidelines and local code.
- UL Listed.
- c. T&P Relief Valve
 - Listed and manufactured to ANSI Z21.22.
 - Conformance with sizing/pressure requirements of the water heater listing.
- d. Automatic Gas Shutoff Valve
 - Where allowed by the AHJ.
 - Listed and manufactured to ANSI Z21.22.
 - Conformance with sizing/pressure requirements of the water heater listing.
- e. Vent systems
 - UL listed vent connectors, components, and Type B vent pipes.
 - Nonmetallic systems shall conform to ASTM D 1785 and D 2665.
- f. Gas piping and valves
 - Gas valves shall be listed (e.g., by UL) and AGA or CSA certified.
 - Flexible connectors shall be listed (e.g., by IAPMO) epoxy-coated or stainless steel units.
 - Fuel-gas gas piping shall comply with current CMC Chapter 13.
 - Copper gas lines and butt-soldered joints not allowed.
- 5. Minimum warranty
 - a. Five (5) year written manufacturer's warranty.
 - b. One (1) year written labor and parts warranty.

15.3 Installation Standards

1. A building permit for the installation shall be obtained from and finalized by the authority having jurisdiction.
2. Installation shall be in conformance with:
 - a. Product listing.

Measure Feasibility

Gas water heater replacement may not be feasible if:

- Fuel used by the existing unit is not supplied by the utility.
- Required drainage cannot be achieved.
- Temperature & pressure regulation cannot be achieved.
 - Drain line for T&P valve or drain pan cannot be properly terminated to outdoors, or to an approved indoor drain, and/or
 - An automatic gas shutoff valve and pressure relief valve cannot be installed in lieu of a T&P valve and drain line.
- Required access, clearance, or combustion air cannot be provided.
- For a unit on a raised floor or in an attic: structure cannot properly and safely support the installation.
- No suitable mounting locations for seismic bracing available.
- A safety hazard is present which cannot be repaired (e.g., vent system defect, nonconforming gas piping).
- A required watertight pan cannot be installed under the unit.
- A plumbing condition exists which prevents achieving satisfactory water pipe connections.
- A whole house fan exhausts into the attic, the existing water heater is in the attic, and relocation or installation of a closed combustion unit is not feasible.
- The unit is a central water heater serving more than one dwelling unit.

- b. Manufacturer's instructions and specifications.
 - c. The California Mechanical Code (CMC), the California Plumbing Code (CPC), and Local code.
 - d. Orifice shall be verified to be sized for natural gas, when natural gas is present and propane when propane is present.
 - a. If qualifying product is replacing an existing unit, the existing unit must be natural gas.
3. Location
- a. All units
 - Clearances shall be in compliance with listing requirements, manufacturer's instructions, and local code.
 - Location shall be structurally sized/constructed to safely support weight of the tank.
 - Units supported from the ground shall rest on a level concrete pad, which extends at least 3" above grade.
 - b. Storage units
 - Storage units shall be located to permit seismic bracing per Item 8 below.
 - c. Water heaters in enclosures
 - Access door shall be at least 24" wide, or
 - Wide and high enough to accommodate removal of the water heater.
 - d. Water heaters in attics
 - Water heater shall not be installed in attic with whole house or attic exhaust fan, unless it has a sealed combustion chamber.
 - Access shall be in compliance with CPC Section 509.4 (i.e., minimum 22" x 30" opening, unobstructed passageway, and minimum 30" x 30" working platform on the front service side of the water heater).
 - e. Water heaters in bedrooms and bathrooms
 - An open combustion water heater shall not be installed in a bedroom or bathroom, unless it is inside a dedicated closet with a weather-stripped self-closing door, and combustion air is drawn from outdoors.
 - f. Water heaters in garages and hazardous locations
 - When installed in a garage, unit shall be elevated so that the combustion burner is at least 18" above the finished floor, or as instructed by manufacturer.
 - Units in locations subject to damage (e.g. by an automobile) shall be elevated or protected with barriers per code.
4. Installed position
- a. The tank shall be installed:
 - Plumb and level in a stable position.
 - With information labels and controls facing outward.

5. Plumbing—All units
 - a. Only new parts shall be installed.
 - b. Threaded fittings shall be sealed with Teflon® tape or nontoxic pipe joint compound.
 - c. A cold water supply shutoff valve shall be installed if not present.
 - d. Flexible connectors shall be used to connect tank to rigid hot and cold-water lines.
 - e. Dielectric insulators shall be installed on water piping connections to the tank when required by local code.
6. Drain pan—storage units
 - a. A watertight pan of corrosion resistant material shall be installed when the water heater is located in:
 - An attic or on a floor-ceiling assembly, or
 - Other location for which a pan is required by local code.
 - b. A minimum 3/4" diameter drain line from the pan shall be installed with a continuous downward slope to the exterior, or to a drain system, in accordance with local code.
 - c. Drain pan shall not inhibit proper combustion air flow.
7. Temperature and pressure regulation
 - a. Either of the following shall be installed in conformance with the water heater manufacturer's instructions and local code:
 - A Temperature and Pressure (T&P) relief valve, or
 - An Automatic Gas Shutoff Valve and Pressure-relief valve.
 - b. The T&P relief and Automatic Gas Shutoff Valve shall:
 - Be listed and manufactured to ANSI Z21.22.
 - Meet the sizing/pressure requirements of the water heater listing.
 - c. T&P relief valve drain line
 - Line shall be galvanized steel, hard drawn copper, or CVPC.
 - Internal diameter of the line and fittings shall equal or exceed diameter of the relief valve outlet.
 - The line shall drain fully by gravity and shall not be trapped, and it shall not discharge into the drain pan.
 - Drain line shall terminate outside the building, or in an approved drain system, with the terminal end:
 - No more than 24", nor less than 6", above the surface, and
 - Unthreaded and pointing downward.
 - b. House line pressure

- House line pressure shall be verified to be in compliance with the water heater manufacturer's specifications.
 - A house line pressure regulator shall be installed or replaced, when needed to limit water pressure to the tank at the specified maximum.
8. Seismic bracing
- a. The tank shall be braced (strapped or anchored) to resist horizontal movement during an earthquake.
 - b. Bracing shall be: (i) installed per manufacturer's instructions and local code, and (ii) securely attached to structural framing or ledger board.
 - c. Strap locations
 - Two straps shall be installed: one within the upper third of the tank, and one within the lower third of the tank.
 - The lower strap shall be at least 4" above the gas control valve.
9. Insulation
- a. Hot and cold water pipes
 - Pipe insulation shall be installed in accordance with Section 17 (Water Heater Pipe Insulation).
 - b. Tank
 - For Water Heater replacement, when external insulation is unfeasible (minimum R-16 internal insulation required).
10. Combustion and ventilation air (CVA)
- a. Combustion air shall be supplied in conformance with current CMC Chapter 7 and applicable program standards, manufacturer's instructions and local code. Reference CPC Section 507.0 and CMC Chapter 7.
 - b. See Combustion Appliance Safety Testing in Inspection Guidelines, Chapter 5, for guidelines.
 - c. Obstructions in existing combustion air vents (e.g., overblown insulation) shall be cleared as needed to provide required NFVA.
11. Gas lines, fittings and valves
- a. All units
 - All gas lines, flexible gas connectors, fittings and valves shall be installed per manufacturer's instructions and local code.
 - Manual gas shutoff valve shall be within 3' of the appliance and in the same room where the appliance is located.
 - A flexible gas connector shall be located between the gas control valve and shutoff valve.

- Readily-accessible sediment trap (drip leg) shall be located just ahead of flexible gas connector, when required by local code.
 - All new and affected gas lines, flexible gas connectors, fittings, and valves shall be checked for gas leaks using a method approved by the local jurisdiction.
- b. Tankless water heaters
- Gas meter and gas line shall be sized to accommodate Btuh Input of the unit.
 - Sizing shall comply with manufacturer's instructions and local code.
12. Vent system (Conventional Homes)
- a. All Vent Systems
- Appliance venting shall be in conformance with manufacturer's instructions.
 - Shall comply with current CMC, Chapter 8.
- b. Vent dampers shall not be used.
- c. Vent pipe (newly-installed must be Type B) shall terminate at least 5' in vertical height above the draft hood.
- d. Horizontal vent connectors shall not dip or sag and shall slope upward a minimum of 1/4" per foot of horizontal length.
- e. Type B and BW Gas Vents
- Vents with listed vent caps 12" in size or smaller shall comply with current CMC regulation.
- f. Vents shall terminate above a roof (minimum 1' above for slopes up to 6/12), provided the vent is located at least 8' from a vertical wall or similar obstruction.
- g. Vents within 8' of a vertical wall or obstacle must terminate:
- At least 2' above the highest point where they pass through the roof, and
 - At least 2' higher than any portion of the building within 10'.
- h. Vent terminations located within 10' of outside-air, makeup-air, and forced-air inlets shall terminate at least 3' above such inlets.
- i. A gas vent extending through an exterior wall shall not terminate adjacent to the wall or below the eaves.
- j. All gas vents shall extend through the roof flashing, roof jack, or roof thimble and terminate with a listed cap or listed roof assembly.
- k. Through-wall mechanical draft vent terminals
- A mechanical draft venting system shall terminate at least 3' above any forced air inlet (e.g., evaporative cooler) located within 10'.
 - A mechanical draft venting system (other than direct vent) shall terminate the following minimum distances from doors, operable windows and gravity inlets into a building:
 - 1' above, or 4' below, or

- o 4' horizontally from the door/window/inlet.
 - l. A common vent system serving both the Water Heater and another appliance shall be sized in accordance with local code and CMC Chapter 8.
 - m. Tankless water heaters
 - Vent system, and location of outdoor unit, shall conform to manufacturer's instructions and local code.
13. Water heater compartment
- a. Compartment floor
 - The floor shall be checked for structural integrity and strength adequate to support a storage water heater.
 - The floor must be secure, stable, and level enough to properly and safely support the water heater.
 - If unsafe, it shall be corrected before a new storage water heater is installed.
 - b. Drip pan and lower CVA vent
 - A drip pan shall be installed and drained per Housing and Community Development (HCD) regulations.
 - If the drip pan covers existing CVA venting in the floor, a new Lower CVA vent shall be installed within 12" of the compartment floor.
14. On-demand hot water recirculation pumps
- a. Install listed pumps (UL, IAPMO, or equivalent) that are AB-1953 Low-Lead compliant, and Energy Star[®] qualified. Must be designed to connect to existing plumbing, without installation of new hot/cold water lines.
 - b. Obtain a building permit, and install in accordance with local code and manufacturer's instructions.
 - c. Install at the usage point (e.g. bathroom) furthest from the water heater.
 - d. Ensure that water pressure at the installation site is in compliance with manufacturer's recommendation.
 - e. If there is more than one hot water system, or hot water is delivered through a branched system, a pump should be installed to serve each system/branch.
 - f. If hot water is supplied by a tankless unit, the pumping system must be sized with adequate flow to activate the tankless heater. If that is not practical, recirculation pump installation is not feasible.
 - g. Pump shall be controlled by a timer (with manual override), a sensor, or a manual activator, in accordance with customer's wishes.
 - h. If a timer is used, it must be set in accordance with occupant's schedule, with the pump operating automatically only during times when hot water is needed.

15.4 Post-Installation Standards

1. Water heater operation
 - a. The water heater shall be tested and shall perform properly.
 - b. Operation shall be explained and demonstrated to the customer, including:
 - Operation of all user-accessible controls.
 - Routine maintenance recommended by the manufacturer.
 - Manufacturer's written instructions and warranty documents shall be provided to the customer in a plastic jacket attached to the side of the water heater tank.
2. Combustion appliance testing shall be conducted per Inspection Guidelines Chapter 5 (CAS Testing).
3. Cleanup
 - a. Paint dust and chips, scraps, and other debris resulting from installation of the water heater shall be cleaned up and removed from the premises—utilizing lead-safe practices when applicable.
 - b. All packing materials and installation debris shall be cleaned up and removed from the premises.
 - c. Household items moved for water heater installation shall be returned to their original positions.
 - d. All replaced equipment and parts shall be removed from the premises and disposed of properly.

15.5 Additional Health & Safety Considerations

1. All federal, state, local and program specific health and safety regulations should be followed.
2. Lead-safe practices shall be employed when working with pre-1978 painted materials per state codes T8 Section 1532.1 and T17 Section 36000, et seq.

16. Water Heater Replacement - Electric

16.1 Material Standards

1. Replacement of domestic hot water systems shall comply with Title 24 Residential Compliance Manual, shall meet or exceed Energy Star® standards when applicable and shall meet program standards (see Program Specifications).
2. All units and materials: UL Listed (or equivalent)
3. Conventional storage water heaters
 - a. Electric storage type
 - b. Minimum capacity 30 gallons
 - c. Minimum internal insulation R-16
4. Tankless water heaters:
 - a. Whole-house model to replace existing storage electric water heater, or existing electric tankless water heater, not point-of-use unit
5. Heat Pump storage water heaters
 - a. Minimum capacity 50 gallons
 - b. Minimum Energy Factor (EF) 2.0
 - c. Minimum internal insulation R-16
6. T&P relief valve:
 - a. Listed and manufactured to ANSI Z21.22.
 - b. Conformance with sizing/pressure requirements of the water heater listing.
7. Electrical wiring and overcurrent protection
 - a. Conformance with manufacturer's specifications and the current California Electrical Code (CEC).
8. Minimum warranty
 - a. Five (5) year written manufacturer's warranty.
 - b. One (1) year written labor and parts warranty.

Measure Feasibility

This measure may not be feasible if:

- Proper electrical service or wiring is not available.
- A required watertight pan cannot be installed under the unit.
- Drain line for T&P valve or drain pan cannot be properly terminated to outdoors, or to an approved indoor drain.
- Required access or clearance cannot be provided.
- For a heat pump water heater, a "semi-conditioned" space of adequate volume is not available.
- For a unit on a raised floor or in an attic: structure cannot properly and safely support the installation.
- Proper seismic bracing cannot be provided.
- An unsafe condition is present which cannot feasibly be repaired (e.g., substandard electrical circuit).
- A plumbing condition exists which prevents feasibly achieving satisfactory water pipe connections.
- The unit is a central water heater serving more than one dwelling unit.
- Customer refuses.

16.2 Installation Standards

1. General
 - a. A building permit for the installation shall be obtained from and finalized by the authority having jurisdiction.
 - b. Installation shall be in conformance with:

- Manufacturer’s instructions and specifications.
 - Current California Plumbing Code (CPC), and local code.
- c. If qualifying product is replacing an existing unit, the existing unit must be electric.
2. Water heater sizing
- a. Conventional and heat pump storage water heater capacity
- Unit shall comply with the greater of:
 - Manufacturer’s sizing recommendations, or
 - Local code requirements.
 - First Hour Rating shall be no less than the current California Plumbing Code (CPC) minimum guidelines, as shown in Table 16-1.

Table 16-1: Storage Water Heater Minimum Capacity (First Hour Rating)

Number of Bathrooms	1 to 1.5			2 to 2.5				3 to 3.5			
Number of Bedrooms	1	2	3	2	3	4	5	3	4	5	6
First Hour Rating ¹⁸	42	54	54	54	67	67	80	67	80	80	80

- b. Tankless water heater
- Unit capacity (Btuh Rating) shall be:
 - Based on hot water usage in the residence, and
 - In accord with manufacturer’s guidelines and local code.
3. Location
- a. All water heaters
- Clearances shall comply with listing requirements, manufacturer’s instructions, and local code.
 - Location shall be structurally sized/constructed to safely support the weight of the water heater in operating condition.
 - The floor shall be secure, stable, and level enough to properly and safely support the water heater.
 - If unsafe, it shall be corrected before a new water heater is installed.
 - Units supported from the ground shall rest on a level concrete pad, which extends at least 3" above grade.

¹⁸ First Hour Rating, the water heating capacity expressed in gallons, is the amount of hot water the heater can supply per hour (starting with a tank full of hot water). The First Hour Rating is shown on the yellow Energy Guide label.

- Earthquake bracing for storage units shall be installed per Section 15 (Water Heater Replacement – Gas).
 - b. Units in enclosures
 - Access door shall be at least 24" wide, or wide and high enough to accommodate removal of the water heater.
 - c. Units in attics
 - Access shall comply with current California Plumbing Code (CPC).
 - d. Units in garages and hazardous locations
 - Units in locations subject to damage (e.g. by an automobile) shall be elevated or protected with barriers per code.
 - e. Heat pump water heaters
 - Large-volume “semi-conditioned” space, such as a garage or basement.
 - Locate where temperature does not drop below 40°F, when possible.
 - Locate where a gravity condensate drain can be installed, when possible.
 - Room volume must satisfy manufacturer’s specifications for CVA. See Inspection Guidelines, Chapter 4.
 - Discharge ducting to outdoors:
 - Allowed only when approved/recommended by water heater manufacturer.
 - Shall be designed and installed in accordance with manufacturer’s instructions.
 - Shall not cause open combustion appliances located in the same space to spill or draft improperly.
4. Installation
- a. The tank shall be installed:
 - Plumb and level in a stable position.
 - With minimum clearances per manufacturer’s instructions.
 - With information labels and controls facing outward.
 - b. Plumbing
 - All units
 - Only new parts shall be installed.
 - Threaded fittings shall be sealed with Teflon® tape or approved nontoxic pipe joint compound.
 - A cold-water supply shutoff valve shall be installed if not present.
 - Flexible connectors shall be used to connect the tank to the rigid hot and cold-water lines.

- Dielectric insulators shall be installed on water piping connections to the tank when required by local code.
 - Heat pump water heaters
 - Condensate drain shall be installed in accordance with manufacturer's instructions and local code.
 - When a gravity drain is not possible, a condensate pump and drain line shall be installed in accordance with water heater and pump manufacturers' instructions.
 - c. Drain pan
 - Storage units
 - A watertight pan of corrosion resistant material shall be installed when the water heater is located in:
 - An attic or on a floor-ceiling assembly, or
 - Other location for which a pan is required by local code.
 - A minimum 3/4" diameter drain line from the pan shall be installed with a continuous downward slope to the exterior, or to a drain system, in accordance with local code.
 - Drain pan shall not inhibit proper combustion air flow.
 - Tankless Units: Floor protection shall be provided in accordance with manufacturer's recommendation and local code requirements.
5. Temperature and pressure relief
- a. A temperature and pressure (T&P) relief valve shall be installed in conformance with the water heater manufacturer's instructions and local code.
 - b. T&P relief valve drain line
 - Line shall be galvanized steel, hard drawn copper, or CVPC.
 - Internal diameter of the line and fittings shall equal or exceed diameter of the relief valve outlet.
 - The line shall drain fully by gravity, it shall not be trapped, and it shall not discharge into the drain pan.
 - Drain line shall terminate outside the building, or in an approved drain system, with the terminal end:
 - No more than 24", nor less than 6", above the surface, and
 - Unthreaded and pointing downward.
 - c. House line pressure
 - House line pressure shall be verified to be in compliance with the water heater manufacturer's specifications.
 - A house line pressure regulator shall be installed or replaced, when needed to limit water pressure to the tank at the specified maximum pressure.

6. Seismic bracing
 - a. The tank shall be braced (strapped or anchored) to resist horizontal movement during an earthquake.
 - b. Bracing shall be:
 - installed per manufacturer's instructions and local code, and
 - Securely attached to structural framing or ledger board.
 - c. Strap locations
 - Two straps shall be installed: one within the upper third of the tank, and one within the lower third of the tank.
 - The lower strap shall be at least 4" above the gas control valve.
7. Insulation
 - a. Hot and cold-Water pipes
 - Pipe insulation shall be installed in accordance with Section 17 (Water Heater Pipe Insulation).
 - b. Tank
 - For water heater replacement, tank insulation is unfeasible (minimum R-16 internal insulation required).
8. Electrical supply
 - a. All electrical wiring, connections, and overcurrent protection shall be in conformance with manufacturer's instructions and local code.
 - b. The branch circuit supplying power to the unit shall have:
 - Capacity of at least 125% of the nameplate rating of the water heater.
 - Properly-sized conductors for the overcurrent protection used.
 - c. The water heater shall be:
 - Protected by a fuse or circuit breaker of the proper amperage rating.
 - Properly grounded to the electrical service.

16.3 Post-Installation

1. Water heater operation
 - a. The water heater shall be tested and shall perform properly.
 - b. Operation shall be explained and demonstrated to the customer, including:
 - Operation of all user-accessible controls.
 - Routine maintenance recommended by the manufacturer.
 - Manufacturer's written instructions and warranty documents shall be provided to the customer in a plastic jacket attached to the side of the water heater tank.

2. Cleanup

- a. Paint dust and chips, scraps, and other debris resulting from installation of the water heater shall be cleaned up and removed from the premises—utilizing lead-safe practices when applicable.
- b. All packing materials and installation debris shall be cleaned up and removed from the premises.
- c. Household items moved for water heater installation shall be returned to their original positions.
- d. All replaced equipment and parts shall be removed from the premises and disposed of properly.

16.4 Additional Health & Safety Considerations

1. All federal, state, local and program specific health and safety regulations should be followed.
2. Lead-safe practices shall be employed when working with pre-1978 painted materials per state codes T8 Section 1532.1 and T17 Section 36000, et seq.

17. Water Heater Pipe Insulation

17.1 General Requirements

1. Must meet state code, local code and program requirements for thermal resistance (see Program Specifications).

17.2 Material Standards

1. All materials
 - a. Maximum flame-spread index of 25 and maximum smoke-developed index of 450, per ASTM E84, or UL 723, or UBC Standard 8-1. 19
 - b. All material shall be corrosion-resistant.
2. Insulation
 - a. Preformed foam (e.g. closed cell polyethylene) conforming to ASTM C534.20
 - b. Compliance with current Title 24 Building Energy Efficiency Standards Residential Compliance Manual.
 - c. Inside diameter of preformed material shall be appropriate for the size pipe being insulated, so it fits against the pipe without air gaps.
 - d. Minimum thermal performance rating of 180°F.
3. R-value for existing tank and pipes
 - a. R-4 minimum for pipes up to 1-1/2" in diameter.
 - Minimum 1" insulation wall thickness.
 - *Exception:* 3/4" wall thickness acceptable if R-value requirement is met.
 - b. R-6 minimum for pipes greater than 1-1/2" in diameter.
 - Minimum 1-1/2" insulation wall thickness.
4. Tape
 - a. Tape specified by insulation manufacturer, or
 - b. Minimum 2" wide pressure-sensitive metallic tape meeting or exceeding strength and adhesive requirements of UL 181A-P or UL 181B-FX.
 - c. Cloth duct tape and electrical tape are not allowed.

Measure Feasibility

This measure may not be feasible if:

- Plastic piping (e.g., CPVC) is present in the cold or hot water line to/from the tank.
- Leak present in tank or water pipe(s).
- Functioning pipe insulation is present on the first 5 feet of accessible piping to/from the tank.
- Water heater pipes are exposed to the elements (e.g., sunlight and precipitation in outdoor location).
- Less than 1 foot of continuous insulation can be installed.
- Pipes are inaccessible, or the configuration prevents proper installation.
- Customer refuses.

¹⁹ American Society for Testing of Materials International, *ASTM E84 - 11a Standard Test Method for Surface Burning Characteristics of Building Materials*, <http://www.astm.org/Standards/E84.htm>

²⁰ Current California Energy Commission, Building Energy Efficiency Standards Residential Compliance Manual

5. Glue must be compatible with insulation material and manufacturer's instructions.
6. Ties and sleeves
 - a. UV-resistant plastic cable ties.
 - b. Corrosion-resistant wire (minimum 18 gauge).
 - c. Corrosion-resistant metal sleeves.
7. Materials not allowed: Sheet or semi-molded insulation, heat tape, and strap insulation.

17.3 Installation Standards

1. Check for safety concerns that prohibit pipe insulation.
2. Remove old poorly-functioning pipe insulation.
3. Install all insulation materials in accordance with manufacturer's recommendations and recognized industry practices.
4. Pipes to be insulated
 - a. All water heaters (Including Tankless)
 - Install insulation on hot and cold-water pipes which are free of leaks and:
 - Connected to the water heater.
 - Under continuous water pressure (storage units only).
 - Install insulation on both rigid and flexible lines, as feasible.
5. Coverage requirements
 - a. Cover all accessible portions of each pipe (hot and cold) in unconditioned space.
 - b. Begin at the tank, unless prevented by clearance requirement (see Item **Error! Reference source not found.**).
 - c. Cover elbows and curves without gaps.
 - d. Cover valves, but leave handles clear to operate freely.
6. Coverage Restrictions
 - a. All Units
 - Do not cover the following with insulation and attachments:
 - Temperature and pressure (T&P) relief valve, or automatic gas shutoff valve.
 - Leaking pipes, valve handles, control and safety devices, T&P drain line.
 - b. Gas units
 - Maintain clearances per Table 17-1, or as specified by the pipe listing.
 - Bend flexible lines away from the vent pipe as feasible to allow installation of more insulation closer to the tank.

Table 17-1: Clearance between Insulation and Pipe/Component

Pipe/Component	Clearance from Insulation
Single-wall Pipe	6"
Type B Double-wall Pipe	1"
Type L Double-wall Pipe	3"
Draft Hood Opening	Shall not be obstructed

7. Insulation position and sealing
 - a. Install insulation materials with continuous, full-length pieces if possible (rather than butting together smaller pieces).
 - b. Position slits downward on horizontal pipe.
 - c. Miter and/or notch insulation on bends, corners, and joints to provide complete closure.
 - d. All mitered sections of insulation must be equivalent in thickness and composition to that installed on straight pipe runs and must be sealed at seams.
 - e. Install transition pieces firmly to ensure complete, tight fit over all piping surfaces.
 - f. Firmly secure insulation with plastic ties, tape, wire, or sleeves.
 - g. Glue or tape all slits and joints to achieve complete closure.
 - h. Use tape to seal bends, 90° elbows, and joints.
8. Attachment options
 - c. Install ties and tape:
 - Within 1" of each end, and a maximum of 12" apart.
 - With 1/4" total compression at ends only.
 - b. Sleeves:
 - Do not compress insulation, except for 1/4" total compression at ends.

17.4 Additional Health & Safety Considerations

1. Gas water heaters
 - a. Unit must pass combustion appliance safety (CAS) testing, per Inspection Guidelines, Chapter 5.
 - b. Correct unsafe conditions that make tank insulation unfeasible, before installing water heater pipe insulation.
2. Electric Water Heaters
 - a. Correct unsafe conditions (including hazardous electrical wiring) that make tank insulation unfeasible, before installing water heater pipe insulation.
3. Do not install pipe insulation on a water heater standing on a substandard, weak, damaged wooden floor, especially if the tank is leaning.

18. Low-Flow Showerheads

18.1 General Requirements

1. Must meet state, local and program requirements (see Program Specifications).

18.2 Material Standards

1. Compliance with:
 - a. Current Title 24 Residential Manual.
 - b. WaterSense standards and WaterSense labeling.
2. All showerheads
 - a. Non-aerating and “self-cleaning” type, or cleanable while on the shower arm.
 - b. Ball Joint: Metal (e.g., chrome-plated brass).
 - c. Flow Rate
 - Maximum: 2.0 gpm at 80 psi.
 - Minimum: 1.2 gpm at 60 psi.
 - d. Flow-restricting Device: Factory-installed, mechanically-retained, and not removable.
3. Hand-held showerheads
 - a. Flexible vinyl or PVC hose at least 48" long, reinforced (e.g., with nylon), and capable of swiveling at both ends.
 - b. Mounting bracket of heavy-duty thermoplastic (e.g., ABS) or equivalent, designed to attach to shower arm (not the wall), with metal swivel ball (e.g., chrome-plated brass).
4. Shower arm adapters: Metal (e.g., chrome-plated brass) with 5/8" long male pipe threads, and minimum taper of 3% on showerhead end.
5. Shower control valve ("Trickle Valve")
 - a. Chrome-plated brass.
 - b. Designed to fit standard 1/2" showerheads and arms.
 - c. Flow rate from 2.0 gpm to a trickle.
 - d. May be separate or built into the showerhead.
6. Thermostatically-controlled Shower Valve (TSV): Selected and installed in accordance with Section 19 (TSVs).
7. Minimum three-year warranty on all products.

Measure Feasibility

This measure may not be feasible if:

- Existing showerhead is required for medical reasons.
- Existing showerhead flow rate is 2.0 gpm or less.
- Existing shower arm is plastic and is likely to break if removed.
- Shower is not mechanically functional or contains physical defects likely to result in water leaks—and correction of defect is not feasible.
- Piping is in such poor condition that showerhead installation will cause plumbing problems—and corrections are not feasible.
- Water pressure exceeds maximum specified by showerhead manufacturer or local code—and installation of a pressure regulator for the home is not feasible.
- Customer refuses.

18.3 Installation Standards

1. Contractor shall recommend the installation of a low-flow showerhead with TSV in all functional showers.
2. Do not install on a shower that is non-functional due to plumbing problems or due to physical defects that are likely to result in water leaks (such as broken or missing tiles, hole in the wall/surround, etc.)—unless the condition will be corrected.
3. Do not install on a plastic or damaged shower arm.
4. Hand-held Showerheads: Install when required due to physical limitations or when requested by customer.
5. Shower arms and adapters
 - a. Replace plastic shower arms.
 - b. Install an adapter when required.
 - c. Ensure that all components function properly, and connections do not leak.
6. Function
 - a. All components shall function properly (i.e., showerhead, shower arm adapter, TSV).
 - b. Threaded connections shall not leak.
7. Instructions and warranties
 - a. Occupants shall be:
 - Instructed in the proper operation and care of the installed components
 - Provided with manufacturer’s written instructions and warranty documents.
 - Warned that the TSV provides no safety upgrade or scald protection.
8. Cleanup and Disposal
 - a. All packaging materials and other debris shall be cleaned up and removed from the premises.
 - b. Replaced parts shall be removed from the premises.
 - *Exception:* Pre-existing showerhead, if replaced, may be left with the occupants upon their request.

18.4 Additional Health & Safety Considerations

None

19. Thermostatically-controlled Shower Valves (TSV)

19.1 General Requirements

1. Must meet state code, local code and program requirements (see Program Specifications).

19.2 Material Standards

1. Thermostatically-controlled shower valves shall be:
 - a. In compliance with the following standards:
 - Current ASME for plumbing supply fittings.
 - ASSE 1062 (Temperature Actuated, Flow Reduction Valves for Individual Supply Fittings).
 - b. Designed to automatically reset after each shower.
 - c. Made of metal (e.g., chrome-plated solid brass).
 - d. Threaded with a female 1/2" NPT to fit standard shower arms threaded with a male 1/2" NPT, in accordance with ANSI/ASME B1.20.1.
2. Temperature actuation
 - a. The TSV shall automatically reduce flow within 5 seconds to a trickle (0.25 GPM or less at 80 psi), in response to incoming water temperatures exceeding a preset actuation temperature no higher than 95 °F (35 °C).
 - b. Water flow shall be easily reactivated with a manual control.
3. Showerheads and shower arm adapters
 - a. When a TSV is installed in conjunction with a low-flow showerhead, installation of the showerhead (and adapter if used) shall comply with low-flow showerhead installation specifications described in Section 18 (Low-Flow Showerheads).
4. Minimum three-year warranty.

Measure Feasibility

This measure may not be feasible if:

- Existing shower arm:
 - Is made of plastic (including ball joint).
 - Is cracked, broken, or missing.
 - Requires removal.
- A shower arm adapter is needed, and standard metal adapters will not work.
- Piping is in such poor condition that Thermostatic Shower Valve installation could cause plumbing problems.
- Hot water is supplied by an on-demand or tankless water heater.
- Shower is a "sit-down" type shower
- Hot water is supplied by a continuously-circulating system, unless allowed by utility policy.

19.3 Installation Standards

1. A thermostatically-controlled shower valve (TSV) shall be installed on all functional showers if not already so equipped.
2. Thermostatic control can be achieved by installing a retrofit device or by installing a new showerhead with an integral device. Both integral and retrofit devices are referred to here as TSV.
3. Installation shall be performed:
 - a. In accordance with manufacturer's instructions.

- b. Only on functional showers—not on those not functional due to plumbing or physical defects.
4. Shower arm adapters shall be installed when required for installation of the TSV.
5. Threaded connections
 - a. All threads shall be cleaned and prepared for a good seal.
 - b. Teflon plumber’s tape or equivalent shall be used to seal connections; pipe dope and other liquid/paste sealing compounds are prohibited.
 - c. Connections shall be checked for leaks (i.e., at the TSV, shower arm, showerhead, and adapter).
6. Function
 - a. All components shall function properly (i.e., TSV, showerhead, and shower arm adapter).
 - b. Threaded connections shall not leak.
7. Instructions and warranties
 - a. Occupants shall be:
 - Instructed in the proper operation and care of all installed components.
 - Provided with manufacturer’s written instructions and warranty documents.
 - Warned that the TSV provides no safety upgrade or scald protection.
8. Cleanup and disposal
 - a. All packaging materials and other debris shall be cleaned up and removed from the premises.
 - b. Replaced parts shall be removed from the premises.
 - Exception: Pre-existing showerhead, if replaced, may be left with the occupants upon their request.

19.4 Additional Health & Safety Considerations

None

20. Carbon Monoxide (CO) Alarms

20.1 General Requirements

1. Must meet state code, local code and program requirements for location and quantity (see Program Specifications).

20.2 Material Standards

1. All alarms
 - a. Listed to latest ANSI/UL 2034 standard.
 - b. Included on the State Fire Marshal’s list of approved products. Alarm may be battery-powered, or AC-powered (line cord, plug-in, or hard-wired).
 - c. Alarm shall provide audible and visual warning signals when:
 - An internal malfunction occurs (i.e., electrical short or failure).
 - The electrochemical sensor's life has expired.
 - (Battery-powered) the battery power is low (reaches the end of its useful life).
 - d. If a combination CO and Smoke alarm is installed, the unit must comply with both CO and smoke alarm criteria.
 - e. Warranty
 - Minimum five-year manufacturer's written material and workmanship warranty.
 - (Battery-powered) Lithium ion battery with five-year warranty.

Measure Feasibility

This measure may not be feasible if:

- No combustion appliance is present in the home, *and* the dwelling does not have an attached garage.
- Existing CO alarms are less than five years old and provide protection in a required location.

20.3 Installation Standards

1. Building permit: When a permit is obtained for home-improvement work, CO alarm requirements of the local jurisdiction shall be followed.
 - a. The residential code requires that CO alarm protection be brought up to code (be present and functioning in all required locations) when a building permit is issued for more than \$1,000 in home improvements.
 - b. Each jurisdiction may have its own interpretation of this issue, so it is best to verify with the building department what they require.
2. Existing CO alarms
 - a. In a required location (see Item 6):
 - An alarm must be replaced if either if the following conditions exists:
 - It does not function properly when the “Test” button is pressed.
 - It functions, but it is past the replacement date, or the replacement date cannot be determined.
 - There is no requirement to replace a properly-functioning alarm in a required location.

- b. Not in a required location:
 - There is no requirement to test or replace the alarm. Installation Instructions
 - c. Installation must be in compliance with manufacturer's instructions regarding best location, mounting the alarm, minimum clearances, and locations to avoid.
 - d. When a conflict occurs between manufacturer's instructions and these standards or local code, the more restrictive provision must be followed.
3. Replacement date
 - a. The date by which the alarm should be replaced shall be written with permanent ink in the space provided on the alarm (typically on the bottom or side).
 - b. The replacement date is the date of installation plus the expected life of the alarm.
 - c. The expected life is 5 years or as stated by the manufacturer, if greater.
 - d. Protection shall be provided by properly-functioning CO alarms that are less than five years old.
 4. Battery compartment
 - a. The alarm manufacturer's original battery shall be used, and the battery compartment shall not be modified.
 5. Required areas of protection
 - a. California CRC Section 314 and 315 must be met.
 6. Alarm locations not allowed
 - a. On an outside wall, except as permitted by manufacturer's instructions.
 - b. In the furnace enclosure, garage, or an unconditioned space (other than a basement).
 - c. In a drafty location (e.g., near shell leaks, doors, windows).
 - d. Locations with limited air circulation, such as:
 - High on a gable wall, or near the peak of a vaulted ceiling.
 - Behind furniture or draperies, or behind a door in opened position.
 - Near an inside corner, in an alcove or closet, etc.
 - e. Storage area for household chemicals, paint, etc.
 - f. An area that may get hotter or colder than the high and low temperature limits specified by the manufacturer.
 - g. All other locations specified by the manufacturer to be avoided, such as areas that are excessively greasy, dusty or humid.
 7. Minimum distances
 - a. Alarm shall be located at least 1 foot away from the ceiling/wall junction.
 - b. Alarm shall be installed at least 3 feet away from:
 - The air path of supply registers, return grille, fresh air vents, and exhaust fans.

- The door or opening to:
 - a bathroom that contains a bathtub or shower,
 - a laundry room with washer or sink, or
 - Another moisture-producing source.
 - d. Alarm shall be installed at least 5' away from any of the following:
 - Cooking appliances (gas or electric).
 - An operable window or entrance door from outdoors.
 - Ceiling fan, or drafty locations (such as shell leaks).
 - A floor furnace (minimum 5' horizontally from the edge of the furnace grille).
 - Other furnace/heater or water heater (minimum 5' horizontally from, and not directly above).
 - Source of chemical odors, including a diaper pail or cat litter box.
 - e. Follow manufacturer's instructions, which may specify distances greater than 5'.
8. Acceptable positions
- a. Alarm must be accessible to reach the test and reset buttons, and to see visual display (colored lights and/or readout).
 - b. Interior walls
 - When possible, mount the alarm on a wall (interior only).
 - Mount the alarm 5' to 6' above the floor (measured to center of Alarm), but not within 1' of the ceiling.
 - *Exception:* Alarm may be mounted as low as 4' above the floor for adult occupants when: (a) one is handicapped and using a wheelchair or walker, or (b) a person's height justifies a lower location.
 - c. Ceilings:
 - Install CO alarm on an insulated ceiling only when there is no acceptable wall location
 - Do not install alarm on a poorly-insulated or uninsulated ceiling.
 - Alarms shall be centrally-located on the ceiling to the extent feasible, and at least 1' from the ceiling/wall junction.
 - d. Direct Plug-in: Receptacle should be located at least 4' above the floor or as specified by manufacturer.
9. Alarm mounting/installation
- a. Tamper-resistant mounting system recommended.
 - Alarm should be secured so it cannot be detached without removing one or more screws.

- Do not modify alarm manufacturer's original mounting system, battery compartment, or any other alarm components.
- b. Alarms with mounting plate
- Secure mounting plate with at least two standard screws that are anchored in the wall/ceiling.
 - Secure alarm to the mounting plate with one or more standard screws that extend through the alarm cover/body and into the mounting plate.
- c. Alarms without mounting plate: Secure alarm with at least two standard screws that:
- extend through the alarm cover/body and into the mounting surface, and
 - Are anchored in the wall/ceiling.
- d. Screw installation/anchoring—All except plug-in models
- Mounting screws should penetrate a framing member or solid wood sheathing when possible.
 - Screw-in or expansion anchor (e.g., drywall anchor, "molly" fastener, toggle bolt, etc.) should be used when screw does not penetrate solid wood.
 - Use standard mounting screws (Phillips or slotted), unless tamper-resistant mounting screws are required.
- e. Tamper-resistant power connection—Line cord and plug-in Units: Cord or alarm should be secured to the receptacle with at least one screw installed through an integral retainer or separate retaining bracket.
10. AC-powered Models
- a. Power Source: Circuit must be energized (hot) at all times, and must not be controlled by a GFCI breaker or receptacle.
- b. Raceway: Exposed wiring must be housed in a raceway that is UL Listed and rated for 120-volt service (nonmetallic raceway flame-resistant per UL 94-VO).
11. Alarm test
- a. Test the installed alarm (with alarm sound muffled).
- b. Alarm must function properly, in accordance with manufacturer's specifications.
12. Client education
- a. Provide both verbal and written instructions regarding:
- Maintenance of the alarm.
 - Testing of the alarm.
 - Response to an activated alarm.
 - Response to failure signal (how to request replacement of the alarm or battery should failure occur during the five-year warranty period).
 - Carbon monoxide.

- The effects of CO on the human body.
- The symptoms associated with CO poisoning.

20.4 Additional Health & Safety Considerations

1. Lead-safe practices shall be employed when working with pre-1978 painted materials per state codes T8 Section 1532.1 and T17 Section 36000, et seq.

21. Hardwired Lighting

21.1 General Requirements

1. Must meet current Title 24 Efficacy Standards, state code, local code and program requirements (see Program Specifications).

21.2 Material Standards

1. Fixture must be UL listed (and either Energy Star[®] qualified or Title 24 labeled).
2. Title 24 efficacy compliance
 - a. Fixture must allow for lamp replacement and utilize high efficacy pin-based lamps.
 - b. Light output shall be sufficient to maintain pre-existing light level, unless a lower level is acceptable to the customer.
3. Replacement recessed light fixtures must be rated ICAT (Insulation Contact Air Tight).
4. Fixtures and lamps must be fully warranted for one year from date of installation.

21.3 Installation Standards

1. Install fixtures in accordance with the current CEC and local code.
2. Interior locations: All wiring not inside a building cavity must be housed in a raceway.
3. Exterior locations
 - a. All wiring, controls, and components must be designed for exterior use.
 - b. Install the fixture in a manner which prevents water from entering or accumulating in wiring compartment, lamp holder or electrical parts.
4. Damp and wet locations
 - a. Install fixtures marked "Suitable for Damp Locations" out of direct contact with precipitation in partially protected locations (e.g., under canopies, in enclosed porches, and in carports).
 - b. Fixtures marked "Suitable for Wet Locations" may be:
 - Installed in damp locations and in unprotected outdoor locations more than 4' above the ground.
 - Exposed to precipitation and/or sprinklers.
5. Electrical requirements

Measure Feasibility

This measure may not be feasible if:

- Existing location of the fixture is not suitable.
- A thread-based light bulb will fit in the existing fixture.
- Electrical box is substandard and/or cannot be properly secured.
- Wiring is substandard, in a deteriorated condition, and/or rewiring is necessary.
- Circuit does not operate properly (e.g., defective switch) and correction is not feasible.
- Circuit is controlled by a solid-state timer.
- Circuit is controlled by a dimmer not compatible with available hard-wired CFL/LED fixtures, and replacement with a standard switch is not feasible.
- Existing fixture is in a wet location, and a grounding conductor is not available, and alternatives (plastic fixture or GFCI-protected switch) are not feasible or not allowed by local code.
- Existing fixture is not on the customer's electric meter/bill.
- Customer refuses.

- a. Fixtures shall be installed only in 110-120 volt circuits with proper grounding.
 - b. All connections shall be secured with properly-sized pressure splicing connectors (e.g., wire nuts) or “poke-in” or “stab-in” type electrical connectors.
 - c. Electrical tape may be used only as a supplement to a properly-installed pressure splicing connector; however, it shall not be relied upon to secure the connection.
 - d. Dissimilar wires (e.g., aluminum and copper) shall not be spliced together, except in accordance with manufacturer’s instructions and local code.
6. Dimmers, photoelectric sensors, and occupancy sensors
- a. Only CFLs/LEDs rated for use with dimmers, photoelectric sensors, and occupancy sensors shall be installed on circuits controlled by such devices.
 - b. When a dimmer or sensor is present in the light circuit, it must be:
 - in conformance with lamp manufacturer’s specifications, or
 - replaced by a standard switch.
7. All new and retrofit installations
- a. Installations shall comply with local code and the California Electrical Code (CEC).
 - b. Fixture shall be secured to a plate, electrical box, or to structural members—not to interior sheathing (plaster, drywall, etc.).
 - c. Installation shall not damage, disable, alter, or result in the removal of any existing emergency lighting fixture, lamp, inverter, standby generator, batteries, controls, etc.
8. Securing fixtures
- a. Mounting plates and fixtures attached directly to the electrical box:
 - Secure with a minimum of two fasteners.
 - Additional screws not required when fixture is attached by a properly-installed treaded nipple and nut.
 - b. Attached fixtures to structure with screws that penetrate solid wood at least 3/4".
9. Fixture Wiring
- a. Wiring must not be damaged (e.g., no slices, cuts, nicks or other damage).
 - b. Splices must be contained within a fixture, ballast cover, junction box, etc.
 - c. Twist-type pressure splicing connectors (e.g., wire nuts) must be UL listed, new, properly sized (type, size and number of conductors), and properly installed.
 - Strip wire to length specified by connector manufacturer.
 - Pre-twist wires when specified by connector manufacturer or local code.
 - d. “Poke-in” and “stab-in” type electrical connections may be used in lieu of twist-type in accordance with fixture manufacturer’s instructions and local code.
10. Grounding requirements

- a. Ground fixture in compliance with manufacturer's specifications and local code.
- b. Three-conductor wiring systems:
 - Connect fixture ground lead to the system grounding conductor.
 - When a grounding conductor is not available in the fixture box:
 - A plastic fixture may be installed, or
 - A GFCI-protected switch may be installed in lieu of grounding, or
 - Other procedure approved by local code may be employed.
- c. Two-conductor wiring systems:
 - Grounding the fixture is not required if not mandated by local code.
 - When grounding is required, the following options may be employed, if allowed by local code:
 - A plastic fixture may be installed, or
 - A GFCI-protected switch may be installed in lieu of grounding, or
 - Other approved procedure.

21.4 Post-Installation Standards

1. Clean up and remove from the premises all dust, chips, scraps, and other debris resulting from fixture installation—utilizing lead-safe practices when applicable.
2. Return furniture and other household items moved for installation work to original positions.

21.5 Additional Health & Safety Considerations

1. Any program specific health and safety protocols.
2. All federal, state, local and program specific health and safety regulations should be followed.
3. Lead-safe practices shall be employed when working with pre-1978 painted materials per state codes T8 Section 1532.1 and T17 Section 36000, et seq.

22. Refrigerator Installation and Removal

22.1 General Requirements

1. Must meet current Title 24 Standards, state code, local code and program requirements (see Program Specifications).

22.2 Material Standards

1. All units shall be:
 - a. UL listed.
 - b. Energy Star® qualified.
 - c. Frost free.
2. Warranty: Minimum 1-year warranty parts and labor.
3. Sizing guidelines
 - a. The minimum size for primary refrigerators replaced is 10 cu. ft.
 - b. One of the refrigerators replaced must be a primary refrigerator. The primary refrigerator is the main refrigerator in the home, usually located in the kitchen.
 - c. The size of the replacement refrigerator shall be approximately equal to the size of existing unit. When two refrigerators and/or freezers are exchanged for a single unit, the replacement unit may not be larger than the combined size of units, and may not be larger than 23 cubic feet.
4. Door swing: Direction of door swing shall be in compliance with customer's wishes.

Measure Feasibility

This measure may not be feasible if:

- Refrigerator to be removed was manufactured 1999 or later.
- The electrical outlet used by the existing refrigerator is:
 - not properly grounded and cannot be properly grounded, or
 - unsafe (hazardous electrical condition exists).
- The refrigerator is not accessible for removal (e.g., doors from room are too small, refrigerator is encased in tile).
- An appropriate location is not available, due to such factors as the following:
 - The floor is not structurally adequate to safely support the refrigerator.
 - Clearance requirements cannot be met.
 - The refrigerator cannot be installed in a level, plumb, and stable position.
- Customer refuses.

22.3 Installation Standards

1. Electrical Requirements
 - a. Electrical circuit
 - Overcurrent protection and size of conductors shall be in conformance with manufacturer's specifications and local code.
 - A GFCI-protected circuit or receptacle, or a switched outlet, shall not be used.
 - b. Electrical outlet
 - Refrigerator shall be plugged into its own individual electrical outlet (not shared with another appliance).
 - The receptacle shall be properly grounded in conformance with the California Electrical Code (CEC) and local code.
 - The receptacle and cover plate shall be in good condition.

- Refrigerators shall not be connected to two-prong non-grounded outlets.
 - Installation of a new grounded receptacle:
 - Permit: A building permit shall be obtained and finalized when required by the local jurisdiction.
 - A new 3-prong receptacle with ground lug shall be installed when the existing receptacle is nonconforming.
 - The new receptacle shall be properly grounded, with the ground lug in the bottom position, unless refrigerator cord has a right-angle plug designed to be installed with ground lug at top.
 - When installation of a grounding conductor is required to provide proper grounding, it shall be installed in conformance with local code.
 - c. Use of adapters
 - Three-prong adapters
 - Shall not be used to permanently connect a refrigerator.
 - May be used as a temporary measure, if allowed by local code and the refrigerator manufacturer's instructions and approved by the owner/occupant.
 - When adapters are used, they shall be:
 - Aligned to provide proper polarity with the outlet and the power cord.
 - Connected to a ground source (e.g., a properly-grounded 2-prong receptacle or metal outlet box).
 - d. Extension cord
 - An extension cord may be used when allowed by refrigerator manufacturer's instructions.
 - Extension cord shall be:
 - UL listed, 3-conductor cord, with 3-prong plug and receptacle.
 - Minimum 14 AWG.
 - Maximum 6' in length.
 - Appliance cord and extension cord shall not be located where either can create a tripping hazard.
2. Access:
- a. Space must be physically large enough to accommodate the new refrigerator, with clearances recommended by the manufacturer.
 - b. Access route to the refrigerator location, including entrance and passageways, must be sufficient to allow removal of the existing refrigerator and installation of the new one without causing damage to the home or furnishings.
3. Location
- a. The floor shall be structurally adequate to safely support the refrigerator.

- b. Clearances shall meet manufacturer's specifications.
4. Installation
 - a. The refrigerator shall be installed in a level, plumb, and stable position.
 - Leveling devices on the refrigerator shall be adjusted accordingly.
 - Supplementary supports (e.g., shims) shall be used as needed.
 - b. Installation shall not damage the floor covering or interior finishes.
 5. Removal and disposal of existing refrigerator
 - a. Packing materials and installation debris shall be cleaned up and removed from the premises.
 - b. The existing refrigerator shall be:
 - Removed from the customer's premises by the installer.
 - Disposed of and recycled (de-manufacture) in an environmentally safe manner and in accordance with federal, state, and local regulations and codes, including:
 - Clean Air Act 1990, section 608, as amended by 40 CFR 82, 5/14/93).
 - Metal Discard Act, effective January 1, 1994, which prohibits disposal of refrigerators/freezers in landfills.

22.4 Additional Health & Safety Considerations

1. Any program specific health and safety protocols.
2. All federal, state, local and program specific health and safety regulations should be followed.
3. Lead-safe practices shall be employed when working with pre-1978 painted materials per state codes T8 Section 1532.1 and T17 Section 36000, et seq.

23. Appendix A - Attic Ventilation

23.1 Screen and Louver Reduction Factors

1. The following table contains the “reduction factors” upon which the attic vent NFVA tables in this appendix are based.
2. In situations when the vent being evaluated does not “fit” an NFVA table, use the following table to calculate NFVA.
3. Example: An eave vent has ¼-inch screen (no louvers), with a vent opening (excluding the frame) that is 2.5” x 17”. $2.5 \times 17 = 42.5$
 - a. The screened opening is 42.5 sq. in. The reduction factor from the following table is 0.90.
 - b. $42.5 \times 0.90 = 38.25$ sq. in. = NFVA. Divide square *inches* by 144 to calculate square *feet*.
 - c. $38.25 \div 144 = 0.27$ sq. ft. NFVA

Screen and Louver Reduction Factors

(A) Mesh Only	1/4" Mesh (hardware cloth)	1/8" Mesh (wire mesh)	1/16" Mesh (insect screen)
	0.90 (90%)	0.75 (75%)	0.50 (50%)
(B) Louvers & Mesh	Metal Louvers <u>or</u> Metal Louvers <u>and</u> 1/4" <u>or</u> 1/8" Mesh	Metal Louvers, <u>or</u> Metal Louvers <u>and</u> 1/16" Mesh	Wood Louvers <u>or</u> Wood Louvers <u>and</u> 1/16" to 1/4" Mesh
	0.75 (75%)	0.50 (50%)	0.25 (25%)

23.2 Quick Reference for Determining Required Attic Venting NFVA

1. The two tables on the following page provide a quick reference for determining the amount of Net Free Venting Area (NFVA) required for an attic (or rectangular attic section).
2. Table 1 (1 to 150 ratio) applies when 1 sq. ft. NFVA is required per 150 sq. ft. of attic floor, and Table 2 (1 to 300 ratio):
 - a. Determine which ratio applies. See Section 6, Attic Insulation.
 - b. In the applicable table, find the length of the attic (or section) in the left column.
 - c. Move across that row to the column representing the attic width (in the top row).
 - d. At the intersection of the length row and width column, the number in the table is the sq. ft. of NFVA required for an attic (or section) of that size.
 - e. If the house is not a simple rectangle, determine the NFVA required for each rectangular section, and add the amounts together to calculate total NFVA.

Example: 1 sq. ft. NFVA per 150 sq. ft. of attic floor (1 to 150 ratio), use Table 1.

- For an attic 40' long and 30' wide, 8.0 sq. ft. NFVA is needed.

- For an L-shaped house with a 20' x 20' section and another 20' x 30' section, the NFVA amounts are $2.7 + 4.0 = 6.7$ sq. ft. total NFVA.

TABLE 1—NFVA (sq. ft.) for 1 to 150 ratio:

		Attic Width (Feet)															
		10'	12'	14'	16'	18'	20'	22'	24'	26'	28'	30'	32'	34'	36'	38'	40'
Attic Length (Feet)	10'	0.7	0.8	0.9	1.1	1.2	1.3	1.5	1.6	1.7	1.9	2.0	2.1	2.3	2.4	2.5	2.7
	12'	0.8	1.0	1.1	1.3	1.4	1.6	1.8	1.9	2.1	2.2	2.4	2.6	2.7	2.9	3.0	3.2
	14'	0.9	1.1	1.3	1.5	1.7	1.9	2.1	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.5	3.7
	16'	1.1	1.3	1.5	1.7	1.9	2.1	2.3	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.1	4.3
	18'	1.2	1.4	1.7	1.9	2.2	2.4	2.6	2.9	3.1	3.4	3.6	3.8	4.1	4.3	4.6	4.8
	20'	1.3	1.6	1.9	2.1	2.4	2.7	2.9	3.2	3.5	3.7	4.0	4.3	4.5	4.8	5.1	5.3
	22'	1.5	1.8	2.1	2.3	2.6	2.9	3.2	3.5	3.8	4.1	4.4	4.7	5.0	5.3	5.6	5.9
	24'	1.6	1.9	2.2	2.6	2.9	3.2	3.5	3.8	4.2	4.5	4.8	5.1	5.4	5.8	6.1	6.4
	26'	1.7	2.1	2.4	2.8	3.1	3.5	3.8	4.2	4.5	4.9	5.2	5.5	5.9	6.2	6.6	6.9
	28'	1.9	2.2	2.6	3.0	3.4	3.7	4.1	4.5	4.9	5.2	5.6	6.0	6.3	6.7	7.1	7.5
	30'	2.0	2.4	2.8	3.2	3.6	4.0	4.4	4.8	5.2	5.6	6.0	6.4	6.8	7.2	7.6	8.0
	32'	2.1	2.6	3.0	3.4	3.8	4.3	4.7	5.1	5.5	6.0	6.4	6.8	7.3	7.7	8.1	8.5
	34'	2.3	2.7	3.2	3.6	4.1	4.5	5.0	5.4	5.9	6.3	6.8	7.3	7.7	8.2	8.6	9.1
	36'	2.4	2.9	3.4	3.8	4.3	4.8	5.3	5.8	6.2	6.7	7.2	7.7	8.2	8.6	9.1	9.6
	38'	2.5	3.0	3.5	4.1	4.6	5.1	5.6	6.1	6.6	7.1	7.6	8.1	8.6	9.1	9.6	10.1
	40'	2.7	3.2	3.7	4.3	4.8	5.3	5.9	6.4	6.9	7.5	8.0	8.5	9.1	9.6	10.1	10.7

TABLE 2—NFVA (sq. ft.) for 1 to 300 ratio:

		Attic Width (Feet)															
		10'	12'	14'	16'	18'	20'	22'	24'	26'	28'	30'	32'	34'	36'	38'	40'
Attic Length (Feet)	10'	0.3	0.4	0.5	0.5	0.6	0.7	0.7	0.8	0.9	0.9	1.0	1.1	1.1	1.2	1.3	1.3
	12'	0.4	0.5	0.6	0.6	0.7	0.8	0.9	1.0	1.0	1.1	1.2	1.3	1.4	1.4	1.5	1.6
	14'	0.5	0.6	0.7	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9
	16'	0.5	0.6	0.7	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1
	18'	0.6	0.7	0.8	1.0	1.1	1.2	1.3	1.4	1.6	1.7	1.8	1.9	2.0	2.2	2.3	2.4
	20'	0.7	0.8	0.9	1.1	1.2	1.3	1.5	1.6	1.7	1.9	2.0	2.1	2.3	2.4	2.5	2.7
	22'	0.7	0.9	1.0	1.2	1.3	1.5	1.6	1.8	1.9	2.1	2.2	2.3	2.5	2.6	2.8	2.9
	24'	0.8	1.0	1.1	1.3	1.4	1.6	1.8	1.9	2.1	2.2	2.4	2.6	2.7	2.9	3.0	3.2
	26'	0.9	1.0	1.2	1.4	1.6	1.7	1.9	2.1	2.3	2.4	2.6	2.8	2.9	3.1	3.3	3.5
	28'	0.9	1.1	1.3	1.5	1.7	1.9	2.1	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.5	3.7
	30'	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0
	32'	1.1	1.3	1.5	1.7	1.9	2.1	2.3	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.1	4.3
	34'	1.1	1.4	1.6	1.8	2.0	2.3	2.5	2.7	2.9	3.2	3.4	3.6	3.9	4.1	4.3	4.5
	36'	1.2	1.4	1.7	1.9	2.2	2.4	2.6	2.9	3.1	3.4	3.6	3.8	4.1	4.3	4.6	4.8
	38'	1.3	1.5	1.8	2.0	2.3	2.5	2.8	3.0	3.3	3.5	3.8	4.1	4.3	4.6	4.8	5.1
	40'	1.3	1.6	1.9	2.1	2.4	2.7	2.9	3.2	3.5	3.7	4.0	4.3	4.5	4.8	5.1	5.3

For dimensions not shown in the tables, calculate the attic area, and divide that square footage by 150.

- For a 31' by 41' attic, area = $31' \times 41' = 1271$ sq. ft. $1271 \div 150 = 8.47$, rounded up = 8.5 sq. ft. NFVA.

VENT TABLE INSTRUCTIONS

23.3 Using the Tables

1. The tables on the following pages can be used to determine the Net Free Venting Area (NFVA) provided by a particular type and size of vent. The NFVA for that vent is given in square feet.
2. When vent measurements are between the sizes listed, calculate manually.

23.4 Sample NFVA Table

**RECTANGULAR GABLE VENTS—1/4" or 1/8" SCREEN with METAL LOUVERS
(Reduction Factor = 0.75)**

		WIDTH (Inches)												
		12	14	16	18	20	22	24	26	28	30	32	34	36
HEIGHT (Inches)	12	0.75	0.88	1.00	1.13	1.25	1.38	1.50	1.63	1.75	1.88	2.00	2.13	2.25
	14	0.88	1.02	1.17	1.31	1.46	1.60	1.75	1.90	2.04	2.19	2.33	2.48	2.63
	16	1.00	1.17	1.33	1.50	1.67	1.83	2.00	2.17	2.33	2.50	2.67	2.83	3.00
	18	1.13	1.31	1.50	1.69	1.88	2.06	2.25	2.44	2.63	2.81	3.00	3.19	3.38
	20	1.25	1.46	1.67	1.88	2.08	2.29	2.50	2.71	2.92	3.13	3.33	3.54	3.75
	22	1.38	1.60	1.83	2.06	2.29	2.52	2.75	2.98	3.21	3.44	3.67	3.90	4.13
	24	1.50	1.75	2.00	2.25	2.50	2.75	3.00	3.25	3.50	3.75	4.00	4.25	4.50

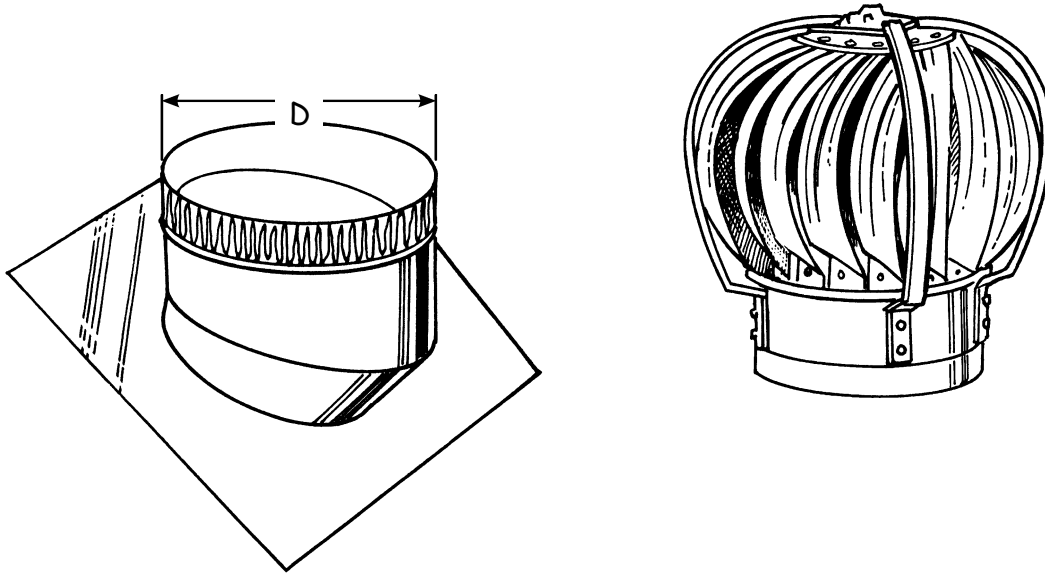
Example 1: If 16" *high* by 14" *wide* Gable Vents are to be installed, first find the 16" *height* in the left column. Move across that row to the column representing the 14" *width* (shown in the top row). At the intersection of the 16" height row and 14" width column, you find "1.17".

▶The "1.17" means 1.17 sq. ft. of NFVA is provided by 1 vent.

Example 2: If 18" *high* by 14" *wide* Gable Vents are to be installed, first find the 18" *height* in the left column. Move across that row to the column representing the 14" *width*. At the intersection of the 18" height row and 14" width column, you find "1.31".

▶The "1.31" means 1.31 sq. ft. of NFVA is provided by 1 vent.

23.5 Turbine Ventilators



TURBINE VENTILATORS

# of 12" Turbines	1		2		3		4		5	
# of 14" Turbines		1		2		3		4		5
Sq. Ft. of NFVA Provided	0.79	1.10	1.60	2.20	2.40	3.30	3.20	4.40	4.00	5.50

Several styles of turbine ventilators exist, each with different NFVA specifications. Use the actual product manufacturer's NFVA specifications when available. Use the above table only when the manufacturer's NFVA specifications are not available.

23.6 Round Vent Holes

Bird Holes

BIRD HOLES—1/4" SCREEN, NO LOUVERS
(Reduction Factor = 0.90)

	DIAMETER (INCHES)						
	1.5	1.75	2	2.25	2.5	2.75	3
Sq. Ft. of NFVA Provided by 1 Vent	0.0110	0.0150	0.0196	0.0248	0.0307	0.0371	0.0442
# of Vents Needed for 1 Sq. Ft. NFVA	91	67	51	40	33	27	23

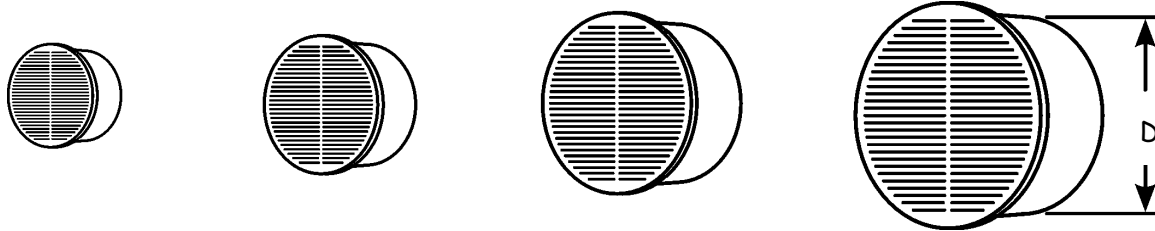
NFVA calculations are for vents screened with 1/4" (#4) weave mesh (required on new vents).

BIRD HOLES—1/8" SCREEN, NO LOUVERS
(Reduction Factor = 0.75)

	DIAMETER (INCHES)						
	1.5	1.75	2	2.25	2.5	2.75	3
Sq. Ft. of NFVA Provided by 1 Vent	0.0092	0.0125	0.0164	0.0207	0.0256	0.0309	0.0368
# of Vents Needed for 1 Sq. Ft. NFVA	109	80	61	48	39	32	27

NFVA calculations are for vents screened with 1/8" (#8) weave mesh (found on some existing vents).

Mini-Circular Vents

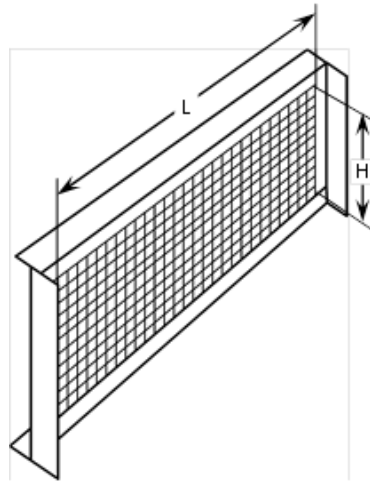


MINI-CIRCULAR VENTS

	DIAMETER (INCHES)								
	1	1.5	2	2.5	3	4	5	6	8
Sq. Ft. of NFVA Provided by 1 Vent	.0019	.0043	.0076	.0119	.0172	.0305	.0477	.0687	.1222
# of Vents Needed for 1 Sq. Ft. NFVA	524	233	131	84	58	33	21	15	8

Many styles of mini-circular vents exist, each with different NFVA specifications. Use the actual product manufacturer's NFVA specifications when available. Use the above table only when the manufacturer's NFVA specifications are not available.

23.7 Eave Vents—1/4" and 1/8" Screen, No Louvers



EAVE VENTS—1/4" SCREEN, NO LOUVERS
(Reduction Factor = 0.90)

		LENGTH (Inches)								
		10	12	13	14	14.5	16	18	21	22.5
HEIGHT (Inches)	3	0.19	0.23	0.24	0.26	0.27	0.30	0.34	0.39	0.42
	3.5	0.22	0.26	0.28	0.31	0.32	0.35	0.39	0.46	0.49
	4	0.25	0.30	0.33	0.35	0.36	0.40	0.45	0.53	0.56
	4.5	0.28	0.34	0.37	0.39	0.41	0.45	0.51	0.59	0.63
	5	0.31	0.38	0.41	0.44	0.45	0.50	0.56	0.66	0.70
	5.5	0.34	0.41	0.45	0.48	0.50	0.55	0.62	0.72	0.77

NFVA calculations are for vents screened with 1/4" (#4) weave mesh (required on new vents).

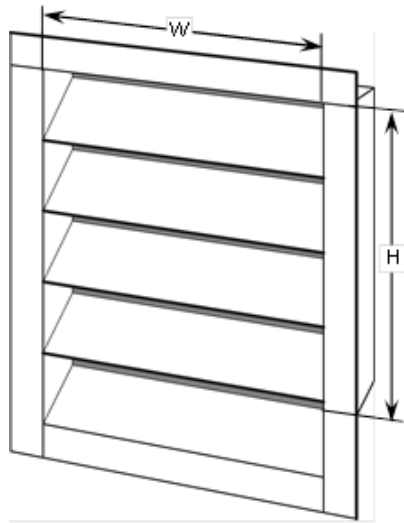
EAVE VENTS—1/8" SCREEN, NO LOUVERS
(Reduction Factor = 0.75)

		LENGTH (Inches)								
		10	12	13	14	14.5	16	18	21	22.5
HEIGHT (Inches)	3	0.16	0.19	0.20	0.22	0.23	0.25	0.28	0.33	0.35
	3.5	0.18	0.22	0.24	0.26	0.26	0.29	0.33	0.38	0.41
	4	0.21	0.25	0.27	0.29	0.30	0.33	0.38	0.44	0.47
	4.5	0.23	0.28	0.30	0.33	0.34	0.38	0.42	0.49	0.53
	5	0.26	0.31	0.34	0.36	0.38	0.42	0.47	0.55	0.59
	5.5	0.29	0.34	0.37	0.40	0.42	0.46	0.52	0.60	0.64

NFVA calculations are for vents screened with 1/8" (#8) weave mesh (found on some existing vents).

- Screens must be clean, and vents must be free of insulation and other obstructions.

23.8 Rectangular Gable Vents—1/4" or 1/8" screen with Metal Louvers



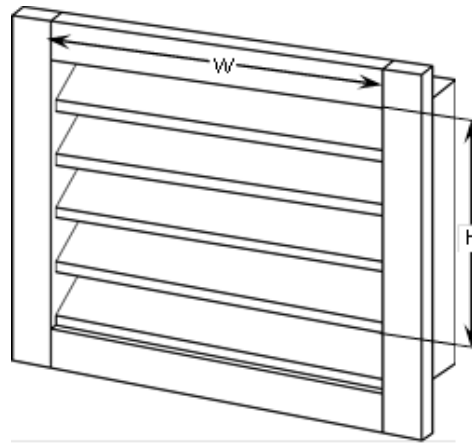
RECTANGULAR GABLE VENTS—1/4" or 1/8" SCREEN with METAL LOUVERS
(Reduction Factor = 0.75)

		WIDTH (Inches)									
		11	12	14	16	18	20	22	24	30	36
HEIGHT (Inches)	8	0.46	0.50	0.58	0.67	0.75	0.83	0.92	1.00	1.25	1.50
	10	0.57	0.63	0.73	0.83	0.94	1.04	1.15	1.25	1.56	1.88
	12	0.69	0.75	0.88	1.00	1.13	1.25	1.38	1.50	1.88	2.25
	14	0.80	0.88	1.02	1.17	1.31	1.46	1.60	1.75	2.19	2.63
	16	0.92	1.00	1.17	1.33	1.50	1.67	1.83	2.00	2.50	3.00
	18	1.03	1.13	1.31	1.50	1.69	1.88	2.06	2.25	2.81	3.38
	20	1.15	1.25	1.46	1.67	1.88	2.08	2.29	2.50	3.13	3.75
	22	1.26	1.38	1.60	1.83	2.06	2.29	2.52	2.75	3.44	4.13
	24	1.38	1.50	1.75	2.00	2.25	2.50	2.75	3.00	3.75	4.50
	26	1.49	1.63	1.90	2.17	2.44	2.71	2.98	3.25	4.06	4.88
	28	1.60	1.75	2.04	2.33	2.63	2.92	3.21	3.50	4.38	5.25
	30	1.72	1.88	2.19	2.50	2.81	3.13	3.44	3.75	4.69	5.63
	32	1.83	2.00	2.33	2.67	3.00	3.33	3.67	4.00	5.00	6.00
	34	1.95	2.13	2.48	2.83	3.19	3.54	3.90	4.25	5.31	6.38
36	2.06	2.25	2.63	3.00	3.38	3.75	4.13	4.50	5.63	6.75	

NFVA calculations are for vents screened with 1/4" (#4) weave mesh (required on new vents) or 1/8" (#8) weave mesh (found on some existing vents).

- Screens must be clean, and vents must be free of insulation and other obstructions.

23.9 Rectangular Gable Vents—1/4" or 1/8" Screen with Wood Louvers



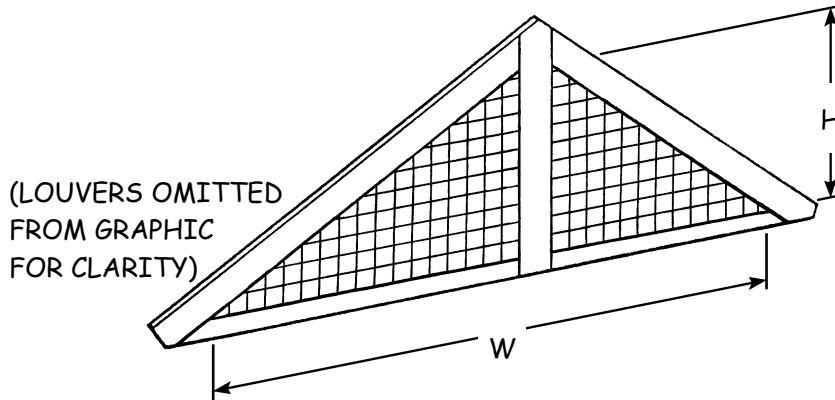
RECTANGULAR GABLE VENTS—1/4" or 1/8" SCREEN with WOOD LOUVERS
 (Reduction Factor = 0.25)

		WIDTH (Inches)								
		12	14	16	18	20	22	24	30	36
HEIGHT (Inches)	8	0.17	0.19	0.22	0.25	0.28	0.31	0.33	0.42	0.50
	10	0.21	0.24	0.28	0.31	0.35	0.38	0.42	0.52	0.63
	12	0.25	0.29	0.33	0.38	0.42	0.46	0.50	0.63	0.75
	14	0.29	0.34	0.39	0.44	0.49	0.53	0.58	0.73	0.88
	16	0.33	0.39	0.44	0.50	0.56	0.61	0.67	0.83	1.00
	18	0.38	0.44	0.50	0.56	0.63	0.69	0.75	0.94	1.13
	20	0.42	0.49	0.56	0.63	0.69	0.76	0.83	1.04	1.25
	22	0.46	0.53	0.61	0.69	0.76	0.84	0.92	1.15	1.38
	24	0.50	0.58	0.67	0.75	0.83	0.92	1.00	1.25	1.50
	26	0.54	0.63	0.72	0.81	0.90	0.99	1.08	1.35	1.63
	28	0.58	0.68	0.78	0.88	0.97	1.07	1.17	1.46	1.75
	30	0.63	0.73	0.83	0.94	1.04	1.15	1.25	1.56	1.88
	32	0.67	0.78	0.89	1.00	1.11	1.22	1.33	1.67	2.00
	34	0.71	0.83	0.94	1.06	1.18	1.30	1.42	1.77	2.13
36	0.75	0.88	1.00	1.13	1.25	1.38	1.50	1.88	2.25	

NFVA calculations are for vents screened with 1/4" (#4) weave mesh (required on new vents) or 1/8" (#8) weave mesh (found on some existing vents).

- Screens must be clean, and vents must be free of insulation and other obstructions.

23.10 Triangular Gable Vents—1/4" or 1/8" Screen with Metal Louvers



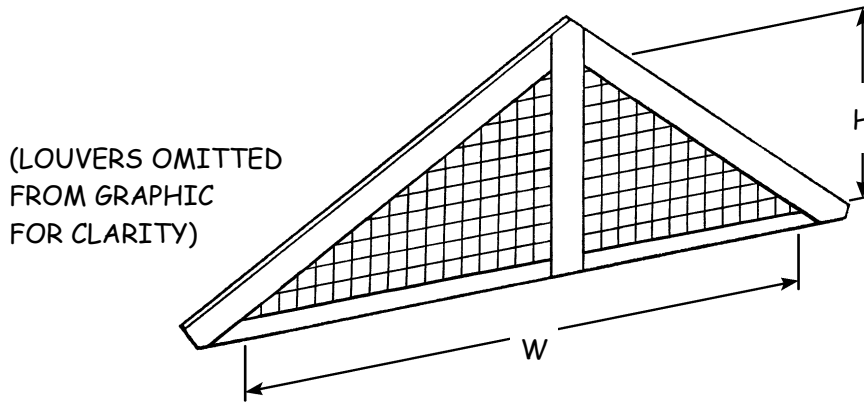
TRIANGULAR GABLE VENTS—1/4" or 1/8" SCREEN with METAL LOUVERS
 (Reduction Factor = 0.75)

		WIDTH (Inches)							
		24	30	36	42	48	54	60	72
HEIGHT (Inches)	10	0.63	0.78	0.94	1.09	1.25	1.41	1.56	1.88
	12	0.75	0.94	1.13	1.31	1.50	1.69	1.88	2.25
	14	0.88	1.09	1.31	1.53	1.75	1.97	2.19	2.63
	16	1.00	1.25	1.50	1.75	2.00	2.25	2.50	3.00
	18	1.13	1.41	1.69	1.97	2.25	2.53	2.81	3.38
	20	1.25	1.56	1.88	2.19	2.50	2.81	3.13	3.75
	22	1.38	1.72	2.06	2.41	2.75	3.09	3.44	4.13
	24	1.50	1.88	2.25	2.63	3.00	3.38	3.75	4.50
	26	1.63	2.03	2.44	2.84	3.25	3.66	4.06	4.88
	28	1.75	2.19	2.63	3.06	3.50	3.94	4.38	5.25
	30	1.88	2.34	2.81	3.28	3.75	4.22	4.69	5.63
	32	2.00	2.50	3.00	3.50	4.00	4.50	5.00	6.00
	34	2.13	2.66	3.19	3.72	4.25	4.78	5.31	6.38
36	2.25	2.81	3.38	3.94	4.50	5.06	5.63	6.75	

NFVA calculations are for vents screened with 1/4" (#4) weave mesh (required on new vents) or 1/8" (#8) weave mesh (found on some existing vents).

- Screens must be clean, and vents must be free of insulation and other obstructions.

23.11 Triangular Gable Vents—1/4" or 1/8" Screen with Wood Louvers



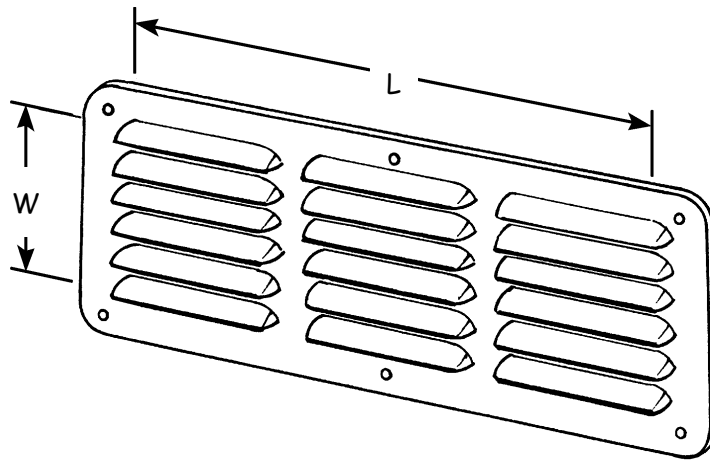
TRIANGULAR GABLE VENTS—1/4" or 1/8" SCREEN with WOOD LOUVERS
 (Reduction Factor = 0.25)

		WIDTH (Inches)							
		24	30	36	42	48	54	60	72
HEIGHT (Inches)	10	0.21	0.26	0.31	0.36	0.42	0.47	0.52	0.63
	12	0.25	0.31	0.38	0.44	0.50	0.56	0.63	0.75
	14	0.29	0.36	0.44	0.51	0.58	0.66	0.73	0.88
	16	0.33	0.42	0.50	0.58	0.67	0.75	0.83	1.00
	18	0.38	0.47	0.56	0.66	0.75	0.84	0.94	1.13
	20	0.42	0.52	0.63	0.73	0.83	0.94	1.04	1.25
	22	0.46	0.57	0.69	0.80	0.92	1.03	1.15	1.38
	24	0.50	0.63	0.75	0.88	1.00	1.13	1.25	1.50
	26	0.54	0.68	0.81	0.95	1.08	1.22	1.35	1.63
	28	0.58	0.73	0.88	1.02	1.17	1.31	1.46	1.75
	30	0.63	0.78	0.94	1.09	1.25	1.41	1.56	1.88
	32	0.67	0.83	1.00	1.17	1.33	1.50	1.67	2.00
	34	0.71	0.89	1.06	1.24	1.42	1.59	1.77	2.13
36	0.75	0.94	1.13	1.31	1.50	1.69	1.88	2.25	

NFVA calculations are for vents screened with 1/4" (#4) weave mesh (required on new vents) or 1/8" (#8) weave mesh (found on some existing vents).

- Screens must be clean, and vents must be free of insulation and other obstructions.

23.12 Soffit Vents—1/4" or 1/8" Screen with Metal Louvers



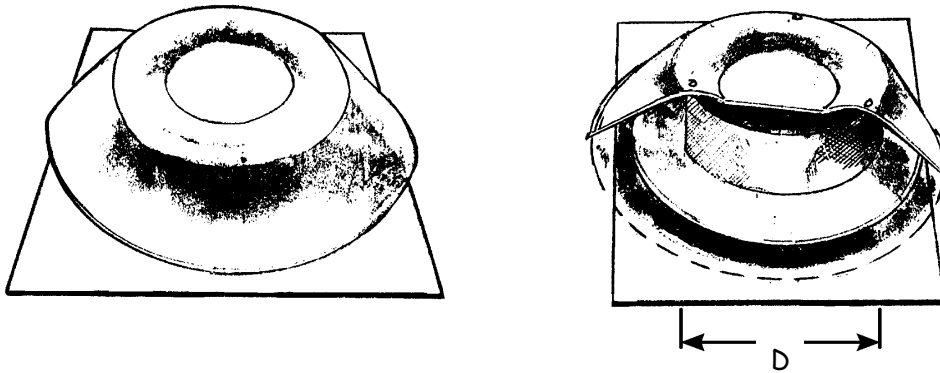
SOFFIT VENTS—1/4" OR 1/8" SCREEN with METAL LOUVERS
 (Reduction Factor = 0.75)

		LENGTH (Inches)								
		10	12	14	15	16	18	20	22	24
HEIGHT (Inches)	2	0.10	0.13	0.15	0.16	0.17	0.19	0.21	0.23	0.25
	3	0.16	0.19	0.22	0.23	0.25	0.28	0.31	0.34	0.38
	3.5	0.18	0.22	0.26	0.27	0.29	0.33	0.36	0.40	0.44
	4	0.21	0.25	0.29	0.31	0.33	0.38	0.42	0.46	0.50
	4.5	0.23	0.28	0.33	0.35	0.38	0.42	0.47	0.52	0.56
	5	0.26	0.31	0.36	0.39	0.42	0.47	0.52	0.57	0.63
	6	0.31	0.38	0.44	0.47	0.50	0.56	0.63	0.69	0.75
	8	0.42	0.50	0.58	0.63	0.67	0.75	0.83	0.92	1.00
	10	0.52	0.63	0.73	0.78	0.83	0.94	1.04	1.15	1.25

NFVA calculations are for vents screened with 1/4" (#4) weave mesh (required on new vents) or 1/8" (#8) weave mesh (found on some existing vents).

- Screens must be clean, and vents must be free of insulation and other obstructions.

23.13 Mushroom Vents—1/4" and 1/8" Screen



MUSHROOM VENTS—1/4" SCREEN
(Reduction Factor = 0.90)

		DIAMETER (Inches)									
		6	7	8	9	10	11	12	13	14	15
Sq. Ft. NFVA		0.18	0.24	0.31	0.40	0.49	0.59	0.71	0.83	0.96	1.10

NFVA calculations are for vents screened with 1/4" (#4) weave mesh (required on new vents).

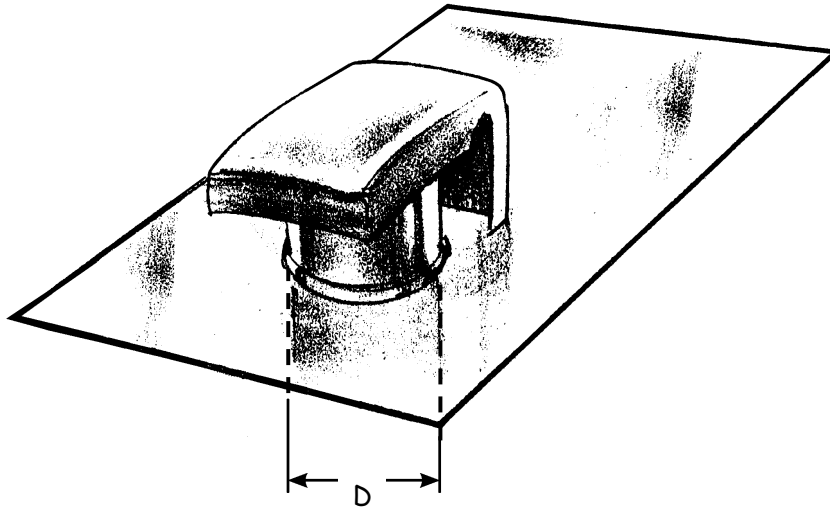
MUSHROOM VENTS—1/8" SCREEN
(Reduction Factor = 0.75)

		DIAMETER (Inches)									
		6	7	8	9	10	11	12	13	14	15
Sq. Ft. NFVA		0.15	0.20	0.26	0.33	0.41	0.49	0.59	0.69	0.80	0.92

NFVA calculations are for vents screened with 1/8" (#8) weave mesh (found on some existing vents).

- Screens must be clean, and vents must be free of insulation and other obstructions.

23.14 Hood Vents & Roof Jacks—1/4" and 1/8" Screen



HOOD VENTS & ROOF JACKS — 1/4" SCREEN
 (Reduction Factor =0.90)

		DIAMETER (Inches)									
		6	7	8	9	10	11	12	13	14	15
Sq. Ft. NFVA		0.18	0.24	0.31	0.40	0.49	0.59	0.71	0.83	0.96	1.10

NFVA calculations are for vents screened with 1/4" (#4) weave mesh (required on new vents).

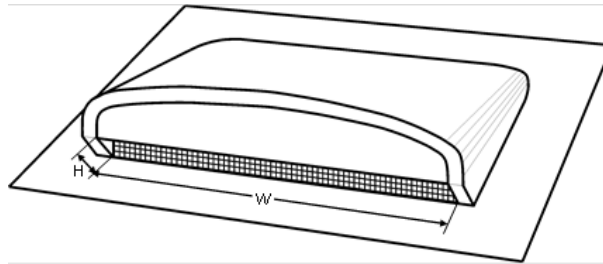
HOOD VENTS & ROOF JACKS—1/8" SCREEN
 (Reduction Factor =0.75)

		DIAMETER (Inches)									
		6	7	8	9	10	11	12	13	14	15
Sq. Ft. NFVA		0.15	0.20	0.26	0.33	0.41	0.49	0.59	0.69	0.80	0.92

NFVA calculations are for vents screened with 1/8" (#8) weave mesh (found on some existing vents).

- Screens/louvers must be clean, and vents must be free of insulation and other obstructions.

23.15 Eyebrow Vents



**EYEBROW VENTS—1/4" SCREEN, NO LOUVERS
(Reduction Factor = 0.90)**

		WIDTH (Inches)							
		10	12	14	15	16	18	20	22
HEIGHT (Inches)	3	0.19	0.23	0.26	0.28	0.30	0.34	0.38	0.41
	5	0.31	0.38	0.44	0.47	0.50	0.56	0.63	0.69
	6	0.38	0.45	0.53	0.56	0.60	0.68	0.75	0.83
	7	0.44	0.53	0.61	0.66	0.70	0.79	0.88	0.96
	7.5	0.47	0.56	0.66	0.70	0.75	0.84	0.94	1.03
	8	0.50	0.60	0.70	0.75	0.80	0.90	1.00	1.10
	8.5	0.53	0.64	0.74	0.80	0.85	0.96	1.06	1.17
	9	0.56	0.68	0.79	0.84	0.90	1.01	1.13	1.24

NFVA calculations are for vents screened with 1/4" (#4) weave mesh (required on new vents).

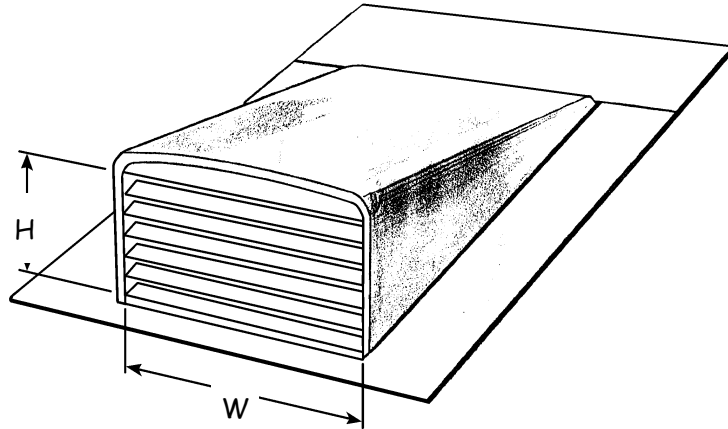
**EYEBROW VENTS—1/4" OR 1/8" SCREEN with LOUVERS
(Reduction Factor = 0.75)**

		WIDTH (Inches)							
		10	12	14	15	16	18	20	22
HEIGHT (Inches)	3	0.16	0.19	0.22	0.23	0.25	0.28	0.31	0.34
	5	0.26	0.31	0.36	0.39	0.42	0.47	0.52	0.57
	6	0.31	0.38	0.44	0.47	0.50	0.56	0.63	0.69
	7	0.36	0.44	0.51	0.55	0.58	0.66	0.73	0.80
	7.5	0.39	0.47	0.55	0.59	0.63	0.70	0.78	0.86
	8	0.42	0.50	0.58	0.63	0.67	0.75	0.83	0.92
	8.5	0.44	0.53	0.62	0.66	0.71	0.80	0.89	0.97
	9	0.47	0.56	0.66	0.70	0.75	0.84	0.94	1.03

NFVA calculations are for vents screened with 1/4" (#4) weave mesh (required on new vents) or 1/8" (#8) weave mesh (found on some existing vents).

- Screens must be clean, and vents must be free of insulation and other obstructions.

23.16 Dormer Vents—1/4" or 1/8" Screen with Metal Louvers



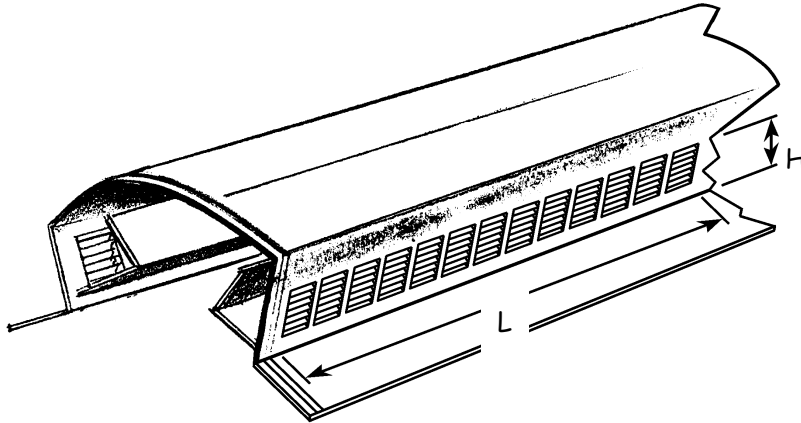
**DORMER VENTS—1/4" or 1/8" SCREEN with METAL LOUVERS
(Reduction Factor =0.75)**

		WIDTH (Inches)							
		10	12	14	15	16	18	20	22
HEIGHT (Inches)	5	0.26	0.31	0.36	0.39	0.42	0.47	0.52	0.57
	6	0.31	0.38	0.44	0.47	0.50	0.56	0.63	0.69
	7	0.36	0.44	0.51	0.55	0.58	0.66	0.73	0.80
	7.5	0.39	0.47	0.55	0.59	0.63	0.70	0.78	0.86
	8	0.42	0.50	0.58	0.63	0.67	0.75	0.83	0.92
	8.5	0.44	0.53	0.62	0.66	0.71	0.80	0.89	0.97
	9	0.47	0.56	0.66	0.70	0.75	0.84	0.94	1.03

NFVA calculations are for vents screened with 1/4" (#4) weave mesh (required on new vents) or 1/8" (#8) weave mesh (found on some existing vents).

- Screens must be clean, and vents must be free of insulation and other obstructions.

23.17 Roof Ridge Vent



ROOF RIDGE VENT with LOUVERS

(Reduction Factor = 0.50)

		LENGTH (INCHES)								
		12	120	144	168	192	216	240	264	288
HEIGHT (INCHES)	1	0.04	0.42	0.50	0.58	0.67	0.75	0.83	0.92	1.00
	1.5	0.06	0.63	0.75	0.88	1.00	1.13	1.25	1.38	1.50
	2	0.08	0.83	1.00	1.17	1.33	1.50	1.67	1.83	2.00
	2.5	0.10	1.04	1.25	1.46	1.67	1.88	2.08	2.29	2.50
	3	0.13	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00
	3.5	0.15	1.46	1.75	2.04	2.33	2.63	2.92	3.21	3.50

Several styles of ridge vent exist, each with different NFVA specifications. Use the actual product manufacturer's NFVA specifications when available. When possible, measure the openings and apply reduction factor **0.50**. The last option is to use the above table only when the manufacturer's NFVA specifications are not available.

24. Appendix B – Effective R-Values for Batt Insulation

Use the following table to determine the effective R-values for batt insulation installed in attics.

1. Measure insulation thickness.
2. Determine the condition of the installation using the following criteria:
 - GOOD – No gaps or other imperfections
 - FAIR – Gaps over 2.5% of the insulated area. (This equals 3/8 inch space along a 14.5 inch batt.)
 - POOR – Gaps over 5% of the insulated area. (This equals 3/4 inch space along a 14.5 inch batt.)
3. Look up the effective R-value of the installed insulation using the condition and measured insulation thickness in inches.

	GOOD	FAIR	POOR
Measured Batt Thickness	Effective R-value (2.5 per inch)	Effective R-value (1.8 per inch)	Effective R-value (0.7 per inch)
0	0	0	0
1	3	2	1
2	5	4	1.5
3	8	5	2
4	10	7	3
5	13	9	3.5
6	15	11	4
7	18	13	5
8	20	14	5.5
9	23	16	6
10	25	18	7
11	28	20	8
12	30	22	8.5

(END)