213 Sidewall Insulation

Best Practice Recommendation:

- Dense-packing sidewalls with the one-hole tubing method.

Installing insulation with uniform coverage and density is very important because it maximizes the insulating value, minimizes insulation settling, and reduces air leakage through the sidewall.

Densely packed insulation should be added to uninsulated and poorly insulated walls when cost effective.

Insulation should be added to provide complete coverage where uninsulated wall sections exist. Perimeter walls that separate spaces from unconditioned areas (garages, unheated porches, etc.) should also be insulated.

The one-hole method for insulating sidewalls is described in this section as it achieves a dense pack that acts to reduce air leakage and assures that the insulation will not settle over time.

2131 Safety

Workers installing, cutting and handling insulation must wear appropriate respirators, eye protection and clothing while working with the insulation materials.

Correct any electrical hazards such as bare, frayed or uninsulated wiring on house connections prior to any other wall work. Correct any problems at exterior flues, gas or oil lines, or fuel tanks prior to beginning wall insulation.

Use appropriate safety measures before setting up near insect, plant, or animal hazards.

Set up ladders in a safe manner, using ladder levelers or other safety devices, to compensate for yard inclines or other physical obstructions to safe ladder use.

2132 Preparation

Inspect walls for evidence of moisture damage. If existing condition of the siding, sheathing, window/door framing (missing, rotting, deteriorated paint, etc), interior wall finish (weakened plate/drywall, water stains, etc) indicates an existing moisture problem, no sidewall insulation is to be installed until the moisture problem has been corrected.

Note the existence and condition of any exposed structural components, such as wall studs, sill plates and sole plates. Note the presence and condition of structural additions, such as porches and porch roofs. Also note any room additions to the main structure.

Seal gaps in external window trim and other areas that may leak water into the wall.

Note the existence and condition of all electrical outlets and switches on exterior walls. Note the location and condition of vent fan penetrations, clothes dryer vent terminations, wall heaters, and air conditioners. Identify chase ways or wall cavities containing utility runs or ductwork.

Wall cavities open to return air ducts or plenums are to be sealed so the cavity may be insulated. Upper story returns in sidewall cavities are to be sealed. Return air from upper stories is to be routed through the home. A balanced system is desired (see section 227, "Duct Improvements").

Filling the hopper of the Krendl insulation blowing machine

Determine approximate age of the structure and type of wall construction with an awareness of regional/local construction details. Locate all critical framing junctures: wall/ceiling junctures, cantilevers, porch ceiling/wall connections, and plan the best way to insulate them.

Inspect indoor areas on exterior walls to assure that they are strong enough to withstand the installation process. Inspect for interior openings from which insulation may escape, such as holes, missing trim, pocket doors, wall cavities open at the top or bottom, openings above dropped ceilings, cabinets, soffits and closets. Seal and/or repair openings and weak surfaces such as paneling.

Inspect walls for live knob-and-tube wiring. Mark wall cavities containing knob-and-tube wiring. There may be a significant number of wall cavities that do not contain live knob-and-tube wiring where installing sidewall insulation is not an issue. See section 1381, "Knob-and-Tube Wiring", for additional guidance with respect to knob-and-tube wiring.

Calculate the amount of cellulose insulation needed to insulate sidewalls to 3.25 to 4.0 pounds per cubic foot (lbs/ft^3). Blown fiberglass insulation, if used, should be installed to a density of 1.6 lbs/ft^3.

2133 Installation – Closed Cavity

21331 Wall Cavity Access

In some cases, access to wall cavities may be possible through open top or bottom plates (balloon construction) or other areas that don't require siding removal or interior surface drilling. In most cases, however, access through the exterior and/or interior wall surfaces will be required.

Note the types of siding materials on the house especially if that material contains asbestos. Wherever possible, determine the presence and condition of previous layers of siding or sub-siding. Consult with the homeowner/authorized agent to determine the best sidewall insulation and access strategy. The favored method is lifting and/or temporarily removing the siding to gain access for drilling the subsiding. Written permission must be obtained in order to drill and plug the finish siding.

Remove as many rows of siding as is necessary to access all wall cavities. Access above windows and doors may require additional pieces of siding to be removed for full access.

Knowledge of effective siding removal is very important

- Vinyl and aluminum siding may be removed by un-hooking the bottom lip of the row with a "zip tool" manufactured for that purpose.
- Wooden clapboards may be removed by cutting or removing the nails of the row to be removed and the row directly above it with a flat pry bar. Care must be taken that the siding does not split. Wooden shingle siding can be scored/cut at the shadow line and removed.
- Cement board siding may be removed by cutting the nails and removing two rows of siding similar to the process of accessing clapboard siding. Cement board siding often contains some level of asbestos so care must be taken when handling this material. Refer to approved asbestos-safe work practices in your state. Drilling this type of siding is <u>not</u> an acceptable procedure.
- If a home cannot be insulated from the exterior, insulation may be installed from the interior after written approval from the homeowner is obtained. Refer to approved lead-safe work practices in your state. Holes drilled for insulation must be finished and returned to condition as close to the original as possible. Access holes in the walls should be patched or plugged with an appropriate material and the surface made ready for painting.

Probe all wall cavities through holes with a non-conductive probe, to identify fire blocking, diagonal bracing and other obstacles. Identify cavities located at corners and near windows and doors and whether cavities are present above windows so that they can be fully insulated. Additional access and probing may be necessary

to determine how to best insulate around structural obstacles and critical junctures.

After probing, drill additional holes as necessary to ensure complete coverage.

Pack pulley wells with insulation if pulley wells are no longer used for window operation. Holes may be drilled through the jamb and sealed with plugs following installation of insulation.

Each application may have several installation methods that will do the job. Choosing the most effective is a very important challenge for the weatherization staff. Some jobs will require the installers to use several methods on the same house.

21332 One-Hole (Tubing) Method

Install insulation in accordance with the manufacturer's recommended application procedures.

Drill minimum 2 to 3 inch diameter holes to access stud cavity. Choose the most effective location for the row of holes that will access the most wall area without requiring additional access points. Avoid drilling holes in the vicinity of electrical outlets and switches.

Cellulose insulation must be blown at a minimum of 3.25 lbs/ft^3 to prevent settling. This minimum density translates into just over one pound per square foot in a two-by-four wall cavity. Uniformly blowing cellulose insulation to this density requires a fill-tube.

Cellulose insulation from most manufacturers is available in at least two grades that are characterized by the fire retardant added to the insulation. The fire retardants are usually 1) a mix of ammonium sulfate and boric acid or 2) boric acid only (termed "borate only"). It's recommended that cellulose insulation be the "borate only" grade.

The one-hole method using a tube long enough to reach to the furthest corner of the cavity is the best way to dense pack walls

The fill tube should be 1 inch or 1 ¼ inch inside diameter tubing with the appropriate stiffness for the job and outdoor temperature. The weatherization agency should have at least one winter and one summer grade tube.

Most installers prefer to blow up the wall cavity and then down. Research in the field has demonstrated that this usually results in a more uniform density than blowing down and then up. However, blowing down and then up is acceptable.

The installer must make sure that the end of the tube makes its way to within one foot of all areas within the cavity. A densely packed and uniform blow will not result unless this rule is followed.

Dense packed wall insulation is best installed using a blower equipped with separate controls for air and material feed. The recommended insulation blower takeoff pressure should be at least 2.9 pounds per square inch (80 inches of water column).

Marking the fill-tube in one-foot intervals allows the person blowing insulation to verify the amount of penetration of the tube into the wall. The installer must be careful to avoid a tube's tendency to bend over and reverse direction.

Starting with several full height, unobstructed wall cavities allows the crew to measure the insulation density and adjust the machine settings. Start with an empty hopper. Fill the hopper with a bag with a known weight. An eight-foot cavity should consume a minimum of 10 pounds of insulation. For most insulation brands, you will run out of insulation in the hopper just before you finish blowing the third 8 foot wall cavity, assuming about a 3.5 pounds per cubic foot density.

Except as previously noted, fill all wall cavities. In some cases wall cavities close to critical framing junctures will take more insulation to plug and fill those areas, which is often necessary in order to assure the proper air sealing of the house.

Seal the holes with expandable foam or stuff tightly with fiberglass. Cover the hole with a plug or with a piece of felt before replacing siding.

21333 Rim Insulation

The bandjoist area between floors in a multi-story homes should be included as part of a sidewall insulation retrofit. Only those parts of these floor cavities that border the exterior must be insulated.

In platform-framed buildings, these cavities must be accessed from the rim or band joists. In balloon framed buildings, these cavities are usually open to the walls, allowing access from the rim or band joists and also from the wall cavities above or below these floor cavities. The R-value of the insulation in these floor cavities must be at least equal to the R-value of the insulation installed in the adjacent wall cavities.

Follow “Safety” and “Preparation” guidelines as described above in sections 2131 and 2132. Pay particular attention to location of light fixtures, exhaust fans, wiring and ductwork located in ceilings between floors.

Remove exterior finish material as described in section 21331, “Wall Cavity Access”.

Drill 2 inch or 2-1/2 inch diameter holes to access each cavity between ceiling joists.

Insert hose nozzle in cavity. Reduce air setting and raise flow on the hopper. Spray insulation into cavity. The objective is to create an “insulation plug” in the ceiling cavity usually within 3 feet to 4 feet from the bandjoist. Alternately, a 90^{o} nozzle may be inserted into the cavity. An “insulation plug” will be created closer to the bandjoist by spraying insulation up against the subfloor.

Another method for insulating these cavities is the bag, or “bladder”, method. This method is probably the most cost effective when considering time and materials.[18]

Joist cavities on the remaining two sides of the home (where joists are parallel to bandjoist) should be completely filled with insulation. Insert rigid fill tube half the width of the cavity. Pack the joist cavity with insulation.

2134 Installation – Open Wall Cavity

21341 Batt Insulation

Batt insulation must be cut to the exact length of the cavity. A batt that is too short creates air spaces above and beneath the batt, allowing convection. A long batt that is too long will bunch up, creating air pockets. Air pockets and convection currents significantly reduce insulation’s thermal performance. Each wall cavity should be completely filled with batt insulation.

If possible, use unfaced friction-fit batt insulation. Fluff to fill entire wall cavity.

Staple faced insulation to outside face of studs, do not use inset stapling.

Split batts around wiring rather than letting the wiring bunch the batt to one side of the cavity. Insulate behind and around obstacles with scrap pieces of batt or rigid foam pieces before installing batt.

Depending upon the climate region, a vapor retarder may be required. The vapor retarder should have a perm rating of less than one. The vapor retarder should face the “warm in winter” side of the insulation. The vapor retarder should be fastened at all seams and edges.

[18] Woven plastic bags are available from NYP Cop., 805 East Grand Street, Elizabeth NJ 070201, 800-524-1052. Seconds might be available. For normal floor cavity use, bag size should be at least 24 inches wide.

Fiberglass insulation exposed to the interior living space must be covered with minimum ½ inch drywall or other material that has an ASTM flame spread rating of 25 or less.

21342 Wet Spray

Cellulose or rock wool insulation can be mixed with water and sprayed into an open cavity. The insulation is installed from the interior of the home. Note that trained installers and special equipment are required. Manufacturer's instructions with regard to equipment, amount of water to be added, application process and drying time should be followed.

If the insulation has not been pre-mixed with a dry adhesive, a wet adhesive is mixed during the installation process to assure cohesion and stability following application.

Windows, junction boxes and other items from which insulation is to be excluded should be masked. All rough-in work on exterior walls should be completed prior to insulating walls.

Wet spray cellulose being installed

Insulation should be installed to a density of 3.25-4.00 lbs/ft^3.

A "stud scrubber" is used to remove excess insulation. Face of insulation should be flush to face of studs. Floor area around application area should be clean of all debris as excess insulation is collected and placed back in the hopper.

Insulation should completely fill cavity between studs and should be continuous behind interior partition walls. Insulation should fit around all electrical boxes, wiring, conduit and pipes ensuring that all gaps and voids within the wall cavity are filled. Narrow spaces, such as between a junction box and the exterior sheathing, may be insulated with low expanding foam.

Exposed bandjoist between floors should be insulated to same depth as wall cavity.

Most authorities agree that vapor retarders of any type should not be used with spray applied insulations. This recommendation may conflict with some building codes, but knowledgeable code officials understand the special nature of spray-

applied insulations and normally grant exceptions when this application process is used[19].

Wet spray cellulose exposed to the interior living space must be covered with minimum ½ inch drywall or other material that has an ASTM flame spread rating of 25 or less.

2135 Completion of Wall Insulation

Ensure that no insulation dust or debris have been left in or around the house.

The duct system should be inspected to assure that ducts are free of insulation. Turn on air handler and look for signs of insulation.

When sidewall insulation is not recommended as a retrofit or sidewalls cannot be insulated an explanatory note must be included in the file.

Provide information on the wall insulation application levels (R-value, quantity of insulation, etc.) required by the certificate of insulation to be posted in the home.

[19] Cellulose Insulation Manufacturers Association, Technical Bulletins #2 and #3.

214 Foundation Insulation

Best Practice Recommendations:

- Basements should generally be considered part of the conditioned space of a home.
- Foundation walls of crawl spaces containing mechanicals should generally be considered the thermal boundary.
- Foundation wall insulation should be a minimum R10.
- Floor joist cavity insulation should be the maximum R-value structurally allowable or highest SIR value in cases where the floor above the crawl space is the thermal boundary.
- Properly installed ground covers are recommended for crawl spaces, regardless of the thermal boundary location.
- Crawl space vents should be sealed where the foundation walls form the thermal boundary.
- Band joists should be both air sealed and insulated.

This section addresses basement wall insulation, crawl space wall and floor insulation, slab-on-grade insulation and rim joist insulation. Standards relating to ground moisture barriers and crawl space ventilation are also provided here.

2141 Identifying the Thermal Boundary

Basement walls are generally part of the home's thermal boundary. As such, the basement ceiling is not insulated nor are bypasses in the basement ceiling air sealed for energy savings. If it is determined that the basement walls are not part of the thermal boundary, the basement ceiling may be insulated and air sealed. Ceilings in basements with the following characteristics may be considered the thermal boundary.

- Space heating and water heating appliances are not located in the basement,
- It is clear that the occupants do not use the basement on a regular basis; for example, access to the basement is through an exterior door or hatch, or
- Basement moisture problems that weatherization work cannot solve.

Either the crawl space walls or floor above the crawl space form the thermal boundary in homes with crawl spaces. Determine whether to air seal and insulate the walls or the floor above the crawl space.

Zone pressure diagnostics can assist in determining whether a basement or crawl space is "more inside" or "more outside" the conditioned space. The existing thermal boundary may not be appropriate, however. Weatherization can alter this by appropriate air sealing. See section 112, "Zone Pressure Tests", for additional information.

In general, the crawl space walls should be considered the thermal boundary if plumbing and ductwork are located within a crawl space and if vents can be sealed. If there are no signs of standing water, the crawl space is dry, there is proper surface drainage and there

is a properly installed ground moisture barrier (or one can be installed as part of weatherization), the crawl space walls may be insulated. Otherwise, the floor above the crawl space should be insulated. If the crawl space is connected to a basement, decide if isolating it from the basement is appropriate.

If the heating system is located in the crawl space, precautions must be taken to ensure that adequate combustion air is available. Consideration should be given to insulating the floor above the crawl space if a combustion appliance is located within it. Exposed pipes and ducts are to be insulated if the floor above a crawl space is the thermal boundary.

Floor insulation is generally preferred where crawl space moisture problems exist, the building has a relatively large perimeter for a relatively small floor area, or the foundation wall surface is too irregular to permit foundation insulation.

2142 Preparation

Inspect the foundation from the interior and exterior of the home. Identify all potential hazards and repair prior to air sealing and insulating. Pay particular attention to current or existing moisture problems, such as mold, mildew, wood rot or sewage leakage. Determine if problems can be corrected as part of weatherization.

An inspection from the exterior of the home should include an examination of the following:

- Foundation type and condition,
- Location of electrical, gas, oil and phone lines,
- Plumbing pipes,
- Existing moisture and drainage problems, and
- Existing structural problems.

An inspection from the interior of the home should include an examination of the following:

- Interior foundation wall type and condition,
- Location of electrical and plumbing utilities, and
- Moisture problems.

Make any necessary repairs before air sealing and insulating. Note presence and location of air leaks in the thermal envelope.

2143 Basement Wall Insulation

Basement wall insulation should be a minimum R10. Basement foundation insulation must be covered with a material that has an ASTM flame spread rating of 25 or less (such as ½ inch gypsum board).

Basement walls may be insulated with rigid foam board insulation or batt insulation. Insulation should be continuous from the top of the basement wall down to the basement floor.

21431 Rigid Foam Board Insulation

Foil-faced rigid insulation may be installed directly to the basement wall with mechanical fasteners and insulation compatible foam. Joints and seams in the insulation should be sealed with sheathing tape to form an air seal. A continuous bead of sealant should be used to seal the top and base of the insulation board to the foundation. Sealant should also be used to seal the insulation to foundation around windows and doors.

Installation of rigid exterior foundation insulation

Unfaced extruded or expanded insulation may also be used to insulate the basement wall. Joints and seams should be sealed as described above. Vertical edges of the insulation may be routed to accept a 1 inch x 2 inch or 1 inch x 3 inch furring strip. The furring strips may be used to help secure the insulation to the basement wall with power driven masonry nails. An acceptable flame spread material such as gypsum board or FSK[20] paper may be attached to the furring strips.

Wood furring strips and gypsum board (if used) shall be held off the basement floor by a minimum 1 inch to prevent capillary action from the basement floor.

21432 Batt Insulation

Use 3 inch or 6 inch thick, vinyl-faced, metal-building fiberglass insulation sometimes referred to as “basement blanket” or “perimeter wrap”. The insulation is available in a 4 foot width with stapling flanges. The insulation is installed horizontally along the wall and attached to furring strips. The vinyl facing meets the flame spread rating.

Window and door openings should be furred-out. The insulation should be attached and sealed with sheathing tape. Joints between pieces of the insulation should also be sealed with sheathing tape.

Note that condensation may occur on the basement walls with this technique if the insulation is not well sealed and the basement is subject to high moisture loads.

[20] A vapor retarder laminate of foil/ scrim (reinforcement) kraft construction. Also known as FSK

Leaks that are not connected to the outdoors should not be sealed if the basement is a conditioned space. However, some penetrations in a basement ceiling, while initially appearing to be between two conditioned zones, might be connected to the outdoors through attics, open interior walls, exteriors wall, or unconditioned attached structures. These circuitous leaks are more likely found in a balloon framed construction. Leaks of this type should be sealed. The following procedure may be used to help identify circuitous basement ceiling leaks that are connected to the outdoors:

- Complete all attic bypass air sealing.
- Insulate the attic after completing the attic bypass air sealing.
- Insulate the house walls. The walls must be dense packed with cellulose unless conditions will not permit.
- Depressurize the house with the blower door after completing the attic air sealing and attic and wall insulation installation.
- With the blower door running, the door to the basement open, and the basement closed to the outdoors, search for leaks in the basement ceiling connected to the outdoors. If air is flowing through penetrations in the basement ceiling, this air is circuitously leaking in from the outdoors. Possible examples of these leaks include:
    - chimney chases
    - plumbing stacks
    - interior walls open to the basement

Basement ceiling penetrations are leaking air from the outdoors should be sealed Note that it is always best to stop these circuitous leaks by sealing attic bypasses or dense packing exterior walls with cellulose. However, in some cases, difficult air leaks remain after this work.

2144 Basement Ceiling Insulation

If basement ceilings form the thermal boundary, they may be insulated. See section 21452, “Crawl Space – Floor Above is Thermal Boundary”, if the thermal boundary of the basement is its ceiling.

Seal all significant leaks in the basement ceiling if the basement is defined as an unconditioned space. The blower door may be used to help find leaks in the basement ceiling by pressurizing the house. Close door to the basement and open an exterior basement window or door to the outside to help identify air leaks. See section 211, “Air Sealing”, before insulation is installed.

2145 Crawl Spaces

The insulation and air barrier should be adjacent to each other to establish an effective thermal boundary. Establishing an effective air barrier in crawl spaces – comparable to the air barriers in the sidewalls and ceiling – may be difficult, not practical or cost-effective.

If a crawl space is connected to a basement, determine if the walls or the floor above the crawl is the thermal boundary. Consider the presence of plumbing, heating ducts and accessibility to the crawl space when deciding. The foundation wall separating the

basement and crawl space should be air sealed and insulated if it's determined that the floor above the crawl is the thermal boundary.

The following items are required regardless of the location of the crawl space thermal boundary.

- An effective ground moisture barrier must be present or one should be installed as part of weatherization.
- Exhaust fans that vent into a crawl space must be ducted to the outside before crawl space insulation is installed. See section 245, "Ventilation".

21451 Wall is Thermal Boundary

Crawl space foundation walls are not to be insulated unless existing moisture problems can be corrected.

Foundation wall insulation shall be a minimum R10 and should extend from the top of the foundation wall down to the crawl space floor.

Extruded polystyrene insulation is the most appropriate insulation for flat concrete or concrete block walls. For rubble masonry walls, use 3 inch or 6 inch thick, vinyl-faced, metal-building fiberglass insulation sometimes referred to as "basement blanket". Two-part foam is also an option for insulating foundation walls and care must be taken to assure that the proper thickness is obtained.

- Existing foundation vents are to be sealed. If foundation vents cannot be sealed, consideration should be given to insulating the floor above the crawl space. Foundation wall insulation is not to be installed unless the crawl space vents can be sealed.
- Air sealing the foundation wall is to be completed before foundation insulation is installed.
- A ground moisture barrier should be installed that runs up the foundation walls at least 6 inches. The barrier shall be sealed to the foundation walls with an appropriate sealant. See section 21433, "Ground Moisture Barrier".
- If the footing or foundation floor is not below the frost line, the insulation should extend two feet horizontally from the foundation wall along the crawl space floor.
- Insulation should be installed to butt snugly together and flush where pieces meet, and should be tight to surfaces at the top and bottom, fastened and protected in accordance with the manufacturer's instructions for the type of insulation utilized.
- Insulation installed horizontally on crawl space floor should be placed on top of the ground moisture barrier.
- Insulation should be kept a safe distance from heat producing sources.
- Insulation should be installed with no voids or edge gaps.
- If present, outside access hatches should be securely attached to foundation wall and insulated to minimum R10. Positive closure (latch,

sash locks, gate hooks, etc) should be installed to provide substantially airtight closure.

- Foundation insulation must be covered with a material that has an ASTM flame spread rating of 25 or less such as FSK paper or 1/8 inch masonite. Vinyl facing on the metal fiberglass insulation also meets this requirement.

  - Batt Insulation
    - Batt insulation should be securely fastened to the wall.
    - Batt insulation may be clamped to the sill plate by a wooden strip, nailed or screwed into the sill.
    - The bottom of the batts should have a weighted object placed at the fold to hold them in place. If there are no weighted objects, 16d nails may be stuck through the insulation batts and into the ground as close to the fold as possible.

  - Rigid Insulation
    - Mechanically fasten insulation and fire-rated material to interior surface, making sure that all surfaces, joints and edges are sealed.
    - Make sure all exposed edges are covered with appropriate materials to meet fire codes.

21452 Floor Above is Thermal Boundary

Floors above crawl spaces may be insulated if they form the thermal boundary.

Seal all significant leaks in the floor to establish an effective air barrier at the floor and prevent air from passing through or around the insulation. The blower door may be used to help find leaks in the floor above the crawl space by pressurizing the house. Close the interior hatch to the crawl space. Open an exterior crawl space hatch if present. See section 211, “Air Sealing”, before insulation is installed.

- Batt Insulation
  - Existing foundation vents may be ignored except where required to provide combustion air to heating appliances located in the crawl space. If heating appliances are located in the crawl space, vent sizes shall be checked to assure adequate combustion air supply.
  - Install full joist cavity insulation to the maximum R-value structurally allowable or highest SIR value recommended by audit.
  - Exposed pipes must be insulated. Any covered water valves should have a tag with “WATER VALVE” written on it and hung below the valve and insulation.
  - Exposed ducts must be sealed and insulated.

- **Insulation must contact the subfloor to prevent convection above the insulation.**
- Floor insulation must be fastened securely in place with wire fasteners, nylon mesh, or other appropriate methods (see below). Friction fitting or stapling of floor insulation is not considered an appropriate method for securing the material. House-wrap sheeting is not to be used to hold insulation in place. If a sheeting material is to be used, consider using netting or a 100 percent polypropylene fabric stapled to the bottom edges of the joists. Reinforce with wood lath as necessary.
    - Wood lath and galvanized nails may be used to hold the insulation in place with a maximum spacing of 18 inches on center. Twine used to hold the insulation in place must be made of polypropylene, nylon or polyester with a breaking strength of at least 150lbs. and 12" maximum spacing between anchor points on the same joist.
    - Wire used to hold the insulation must be zinc coated, stainless or similar corrosive resistant material with a minimum diameter of .035". Wire must be spaced no more than 18 inches apart. Supports and anchors must be zinc coated, stainless steel or similar corrosion resistant material. Staples for wood lath are to have a ¼ inch crown. Staples for wire and twine are to have a 3/8 inch crown and nails are to be galvanized and penetrate the joist at least 5/8 of an inch.
    - Wire hangers may also be used if spaced no more than 18 inches on center and have a minimum thickness of .090 inches. The hanger ends must penetrate the joist at least ½ inch.
    - Insulation supports should not compress insulation by more than one inch.
- Insulation should be fitted tightly around cross bracing and other obstructions.
- Faced insulation should be installed with the facing placed up towards the floor sheathing.
- Ensure that floor insulation is in direct contact with rim joist. If balloon framed, air seal stud cavities prior to installing insulation.
- Insulation should be installed without voids or edge gaps.
- Insulation must not be installed over knob-and-tube wiring.

- Rigid Insulation

Floor cavities may be enclosed and insulation blown into the cavity. Floor cavities may be enclosed with rigid insulation or "belly paper".

Reinforced polyethylene or house-wrap type sheeting is not to be used.

- Floors over crawl spaces may be insulated with rigid insulation board applied to the floor joists. The insulation board is then drilled and insulation is blown into the cavity. If dense pack cellulose is used, density should equal 3.5 pounds of insulation per cubic feet. Multiply 0.29 by the cavity thickness to determine amount of insulation needed per square foot of joist thickness. Plug all holes following insulation installation.
- Enclose floor cavity with belly-paper or similar product. The material used to enclose the floor cavity must be installed in such a manner to support the weight of the insulation. Blown fiberglass insulation may be used to insulate the floor cavity. Dense pack cellulose should not used because of its weight. Slit material and blow insulation into the floor cavity. Tape slits when complete.
- For enclosed floor cavities above unheated areas, loose fill insulation may be added. Insulation should be dense packed to ensure continuous contact with subfloor and to prevent thermal bypasses.
- Plumbing pipes left exposed following floor insulation must be insulated.

21453 Crawl Space Access

Crawl space access hatches from conditioned areas should be weatherstripped and insulated with a minimum of R10. Access covers must be easily removable for entrance into the crawl space.

A new access hatch and hardware may also be installed. The access cover should be constructed of minimum ¾ inch treated wood if access is located on the exterior of the home.

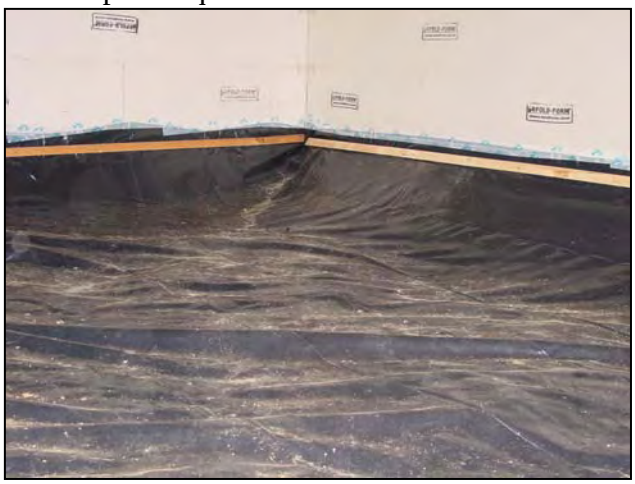
2146 Ground Moisture Barrier

Crawl space moisture can lead to condensation, mold and rot. Air passing through the soil can contain radon and pesticides. Covering the ground with an airtight moisture barrier establishes an air barrier and seals out moisture and soil gases.

Ground moisture barriers should be minimum 6 mil polyethylene plastic. Complete or partial coverage of ground moisture barriers will depend on the accessibility and working conditions in the space. If the entire crawl space floor is not accessible, cover as much as possible.

- Cover the ground completely with a ground moisture barrier without voids or gaps.
- Extend ground moisture barrier up foundation wall a minimum of 6 inches. Seal ground moisture barrier to foundation wall with acoustical sealant or other effective adhesive.

- Secure ground moisture barrier to foundation before installing insulation.
- Overlap ground moisture barrier seams at least 12 inches and seal seams with acoustical sealant, 3M #8086 builders' tape or equivalent.
- Seal the ground moisture barrier to concrete footings with acoustical sealant or other effective adhesive.
- Duct mastic may also be used to seal the ground moisture barrier to the foundation wall and to seal joints between sheets. Apply duct tape to temporarily hold the ground moisture barrier in place. Embed the duct tape in duct mastic assuring that the mastic extends a minimum of 3 inches beyond the edge of the duct tape.



Ground cover sealed to foundation walls

2147 Crawl Space Ventilation

Crawl space ventilation will not solve typical moisture problems found in crawl spaces. The source of the moisture must be identified and corrected.

Vents in crawl spaces with the foundation wall being the thermal barrier may be sealed with rigid insulation. If building codes prohibit sealing crawl space vents, non-operable vents should be replaced with operable vents. Clients should be instructed to close the vents during the heating season.

Vents should not be sealed in crawl spaces with heating appliances unless adequate provisions for combustion air are provided. Vents may be installed in crawl spaces that have combustion heating systems if there are no vents or if the vents are not properly sized for combustion air. Vents should be non-operable and the client should be informed that the vents are to remain open.

Vents should not be installed if the floor above the crawl space is the thermal boundary unless needed to provide combustion air to a heating appliance.

21471 Vent Requirements for Unconditioned Crawl Spaces

Follow local code requirements when installing vents in unconditioned crawl spaces (floor above crawl space is thermal boundary).

2148 Slab Edge Insulation

Perimeter of slabs-on-grade may be insulated with extruded polystyrene foam board insulation. Insulation should be a minimum of R5 and extend a minimum of 6 inches

below grade. Attach insulation boards with glue or mechanical fasteners. Provide drip caps and flash behind sidewall exterior finish.

Insulation should be covered with a durable weather resistant coating or pre-coated insulation panels may be used. The coating must protect the insulation from ultra violet light and potential mechanical damage.

Backfill and tamp to prevent settling of soil at a later date. Maintain a minimum 6 inches between backfill and bottom edge of sidewall exterior finish. Provide positive drainage with a 5% slope away from the house (6 inch fall in the first 10 feet away from the house provides a 5% slope).

2149 Bandjoist Treatment

Seal penetrations in bandjoist before insulating. Two-part spray foam is recommended for air sealing and insulating the bandjoist. Polystyrene or polyurethane foam board may also be used, but the board must be caulked or foamed in place to provide an air seal.

Stuffing the band joist area with an "insulation pillow" (a plastic bag filled with fiberglass)

Fiberglass batt insulation is generally not recommended as it does not form a vapor seal between the conditioned space and rim joist. Even with kraft or vinyl-faced batt insulation, vapor can move between the batt and floor framing causing condensation on the bandjoist. This is particularly a problem in crawl spaces and basements with high moisture loads in cold climates.

Joist cavities that are parallel to the foundation wall may be sealed and blown with wall insulation unless moisture is present.

21491 Two-Part Spray Foam

Provide R10 or R-value recommended by audit with spray foam. Foam should make a good seal between the subfloor and bandjoist and between bandjoist and sill plate. Spray foam should also extend down past sill plate to seal sill plate to foundation wall.

21492 Rigid Foam Insulation

Provide a minimum R10 rigid insulation. Insulation board should be placed firmly against bandjoist. Insulation should be cut to fit tightly between floor joists and between subfloor and sill plate. Perimeter of insulation should be caulked or foamed to the floor joists, subfloor and sill plate.

215 Window Measures

Best Practice Recommendations:

- Window measures should be governed by cost effectiveness or the individual home's need for window repair. Window measures to solve minor comfort complaints should be avoided.
- Window measures should be accomplished using lead-safe weatherization practices.
- Replacement windows should be ENERGY STAR® rated.

Windows and doors were once thought to be a major air-leakage problem. However, the gaps and holes in a home's air barrier are usually much more significant than air leakage around windows and doors. Consequently, window and door air sealing has been deemphasized as part of weatherization.

A window's energy efficiency is improved in two primary ways: increasing thermal resistance and reducing air leakage. Limiting factors to the application of these measures are money and time. In the past, window measures – especially storm windows and replacement windows – were overemphasized. The application of window and door measures should be governed by cost effectiveness or the individual home's need for window repair. Expensive and time consuming window measures to solve minor comfort complaints should be avoided.

2151 Air Sealing

Window air sealing measures should be accomplished using lead-safe weatherization practices.

21511 Caulking

- To prevent air leakage, condensation, and rain leakage, seal between window frame and other building materials on interior or exterior walls. Remove loose or brittle material before caulking.
- If crack is deeper than 5/16 inch, install backer rod before sealing with caulk. Backing material includes flexible polyurethane, neoprene butyl rod, fiberglass or sponge rubber.
- Use sealants with rated adhesion and joint movement characteristics appropriate for both the window frame and the building materials surrounding the window. Caulking should be applied in a manner that seals the area thoroughly and is neat in appearance.

21512 Weatherstripping

- Large gaps between sash and sill and sash and stops may be weatherstripped. Meeting rails may also be weatherstripped or planed.
- Weatherstrip is to be secured by nails or staples, form a permanent airtight seal and not obstruct the operation of the sash.

- Replace/repair missing or non-functional top and side sash locks, hinges or other hardware if such action will reduce a significant amount of air leakage.

2152 Exterior Storm Windows

Storm windows are usually marginally cost effective even though they perform several tasks. A storm window only increases a single-pane window's thermal resistance from approximately R1 to R2 and it protects the primary window from weathering. Storm windows help increase the surface temperature of the prime window, improving comfort and reducing the potential for window condensation. Storm windows installed in kitchens, baths and other high moisture areas should be operable if they provide the only source of fresh air ventilation into the space.

Double hung sash with exterior aluminum storm window

Select metal exterior storm windows with the following qualities.

- Frame should have sturdy corners and not tend to rack out-of-square during transport and installation.
- The gasket sealing the glass should surround the glass edge and not merely wedge the glass in place against the metal frame.
- Storm window sashes must fit tightly in their frames.
- The window should be sized correctly and fit well in the opening. Storm windows must be securely fastened in place; installed straight, plumb, and level, and without distortion.
- Storm windows should be caulked around the frame at time of installation except for weep holes which are to remain open. If weep holes are not manufactured into new storm window, weep holes are to be drilled.
- Storm window sashes must be removable from indoors.
- New storm windows should not be used to replace existing storms if the existing storms are in good condition or can be repaired at a reasonable cost.
- Wood storm window inserts should fit neatly within window frame with the appropriate turn buttons, latches or closing hardware.
- Fixed storm windows should not restrict the exiting capacity and access required for emergency exits.

2153 Replacement

Primary window replacements are generally not cost effective. The decision to replace a window should be based on cost effectiveness and not on client requests. Replace windows when the window is missing, damaged beyond repair, or found to be cost effective.

Replacement window sash should be easily operable by the client.

Replacement windows should be Energy Star® rated and meet the US Department of Energy U-value recommendations.

State		U-Value
Minnesota, Wisconsin, Michigan	–	0.35 Btus/ft^2-^{o}FDay
Iowa, Missouri, Illinois, Indiana, Ohio	–	0.40 Btus/ft^2-^{o}FDay

Replacement windows should have U-values rated by the National Fenestration Rating Council (NFRC). U-value shall be window unit and not center-of-glass U-value.

When feasible, window repairs must be done, instead of replacement, whenever the total cost of the repair is less than seventy-five percent of the cost of a replacement window.

2154 Window Repair

Measures listed below are air-sealing measures and may be part of an overall air-sealing plan. Otherwise, they are repair items done to increase building durability. Cost for these measures should be considered within the overall weatherization budget of the home.

Window repair should be accomplished using lead-safe weatherization practices. The finished window shall operate smoothly, form a tight seal and be neat in appearance. All work to the window shall be neat in appearance.

It is not required to make windows sashes operable unless stipulated by building codes.

21541 Glass Replacement

Replace missing or broken glass or glass that is cracked and noticeably separated that affects the structural integrity of the window. Ignore glass cracks that are not noticeably separated.

- Glass should be secured with glazing points (2 inches from each corner and not less than 8 inches apart) and puttied with latex or oil based glazing compound, or sealed with plastic or vinyl glazing strips.
- Glass set in metal frames should have metal-glazing clips no more than 12 inches apart and within 4 inches of each corner and the joint between the two surfaces puttied.
- Glass over 25 inches in either dimension should not be less than “B” grade double strength.

- Safety glass is required in windows located within 12 inches of a door when the bottom edge is less than 60 inches above the floor or if panes are larger than 9 ft^2 when the bottom edge is less than 18 inches above the floor.

21542 Re-glazing

Re-glazing window sashes is best accomplished as part of a comprehensive window rehabilitation project. Without scraping, priming, and painting, re-glazing wood windows may not be a durable repair.

- Window glazing compound should only be replaced if the existing glazing is deteriorated to the degree that the window glass is in jeopardy of falling out if the sash.
- Caulk may not be used in place of a glazing compound.
- A coat of primer or linseed oil must be applied to wood sashes before the glazing compound is applied.
- Glazing compound is to be tooled smooth to form a concave surface and be neat in appearance.

21543 Stops

Window stops should be adjusted if large gaps exist between stop and jamb. Window stops should be installed in such a way as to insure a tight seal between the jamb, sash, and stop. Ensure that window operates smoothly following stop adjustment.

- Wood installed should be similar in size and shape to other existing window stop in the house.
- Installed window stop is to be planed or sanded smooth.
- New stop is to be painted or varnished to blend with current trim.
- Corners of installed materials are to be mitered or coped
- If matching window stop is not available, then all stop on the window is to be replaced.

Double hung sash with sash lock

21544 Sills

Factory made sills or sills made from copper treated lumber must be used for window sill replacements. CCA (chromated-copper-arsenate) lumber is not to be used.

- Sill is to be beveled flush with the interior wall.
- Sill shall be the same distance from the house as other window sills.
- Sill shall be installed at the same angle as other windows sills on the home.

- All seams shall be caulked after installation.
- Sills shall be painted to match the rest of the windows on the home.

21545 Sash Locks

The meeting rails of the upper and lower sashes are to be flush.

- Blocks under the sash lock or chiseling out part of the sash to recess the lock is not acceptable.
- Sash locks are to be centered on the check rails.
- Cam-type sash locks may be used. If they are, one must be installed at each side rail of the bottom sash.

21546 Sash Replacement

New sashes are to be installed in a manner as to allow the lower sash to stay in an open position when raised and down when closed. The client should be able to open and close sash easily.

- The lower sash must have the same bevel on the bottom rail as that of the sill.
- The top sash is to be caulked in place, but only if the old top sash was caulked or painted shut. The client must give permission before this is done.
- Sashes are to be painted or varnished to match the existing sashes.

216 Door Measures

Best Practice Recommendation:

- Door measures should be governed by cost effectiveness. Door related security and durability issues should be addressed within the overall budget context. Door measures to solve minor comfort complaints should be avoided.

Door measures are usually not cost effective unless they have a very low cost. Doors have a small surface area and their air leakage is usually more of a comfort problem than a serious energy problem most of the time. However, security and building durability issues are still very important door issues that should be addressed.

2161 Air Sealing

Door weatherstrip, thresholds and sweeps are marginally cost effective. These measures may be addressed if they are found to be cost effective. Otherwise, they are items done to increase building durability.

21611 Weatherstripping

Before weatherstripping, tighten door hardware and adjust door to close snugly against its stops. Weatherstrip is to consist of a semi-rigid strip with vinyl or neoprene flap. A bulb type weatherstrip is also acceptable if the bulb is made of siliconized rubber and a minimum of ¼ inch diameter. A third type that can be used is a tough vinyl tear-resistant skinned material enclosing cellular foam.

New weatherstrip must form a tight seal, be neat in appearance, and be fastened in such a way as to prevent buckling or gaps. Door should close without having to use excessive force following weatherstrip installation.

- All existing weatherstrip is to be removed from the door if installing new.
- Door trimming and adjustments, including hinge tightening and strike plate adjustments may be necessary and must be done before installing weatherstrip.
- A small bead of caulk is to be applied to make the weatherstrip and the door stop airtight.
- Nails or other fasteners are to be made of a non-rust material.
- Installation is to be in accordance

Exterior door metal/vinyl weatherstripping

with the manufacturer's instructions.

21612 Thresholds

Thresholds and door sweeps shall be installed to prevent infiltration while not preventing the door from operating properly.

- Thresholds are to be set entirely on the sill or a continuous shim from end to end so no gap exists between the threshold and doorsill.
- Thresholds are to fit snugly between the jambs and fastened to the sill and the floor with screws.
- Thresholds are to be caulked on both the interior and exterior to form a tight seal with the doorsill.
- All thresholds are to be wood with metal and vinyl insert.
- All unfinished wood installed is to be painted or varnished to a smooth finish.

21613 Sweeps

Sweep installation is to be neat in appearance, form an airtight seal and not interfere with the operation of the door.

Exterior door threshold sweep

- Sweeps are to be a metal strip with a vinyl or neoprene insert, or a brush type installed with screws on the interior side of the door.
- Sweeps are to be cut to the same width as the door.
- Sweep shall be secured within 2 inches of the door edge on each end.
- Sweeps shall have a threshold or carpet bar to seal against.

2162 Door Replacement

Door replacements are rarely cost-effective energy conservation measures. When feasible, a door must be repaired rather than replaced whenever the total cost of the repair is seventy-five percent or less than the cost of the replacement door. Tight uninsulated doors in good condition should not be replaced with insulated doors. It is not required to make existing stuck doors operable, except for meeting code with respect to egress.

21621 Replacement Doors

- All replacement doors should be exterior-grade foam core. Replacing an exterior panel door with another panel door is not allowed.
- Whenever possible, 1-3/4 inch thick doors are to be used.
- Replacement door should not have glass panes. If homeowner is persistent, install smallest glass pane as possible or a door viewer.
- All new wood doors are to operate smoothly, be sanded, and be painted or varnished to a smooth water repellent finish.

- Doors shall have a 5° bevel cut on the bottom to form an airtight seal between the bottom of the door and the gasket of the threshold.
- New 1-3/4 inch doors shall receive three new 4 inch x 4 inch butt hinges; 1-3/8 inch doors shall have three new 3 ½ inch x 3 ½ inch butt hinges that are mortised into the door and jamb.
- When installing a new door and jamb, the hinges are to be placed at 7 inches from the top of the door, 11 inches from the bottom of the door, and the third hinge centered between the top and bottom hinge.
- New door shall have a new door lock installed (whenever possible a 2-3/4 inch backset should be used unless using a pre-hung door that is pre-drilled for a 2-3/8 inch lockset). The client is to receive all keys - minimum two keys per lockset.

21622 Pre-Hung Replacement Doors

If a pre-hung door is needed, either a wood or steel foam filled door may be used.

- All door jambs must receive at a minimum, shims behind each hinge and lockset and any other area needed to support the door jamb.
- New jambs must be trimmed out to match existing interior and exterior trim.
- Galvanized casement nails must be used, counter sunk and filled.
- All doorsills installed must be flush with the floor of the house.

2163 Door Repair

Door repair items improve home security and building durability. Cost of these items should be addressed within the context of the overall weatherization budget for the home. All repair work must be within accepted carpenter standards. All replacement materials are to be of the type and size already existing on the door.

21631 Jambs

Remove damaged or deteriorated portion of the jamb and replace with matching materials, butting uniformly to adjacent members. All work is to be neat and form a tight seal.

- All loose sub members and casing is to be secured and all wood installed is to be finish grade or factory made jamb material.
- All installed lumber is to be planed or sanded smooth and painted or varnished to a smooth finish to match existing.
- Installer is to tighten or re-set hinges. Work is to be done in accordance with accepted carpentry standards. New installations require hinges to be mortised.
- Casing used is to match the existing casing on the house. If matching casing is not available, then all of the casing on the door is to be replaced. Wood is to be installed flush with the wall to insure a tight fit.
- Any damaged interior wall is to be repaired with like materials.
- Strike plate shall be tightened or re-set to hold the door flush with the doorstop.

- Strike plate is to be mortised into the jamb.

21632 Stops

Reposition stops if necessary. Seal gaps between the stop and jamb with caulk.

- Wood used for door stop is to be manufactured as doorstop.
- If a section of the stop is missing or must be replaced and the stop can not be matched to the existing stop, then the entire stop on that jamb is to be replaced.
- Joints are to be mitered or coped to form a tight corner joint.
- Wood installed is to be sanded smooth and painted or varnished to a smooth finish and approximately match the existing wood.

21633 Locksets/Strikeplates

Replace missing or inoperable lock sets; or reposition the lock set/strikeplate; or install a modernization kit so that the door can be held in a tightly closed position.

- Lock set is to be installed between 36 inches and 39 inches from the floor with a 2-3/4 inch backset whenever possible.
- Cover plates are to completely cover the hole drilled for the lockset cylinder.
- Faceplate and strike plates are to be mortised flushed with the wood of the door and jamb. Screws are to be installed straight and be flush with the face and strike plates.
- Strike plate must be installed in a manner as to allow the door to latch easily but with minimum play between the door and stop.

221 Clean & Tune – Gas & Oil Fired Furnaces & Boilers

Best Practice Recommendations:

- Heating systems should be cleaned and tuned to ensure that they are operating in a safe and efficient manner.
- Shell retrofits should not be done until health and safety issues, such as gas leaks, high CO readings or venting problems are corrected.
- Comprehensive testing protocols should be adopted to ensure proper operation, venting and combustion air supply for gas- and oil-fired space heating appliances.

Weatherization agencies have a responsibility to assure that their clients' heating systems are operating in a safe and efficient manner. As such, agencies should provide a full range of heating system services including safety testing, heating system repair and retrofit, and heating system replacement. Shell retrofits should not be done until health and safety issues, such as gas leaks, high CO readings or venting problems are corrected.

Weatherization agencies have two options with respect to heating systems:

- Heating systems can be tuned and repaired and then retrofitted for safe and more efficient operation, or
- Heating systems can be replaced.

Heating appliances that are non-operational or non-repairable may be replaced. Before deciding to replace a heating system, efforts to repair and retrofit it should be made. Repair is any work needed to bring a heating appliance up to manufacturer's specifications for proper operation. Repair items can include replacing blower motors and pumps, fixing vent connectors and chimneys, or tuning up burners.

This chapter provides standards for cleaning and tuning gas and oil-fired furnaces and boilers. Standards for heating system retrofits (222, "Heating System Retrofits") and heating system replacement (223, "Heating System Replacement") follow this chapter.

Servicing standards for the following heating systems are provided here.

- Gas-fired appliances,
- Oil-fired appliances,
- Furnaces, and
- Boilers.

2211 Gas Burner Servicing Requirements

The following standards apply to gas-fired furnaces, boilers, water heaters, and space heaters.

Maintenance and burner adjustment is not required unless one of the following is found:

- The appliance has not been serviced for two years or more,

- Carbon monoxide emissions measure greater than 100 ppm (as-measured) or 200 ppm (air-free),
- There are visual indicators of soot or flame roll-out,
- Steady-state efficiency (SSE) is less than 75 percent,
- Burners are visibly dirty, or
- Measured draft is low.

22111 Gas Burner Maintenance and Adjustment

Combustion test analysis shall be done following gas burner maintenance and shall meet the standards shown in Table 221-1.

- Remove causes of CO and soot, such as closed primary air intake, over-firing, and flame impingement. Measure CO before dilution air has entered the vent system. CO should be less than 100 ppm (as-measured) or 200 ppm (air-free).
- Remove dirt, rust, and other debris that may be interfering with the burners.
- Test gas valves to ensure that, in the event of a pilot outage, the flow of gas to the burners is interrupted. For gas valves with 100 percent safety shutoff, ensure that the flow of gas to the pilot is also interrupted in the event of a pilot outage.

Atmospheric natural gas burners on a large boiler

- Install new thermocouple (if an intermittent ignition device, or IID, is not being installed). Adjust pilot flame so that the hot tip of the thermocouple is enveloped by the flame.
- Adjust gas input if burners are over-fired or under-fired. Adjust input by adjusting gas pressure to between 3.4 and 4.3" water column (w.c.) for gas and 11" w.c. for propane, or replace the burner orifices.
- If the measured draft is inadequate, take action to correct. Poor draft can be caused by a leaking vent system, an obstructed chimney, lack of combustion or dilution air or leaking return air ductwork.
- Seal leaks in vent connectors and chimneys with high temperature sealant.
- Clean and adjust thermostat and check anticipator setting.
- Set heat anticipator to the proper amp setting by matching amp draw of the gas valve or per manufacturer's instructions.

Acceptable Combustion Test Analysis Measurements - Gas

Table 221-1

Heating Unit Type	Oxygen (O_2)	Carbon Dioxide (CO_2)	Stack Temperature	(CO) Carbon Monoxide Maximum ppm
Gas Atmospheric (natural gas, propane)	4 – 9%	NG: 9.6 – 6.8% LPG: 11.2 - 7.8%	300 – 600 ^{o}F	100 (as-measured) 200 (air-free)
Fan Assisted	4 – 9%	NG: 9.6 – 6.8% LPG: 11.2 - 7.8%	300 – 480 ^{o}F	100 (as-measured) 200 (air-free)
Condensing	PMI[1]	PMI[1]	PMI[1]	100 (as-measured) 200 (air-free)
Space Heaters	5 – 15%		300 – 650 ^{o}F	100 (as-measured) 200 (air-free)
Standard Power Burner	4 – 9%	NG: 9.6 – 6.8% LPG: 11.2 - 7.8%	276 – 550 ^{o}F	100 (as-measured) 200 (air-free)

[1] – Per Manufacturer's Instructions

2212 Oil Burner Servicing Requirements

Oil burners need annual maintenance to retain operational safety and combustion efficiency. Testing for steady state efficiency, draft, carbon monoxide, and smoke should be used to guide and evaluate the need and effectiveness of maintenance work. The following procedures pertain to oil-fired furnaces, boilers and water heaters.

Proceed with maintenance when any one of the following items is found with a gun-type burner. A flame-retention oil burner may be considered as an alternative to adjusting an existing gun-type oil burner (see chapter 222, "Heating System Retrofits").

Flame retention head oil burner on a wet base boiler

- The appliance has not been serviced within one year.
- The smoke number is greater than 2.
- Steady-state efficiency (SSE) is less than 75 percent.
- Carbon monoxide is greater than 100 ppm (as-measured).
- Improper flame color or combustion chamber impingement.
- Improper flame ignition and cut-off.
- The burner, combustion chamber, or heat exchanger is visibly dirty.

22121 Oil Burner Maintenance and Adjustment

Some or all of the following maintenance tasks may be needed to optimize safety and efficiency after evaluating the oil burner's operation. Combustion test analysis shall be done following oil burner maintenance and shall meet the standards shown in Table 221-2. Replacing the burner with a flame-retention burner may be alternative to adjusting the existing burner.

- Verify correct flame-sensor (cad cell) operation. Replace if necessary.
- Clean or replace burner nozzle according to the size on unit nameplate or post-weatherization heat loss calculations.
- Clean the burner's blower wheel.
- Clean or replace oil filter(s).
- Clean or replace air filter.
- Remove soot and sludge from combustion chamber.
- Remove soot from heat exchange surfaces.
- Clean the oil pump screen.
- Clean dust, dirt, and grease from the entire burner assembly.
- Set oil pump to 100 psi pressure or per manufacturer's instructions.
- Adjust air shutter for recommended smoke reading.
- Adjust barometric damper to about 0.04-to-0.06 inches w.c. draft downstream at the breech.
- Replace defective primary controls.
- Replace electrodes or adjust gap between electrodes to manufacturer's specifications.
- Repair ceramic combustion chamber, or replace it if necessary.
- Replace or adjust barometric damper.
- Measure CO in flue gases at the breech. CO should be less than 100 ppm (as-measured).
- Check oil tank for water (drain if necessary).

Acceptable Combustion Test Analysis Measurements - Oil

Table 221-2

Heating Unit Type	Oxygen (O_2)	Carbon Dioxide (CO_2)	Stack Temperature	Smoke Test	(CO) Carbon Monoxide Maximum ppm
Oil Gun Burner	4 – 9 %	12.5 – 8.8%	325 – 600 ^oF	2 or less	100 (as-measured)
Flame Retention	4 – 7%	12.5 – 10.3%	325 – 600 ^oF	2 or less	100 (as-measured)
Condensing	PMI[1]	PMI[1]	PMI[1]	2 or less	100 (as-measured)

[1] – Per Manufacturer's Instructions

2213 Improving Inadequate Draft

If measured draft is below the minimum draft pressures listed in Table 221-3, check for flue or chimney obstructions, disconnected vents, or an improperly designed vent system. Check the National Fuel Gas Code (NFGA) for proper vent sizing.

Minimum Draft Pressures
Table 221-3

Atmospheric Gas Appliances Only *Acceptable Draft Test Readings for Various Outdoor Temperature Ranges*					
ºF	<20	21-40	41-60	61-80	>80
Pascals	-5	-4	-3	-2	-1
Water Column inches	-.02	-.016	-.012	-.008	-.004

Power Oil Burners *Acceptable Draft Readings Overfire and at Breech*	
Draft Reading Location	**Acceptable Draft**
Overfire Draft	-0.01 to -0.02 inches or -2.5 to -5 Pascals
Vent Connector or Breech	-0.04 to -0.06 inches or -10 to -15 Pascals

2214 Heating Appliance Venting

Venting problems are common in low-income housing and solving them is the responsibility of a weatherization agency. Proper venting is essential to operation, efficiency, safety and durability of combustion appliances. Many chimneys and vent connectors have been neglected for decades. Air tightening the home can weaken draft, and weatherization work can reduce a heater's operating time, resulting in a cooler flue. **Perform a draft test on all vented combustion appliances prior to and after weatherization to assure proper venting in accordance with the applicable NFPA code. See section 123, "Worst-Case Draft Testing".**

Inspect chimney, vents and vent connectors to ensure adequate draft, clearance, soundness and freedom from combustible deposits. Clean if necessary. Repair or replace sections of the venting system that are seriously corroded or rusted, contain cracks or holes, and/or are unsealed, loose, or disconnected.

Sizing vents and chimney liners and selecting venting materials are two important tasks when inspecting and repairing venting systems. Too large a vent often leads to condensation and corrosion. Too small a vent can result in spillage. The wrong vent materials can corrode or deteriorate from heat.

Ensure all venting materials meet clearances from combustible materials in accordance with the applicable NFPA code. When called for, correct cases where vent clearance requirements are not met.

Ensure that vent/chimney connections are securely fastened. Horizontal runs in the vent connector should have a rise of at least ¼ inch per foot. Existing connectors that do not meet this requirement are to be repaired <u>unless</u> the appliance drafts properly under worst-case draft conditions (see section 123, "Worst-Case Draft Testing").

A ‘Y’ connector is the preferred connection when a common flue is used for more than one appliance. Vent connections are not to be located directly across from each other when an induced appliance is used.

22141 Chimneys

Chimneys should terminate near the highest part of a roof and be at least 3 feet above the roof penetration and 2 feet above any obstacle within 10 feet of the chimney outlet. Chimneys should have a cap to prevent rain and strong downdrafts from entering. Install caps on metal chimneys if caps are missing.

An example of a very hazardous venting problem

Determine whether all chimneys and existing liners are in good condition and unobstructed. Repairs must be made if chimney is in disrepair or a new liner is necessary. See section 225, “Chimney Liners”.

Masonry chimneys should be lined with a fireclay flue liner or a retrofitted metal flue liner if the chimney is not properly sized or is in poor condition.

All disconnected chimneys in the attic must be plugged and sealed.

Clean solid-fuel chimneys that contain creosote. Wood-fired appliance metal chimney sections penetrating floor, ceiling, or roof should have approved thimbles, support packages, and ventilated insulation shields if the chimney passes through insulation.

22142 Venting Devices, Materials and Sizing

The National Fire Protection Association (NFPA) is the authoritative source for information on material choice and sizing for vent connectors and chimneys. The information in this venting section is based on the following NFPA documents. Consult these references for specific venting requirements and tables for vent and chimney sizing.

- NFPA 54: The National Fuel Gas Code
- NFPA 31: Standard for the Installation of Oil-Burning Equipment
- NFPA 211: Standard for Chimneys, Fireplaces, Vents, and Solid-Fuel-Burning Appliances 1996 Edition

22143 Vent Connectors

A vent connector connects the venting outlet of the appliance with the chimney. Approved vent connectors for gas- and oil-fired appliances are made from the following materials.

- Galvanized-steel pipe ($\geq$ 0.018 inch thick),
- Type-B vent, consisting of a galvanized-steel outer pipe and aluminum, inner pipe ($\geq$ 0.027 inch thick),
- Stainless-steel pipe ($\geq$ 0.012 inch thick),
- Type-L vent, like Type-B only with a stainless-steel inner pipe, or
- Various manufactured vent connectors.

22144 Sizing Vent Connectors and Chimneys

Sizing tables and procedures for chimneys and vent connectors are found in NFPA documents numbered 54, 31 and 211 as described earlier. NFPA 54, the *National Fuel Gas Code*, Part 11 provides tables for sizing various types of chimneys and vent connectors.

22145 Orphaned Water Heaters

Water heaters formerly vented with a furnace must pass draft testing. Replacing an atmospherically vented furnace with a horizontally vented 90 percent plus furnace will necessitate relining the chimney with a liner sized for the water heater alone. This will prevent increased condensation and decay in the old chimney.

2215 Combustion Air

Combustion appliances located in most attics and crawl spaces get adequate combustion air from leaks in the building shell. Even when a combustion appliance is located within the home's living space, it usually gets adequate combustion air from air leaks in the building shell. However, if an appliance is located in a small room with tight walls and door, it may not get adequate combustion air. Also, if the home is very air-tight, the appliance may not get adequate combustion air.

In the absence of local codes, combustion air should be provided in accordance with the applicable NFPA code listed below.

- Natural Gas, Propane – NFPA 54, code #5.3
- Oil – NFPA 31, code #1-9
- Solid Fuels, NFPA 211, code #9-3

Generally, two combustion air openings are required to prevent wind from pressurizing or depressurizing the combustion zone. One opening is located near the ceiling and one near the floor. The preferred installation is for one or both openings to connect to a ventilated attic or crawl space or to some other unheated and non-airtight intermediate zone within the building. For openings connecting the combustion zone with outdoors, choose an outdoor location that is sheltered that does not sit at a right angle to prevailing winds. Wind blowing at a right angle to an opening tends to depressurize the opening and connected zone. Find and use applicable code for additional information.

2216 Forced Air System Standards

The overall system efficiency of a gas or oil fired forced air heating system is affected by blower operation, duct leakage, balance between supply and return air, and duct insulation levels.

22161 Furnace Operation Standards and Improvements

Apply the following furnace operation standards to maximize the furnace's seasonal efficiency and safety. Refer to Table 221-4 for furnace operating guidelines.

- Check temperature rise after 10 minutes of operation. Refer to manufacturer's nameplate for acceptable heat rise (supply temperature minus return temperature). The heat rise should be between 40°F and 70°F with the lower end of this scale being preferable for maximum efficiency.
- The fan-off temperature should be between 85°F and 100°F, with the lower end of the scale being preferable for maximum efficiency.
- The fan-on temperature should be 90°F and 115°F if possible.
- The high-limit controller should shut the burner off before the furnace temperature reaches 200° F. Operate unit with blower disconnected to check high limit control and repair as necessary.
- Check for proper sequencing and operation of elements for electric furnaces.
- If needed, seal (with compatible sealing materials) unsealed blower compartment openings and blower compartment door.

Category I fan-assisted gas furnace

Furnace Operating Temperatures
Table 221-4

Inadequate heat rise, Condensation and corrosion possible.	Heat rise good for both efficiency and avoidance of condensation.	Heat rise excessive. Check fan, heat exchanger, ducts and fan speed.
20^o 40^o	40^o 70^o	70^o 95^o
Heat rise = Supply temperature – Return temperature		

Excellent fan-off temperature if comfort is acceptable.	Borderline acceptable. Consider replacing fan control.	Unacceptable range. Savings possible by replacing fan control.
90^o 100^o	100^o 115^o	115^o 130^o
Fan-off Temperature		

Excellent. No action needed.	Fair. Consider fan control replacement only if fan-off is unacceptable.	Poor. Consider fan control replacement.
100^o 115^o	115^o 130^o	130^o 150^o
Fan-on Temperature		

If the heating system does not conform to the standards in Table 221-4, consider the following improvements.

- Reduce heat rise by cleaning or changing dirty filters, cleaning the blower, increasing fan speed and improving ducted air circulation.
- Adjust fan control to conform to the above standards or replace the fan control if adjustment fails (this control may be non-adjustable on some furnaces).
- Adjust the high-limit control to conform to the above standards or replace the high-limit control (this control may be non-adjustable on some furnaces).

In all cases, the following furnace measures will be done:

- Furnace filters should be cleaned or replaced. One extra filter should be left with the client.
- Blower fan and compartment should be cleaned (cleaning may entail vacuuming or wiping parts with cleaning solvents).
- Blower belt should be adjusted or changed if necessary.
- Inspect blower assembly's electrical wiring system for bad insulation and loose connections and repair as necessary. Inspect blower and squirrel cage for excessive free play and correct as necessary.
- Inspect pulleys and drive assembly for alignment, wear, and tension. Belt should free of cracks and have one inch of free play when measured between the pulleys. Replace as necessary.
- Lubricate the blower motor, if appropriate.

- Check for proper operation of the thermostat.

22162 Filter and Blower Maintenance

A dirty filter can reduce airflow significantly. Special high efficiency filters offer more airflow resistance than standard filters, especially when saturated with dust. Take action to prevent airflow restriction with the following:

- Ensure that filters are easy to change or clean.
- Stress the importance of changing or cleaning filters, and suggest to the client a regular filter maintenance schedule.

When the air handler is on there should be a strong flow of air out of each supply register, providing its balancing damper is open. Low airflow may mean that a branch duct is blocked, ductwork is disconnected, or that return air ductwork is restricted. When low airflow is a problem, consider the following improvements.

- Clean or change filter.
- Clean furnace blower.
- Lubricate blower motor and check tension on drive belt.
- Remove obstructions in the ductwork.
- Ensure all duct joints are properly connected.
- Add another return air duct (see section 2273, “Improving Duct System Airflow”).

22163 Cleaning Air Conditioning Coils

Dirty air conditioning coils are a common cause of low airflow and low heating and cooling efficiency. Follow the general guidelines listed below to clean air conditioning coils. See section 226, “Heat Pumps and Air Conditioners”, for additional information.

- Identify the coil location and the coil surface where the air enters – most of the dirt will be attached to this surface.
- Remove access panel in air handler or duct; or cut access panel in duct; or disassemble duct to gain access to air conditioning coil.
- Use a stiff hair brush to remove surface dust, dirt, and lint. Be very careful not to damage the delicate cooling coils.
- Spray the coil with cleanser and after a while spray water to rinse out the cleanser and dirt. Repeat the spraying if necessary.
- Ensure that the pan and drain hose are doing their job. Water and cleanser should be flowing out the end of the hose, not overflowing into the duct. Clean the pan and unplug the hose if necessary.

2217 Hydronic Standards

The following standards refer to hydronic systems commonly found in single family homes. Hydronic systems found in multifamily buildings are generally more complex and should be tested and evaluated by professionals experienced in their operation. Observe the following standards for servicing hydronic heating systems in single family structures.

- Repair water leaks in the system.

- Clean fire side of heat exchanger of noticeable soot buildup.
- Lubricate circulator pump if necessary.
- Boiler should not have low-limit control for maintaining a minimum boiler water temperature, unless the boiler is heating domestic water in addition to space heating.
- Test pressure tank for its rated air pressure.
- High-limit control should deactivate boiler at a water temperature of 200°F or less.
- Replace or add pressure relief valve if necessary.
- Bleed air from radiators and piping through vents in elbows or radiators. Most systems have an automatic fill valve. If there is a manual fill valve for refilling system with water, it should be open to push water in and air out.

Hot water baseboard distribution usually operates with a maximum water temperature from 180 to 200^{O}F

- Verify that the water pumps, low water cutoff, automatic feed control, and high-pressure controls are in operating condition and repair if necessary.
- Insulate hot water supply lines passing through unconditioned areas (see chapter 222, “Heating System Retrofits”).
- Check and clean thermostat.
- Vacuum and clean baseboard unit fins, if appropriate.
- If necessary, adjust the aquastat high limit and pump control in with the manufacturer’s suggested set-point.
- Ensure that thermostatically controlled zone valves are functioning properly. Repair or replace defective valves.
- If present, adjust aquastat high limit and pump control in accordance with manufacturer's recommendations. The maximum high limit setting is 200^{o}F.
- Check the compression tank for sufficient air pressure. Replace defective tanks.

For steam systems, observe the following.

- Check vents and traps. Clean or replace steam vents and steam traps as necessary.
- Verify that water pump, low water cutoff, automatic feed control and high pressure controls are in operating condition and repair as necessary.
- Replace/clean sight glass if water level cannot be seen due to dirt build-up on glass.

2218 Controls

Move improperly located thermostats to an area free from drafts or heat from the heating system, lights or appliances.

Replace defective thermostats.

Consider replacing existing single stage thermostats with automatic setback thermostats (see chapter 222, “Heating System Retrofits”).

2219 Certification

Once heating appliance has been serviced, the installer must place a sticker on the appliance certifying that the system has been properly serviced. Sticker shall indicate the date of service, name of service contractor and phone number of service contractor.

222 Heating System Retrofits

Best Practice Recommendations:

- The following heating system retrofits are recommended for the Midwest Region;
  - Automatic setback thermostat,
  - Intermittent ignition device and vent damper,
  - Boiler pipe insulation, and
  - Flame retention head burner.
- Heating system retrofits should be considered based on cost effectiveness, condition and life expectancy of heating system and client being served.

2221 Automatic Setback Thermostat

Assessors may recommend setback thermostats if it is determined that the client is capable and willing to use a setback thermostat. In homes with multiple heating zones setback thermostats should be installed in all zones in which the client will utilize a setback.

An electromechanical or electronic setback thermostat should be installed. The thermostat should have two setback periods, allowing residents to set the temperature lower (or higher for air conditioning) twice each day – once for sleep and once for vacancy, such as work and school. If the home is centrally air conditioned, a heating/cooling thermostat must be used. Installation of setback thermostat must be done in compliance with local codes by an HVAC contractor. Manual setback or large-lettered thermostats may be installed for seniors or people with visual impairments, as appropriate.

New setback thermostats should generally be installed in the same location as the old thermostats. In cases where the old thermostat is located in the kitchen, in direct sunlight, over a heat register or radiator, or other location which would impede performance, the new setback thermostat should be relocated.

All thermostats must be installed according to manufacturers' instructions. Thermostats are to be level and dirt free. Installation shall include an appropriate wall plate.

Clients shall be instructed on the setting and operation of new clock thermostats and the replacement of batteries for thermostats utilizing batteries

2222 Intermittent Ignition Device and Vent Damper

Older gas fired heating appliances have standing (constant) pilot flames for ignition. The pilot light provides for ignition when gas is supplied to the main burner. A standing pilot is also required to hold open the safety gas valve via the thermocouple that proves the presence of the pilot light. Though required for the above reasons, a standing pilot wastes energy during the non-heating season.

An intermittent ignition device (IID) eliminates the need for a standing pilot while maintaining the safety provided by a pilot/thermocouple. With an IID, the pilot flame is ignited by a spark, so the pilot only burns when needed. Gas flows to the main burner once pilot ignition is proven (a pilot burner is still used for ignition). Both the pilot and main burner are extinguished when the thermostat is satisfied.

A vent damper is a device installed within the vent system of the heating appliance that automatically closes the vent system when the appliance is off. The damper automatically opens during combustion. The damper prevents warm air from escaping through the chimney when the heating unit is not operating. The vent damper is only effective when the heating is off and the heating appliance is located in the conditioned space of the home. **Only electronic vent dampers may be installed – thermal vent dampers are not permitted.**

Thermal-mechanical vent dampers are not allowed

Installing an intermittent ignition device (IID) and vent damper can increase the steady-state efficiency of an atmospheric furnace or boiler to around 80 percent. Cost effectiveness of installing vent dampers/IIDs on furnaces is marginal and should carefully be checked. IIDs will be less cost-effective on boilers that also provide domestic hot water.

The IID and vent damper must be installed according to manufacturer's specifications and be AGA/UL approved.

- IID must be purchased as a complete system, consisting of control module, dual combination gas valve, igniter-sensor, and wiring.
- A vent damper may not be installed without an IID.
- The vent damper must be equipped with an interlocking switch to prevent gas valve opening, in the event of vent damper failure.
- The technician must watch the furnace or boiler cycle several times to ensure correct operation of the new IID and vent damper.
- The damper should never bind closed or fail to open completely while the burner is fired. There should be no spillage of flue gasses at the diverter. Control module must lock out in case of damper failure.
- Main burner must ignite without delay and without flame roll out.
- Vent dampers used on oil-fired systems must be approved for use on oil systems.

IIDs are not to be installed in damp areas. Assessors should verify that mold, mildew, excessive corrosion, rot or other evidence of moisture problems do not exist prior to scheduling IID installation.

2223 Pipe Insulation

All hot water and steam heating pipes and domestic water supply pipes which pass through unconditioned areas shall be insulated. A minimum R3.5 pipe insulation should be used.

All materials used in conjunction with pipe insulation must be capable of continuous operation at 180^{o}F and have a smoke density rating of 50 or less.

Install all insulation materials in accordance with requirements of the governing code and the manufacturer's recommendations. Additional support straps shall be provided for pipes, as necessary.

Fasteners shall not compress insulation more than 50 percent of its normal thickness. All "Ts," elbows, and bends shall be completely insulated. Pipe insulation shall be taped (using a high quality tape with good adhesion), caulked (with appropriate caulk to secure and adhere to insulation), or glued at all joints. Where freezing pipes are determined to be a potential problem, electric, freeze-prevention tape can be installed prior to insulating. Any freeze-prevention tape used must be UL labeled.

Notes: Allow 3 feet clearance between the furnace/boiler and insulation. Insulation shall be maintained a minimum 6 inches from exhaust vents (18 inches for single wall vents to oil, wood, and coal furnaces). Do not insulate over control and safety devices, pumps, valves, boiler feed lines, pressure relief devices, dampers, or vents.

2224 Flame Retention Head Burner

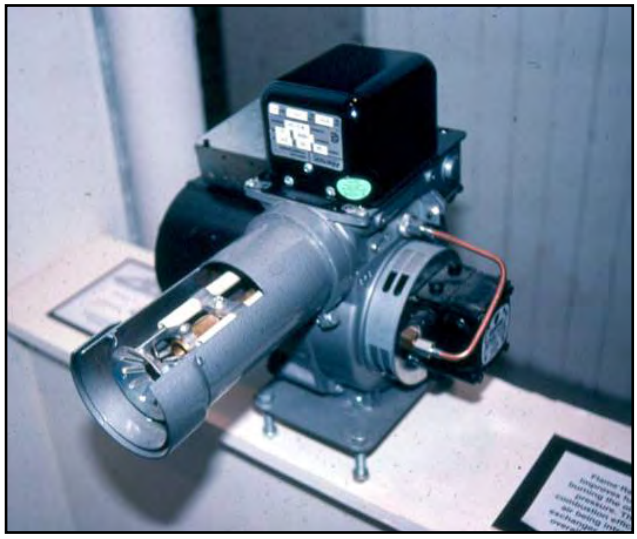
If an oil-fired furnace or boiler has a sound heat exchanger but the burner is inefficient or unserviceable, the burner may be replaced by a newer flame retention head burner. The new burner must be tested for efficient and safe operation.

A flame retention head burner is an oil burner that provides higher combustion efficiency by swirling the mist of oil and air to produce better mixing. Flame retention head burners waste less heat and have combustion efficiencies of 80 percent or slightly more. Replacing an existing gun-type burner with a flame retention model may be cost effective if the existing steady state efficiency (SSE) is less than 75 percent.

Many existing burners may be retention head burners as they have been available for about 35 years. If the existing burner has an RPM of 1725, it is a gun-type burner and should be replaced with a retention head burner. Steady state efficiency will increase by about 10 percent. If the existing burner has an RPM rating of 3450, it is already a retention head burner and replacement may not be cost-effective.

Installation of flame retention burners must be done by a licensed mechanical contractor and a mechanical permit shall be obtained from the responsible code enforcement authority, if necessary. Existing gun-type burners shall be replaced with a flame retention burner in accordance with governing code requirements and manufacturer's recommendations. In addition, the following shall be completed as needed:

- Size the burner and nozzle to match the building's heat load, making adjustments for new insulation and air sealing done during weatherization.
- Install new combustion chamber, choosing one that fits the size and shape of the burner flame. Or, change nozzles on the new burner to produce a flame that matches an existing combustion chamber that is still in good condition. Either way, the flame must fill the combustion chamber without impinging on it.
- Complete clean out and sealing of boiler sections, fire doors, flue pipe joints, and anywhere excess air can infiltrate the combustion area or flue passages.
- Install new primary control.
- Over-fire draft shall be set according to manufacturer's specifications, usually at 0.01 or 0.02 inches of water column.
- Replace barometric damper and flue pipe as necessary.
- Replace any controls or wiring required for safe, reliable operation.
- Replace furnace filter.



Retention head burner with air blast tube cut away, exposing nozzle and electrodes

Upon installation, heating appliances receiving a flame retention burner must meet the following requirements:

- An oxygen (O_2) reading of 4 to 7 percent (carbon dioxide of 12.5 - 10.3 percent).
- A maximum smoke of 2.
- Stack temperature between 300^{o}F and 600^{o}F.

223 Heating System Replacement

Best Practice Recommendations:

- Every effort to repair and retrofit heating appliances should be made prior to replacement. Heating appliances that are non-operational or non-repairable should be replaced.
- Replacement heating systems must be sized according to accepted calculations such as the *Residential Load Calculation* (Manual J) or approved computerized load calculation software. Sizing should account for lower heating loads resulting from insulation and air sealing work. Sizing calculations must be included as a permanent part of the client file.
- Replacement heating appliances should meet the guidelines and efficiency ratings as shown in the table below or be ENERGY STAR® rated unless shown not to be cost-effective or if existing conditions are not appropriate for their installation.

Natural Gas/LP Furnaces	90%, direct vent sealed combustion
Oil Furnaces	83%
Gas and Oil Boilers	85%

- Weatherization work shall not be done in any home with an unvented space heater where client does not permit its removal.

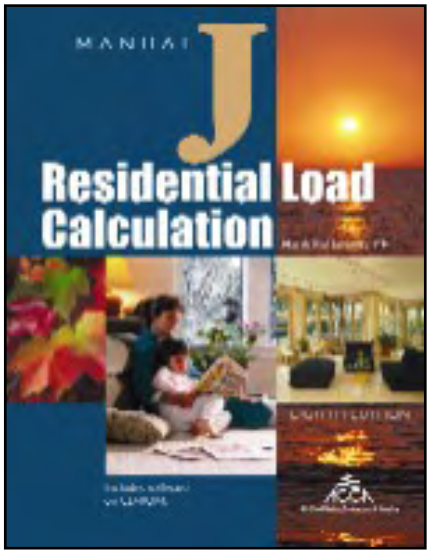
Heating appliances that are non-operational or non-repairable should be replaced. Before deciding to replace a heating system, every effort to repair and retrofit it should be made. Repair is defined as any work needed to bring a heating appliance up to manufacturer's specifications for proper operation. Repair items include replacing blower motors and pumps, fixing vent connectors and chimneys.

New heating appliances must be installed to manufacturers' specifications, following all applicable building and fire codes.

System sizing calculations must meet accepted standards such as *Residential Load Calculation* (Manual J), 7th or 8th edition, by the Air Conditioning Contractors of America or approved computerized load calculation software. Sizing should account for lower heating loads resulting from insulation and air sealing work. Sizing calculations must be included as a permanent part of the client file.

All new heating appliances shall carry a minimum one year warranty on workmanship. New condensing units must have a lifetime manufacturer warranty on the primary heat exchanger, and a 10-year warranty on the secondary heat exchanger.

Each client shall receive all manufacturer's product warranty information, clear maintenance instructions, educational information and a local telephone number for warranty problems.



Manual J, 8th edition is more difficult to use than the 7th edition, which is still in print from ACCA

If a home has central air conditioning and is a candidate for primary heating system replacement, the cost for the primary heating system replacement work must include reinstallation of the existing central air conditioning unit with the new primary heating system. Central air conditioning is not a candidate for repair or replacement.

New heating appliances that are to be installed on a concrete, dirt, or damp floor, should be raised a minimum of 1 inch above the floor surface, or per local code. Properly remove and dispose of existing unit. Seal openings in chimneys where atmospheric vented appliances are eliminated.

Replacement heating appliances should meet the guidelines and efficiency ratings as shown in Table 223-1.

- Natural Gas and LP Forced Air

Replacement gas furnaces should have a minimum AFUE of 90 percent and be direct-vent sealed combustion if shown to be cost-effective. Gas-fired atmospheric vented furnaces with efficiencies less than 75 percent steady-state and having less than a 5 year life expectancy are candidates for replacement. Propane-fired furnaces with efficiencies less than 80 percent steady-state and having less than a 5 year life expectancy are also candidates for replacement. Furnaces may also be replaced if they are old gravity units.

Non-condensing furnaces with a minimum AFUE of 80 percent can be installed if it is shown that the 90 percent replacement furnaces are not cost-effective. Furnaces with an 80 percent AFUE may also be installed where condensing units cannot be installed, such as attic installations where there is no place to drain condensate.

- Oil Forced Air

Replacement oil furnaces must have a minimum AFUE rating of 83 percent. Oil-fired furnaces with less than a 5-year life expectancy and less than 75 percent steady-state efficiency are candidates for replacement.

- Boilers

Boilers with a seasonal efficiency less than 80 percent and have less than a 5 year life expectancy are candidates for replacement. Replacement boilers must have a minimum AFUE of 85 percent. Boilers may also be replaced if they are a gravity unit.

- Wood Burning Units

Replacement wood heating system installation must conform to NFPA 211 and EPA requirements or local standards, whichever is most strict.

- Space Heaters used as the Primary Heat Source

Replace unvented space heaters with direct-vent sealed combustion space heaters. Replace vented space heaters greater than 10 years old with direct vent sealed combustion units. Vented space heaters less than 10 years old shall be inspected for health and safety problems. **Ventless space heaters shall not be installed under any circumstances.** If a client refuses to have an unvented space heater replaced, the house should not be weatherized.

Efficiency (AFUE) of Replacement Heating Appliances

Table 223-1

Natural Gas/LP Furnaces	90%, Direct vent sealed combustion
Oil Furnaces	83%
Gas and Oil Boilers	85%

2231 Fuel Switching

Switching from the existing fuel source to a different fuel source for use by the heating appliance is prohibited without written approval by the State Weatherization Office. Requests for fuel switching must describe the technical reasons for the decisions and include cost justification and written authorization from the party responsible for purchasing the fuel.

2232 Gas-Fired Heating Installation

- Check clearances of heating unit and its vent connector to nearby combustibles, according to NFPA 54, tables 6.2.3 (a) and 6.2.3 (b).
- All gas piping must be installed according to the American Gas Association (AGA) specification and any other appropriate codes.
- Test water heater to ensure that it vents properly after installation of direct vent sealed combustion appliance.
- Ensure proper sediment trap on gas line.
- Measure gas pressure to ensure that it is within manufacturer's specifications. Adjust gas pressure if necessary to obtain proper gas input. Verify Btu input by clocking gas meter.
- Set thermostat's heat anticipator to the amperage measured in the control circuit.
- Repair or replace sections of the venting system that are corroded, rusted, clogged or blocked, contain cracks or holes or are unsealed, loose or disconnected.
- Follow manufacturer's venting instructions and NFPA 54 Chapters 7 and 10 to establish a proper venting system.
- Repair or replace unsafe power supply to appliance.
- Install a properly sized and fused dedicated circuit to the heating appliance if one is necessary.

2233 Oil-Fired Heating Installation

- Examine existing chimney and vent connector for suitability as venting system for new appliance. The vent connector may need to be re-sized and the chimney may need to be re-lined. Venting should be in compliance with NFPA 31, chapters 1 through 11.
- Check clearances of heating unit and its vent connector to nearby combustibles, by referring to NFPA 31, tables 4-4.1.1, 4-4.1.2 and 5-5.1.
- Test oil pressure to verify compliance with manufacturer's specifications.
- Test transformer voltage to verify compliance with manufacturer's specifications.
- Adjust air, flue-gas temperature, and smoke number to within manufacturer's specifications.
- Inspect oil tank and remove deposits at bottom of tank as part of new heating system installation.
- Install new fuel filter and purge fuel lines as part of new installation.
- Bring tank and oil lines into compliance with NFPA 31, Chapters 2 and 3, and appropriate state regulations.
- Repair or replace an unsafe power supply to appliance.
- Install a properly sized and fused dedicated circuit to the heating appliance if one is necessary.

2234 Furnace Installation

Installers should give purchasing preference to furnaces with electronically commutated blower motors (ECM) or switched reluctance blower motors because these improved motors are significantly more efficient than standard split-capacitor blower motors.

Observe the following standards in furnace installation.

- All furnace work must be in compliance with:
  - The Uniform Mechanical Code
  - National Fire Prevention Association (NFPA)
  - Local Codes (where existing)
  - Furnace Manufacturer's Specifications
- Furnace should be sized to the home's heating load, accounting for weatherization heat loss reductions.
- Installer must be prepared to add return ducts or supply ducts as part of furnace replacement to improve air distribution and to establish acceptable values for static pressure and heat rise.
- Supply and return plenums must be mechanically fastened with screws and sealed to air handler to form an essentially airtight connection.

Category I fan-assisted furnace

- Heat rise (supply temperature minus return temperature) must be within manufacturer's specifications.
- High limit must stop fuel flow at less than 200°F. Furnace must not cycle on high limit.
- Fan control should be set to activate fan at 115°F and deactivate it at 90°F if possible. Slightly higher settings are acceptable if these recommended settings cause a comfort complaint.
- Static pressure, measured in both supply and return plenums, must be within manufacturer's specifications. Static pressure outside of manufacturer's specifications may not be corrected with the installation of a grille on the return air plenum.
- Blower must not be set to operate continuously.
- Filters must be held firmly in place and provide complete coverage of blower intake or return register. Filters must be easy to replace.
- Existing air conditioning coils must be re-installed with an airtight, removable panel, providing convenient access for cleaning.
- Furnaces which do not have a readily accessible filter access/location should have a filter rack with a cover, installed in the return air plenum, in an accessible location.
- Install a condensate pump where needed to reach an appropriate drain, if necessary.
- No used furnaces may be installed.
- Contractors must remove and dispose of equipment being replaced unless otherwise directed by the agency.

2235 Boiler Installation

- All boiler work must be in compliance with:
  The Uniform Mechanical Code
  National Fire Prevention Association (NFPA)
  Local Codes (where existing)
  Boiler Manufacturer's Specifications
- Boiler should be sized to the home's heating load, accounting for weatherization heat loss reductions.
- Maintaining a low-limit boiler temperature is not permitted unless the boiler is used for domestic water heating.
- An effective air-excluding device or devices must be part of a new hot water distribution system.
- The pressure tank must be replaced or tested for correct pressure during boiler installation.
- A pressure relief valve must be installed with the new boiler.
- Extend new piping and radiators to conditioned areas like additions and finished basements, currently heated by space heaters.

2236 Space Heater Installation

Replace combustion space heaters with direct-vent sealed combustion space heaters. Install exactly as specified by manufacturer. Installation of ventless space heaters is not permitted.

2237 Wood Heating Unit Replacement

Agencies are responsible for ensuring that:

- All installations meet manufacturer's specifications.
- All wood heating units are certified to meet the EPA phase II emission standards or local standards, whichever are most strict.
- Installed units are certified and labeled by:

  a. National Fire Protection Association under 211; or

  b. International Conference of Building Officials; or

  c. Other equivalent listing organization.
- All clients receive in-home operation instructions to include proper wood-burning practices, safety information and proper maintenance, e.g., stack thermometers, the need for fire extinguishers, etc.

Replace old and hazardous space heaters with direct-vent, sealed combustion units