224 Water Heater

Best Practice Recommendations:

- Water heaters should be cleaned and tuned to ensure that they are operating in a safe and efficient manner.
- The following water heater measures are recommended for the Midwest Region;
  - Water heater temperature setting,
  - Tank insulation,
  - Pipe insulation, and
  - Replacement
- Mechanically vented, direct vent and tankless water heaters should be considered as replacement units based on cost-effective and appropriateness of existing conditions.

Standards for gas, propane, oil-fired and electric water heaters are provided here. Standards include water heater clean and tune, retrofit and replacement.

2241 Clean & Tune

Gas, propane, and oil-fired water heaters must be tested and repaired as described in the following sections:

- 2211 - Gas Burner Servicing Requirements,
- 2212 - Oil Burner Servicing Requirements,
- 2213 - Improving Appliance Draft, and
- 2214 - Heating Appliance Venting.

The following items shall be checked and corrected, if necessary.

- Visually inspect combustion chamber for rust, dirt and proper burner alignment. Clean and adjust if necessary.
- All water heaters must have a pressure and temperature relief valve and a safety discharge pipe. Install a relief valve and discharge pipe if none exists. The pipe must terminate 6 inches above the floor and be made of rigid metallic material or high temperature plastic.
- If pressure and temperature relief valve and discharge pipe are not present and cannot be installed, replace water heater.
- Ensure proper sediment trap on gas line.
- Flexible gas connections are not to be used on water heaters.
- Relocate water heater if required clearances to combustible materials do not meet NFPA code or manufacturer's requirements.
- Test water heater after a clean and tune to ensure that flame roll-out does not occur.
- If hazardous items are stored adjacent to water heater, inform client of fire hazard and move items.

- Determine whether the electric line on an electric water heater is a dedicated circuit that is properly sized and fused according to electrical codes.
- Make sure power to water heater is off before removing access panels on an electric water heater.

2242 Water Heater Measures

22421 Water Heater Temperature Setting

Adjust water heater temperature to 120°F with client's approval unless client has an older dishwasher without an internal water heater. In this case, the setting should be 140°F.

If an electric water heater has two heating elements, the thermostat on both heating elements must be adjusted when turning down water temperature. Set both elements to the same setting. Mark original water heater setting on thermostatic control.

22421 Tank Insulation

Water heaters manufactured after 1990 may not require additional insulation. Do not insulate water heater if the unit has a manufacturer's warning against adding additional insulation. Water heaters located in a living area should not be insulated as this measure is not cost effective.

Before insulating any water heater, be sure that the water heater is operating in a safe condition. Water heater must not be leaking.

Water heaters shall be insulated to at least R10. Insulation must be mineral fiber manufactured as a water heater blanket with vinyl or foil facing. The insulation must conform to ASTM C592-80 and ASTM 892-79 with a flame spread rating no higher than 25.

Oil-fired water heaters are not common

Water heater insulation shall not obstruct pressure relief valves, thermostat, high-limit switch, plumbing pipes or access plates.

Insulation shall be secured to the water heater utilizing:

- A minimum of three vinyl straps or belts commercially available for water heater jackets,
- A minimum of three metal banding straps or wires, or
- A minimum of three strips of vinyl tape commercially available for water heater jackets. Each strip shall form two complete wraps around the water heater jacket.

Fasteners should not compress insulation more than 50 percent of its normal thickness.

Insulation shall be cut and removed around all controls, service panels (including electrical access panels), air inlets, temperature/pressure relief valves, drain valves specifications and instruction panels.

No insulation should come in contact with the floor.

Gas, propane and oil-fired water heater insulation

- Insulation shall be kept at least 2 inches away from access door and burner.
- Water heaters with a thermal or electromechanical vent damper shall not be insulated.
- Insulation and tape shall be kept at least 3 inches from controls and/or air intakes.
- Keep tape or insulation blanket at least 6 inches from the exhaust hood.
- Top surface of gas-fired water heaters shall not be insulated.

Electric water heater insulation

- Set both upper and lower thermostat to keep water at 125°F before insulating water heater.
- Insulation may cover the top of the water heater if the insulation will not obstruct pressure relief valve.
- Access holes must be left in the insulation for the heating-element thermostats.
- Insulation shall not cover drain valve.
- Insulation shall be kept away from power supply to water heater by at least 2 inches.

22423 Pipe Insulation

- Repair plumbing leaks prior to insulating pipes.
- Insulate first 6 feet of both hot and cold water pipes.
- Cover elbows, unions and other fittings to same thickness as pipe.
- Keep pipe insulation at least 6 inches away from flue pipe.
- Interior diameter of pipe sleeve must match exterior diameter of pipe.
- Tape or otherwise seal longitudinal seams. Seal ends and butt joints.
- All material must have a flame spread rating of 150 or less and a smoke density of 50 or less.
- Insulation shall have a minimum R-value of 3.5.

2243 Water Heater Replacement

Replacement gas or oil water heaters must have an energy factor of at least 0.62. Replacement electric water heaters must have an energy factor of at least 0.92.

Water heaters may be replaced under the following conditions.

- Water heater is non-operational.

- The shell of the storage tank leaks and cannot be repaired.
- The water heater leaks at one or more of its pipe fittings, valves or heating elements (if electric), and a permanent watertight seal cannot be made.
- Excessive sediment is built up and cannot be flushed out.
- The tank is near the end of its estimated life (13 years) and is excessively oversized for the needs of the occupants. (In this case, reducing the size or installing a tankless water heater should be considered.)
- Water heater replacement is cost effective.

All water heater work must be in compliance with: the Uniform Mechanical Code, the National Fire Prevention Association (NFPA), local codes (where they exist), and the water heater manufacturer's specification.

No used water heaters may be installed.

All replacement water heaters must have a pressure relief valve and a discharge pipe extending within 6 inches of the floor.

The water heater temperature should be set at 120°F. Educate the client how to use the water heater controls.

Natural draft water heaters may be used as replacement. However, consideration should be given to mechanically vented, sealed combustion (direct-vent) and tankless water heaters[21].

Old and leaking water heaters should be replaced

22431 Mechanically Vented and Direct-Vent Water Heaters

Mechanically vented or sealed combustion water heaters may be installed depending upon budget and conditions in the home. Replacement gas or oil water heaters must be either mechanically vented or direct-vented in tight homes or homes where these appliances are located in living areas. Direct-vent water heaters are preferred in tight homes where the water heater is installed in the living space.

22432 Tankless Water Heaters

Standard storage type water heaters keep water hot 24 hours a day, even though hot water is usually not used continuously over that period. Stored hot water loses heat through the sides of the tank and up the flue pipe (gas and oil water heaters). As the water temperature drops, the heater is activated to reheat the water again.

[21] In this document, a tankless water heater is defined as an automatic instantaneous water heater. It is not a tankless coil operating in conjunction with a space heating boiler. See section 22432, "Tankless Water Heaters".

As a result, the overall efficiency suffers. Tankless water heaters do not store hot water as water is heated only when needed, thus, their efficiency is higher.

Water flow through a tankless unit acts to ignite the burners or heating elements. Cold water enters a tankless water heater and triggers the burners (gas) or heating elements (electric) to turn on when a hot water tap is opened. Water is heated as it flows through the heat exchanger.

A water valve or thermostat controls the heating elements or burner flame to maintain a constant temperature if the water flow changes. The amount of energy used to heat the water is proportional to the volume of hot water being used. The water temperature can be adjusted to produce outlet temperatures ranging from 100° to 140°F. The burners or heating elements shut down when the hot water tap is turned off.

224321 Items to Consider when Installing a Tankless Water Heater

- Tankless water heaters cost more than standard storage tank water heaters. Cost effectiveness should carefully be considered.
- Tankless water heaters have larger BTU inputs than standard storage type water heaters. Tankless units input ratings range from 40,000 Btuh to 170,000 Btuh.
- Gas models either have a standing pilot light or an intermittent ignition device. Standing pilot light reduces efficiency of tankless water heaters.
- Gas models are either natural draft or mechanically vented.
- Flue size varies between 4 inches and 7 inches, depending upon gas input rate.
- Minimum flow rate to activate tankless water heater ranges from 0.50 gallons per minute (gpm) to 0.75 gpm. This may be a problem in homes with poor water pressure.
- Larger systems can handle two “major” simultaneous events (2 showers or 1 shower and the dishwasher, for example).
- The volume of hot water delivered is directly related to the amount of its energy input. The larger the burners or heating elements in the unit, the higher the volume of hot water it can deliver.

224322 Tankless Water Heater Advantages

Advantages of tankless water heaters include:

- Energy savings because there is no storage energy loss.
- Efficiency will not decrease over time.
- Ideal for single or two person households that don’t have simultaneous hot water uses (2 simultaneous showers, for example).
- A tankless water heater will generally outlast a non-maintained standard storage type water heater.
- Works well in locations with hard water.

- When water flow is kept within range, tankless heaters can provide unlimited hot water.

224323 Disadvantages of Tankless Water Heaters

Disadvantages of tankless water heaters include:

- Cost more than standard storage type water heaters ($300 to $1,000).
- Both gas line size and venting or power supply (if electric) will probably need to be increased.
- Standard storage type water heaters (with adequate distribution plumbing) can serve multiple taps simultaneously. Tankless heaters are limited. Smaller gas models and essentially all electric models are meant for one person households. All but the largest gas units have difficulty serving multiple taps.
- If minimum flow rate isn't met, the heater will not work. If maximum flow is exceeded, water at the tap will cool down. Temperatures can fluctuate with changing water demand.
- Parts for tankless water heaters may be more difficult to get. Maintenance is more difficult than standard storage type water heater.

224324 Selecting a Tankless Water Heater

Tankless water heaters should be selected based on the maximum amount of hot water to meet the peak demand of the household. Measure actual flow rates if possible. Use the following assumptions on water flow for various appliances to find the size of unit that is suitable for the client:

Aqua Star tankless gas-fired water heater

- Faucets: 0.75 gpm to 2.5 gpm.
- Low-flow shower heads: 1.2 gpm to 2 gpm.
- Older standard shower heads: 2.5 gpm to 3.5 gpm.
- Clothes washers and dishwashers: 1 gpm to 2 gpm.

Unless the actual incoming water temperature is known, assume that the incoming water temperature is 50°F. The water needs to be heated to 120°F for most uses, or 140°F for dishwashers without internal heaters. Subtract the incoming water temperature from the desired output temperature to determine the needed temperature rise. In this example, the needed rise is 70°F.

List the number of hot water devices that the client may have open at any one time and add their flow rates. This is the desired flow rate for the tankless water heater. Select a manufacturer that makes such a unit. Most tankless water heaters are rated for a variety of inlet water temperatures. Choose the model of water heater that is closest to the needs of the client.

For example, assume the following conditions: One hot water faucet open with a flow rate of 0.75 gpm and one person bathing using a shower head with a flow rate of 2.5 gpm. The combined flow rate is 3.25 gpm. If the inlet water temperature is 50°F, the needed flow rate through the tankless water heater would need to be no greater than 3.25 gpm. Faster flow rates or cooler inlet temperatures will reduce the water temperature at the most distant faucet. Using low-flow shower heads and water-conserving faucets are a good idea with tankless water heaters.

225 Masonry-Chimney Liners

Best Practice Recommendations:

- A flue may be left unlined if the appliance is not to be replaced and the flue and chimney appear to be in good condition.
- Rebuilding a chimney, lining or relining should be considered for unlined chimneys, when existing liners are in poor condition or if the cross-sectional area of the chimney is oversized for the appliance(s).
- It is recommended flues be properly lined for solid-fuel appliances that are used as a primary or frequent secondary space heating source.

2251 Introduction

A chimney liner is a clay, ceramic, or metal conduit installed inside of a chimney flue, intended to contain the combustion products, direct them to the outside atmosphere, and protect the chimney walls from heat and corrosion.

As higher efficiency heating systems are installed over the years, chimney liners become more important because the combustion gases from efficient appliances are cooler, making acidic condensation within the chimney flue more likely.

When inspecting a flue serving a gas- or oil-fired appliance, the flue may be left unlined if the appliance is not to be replaced and the flue and chimney appear to be in good condition. If an unlined chimney or an existing liner is in poor condition, the assessor should consider rebuilding the chimney and/or lining or relining.

If a client regularly uses a solid-fuel appliance, it is strongly recommended that the appliance vent into a properly lined flue. A liner helps protect surrounding materials in the case of a chimney fire.

Accept as noted below, unlined flues are not required to be lined as part of weatherization.

2252 Advantages of Lined Chimneys

Lined chimneys have a number of advantages over unlined chimneys. These advantages include:

- The liner helps create an airtight flue, which can result in a more favorable draft for the appliances connected to the flue.
- A lined chimney is a more durable chimney. The lining protects the masonry surrounding the liner from degradation caused by acidic condensation.
- Lined chimneys are safer during a chimney fire because the liner protects the house from heat transfer to combustibles.
- A chimney liner can serve to reduce the size of a flue that is too large for the appliance(s) it vents.

2253 Appliance Replacement

Whenever a combustion appliance is replaced the flue should be carefully inspected and lined, if necessary. If a gas-fired appliance replaces an oil- or solid-fuel appliance. . . "the chimney passageway shall be examined to ascertain that it is clear and free of obstructions and shall be cleaned. . ."[22] It is important that this inspection and cleaning be completed because the buildup of creosote or soot from solid fuel or oil can be softened by the high degree of water vapor and condensation from gas emissions, causing possible blockage of the flue.

The *National Fuel Gas Code* (NFPA 54) states all chimney flues shall be lined in accordance with the *Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances* (NFPA 211).[23] However, the *National Fuel Gas Code* also includes this exception: "Existing chimneys shall be permitted to have their use continued [that is, without a liner] when an appliance is replaced by an appliance of similar type, input rating, and efficiency."[24]

Chimneys can be blocked by the strangest objects

This section of the National Fuel Gas Code indicates that:

- When a gas-fired appliance replaces an oil- or solid-fuel fired appliance in a flue, the flue must be lined.
- When a gas-fired appliance replaces another gas-fired appliance in a flue, the flue must be lined if the replacement appliance is not a similar type, input rating, and efficiency. This means that an unlined flue will just about always have to be lined when replacing a heating system. However, lining an unlined flue when replacing a natural draft water heater with another natural draft water heater will usually not be necessary.

2254 Types of Chimney Liners

Clay tiles are the most common type of masonry chimney liner and are most often used when constructing a new chimney. They are inexpensive, readily available, and, when properly maintained, perform quite well for all fuel types. However, clay tiles are difficult to insert properly into an existing unlined chimney.

There are two disadvantages to clay tiles. First, a sudden change in temperature from a chimney fire can cause the tiles to crack and break. In severe cases of tile failure, broken pieces can partially or totally block the flue. Second, a clay lined chimney cannot always adequately contain the condensation produced by more efficient modern gas appliances.

[22] *National Fuel Gas Code* (NPFA 54), 2002 edition,10.5.4.1, page 49.
[23] *National Fuel Gas Code* (NPFA 54), 2002 edition,10.5.4.2, page 49.
[24] *National Fuel Gas Code* (NPFA 54), 2002 edition,10.5.4.2, page 49.

Metal chimney liners, usually made of stainless steel or aluminum, are primarily used to upgrade and repair existing chimneys. These liner systems are U.L. tested and listed, and if properly installed and maintained, are extremely safe and durable. Stainless steel is suitable for solid-fuel, gas, or oil appliances. It is usually required that high temperature insulation be used in conjunction with the liners for safety and proper performance.

Cast-in-place liners are lightweight, cement-like materials that are installed inside the chimney, forming a smooth, seamless, insulated passageway for the flue gasses. They can improve the structural integrity of aging chimneys, and are permanent liners suitable for all fuels.

2255 Installation

For chimney liner regulations, refer to the *Standard for Chimneys, Fireplaces, Vents, and Solid-Fuel Burning Appliances* (NFPA 211) by the National Fire Protection Association. For specific installation instructions, refer to NFPA 211 and the manufacturer's installation guidelines for approved chimney liners. To properly size the liner, the installer should also refer to the *National Fuel Gas Code*(NFPA 54) for gas-fired appliances and *Standard for the Installation of Oil-Burning Equipment* (NFPA 31) for oil-fired appliances.

"Where masonry chimneys are relined, the liner shall be listed or of approved material that resists corrosion, softening, or cracking from flue gases at temperatures appropriate to the class of chimney service."[25]

Cleanout doors are an important part of a masonry chimney system. NFPA 211 states: "Cleanout openings or a means for cleaning shall be provided in all chimney flues. Cleanout openings shall be equipped with ferrous metal, precast cement, or other approved noncombustible door and frames arranged to remain tightly closed and secured when not in use."[26] At the time a chimney is relined, make certain that the cleanout door complies with the details of this code.

Even tile liners can fail from excessive thermal stress

2256 Chimney Maintenance

All chimneys and flues should be inspected during combustion appliance cleaning and tuning. The interior of all flues used by combustion appliances should be inspected with a

[25] *Standard for Chimneys, Fireplaces, Vents, and Solid-Fuel Burning Appliances* (NFPA 211), 2000 edition, 4;1.10, page 18.
[26] *Standard for Chimneys, Fireplaces, Vents, and Solid-Fuel Burning Appliances* (NFPA 211), 2000 edition, 4;1.4.1, page 17. In the next paragraph of this code, 4-1.4.2, it states that the lowest edge of a cleanout door must be at least 16 inches from the lowest accessible floor level.

mirror and flashlight. In addition, the outer masonry of the chimney should be inspected where ever possible. In cold climates portions of a chimney exposed to the weather are likely to deteriorate first. These exposed sections should always be inspected.

If the use of a chimney flue is altered from one fuel to another, for example, from oil to gas, the flue must be properly lined (see 2253, “Appliance Replacement”). If the existing flue is properly lined and sized correctly, it should be professionally cleaned before switching fuels.

Any flue used for solid fuels, such as wood, should be cleaned periodically during the heating season. The frequency of cleaning will depend on the wood species, the moisture content of the wood, the type of wood stove, and the manner in which the stove is operated. Cleaning a solid-fuel flue at the beginning of the heating season and then again one-half of the way through the season is a good rule to follow. However, to ensure safe operation, some solid-fuel flues require cleaning more often than twice each heating season.

226 Heat Pumps and Air Conditioners

Best Practice Recommendations:

- All air-source heat pumps with electric auxiliary must be served by a control system – thermostat(s) – to minimize the operation of the electric heaters.
- Clients should be informed about routine maintenance and operation of heat pumps and air conditioners.
- When a heat pump requires more than simple maintenance, a professional service technician should be hired to check coil air flow, inspect for refrigerant leaks and charge, inspect and adjust controls, and perform other specialized testing and adjustment.
- Replacement heat pumps and air conditioners should be sized properly and ENERGY STAR® rated.

2261 Introduction

The savings realized by adding insulation and making homes tighter is usually only a benefit during the winter. However, if a client has a heat pump or a central or window air conditioning unit, energy will also be saved during the cooling months. Generally these summer energy savings are not included in the savings-to-investment calculations performed by energy audits. However, it is important to remember that weatherization not only cuts fuel use and makes a house more comfortable in the winter, it can also cut fuel use and make a house more comfortable in the summer.

2262 Heat Pumps

Heat pumps are generally a better option for the more temperate climates or the sunbelt states because they cool and heat with the same piece of equipment. However, heat pumps will occasionally be found in low-income homes in northern states.

The efficiency for new heat pumps is designated as Seasonal Energy Efficiency Rating (SEER) for cooling performance and Heating System Performance Factor (HSPF) for heating performance. New heat pumps have SEERs ranging from 10.0 to over 16.0 and HSPFs from 8.0 to over 10.0. For split heat pump systems with an indoor and outdoor coil, the system efficiency varies with the match of these coils. The manufacturer should be consulted to determine the combined efficiencies.

Heat pumps in cooling mode work in a manner very similar to central air conditioners. However, in heating mode, their operation is quite different from a typical furnace. For an air-source heat pump, useful thermal energy is extracted from the outdoor air by the vapor compression cycle which uses a refrigerant liquid/gas, an electrically-driven compressor, an indoor condensing coil, and an outdoor evaporator coil.

At an outdoor temperature above about 35^{O}F, the typical heat pump is designed and installed to supply all the heat a dwelling requires. When the temperature drops below 35^{O}F, heat pumps begin to utilize auxiliary heat; as the outdoor temperature drops, more

auxiliary heat is staged in. This auxiliary heat is usually electric resistance coils staged in 5 kW increments.

Some dual-fuel heat pumps use fossil fuel furnaces or boilers for auxiliary heat rather than electric resistance coils. When these auxiliary systems are used, there is no incremental staging, instead the heat pump shuts down at a set outdoor temperature – usually about 35^{O}F – and the fossil fuel auxiliary system takes over. Most heat pump thermostats will indicate when the auxiliary heat is operating.

Unlike the auxiliary heat, the emergency heat control on a heat pump thermostat must be manually activated with a switch on the thermostat. The emergency switch setting allows the auxiliary heat to operate when the heat pump needs service or is not working properly.

22621 Assessment and Replacement of Equipment

The median service life of a residential air-source heat pump is fifteen years, meaning one-half of those studied lasted more than fifteen years and one-half lasted fewer than fifteen years. If a client has a heat pump that is significantly older than this median life, it is likely that it will fail soon or require significant repair.

Carrier residential air source heat pump

It is not appropriate for an assessor to test or tune a heat pump; this should always be left to specialists. However, there are routine maintenance tasks that can be performed by the client; it might be appropriate for the energy auditor to inform the client of these tasks. It is important that the assessor and the client be able to recognize when a heat pump problem is beyond routine maintenance and requires professional help. Routine maintenance and professional service tasks are explained below.

There are heat pump related items that the auditor/inspector should examine in the field. An important one is the integrity of the ductwork. Of course, ductwork that is outside of the conditioned envelope of the dwelling should be well sealed and insulated. Because ductwork used for heat pumps is used most months in a year, duct leakage and lack of insulation can lead to significant energy loss.

All air-source heat pumps with electric resistance auxiliary must be served by a control strategy to minimize the operation of the electric heaters. One of the following options may be used:

- A standard non-programmable or time-clock programmable indoor thermostat may be installed with an outdoor thermostat, or equivalent. The outdoor thermostat should be installed and set so that auxiliary heat does not activate above 35^{O}F, except when supplemental heat is needed during outdoor coil defrost cycle or for emergency heat in the event of refrigeration cycle failure.
- A microprocessor controlled (smart, or adaptive intelligent recovery, or ramping) indoor thermostat may be installed with an enabled heat pump recovery function. The installer should inform the occupants on proper operation of the thermostat. If this strategy is used in conjunction with an outdoor thermostat (this is optional), the first stage of the auxiliary heat should be allowed to operate independently of the outdoor thermostat.

22622 Sizing Heat Pumps

The cooling capacity of the cooling mode of heat pumps is rated by the number of British thermal units (Btu) of heat removed per hour. Within the industry, it is quite common for the cooling mode of a heat pump to be sized by the "ton". One ton is approximately equal to 12,000 Btus.

Unlike central air conditioners, heat pumps also heat homes during the winter, so a heat pump must be properly sized for cooling and heating. It is common to size a heat pump primarily for the cooling load and then evaluate the heating performance after the heat pump package is selected.

The required size of a heat pump depends upon many characteristics of the house and occupants, including:

- The size of the dwelling and the number of windows.
- The amount of insulation.
- The tightness of the home. It is important to remember that the air change per hour (ACH) value used in most weatherization work in the Midwest Region is a winter calculation. The ACH during the cooling season – that which is used in cooling load calculations – is usually significantly less. Properly sizing a heat pump requires the use of the winter and the summer ACH values.
- The amount of shading on windows, walls and roof.
- The number of occupants and the degree of internal heat gain they generate.

It is very important to size a heat pump properly – there are significant disadvantages to under or over sizing. The most common sizing method is *Residential Load Calculation, Manual J*, by the Air Conditioning Contractors of America. If weatherization staff is assisting in any way with the installation of a new or replacement heat pump, they should make certain that the subcontractor

submits a load calculation report as part of the bid. This calculation should always be based upon the *Manual J* methods. For northern states, heat pumps should be selected so that total capacity does not exceed state and local code requirements and is no greater than 125 percent of the total calculated cooling load.

Another important resource for heat pump selection is *Residential Equipment Selection, Manual S*, by the Air Conditioning Contractors of America. This manual explains the unique sizing and selection procedures for air-source heat pumps.

22623 Routine Maintenance and Operation of Heat Pumps

Heat pumps and central air conditioners generally require the same regular maintenance. Please refer to Section 22633, "Routine Maintenance of Central Air Conditioners", for a list of maintenance items, many of which can be performed by the client.

One item that is a unique maintenance task for an air-source heat pump is the occasional observation and care of the outdoor coil in the winter. Unlike the outdoor coil of a central air conditioner, the outdoor coil of a heat pump must operate during cold weather to capture heat from the outdoor air. If appropriate, inform the client of the following:

- Water must drain away from this outdoor coil to prevent damage from ice buildup. Snow should be cleared away to promote the necessary drainage.
- The outdoor coil will occasionally make hissing or gurgling noises and a cloud of steam might rise from the unit. This is all normal and should not concern the client.
- Frost and small amounts of ice usually accumulate on the outdoor coil, especially during damp days with air temperatures just above freezing. If the coil is completely covered with frost, the client should not worry. However, if a significant amount of hard, clear ice builds up on the coil, a service person should be called to check the operation of the defrost cycle.

Additionally, during heating mode, the thermostat should not be set back at night or during the workday unless a "smart" programmable heat pump thermostat is used. Setting the temperature back during heating season with the wrong thermostat can actually increase the heating cost because the auxiliary heat will be activated more often. On the other hand, if a smart Adaptive Intelligent Recovery (or ramping) thermostat is used, one or more temperature setbacks each day will save energy. The microprocessor in a ramping thermostat senses the temperature differential to be overcome during temperature pickup and increases the temperature gradually without activating the auxiliary heat. This minimizes the use of the electric resistance heat.

22624 Professional Maintenance of Heat Pumps

When a client's heat pump needs more than simple maintenance, a professional service technician should be recommended or subcontracted. Ensure that a subcontracted technician completes the following:[27]

- Measure air flow across the indoor coil. Airflow across this coil should be 400 CFM per ton for a wet coil (condensation on coil) and 425 CFM per ton for a dry coil (no condensation on coil), plus or minus 50 CFM.
- Check for correct amount of refrigerant. Follow the manufacturer's specification for refrigerant charge. The airflow across the indoor coil should be adjusted and verified before the refrigerant charge is checked. Any refrigerant that must be evacuated must be captured rather than illegally releasing it to the atmosphere. For systems with fixed metering devices (capillary tube of fixed orifice), the evaporator superheat method should be used along with the manufacturer's recommendations. For systems with thermostatic expansion valves (TXV), the subcooling method should be used along with the manufacturer's recommendations.
- Test for refrigerant leaks using a leak detector.
- Check for and seal duct leakage in central systems. Duct sealing and insulation is especially important for ductwork running through unconditioned spaces.
- Inspect electric terminals, clean and tighten connections, and apply a non-conductive coating if necessary.
- Oil motors and check belts for tightness and wear.
- Check the accuracy of the thermostat.
- Check for proper functioning of the outdoor lockout thermostat. The outdoor lockout thermostat must lock out the auxiliary heat (usually electric resistance) when the outdoor temperature is greater than the heat pump balance point (usually 25^0F to 40^OF, depending on the climate).
- Test for proper operation of the heat pump defrost control. This control for the outdoor coil must be adjusted to optimize heating efficiency.

2263 Central Air Conditioners

22631 Assessment and Replacement of Central Air Conditioners

Today's best air conditioners use 30 to 50 percent less energy than air conditioners made in the 1970s. Even if a client's central air conditioner is only 10 years old, they may save 20 to 40 percent of cooling costs by replacing it with a newer, more efficient model. The median service life of a central air conditioning unit is 15 years, so if a client's unit is 25 years old, the chances of it requiring replacement soon are quite high.

Replacement central air conditioner should be ENERGY STAR® rated. ENERGY STAR® qualified central air conditioners have a higher seasonal efficiency rating (SEER) than standard models, which makes them about 25% more efficient.

[27] See *Specification of Energy-Efficient Installation and Maintenance Practices for Residential HVAC Systems*, Karg and Krigger, Consortium for Energy Efficiency, 2000. This document is available at http://www.cee1.org/resid/rs-ac/hvac.php3.

22632 Sizing Central Air Conditioners

Air conditioners are rated by the number of British thermal units (Btu) of heat they remove per hour. Within the industry, it is quite common for air conditioners to be sized by the "ton". One ton is approximately equal to 12,000 Btus.

The required size of a central air conditioning unit depends upon many characteristics of the house and occupants, including:

- The size of the dwelling and the number of windows.
- The amount of insulation.
- The tightness of the home. It is important to remember that the ACH value used in most weatherization work in the Midwest Region is a winter calculation. The ACH during the cooling season – that which is used in cooling load calculations – is usually significantly less.
- The amount of shading on windows, walls, and roof.
- The number of occupants and the degree of internal heat gain they generate.

It is very important to size an air conditioner properly – there are significant disadvantages to under or over sizing. The most common sizing method is *Residential Load Calculation, Manual J*, by the Air Conditioning Contractors of America. If weatherization staff is assisting in any way with the installation of a new or replacement central air conditioner, they should make certain that the subcontractor submits a load calculation report as part of the bid. This calculation should always be based upon the *Manual J* methods. Cooling capacity should be no more than 115 percent of the calculated cooling load.[28]

22633 Routine Maintenance of Central Air Conditioners

An air conditioner's filters, coils, and fins require regular maintenance for the unit to function effectively and efficiently throughout its years of service. Neglecting necessary maintenance ensures a steady decline in air conditioning performance while energy use steadily increases. Many of the items listed here can be regularly done by clients.

Air Conditioner Filters

The most important maintenance task that will ensure the efficiency of a central air conditioner is to replace or clean its filters monthly. Clogged, dirty filters block normal air flow and can reduce a system's efficiency significantly. Filters are located in the return duct, usually in return grilles or in the air conditioner itself. Filters may need more frequent attention if the air conditioner is in constant use, is subjected to dusty conditions, or if there are fur-bearing pets in the dwelling. The client should not attempt to clean a filter that is designed to be thrown away.

[28] The air conditioner does not ALSO have to satisfy heating load. The heat pump is sized primarily for cooling load and secondarily for heating load, so excess capacity is needed on the heating side. Remember, the value here is for cooling; the 125% is for heat pump heating.

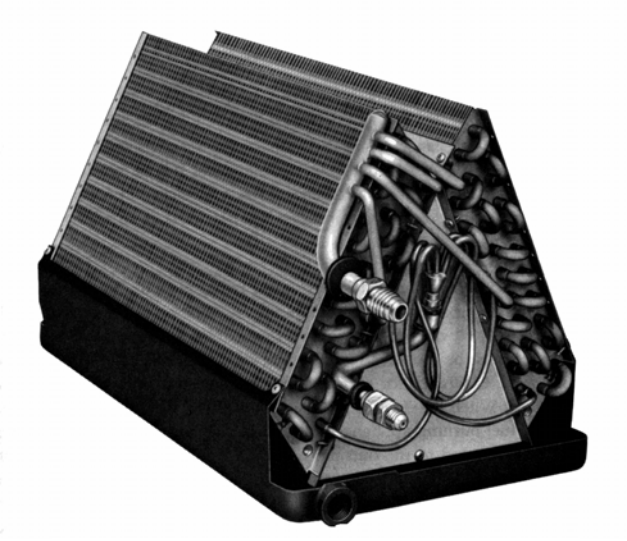
Air Conditioner Coils

An air conditioner's evaporator (indoor) and condenser (outdoor) coils collect dirt. This dirt reduces air flow, insulates the coils, and reduces efficiency. To prevent this reduction in efficiency, the coils should be checked each year and cleaned, if necessary. It is usually best if these coils are cleaned by a professional.

If appropriate, suggest to the client that dirt and debris near the condenser (outdoor) unit be minimized. Dryer vents, falling leaves, and lawn mowing are all potential sources of dirt and debris. Cleaning the area around the coil, removing any debris, and trimming foliage back at least 2 feet will allow for adequate air flow around the condenser.

Evaporator and Condenser Coil Fins

The delicate aluminum fins on evaporator and condenser coils are easily bent. These bent fins can block air flow through the coil and reduce efficiency. Air conditioning wholesalers sell a tool called a “fin comb” that will place these fins back into nearly original condition.



Evaporator coil for residential central air conditioning system

Sealing and Insulating Air Ducts

An enormous waste of energy occurs when cooled air escapes from supply ducts or when hot attic air leaks into return ducts. Field studies indicate that a much as 35 percent of the conditioned air in an average central air conditioning system escapes from the ducts.

For central air conditioners to be efficient, ducts must be airtight and insulated when they run through unconditioned areas. Refer to Sections 113 and 227 for instructions for duct leakage testing and repair.

Obstructions can impair the efficiency of a duct system almost as much as leaks. Make sure that clients have not obstructed the airflow from supply registers or to return grilles with furniture, drapes, or tight fitting closed interior doors. Of course, dirty filters and clogged evaporator coils can also be major obstructions to air flow.

22634 Professional Maintenance of Central Air Conditioners

When a client's air conditioner needs more than the regular maintenance, a professional service technician should be recommended or subcontracted. Ensure that a subcontracted technician completes the following:[29]

- Measure air flow across the evaporator coil. Airflow across the indoor coil should be 400 CFM per ton for a wet coil (condensation on coil) and 425 CFM per ton for a dry coil (no condensation on coil), plus or minus 50 CFM.
- Check for correct amount of refrigerant. Follow the manufacturer's specification for refrigerant charge. The airflow across the indoor coil should be adjusted and verified before the refrigerant charge is checked. Any refrigerant that must be evacuated must be captured rather than illegally releasing it to the atmosphere.
- Test for refrigerant leaks using a leak detector.
- Check for and seal duct leakage in central systems. Duct sealing and insulation is especially important for ductwork running through unconditioned spaces. Chances are high that the weatherization workers already completed this inspection and work.
- Verify the correct electric control sequence and make sure that the heating system and cooling system cannot operate simultaneously.
- Inspect electric terminals, clean and tighten connections, and apply a non-conductive coating if necessary.
- Oil motors and check belts for tightness and wear.
- Check the accuracy of the thermostat.

2264 Window Air Conditioners

22641 Assessment and Replacement of Window Air Conditioners

Window air conditioners usually range from 5,500 Btu per hour to 14,000 Btu per hour in cooling capacity. National appliance standards require room air conditioners built after January 1, 1990, to have an Energy Efficiency Rating (EER) of 8.0 or greater. Any window air conditioner purchased for use in the Midwest Weatherization Region should have an EER of at least 9.0.

Between 1972 and 1991, the average EER of a window air conditioner rose 47 percent. Clients with units manufactured before 1990 should consider replacing these older units. If a client owns a 1970s-vintage window air conditioner with an EER of 5, cooling costs can be cut in half if it is replaced with a new unit having an EER of 10.

The median service life of a window air conditioner is ten years, meaning one-half of those studied lasted more than ten years and one-half lasted fewer than ten years. If a client has a window unit that is significantly older than ten years, the chances of it failing soon are quite high.

[29] See *Specification of Energy-Efficient Installation and Maintenance Practices for Residential HVAC Systems*, Karg and Krigger, Consortium for Energy Efficiency, 2000. This document is available at http://www.cee1.org/resid/rs-ac/hvac.php3.

If a window air conditioning unit is replaced with weatherization funds, it is important to properly dispose of the old unit as part of the replacement process. The weatherization agency must ensure the old unit is not allowed to reenter the marketplace as a used unit. In addition, the refrigerant from the old unit must be reclaimed according to federal guidelines.

22642 Maintenance of Window Air Conditioners

Window air conditioners will last longer and remain more efficient if they are maintained properly. Inform clients with window air conditioners to do the following:

When not in use, window air conditioners should be removed and properly stored or covered with an air tight, protective fabric

- It is best to remove a window air conditioner from its wall sleeve or window during the heating season. This will usually reduce air leakage and increase the longevity of the unit. If a unit cannot be removed, it is best to install an airtight cover on the outside of the unit.
- Clean the air conditioner filter every month. This filter is usually located behind the front grill and can usually be washed with soap and water. After allowing the filter to dry, it should be put back in its position. If the filter looks worn or has holes in it, it should be replaced.
- Clean obvious obstructions such as newspaper and leaves from around the exterior of the unit.
- An air conditioner should not be short-cycled by turning it off and then back on right away. Wait at least ten minutes after shutting the unit off before turning it back on. This gives the pressure in the refrigeration system time to equalize and prolongs the life of the air conditioner.
- The condenser coil of the unit should be cleaned annually. Most agree it is best to clean this coil at the beginning of the cooling season. This coil is at the back (outside) of the air conditioner and requires proper airflow for maximum efficiency and longevity. Clean the coil by blowing compressed air across it, by using a soft bristle brush to remove the dirt, or by using a special chemical cleaning solution.
- Rather than store a window air conditioner in a garage during the winter, it is better to store it in a basement or utility room away from mice and other small animals. Rodents can cause damage to the unit by chewing on wiring and insulation. Wasps, hornets, and bees find air conditioners attractive places to nest. This can reduce airflow, cut into efficiency, and decrease the air conditioners cooling capacity.

227 Duct Improvements

Best Practice Recommendations:

- Ducts located in unconditioned areas must be sealed and insulated.
- Duct system airflow should be checked and corrected if necessary in response to client comfort complaints.

The distribution system of the house is a critical part of the building system. An efficient heating/cooling unit and a well insulated/air sealed building envelope is of little use if the conditioned air doesn't reach the main living spaces of the house. Duct leakage, poor filter and blower maintenance, a clogged evaporator coil, and inadequate supply and return ducting can all contribute to significant energy, comfort, safety and durability problems.

2271 Duct Sealing

Duct leakage is a major energy waster in homes where the ducts are located outside the home's thermal boundary, such as an attic or garage. The weatherization work must include duct sealing and duct insulation for any ductwork in unconditioned areas.

22711 Duct Leakage Sites to Seal

The following joints in ducts located outside the thermal boundary should be inspected and sealed. These same joints will also be found on ducts located within the thermal boundary, such as basements and crawl spaces. Sealing joints on ducts located within the thermal boundary will not save energy, but may solve other problems (see chapter 113, "Duct Leakage Tests"). Generally the sealing begins at the air handler cabinet and proceeds out to the register boots.

- Seal holes in the air handler cabinet and joints between the air handler and the supply and return plenums. The filter slot should have system that will cover the opening but is easy for the homeowner to open and close.
- Seal leaky joints between main supply and return plenums and their branches.
- Seal leaky joints between building materials composing cavity return ducts, such as panned floor cavities and furnace return platforms. Even better: replace cavity return ducts with new metal return ducts.
- Seal leaky joints between supply and return registers and the floor, wall, and ceiling to which they are attached.
- Secure metal duct joints with screws, seal them with mastic, and support joints with duct hangers.
- Flex duct runs should be mechanically attached to the plenum/trunk/boot with clamps or cable ties and sealed.
- Patch or replace metal ducts that have rusted through and ducts with holes cut in them.
- Seal penetrations in ducts made by wires or pipes. Even better: move the pipes and wires and patch the holes.

- Seal the ends of wall cavities used as ducts or chase ways that contain ducts that are open to unconditioned spaces or the outside.
- Close and seal return air grilles located in the basement.
- If there is asbestos on the duct surfaces be sure to avoid disturbing friable material and work in an asbestos safe manner.
- Re-check temperature rise or static pressure to assure that it is within the operating limits of the furnace (see section 2273, "Improving Duct System Airflow").

22712 Duct Sealing Materials

Duct sealing mastics and tapes should be UL181A or UL181B labeled.

- Duct mastic: the preferred material because of its superior durability and adhesion. Apply at least 1/16-inch thick and use reinforcing mesh for all joints wider than 1/8 inch or joints that may experience some movement.

Sealing a register boot with duct mastic

- Tape: An approved aluminum duct tape may be used when duct mastic is not used. The duct surfaces around the joint need to be clean in order for the tape to adhere properly. Tape should never be expected to hold a joint together nor expected to resist the force of compacted insulation or joint movement. Joints should rely on mechanical fasteners to prevent joint movement or separation.
  - Butyl-aluminum tape: High quality tape designed for duct sealing is effective and durable when applied to clean surfaces.
  - Cloth and Aluminum duct tape are **not** acceptable duct sealant materials because of their history of adhesive failure.

2272 Duct Insulation

Insulate supply and return ducts located outside the thermal boundary, such as unconditioned crawl spaces and attics. Use a minimum R8 insulation on supply ducts.

- Always perform necessary duct sealing before insulating ducts.
- Use fiberglass insulation 3 to 6 inches thick (minimum R8) with foil-scrim-kraft facing or vinyl facing. Vapor barrier must be placed to the outside with no exposed insulation.
- Insulation should cover all exposed ducts. This is especially important in air-conditioned homes because the insulation must prevent condensation. Even a small void in the insulation can dampen a large section of insulation through condensation.

- Insulation should be fastened by mechanical means such as stuck-ups, twine, clamp/bag staplers or plastic straps. Tape can be effective for covering joints in the insulation to prevent air convection, but tape will usually fail if expected to resist the forces of compressed insulation or the insulation's weight.
- If the ducts are in the attic and it is feasible, blow cellulose over the ducts to increase the R-value.

2273 Improving Duct System Airflow

If occupants complain of lack of heat (or cooling), there may be inadequate airflow. The airflow capacity of the air handler may be checked in relationship to the size of the furnace or air conditioner. For combustion furnaces there should be 110 to 150 cfm of airflow for each 10,000 Btu of output. Central air conditioners should deliver 450 cfm of airflow per ton of cooling capacity, and heat pumps should deliver 400 cfm of airflow per ton of heating capacity. A contributing factor in some houses for lower than desired air flows through the supply registers is the presence of significant leakage in the ducts running though otherwise conditioned basements and crawlspaces. Diverting this flow from the basement to the living spaces can increase occupant comfort.

22731 Filter and Blower Maintenance

A dirty filter can reduce airflow significantly. Special air cleaning filters may cause more resistance than standard filters, especially when saturated with dust. Take action to prevent filter-caused airflow restriction by the following steps:

- Ensure that filters are easy to change or clean.
- Stress the importance of changing or cleaning filters, and suggest the client follow 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 is blocked or separated, or that return air is not sufficient. When low airflow is a problem, consider the following improvements.

- Clean or change the filter.
- Clean the furnace blower.
- Lubricate the blower motor and check the tension on the drive belt.
- Add another return air duct (see section 22733, "Duct Improvements to Increase Airflow and Improve Comfort").

22732 Cleaning Air-Conditioning Coils

Dirty air conditioning coils located in main ducts or air handlers are a common cause of low airflow and resultant low heating and cooling efficiency. Follow the general guidelines listed below to clean air conditioning coils.

- 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.
- Using a stiff hairbrush, carefully remove surface dust, dirt, and lint.

- Spray the coil with cleanser and after a while spray water to rinse out the cleanser and dirt. Repeat the spraying if necessary.
- Observe whether 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.

22733 Duct Improvements to Increase Airflow and Improve Comfort

Consider the following improvements in response to customer complaints, conditions observed during a thorough duct inspection and measurements such as the temperature rise across the heat exchanger or high static pressure (higher than recommended by furnace manufacturer).

- Make sure that the fan control is adjusted to the optimum fan on/off temperatures and functioning so that the furnace fan is cycling at the desired temperatures.
- Remove obstructions to registers and ducts such as rugs, furniture, and objects placed in ducts, like children's toys and water pans for humidification.
- Remove kinks from flex duct, shorten longer than necessary flex duct sections and replace collapsed flex duct and fiber duct board.

Use duct mastic to seal all ductwork in unconditioned spaces

- Extend supply and return ducts as needed to provide heated air throughout the building, especially into additions to the building.
- Add retrofit crossover ducts.
- Install registers and grilles where missing. Do not install return air grilles in basements or crawl spaces.
- Seal significant supply and return leaks in the basement that may be diverting excess distribution air away from the main living spaces of the house. If there is an excessive number of supply registers in the basement (more than two is usually excessive) close and seal them.
- Undercut bedroom doors, especially in homes with central return systems. Installing a transfer grille between the bedroom and main body of house may also be done to help improve airflow (see section 1142, "Duct-Induced Room Pressures").

22734 Duct Improvements to Solve Improper Draft

Consider the following steps to help establish proper draft (see chapter 1213, "Draft Testing").

- Seal return duct leaks in the combustion appliance zone (CAZ). See section 1114, “Depressurization Tightness Limit” for depressurization limits.
- Seal supply leaks in unconditioned zones.
- Isolate furnace from return registers, exhaust fans, and clothes dryers by air sealing between the combustion zone and zones containing these depressurizing forces.
- Provide combustion air inlet and outlet to combustion zone (see section 2215, “Combustion Air”).

2274 New Ductwork

New ductwork should not be installed in unconditioned spaces unless absolutely necessary. If ductwork is located in unconditioned spaces, joints should be sealed and the ducts insulated as described in sections 2271 and 2272 (“Duct Sealing” and “Duct Insulation”).

- New ductwork must be physically connected to the existing distribution system or to the furnace.
- New supply branches with operable registers must be provided to rooms currently heated by space heaters.
- Return air ducts and registers shall be provided as needed to improve air circulation.
- If flex duct is used, sections longer than 14 feet should be joined with a metal connection, mechanically fastened and the seams properly sealed. All flex duct must be supported according to the manufacturer’s specifications.

230 Baseload

Best Practice Recommendations:

- Fluorescent lamps used for replacement should be ENERGY STAR® rated.
- Low-flow showerheads should be included as part of weatherization services.
- Measuring kWh or referring to http://www.waptac.org/sp.asp?id=68 should be used to determine electrical consumption for refrigerators being considered for replacement.
- Replacement refrigerators should be ENERGY STAR® rated.

Electric baseload usage can account for over 40 percent of a household's energy use. Electric baseload usage includes lighting, refrigerators/freezers, and other electrical appliances.

231 Fluorescent Lighting

Fluorescent lighting is among the most cost-effective measures that can be installed, particularly for lights that are on for long periods. Energy savings are the greatest for those lights that are used the longest periods of time. Assessors should ask the client which lights are on most often as those lights are the best candidates for fluorescent lighting. Fixtures controlled by dimmers should not be considered unless proper lamps are available to the installer. Incandescent fixtures may be replaced with fluorescent fixtures that accept only fluorescent lamps where cost-effective. Fluorescent lamps and fixtures used for replacement should be ENERGY STAR® rated.

Fluorescent lamps use from 50 to 75 percent less electricity than incandescent lamps. Over the life of one compact fluorescent lamp (CFL), a client can avoid replacing up to 13 incandescent lamps.

Fluorescent lighting technology has improved to the point that it is often very difficult to distinguish between the quality of light provided by incandescent and fluorescent lighting. The new CFLs provide high quality, warm light without the flickering or humming of older fluorescent lamps. Many new CFLs also meet the stringent criteria of Energy Star® for long life, energy savings, and brightness.

Generally, incandescent lamps that are on for more than 2 hours a day should be considered for replacement. For example, if a 60 watt incandescent lamp burns 4 hours a day for an entire year, the cost of electricity will be $8.76 (at $0.10/kwh). If replaced with a 13 watt fluorescent lamp, the cost will be $1.90, for a yearly savings of $6.86.

The fluorescent lamp should be sized at approximately one-third the wattage of the incandescent lamp that is being replaced to provide the equivalent lumen, or light, output (see table 230-1). Lumen output for fluorescent lamps is generally displayed on the packaging.

Table 230-1

Incandescent Lamp Wattage (lumen output)	Equivalent Fluorescent Lamp Wattage
25 watts	~ 9 watts
40 watts (500)	~ 14 watts
60 watts (870)	~ 20 watts
75 watts (1190)	~ 25 watts
100 watts (1750)	~ 32 watts
150 watts	~ 50 watts

Exterior incandescent lamps may also be replaced with fluorescent lamps. Exterior fluorescent lamps should be rated for exterior use with a minimum 27 watts with a starting temperature of -12^{o}F and a minimum initial rating of 1,600 lumens. Fluorescent lamps with less than 27 watts may not provide adequate lighting for exterior conditions.

232 Low-Flow Showerheads

Typical flow rates for standard showerheads range between 6 gallons per minute (gpm) to in excess of 10 gpm. Low-flow showerheads are rated between 1.2 to 2.5 gpm. The installation of low-flow showerheads will save the client energy both on their water heating and water usage bills.

Showerheads with flow rates greater than 3.0 gpm may be replaced with low-flow models. The following method may be used to determine the flow rate of an existing showerhead. Cut the top of a one-gallon plastic milk jug to fit over the showerhead. If the container fills in less than 20 seconds, the flow rate is greater than 3.0 gpm.

New showerheads and necessary adapters should be installed according to the manufacturer's instructions. Threads shall be properly sealed with plumbers tape to prevent leaks.

233 Refrigerator Replacement

Refrigerators manufactured before 1990 usually consume over 1000 kilowatt-hours per year. New Energy Star® rated refrigerators use less than 550 kilowatt-hours per year. Replacement should be considered on a case-by-case basis depending on existing refrigerator energy consumption and cost effectiveness (see section 2332, “Measuring Existing Consumption”).

Refrigerators may also be replaced for the following reasons:

- non-operable (if it is the only unit in the home),
- continuously running compressor, and
- unable to maintain safe food storage temperature (temperatures of refrigerator and freezer compartment may be checked during the inspection).

Existing refrigerators must be removed from the client's home and demanufactured in an environmentally friendly manner. The units should be taken to a facility licensed to reclaim the refrigerant. Refrigerators that are replaced are not to be returned to service.

2331 Replacement Requirements

Replacement refrigerators should be Energy Star® rated. At a minimum, replacement models must meet Federal National Appliance Energy Conservation Act (NAECA) ratings. All replacement refrigerators must meet the UL-250 standard.

All new replacement refrigerators must have a fifteen year expected life. The warranty on all replacement refrigerators must meet or exceed a one year full warranty on parts and labor and a minimum five year warranty on the compressor.

The assessor must ensure that the new refrigerator will fit into the space available. Make sure the doors, walls, stairways, etc. will accommodate the moving of the existing and the new refrigerator. Leave ½ inch for clearance. The door to the refrigerator can be taken off if needed to gain 1½ inches.

The size of the replacement unit, barring other physical constraints, should be based on cost-effectiveness, dwelling unit and family size, allowing local flexibility within available models for extenuating circumstances:

- 15 CF unit for one to two bedroom units with up to three residents.
- 18 CF unit for three bedrooms with up to five residents (or two bedrooms with four residents).
- 21 CF for units with four or more bedrooms or five or more residents.

An upgrade in size based on family need may be installed when replacing multiple refrigerators with one where the client agrees to give up more than one refrigerator.

Replacement refrigerators should have the following features:

- White in color
- Freezer on top
- Auto defrost
- Standard shelving
- No ice maker
- No water dispenser
- Reversible doors
- Easy-roll wheels
- Up-front controls

In most cases, replacing a side-by-side unit with another side-by-side unit should not be done because of the higher cost and greater energy consumption of side-by-side units. However, replacement units may be side-by-side if:

- A member of the household is confined to a wheelchair,
- A member of the household has a handicap that makes it difficult to use a top-freezer model, or

- Space limitations dictate the use of a side-by-side (less door-swing space required).

2332 Measuring Existing Consumption

The annual kilowatt-hours (kWh) consumption of existing refrigerators may be determined in one of three ways.

23321 Internet

The annual consumption of tens of thousands of different refrigerators manufactured after 1975 may be found at http://www.waptac.org/sp.asp?id=68. The manufacturer and model number of the existing refrigerator are required (model number may be found on the nameplate). The annual consumption figures are estimates of the refrigerator when it was new. These values should be adjusted by the following degradation factors.

Refrigerator Degradation Factors	
Refrigerator Age	***Factor***
Less than 5 years	1.0
5 to 10 years	1.1
10 to 15 years	1.2
More than 15 years	1.3

23322 KWhr Measurement

Measuring refrigerator energy consumption may be performed during the assessment. A recording kilowatt-hour meter is required and the consumption of the refrigerator should be recorded for at least two hours.

- Connect the refrigerator to the recording kilowatt-hour meter.
- If the refrigerator is an automatic defrost model, check several times during the two hour test to ensure that the automatic defrost has not activated.
- Divide the number of kilowatt-hours by the hour duration of the test. This provides the number of kilowatts. Multiply this number by the total number of hours in a year: 8760 hours. The product of this calculation is annual kWhr.

For example, if a refrigerator's measured consumption is 0.32 kilowatt-hour over a 2-hour period, the annual consumption would be calculated as:

0.32 kilowatts/2 hours = 0.16 kilowatts/hour
0.16 kilowatts/hours * 8760 hours/year = **1,402 kWh/year**

23323 Estimating kWhr/yr

Some refrigerators may be replaced without checking the WAPTAC Website or by metering the consumption. If these refrigerators cannot be found in the AHAM data or cannot be metered, use the estimated kwh/yr consumption listed in parenthesis when determining the cost effectiveness of replacement.

- Units manufactured before 1973 (1,700 kWh/yr)
- Units manufactured from 1973 to 1980 (1300 kWh/yr)
- Units manufactured from 1981 to 1984 (1050 kWh/yr)
- Units manufactured from 1985 to 1988 (1000 kWh/yr)
- Units manufactured from 1989 to 1990 (900 kWh/yr)
- Units that run continuously (2000 kWh/yr)

240 Health & Safety

Best Practice Recommendations:

- At least one smoke alarm should be installed in each weatherized home.
- Fire extinguishers should be given to each weatherization client if they do not already have one.
- At least one CO alarm should be installed in each weatherized home having combustion appliances, when the home has an attached or tuck-under garage or when assessors believe that there are other health and safety situations related to CO.
- CO alarms should also be installed when weatherization services must be deferred due to unsafe combustion appliances.
- Whole house ventilation should be added to homes that are below the BTL or BTLa ventilation rates.
- Consideration should be given to providing whole house ventilation in all homes according to ASHRAE Standard 62.2-2004, *Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings*.
- Exhaust fan ducts should be sized according to ASHRAE 62.2-2004.
- Disconnected or improperly vented clothes dryers should be corrected as part of weatherization.
- Missing or damaged gutter systems should be repaired or replaced if causing an indoor moisture problem.
- Weatherization staff should be knowledgeable of mold remediation procedures and outside funding sources available to remediate moldy surfaces in clients'

241 Smoke Alarms

At least one smoke alarm is required in each home weatherized.

2411 Installation

Install smoke alarms according to manufacturer's instructions. Assure that smoke detectors are properly located.

- Smoke detectors should be installed on the ceiling or six inches below the ceiling on the wall.
- Install one smoke detector on each level of the home.
- One smoke detector should be located at the base of the basement stairwell.
- One smoke detector should be located within 15 feet of every room used for sleeping.
- Do not locate smoke detectors near kitchen stoves or bathroom showers.
- Do not locate smoke detectors within 12 inches of exterior windows and doors.
- Do not locate smoke detectors in front of supply air registers.

Relocate existing smoke detectors as necessary.

2412 Operation

Assure that existing smoke alarms have new batteries. Test all smoke alarms for proper performance following installation.

Hard-wired smoke alarms should be wired to a circuit that is energized at all times. They should not to be wired to a ground-fault circuit interrupter (GFCI).

2413 Client Education

Review smoke alarm testing procedures with clients following alarm installation and advise regarding battery replacement as appropriate.

2414 Specifications

- Smoke alarms that are powered by a battery must emit a signal when the battery is losing power.
- All installation hardware, including a screw mounting bracket, should be included with the alarm.
- Smoke alarms must be approved by Underwriters Laboratories (UL).

242 Fire Extinguishers

Fire extinguishers are an eligible weatherization expense that may be purchased and given to weatherization clients.

Fire extinguishers should be labeled as a combination Class A and Class B (A-B) extinguisher. Class A extinguishers will put out fires from ordinary combustibles such as wood and paper. Class B extinguishers are to be used on fires involving flammable liquids such as grease or gasoline.

Combination A-B extinguishers carrying the Class C rating (A-B-C) are also acceptable. Class C indicates that the extinguisher may be used on electrical fires.

Clients should be instructed on use of the fire extinguisher. The term “PASS” may be used for this explanation.

P = PULL the pin (this unlocks the operating handle).
A = AIM the extinguisher at the base of the fire.
S = SQUEEZE the operating handle discharging the fire fighting agent.
S = SWEEP from side to side, carefully moving in on the fire sweeping back and forth across the base of the fire.

243 Carbon Monoxide (CO) Alarms

CO alarms should be installed in all homes with fuel burning appliances, gas ranges, wood stoves or fireplaces. CO detectors should also be installed in homes with attached or tuck-under garages.

In addition, carbon monoxide alarms should be installed, on a permanent basis, when an agency has to delay weatherization services due to an unsafe furnace, water heater, stove, fireplace or oven.

2431 Location and Placement

CO alarms must be installed according to the manufacturer's directions. Manufacturers generally recommend that CO detectors be installed on each separate living level of the home where household members frequently spend time. Since most fatalities caused by CO occur while families are sleeping, a CO alarm should be installed in, or just outside of, bedrooms occupied by adult members of the household. CO alarms may also be installed in basements.

Do not install alarms in the following areas:

- Near bathrooms or in shower areas,
- In closets,
- Crawl spaces or unheated areas where extreme hot or cold temperatures occur,
- Within 5 feet of fuel burning appliances,
- Close to adjacent walls or in corners,
- Near bathtubs or basins,
- Directly above or below return air grilles or supply registers, and
- Behind drapes, furniture, or other objects that could block air flow to the CO alarm.

2432 Specifications

CO alarms shall:

- Meet or exceed UL2034-98 and/or IAS696 standards.
- Have a manual test and reset button.
- Have a five-year warranty on the detector and sensor. Expiration date, as warranted by the manufacturer, must be written on the front of the alarm in permanent ink.

Assessors should educate clients about the purpose and features of the CO alarms and tell them what to do if the alarm sounds.

244 Ventilation

2441 Required Ventilation

It is recommended that state weatherization programs consider providing whole house ventilation in all homes according to ASHRAE Standard 62.2-2004, *Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings*.

Ventilation requirements may be met by exhaust only, supply only, balanced or a combination of these system types. The ventilation system may be designed to run continuously or intermittently. Intermittent systems will require a larger flow rate than continuous systems.

Note that exhaust only systems may cause negative pressure in the combustion appliance zone (CAZ). Conduct a worst-case draft (see section 123, "Worst-Case Draft Test").

2442 Bathroom Exhaust Fans

All full-baths (bathrooms that include a tub or shower) should have an operable exhaust fan vented to the outside. The following requirements should be met.

24421 Fan Requirements

- Minimum 70 CFM at 0.25 in. w.c.
- Sone rating no higher than 1.5.

24422 Controls

One of the following three types of controls should be utilized for exhaust fans in full baths.

Fan-Delay Timer

Fan-delay timers may be used where a single-switch controls both the light and exhaust fan. The fan delay timer allows the fan to continue to operate when the light is turned-off (the Home Ventilating Institute recommends that a bathroom fan operate for 20 minutes following showering or bathing). When the switch is turned-on, both the light and fan operate. When the light is turned-off, the fan continues to operate for an extended period of time ranging from 1 to 60 minutes. The adjustable timer dial is located beneath the cover plate. The fan delay timer fits in a single-gang box.

Mechanical Timer

A simple mechanical timer may be used in place of an on/off switch that controls only the exhaust fan. The timer operates the fan up to 60 minutes.

Programmed Controller

A programmed controller may be used when the bathroom fan will be used as the whole house ventilation system. The controller cycles the fan on and off, at preset times, throughout the day and/or night. It automatically controls the fan speed and cycle time, while allowing the occupant access to a full speed boost cycle when needed. A similar type of controller (constant duty) may be used to control the bathroom fan when continuous ventilation is desirable. This type of controller is not compatible with all exhaust fans.

2443 Exhaust Fan Ductwork

Smooth metal duct should be used in place of plastic or metal flex duct whenever possible. Minimum duct diameter should be 4 inches. Exhaust ducts should be vented to the outside. Collars used to connect exhaust ducts to termination caps

should be tight to prevent the escape of moisture. Exposed exhaust fan ducts in unconditioned spaces should be insulated.

Refer to Table 240-1 for maximum duct length based on bathroom fan CFM and type of exhaust duct. Use the next highest Fan Rating for fan capacities not shown in the table.

Exhaust Fan Duct Sizing[1]

Table 240-1

Duct Type	**Flex Duct**				**Smooth Duct**			
Fan Rating CFM @ 0.25 in. wg	50	80	100	125	50	80	100	125
Diameter (in)	**Maximum Length (ft)**							
4”	70	3	X	X	105	35	5	X
5”	NL	70	35	20	NL	135	85	55
6”	NL	NL	125	95	NL	NL	NL	145

[1] – Taken from ASHRAE 62.2-2003
X – not allowed
NL – no limit on duct length

The duct lengths shown in Table 240-2 assume no elbows. Reduce length by 15 feet for every elbow. Note that for all intents and purposes, 4 inch flex duct can never be used with the suggested 70 CFM bathroom exhaust fans. If flex duct is being used, it should be 5 inch diameter.

For example, a fan rated at 70 CFM at 0.25 in. w.c. will be installed to replace a non-operable bathroom exhaust fan. The existing fan is vented into 4 inch flex. There is one elbow in the duct at the fan. According to Table 240-2, the 4 inch flex duct may only be vented 3 feet with no elbows and is therefore not sufficient for the new fan. The flex duct may be replaced with 5 inch flex (assuming that the duct length is no more than 55 feet) or 4 inch smooth metal if the duct length is no more than 20 feet.

If flexible duct is used, the entire length should be supported with braces or hangers every 18 inches to prevent sagging. Elbows should be minimized. Elbows with a long radius angle should be used. There should be a 2 foot to 3 foot horizontal run out of the fan before the first elbow.

2444 Kitchen Exhaust Fans

Kitchen exhaust fans should be vented to the outside. Recirculating kitchen hoods should be replaced with kitchen exhaust fans. Kitchen exhaust fans should have a minimum exhaust capacity of 100 CFM. Through-the-wall or ceiling mounted exhaust fans may be used when exhaust range hoods cannot be installed. Refer to Table 240-2 for properly sizing exhaust fan duct.

2445 Continuous Exhaust-Only

Continuous exhaust-only ventilation may be considered when the house is below its BTL or as required by ASHRAE 62.2, 2004. In addition, there may be instances of chronic moisture loads in a home caused by high occupancy, lifestyle or other circumstances that cannot be addressed by weatherization where a continuous exhaust-only system may be considered.

Duct systems for continuous exhaust-only systems should meet the requirements shown in Table 240-2 in this chapter.

Continuous exhaust-only systems force air out of the home while drawing air in through leaks in the building shell. These systems are generally recommended for heating climates.

Continuous exhaust systems may place the home under negative pressure. Depressurization of the combustion appliance zones may occur as a result of continuous exhaust. Attached or tuck-under garages should be well-sealed from the living space so as not to depressurize the garage. Soil gases, radon and moisture may also be drawn into the home as a result of depressurization.

When installing a continuously operating exhaust fan, educating the client about its use is extremely important. The client should be informed about:

- The purpose(s) of the exhaust fan installation.
- The importance of operating the fan whenever the house is closed up, such as during the heating season.
- The disadvantages of not operating the exhaust fan.

Controls of the operation of these systems should be clearly marked.

24451 Bathroom Exhaust Fan as a Continuously Operating System

Some low sone bathroom exhaust fans are rated to operate continuously. These fans are quiet and therefore are not likely to cause noise complaints from the clients. Alternate to operating the fan on a continuous basis, a programmable controller may be utilized (see 24422, “Controls”).

Power consumption of exhaust fans should be considered. Many low sone fans have high efficiency electric motors that minimize operating costs. An example for determining annual operating cost for an exhaust fan that will operate continuously is shown below.

A fan rated for continuous operation has been selected for a 3-bedroom, 1,600 ft^2 home. The fan is rated at 60 CFM at 0.25 in. w.c. with a power consumption of 17 watts. The annual operating cost for electricity is $14.89 a year at $0.10/kwh.

(17 watts/1000 watts/kWh) x 8,760 hours/year x $0.10/kWh = $14.89

24452 Inline Fan as a Continuously Operating System

An inline fan rated for continuous operation may be used instead of a bathroom exhaust fan. The fan is mounted in the attic, above the insulation, to lessen the noise. Up to three bathrooms may be ducted to the fan. Small ceiling grilles are installed in the bathrooms. A low/high switch may be installed to provide a base level of ventilation (20 CFM from each bathroom, for example), but provides the client with the capability to boost the ventilation rate during showering or bathing.

2446 Supply-Only Ventilation

Supply-only systems use a fan to force outside air into the building while air leaks out of the home through holes in the building shell. A simple supply-only system uses the furnace air handler as the ventilation fan and the heating ducts as the distribution system.

Flex duct is installed from the outside of the home to the return side of the furnace. Whenever the air handler operates, fresh air is drawn in from the outside and mixed with the return air. A balancing damper may be installed to control the amount of air being introduced to the home.

Insulated flex duct should be used to reduce condensation during the winter. A filter should be installed between the flex duct and the return duct. A wall cap with insect screen should be installed on the fresh air intake on the outside of the wall.

This supply-only system has some disadvantages. Using the furnace air handler to circulate air may be an expensive way to circulate air throughout the home. The electric cost of using the furnace air handler as the ventilation fan may be significant. Power consumption of the air handler should be considered using this system. Electric costs[30] for using the air handler as part of the ventilation system in Chicago are shown below.

Inefficient Air Handler (700 watts) = $432
Efficient Air Handler (250 watts) = $152

Secondly, during mild weather, the air handler doesn't operate often and there are extended periods when ventilation is not provided unless a timer control is installed (see below). Finally, supply-only systems place the home under a positive pressure, forcing warm moist air into cool building cavities during the heating season. For this reason, supply-only systems are generally recommended for mixed and hot climates only.

Fresh air grille inlets should be located away from sources of poor air supply. Inlets should be located at least 10 feet away from automobile parking areas, side-vented furnaces and water heaters, dryer vents or other sources of poor air quality.

[30] @ $0.09/kwh

Inlets should be installed at least 12 inches above grade so that they will not be covered with snow. The inlet should be designed to prevent rain entry and must have a rodent screen with a mesh not less then ¼ inch to prevent the entry of large particles. Inlets will require periodic cleaning as they tend to become clogged with dirt, debris and insect nests. They should be located for easy accessibility. The client should be instructed about cleaning the intake grille.

This system provides ventilation throughout the entire home, but only when the air handler is operating. The air handler is less likely to operate during the spring and fall (summer also if central air conditioning is not present). A timer control, such as the AirCycler®, may be installed to assure ventilation year round.

The AirCycler® is mounted on the furnace cabinet and wired to the air handler and tracks the operation of the air handler. If the air handler has not run for a certain period of time (20 minutes, for example), the AirCycler® will operate the fan for a period of time (10 minutes, for example). Both the "fan-off" and "fan-on" times are adjustable between 1 and 99 minutes. During periods of high heating or cooling, the air handler will probably run often and the AirCycler® will not affect fan operation.

2447 Balanced Ventilation Systems

Balanced systems provide equal rates of supply and exhaust air, preventing the problems that depressurization (exhaust-only) or pressurization (supply-only) may create in a home. Air that is exhausted from the home is replaced with an equal amount of fresh air.

Balanced systems may be either separate supply and exhaust systems working together for balanced air flow or a package unit that provides heat recovery in addition to ventilation. In tight buildings with limited natural infiltration, a balanced ventilation system can meet the ventilation requirements of a home without creating depressurization or pressurization problems.

Package units can be either heat recovery ventilators (HRV) or energy recovery ventilators (ERV). HRV systems exchange household air with fresh outside air. Sensible heat in the exhausted household air is recovered and transferred to the incoming outside air as both airstreams pass through a heat recovery core. An HRV system is recommended for heating climates when air conditioning is not used in the home.

An ERV system is recommended when cooling is used in the home. An ERV system transfers both sensible and latent (heat and moisture) energy. Heat and moisture in the incoming outside air is transferred to the outgoing exhaust air an ERV so as not to increase the cooling load of a home.

For most effective operation, balanced systems should supply fresh air to all the important living spaces, such as bedrooms, living, dining and family rooms.

Exhaust air should be removed from spaces in which moisture and odor are generated, generally kitchens, bathrooms and utility rooms. The duct system should be well-sealed.

The following items should be considered when installing an HRV or ERV system.

- New ductwork should be installed for the HRV or ERV system. If existing ductwork is used, there is a potential that air will "short-circuit" and not circulate around the home. The furnace air handler may be needed to circulate the air around the home. Unless the air handler has an efficient motor, there may be a significant increase in electric consumption (see section 2446, "Supply-Only Ventilation).
- HRV and ERV systems require filter cleaning. Units should be located for easy accessibility. Client must be willing to maintain system on a regular basis. Fresh air intake must be cleaned of dirt and debris on a regular basis.
- Condensate will form on the cool side of an HRV during the summer. Provisions for draining the condensate must be provided.
- Fresh air grilles should be located away from sources of poor air quality.
- The balanced ventilation systems should be professionally designed, installed and balanced.

Operation instructions should be posted in the vicinity of the installation to avoid occupant override or misuse.

245 Dryer Venting

Disconnected or improperly vented clothes dryer vents should be corrected as part of weatherization.

Dryer vents should be smooth-surfaced aluminum or galvanized rigid duct. Non-combustible flexible metal duct approved for dryer venting may also be used (UL labeled "Clothes Dryer Transition Duct"). Plastic or vinyl flex duct is not to be used.

Duct joints should be lapped taking account of the direction of air flow. Duct sections should be connected with foil-backed metallic tape or approved clamps. Screws or fasteners that extend into the duct are not to be used.

Minimum duct diameter should be 4 inches and length should not exceed 25 feet from the dryer outlet to the termination point (no more than 8 feet for "Clothes Dryer Transition Duct"). If duct length is greater than 25 feet, 5 inch diameter duct should be used. Assume a reduction in maximum length of 2.5 feet for every 45 degree bend and 5 feet for every 90 degree bend. Clothes dryer transition duct should be installed without dips or sags. Dryer vent duct extending through non-conditioned spaces are to be insulated.

Outdoor dryer vent caps should have a backdraft damper that closes when the dryer is not being used. Insect screens or small wire cages are not to be installed over the vent cap because they can become clogged with lint.

246 Gutters & Downspouts

Missing or damaged gutter systems may be repaired or replaced under weatherization to the extent they can be completed within the incidental energy-related repair budget. The gutter system includes the gutters, downspouts, leaders and splash blocks.

- Use minimum 0.027 gauge aluminum gutters. The heavier gauge 0.032 is preferred for heavy ice and snow locations.
- Gutters should be pitched to downspouts at 1 inch for every 16 feet of run. Short gutters may be hung level. In areas with a moderate amount of trees, gutters and downspouts should be oversized where leaves and debris can be flushed more easily.
- Seal gutter connections with mastic or caulk to prevent leaking.
- Half-round gutters are least affected by snow and ice. If unavailable or too costly, the "K-style" gutters may be used.
- Use heavier versions of hangers and secure gutters every 24 inches (18 inches where heavy ice and snow may be a problem). Hangers should be firmly fastened to the fascia, rafter end or truss tails. At a minimum, heavier hangers should be used at stress points, such as corners and downspouts.
- Downspouts may be oversized to help reduce clogging. Elbows and straight sections should be fastened together with pop rivets—screws that project into the downspout can lead to clogging.
- Secure downspouts to house with 3 fasteners, rather than 2.
- Use 1 downspout for every 40 feet of gutter.
- Leaders and splash blocks should be used to direct water away from the home. Water from downspouts should come out at least 3 feet away from a house that has a crawl space and 5 feet away from homes with basements.

247 Mold Remediation

Mold remediation is not an allowable DOE weatherization expenditure. Other funding sources should be sought to cover the cost of cleaning or remediating moldy surfaces.

Recognize, however, that weatherization services may help solve a mold problem. Mold growth on cool interior surfaces may be eliminated by elevating surface temperatures with the addition of insulation and appropriate air sealing. Installation of ventilation systems will help remove moisture from bathrooms and kitchens. Repairing or installing gutter systems and clothes dryer vents are also allowable weatherization measures.

The following is provided as background information for mold remediation activities.

Mold remediation must go "hand-in-hand" with solving the moisture problem lying at the root of a mold problem. It is naïve to clean mold and believe that the mold problem has been resolved without solving the underlying moisture problem. Mold problems will come back if they are not dealt with properly; that is, the moisture problem must be corrected.

Mold can be cleaned with water and a mild detergent. Sometimes a biocide, such as household bleach, may be used. Biocides are substances that can destroy living organisms. The use of a biocide that kills is not recommended as routine practice for mold cleanup. There may be instances, however, when its use may be justified. If disinfectants or biocides are used for mold cleaning, always ventilate the area and exhaust the air to the outdoors. Biocides, such as bleach, are irritating to the eyes, nose and throat. Never mix chlorine bleach solution with other cleaning solutions or detergents that contain ammonia; toxic fumes could be produced.

Note that mold may cause staining and cosmetic damage that will be apparent following its cleaning.

In some cases, what appears to be mold may simply be water stains. Mold will lose its color or disappear if some drops of household bleach are dropped on it. If there is no change in its appearance, it probably isn't mold.

The presence of mold in a home does not mean workers or the occupants will have any health effects from it. Individuals have different sensitivity to mold exposure.
Most people are not affected by exposure to mold unless they are exposed to high concentrations of it. Those who do have an allergic reaction to mold may only have "cold-like" symptoms such as a running nose, congestion, cough, and itchy eyes. Although there is evidence documenting severe health effects of mold in humans, most of the evidence is derived from ingestion of contaminated foods, or exposures in agricultural settings where inhalation exposures were very high. Such high-level exposures are not expected to occur while performing weatherization work.

Exposure to mold will more likely result in severe reactions in persons with the following medical conditions.

- Decreased immune function,
- HIV/AIDS,
- Respiratory problems,
- Asthma,
- Emphysema,
- Severe allergies,
- Persons having undergone recent surgery,
- Infants less than 12 months old, and
- Other serious health concerns.

It is critical to remediate mold and solve a water problem in homes where one of the above conditions exist. Mold remediation guidelines provided here are limited to mold areas that are no more than 30 ft^2 in area. Areas larger may require the services of a professional mold remediator.

2471 General Mold Remediation Guidelines

The procedures are designed to protect the health of the occupants and cleanup personnel during remediation. These procedures are based on the area and type of material affected by water damage and/or mold growth. Asthmatic or allergic individuals should refrain from cleaning mold.

Non-porous (metals, glass, and hard plastics) and semi-porous (wood and concrete) materials that are structurally sound and visibly moldy can be cleaned and reused. Cleaning can be done using a detergent solution. Most porous materials (ceiling tiles, insulation, gypsum board, fabrics) cannot be cleaned and should be removed and discarded.

The following protective equipment should be worn when cleaning mold.

- Respirator

N-95 respirators are recommended. Some N-95 respirators resemble a paper dust mask with a nozzle on the front, others are made primarily of plastic or rubber and have removable cartridges that trap most of the mold spores from entering. The respirator or mask must fit properly to be effective. The instructions supplied with the respirator should be followed carefully.

- Rubber Gloves

Long rubber gloves that extend to the middle of the forearm are recommended. When working with water and a mild detergent, ordinary household rubber gloves may be used. Gloves made from natural rubber, neoprene, nitrile, polyurethane or PVC should be worn if a disinfectant, chlorine bleach or a strong cleaning solution is being used.

- Goggles

Goggles that do not have ventilation holes are recommended.

Common sense should be exercised. Old clothes should be worn and eating should not be done in the moldy area. Try to avoid touching the face and skin with the working gloves.

2472 Small Isolated Areas (10 ft^2 or less per affected area)

Containment of the work area is not necessary. Vacating people from spaces adjacent to the work area is not necessary but is recommended in the case of children less than 12 months old. People suffering from any of the above health conditions should be kept away from the area being cleaned.

The mold should be cleaned with a mild detergent solution. Sponge with a clean, wet rag and let the area dry.

Discarded material should be put in a sealed plastic bag before being disposed. There are no other special requirements for the disposal of the moldy material.

2473 Mid-Sized Isolated Areas (10 ft^2 to 30 ft^2 per affected area)

The work area should be unoccupied. Vacating people from spaces adjacent to the work area is not necessary but is recommended in the case of children less than 12 months old. People suffering from any of the above health conditions should be kept away from the area being cleaned.

The work area should be covered with plastic sheets and sealed with tape before cleaning to contain any dust or debris. Seal duct registers to prevent mixing and circulation of air from the clean-up area. Using an exhaust fan to the outside to keep the area under negative pressure is also helpful.

Misting surfaces (to suppress dust) should be done prior to cleaning. Mold should be cleaned with a mild detergent solution. If it's determined that a bleach solution is required, use a solution of 10% household bleach (1-1/2 cups of bleach in a gallon of water). Wash the mold area with the solution and let stand for 10 minutes.

The work area should be HEPA vacuumed. Discarded material should be put in a sealed plastic bag before being disposed. There are no other special requirements for the disposal.

2474 Cleaning Moldy Gypsum Board

Small mold areas on gypsum board may be cleaned with a damp rag using baking soda or a bit of detergent. Do not allow the gypsum board to get too wet.

Badly damaged or larger areas of gypsum board will have to be removed. Cover the moldy gypsum board area with a piece of 6 mil polyethylene large enough to cover the mold area and at least 8 inches beyond. Secure the edges of the poly with sheathing or duct tape. Cut around the border of the taped area and remove the gypsum board. Bag the moldy material in heavy-duty garbage bags or wrap in 6 mil poly, tape the joints and dispose. Wash the surrounding area with a mild detergent solution and dry quickly.

300 Mobile Homes

Best Practice Recommendations:

- Air sealing should be limited to sealing ductwork and large holes needed to hold insulation in place until all insulation measures have been completed and a blower door test has been conducted.
- Cost effectiveness of insulating floors, sidewalls and roof cavities should be examined by State Weatherization Programs. If cost effective, actions should be taken to increase local agency capacities to include these measures as part of production.
- Replacement windows should be double-glazed.
- Pressure-pan testing should be done in all mobile homes.
- Replacement water heaters should be done with HUD approved units.

Construction practices used in mobile homes differ from those used in site-built homes. As a result, there are a number of inherent thermal deficiencies in mobile homes not found in site-built homes. It is not surprising then that the thermal performance of mobile homes is generally poorer than site-built homes. This section addresses those thermal deficiencies unique to mobile homes. Otherwise, procedures described in other sections of this Guide apply.

The manufacture of mobile homes was not governed by any code prior to the mid-1970s. In 1976, the Department of Housing and Urban Development (HUD) established a national code governing mobile home assembly. Known as the HUD Code, this minimum standard improved both the quality and thermal performance of mobile homes.

Mobile homes manufactured prior to the 1976 HUD Code may be identified from the following characteristics:

- 2”x 2” or 2”x 3” sidewall studs,
- Little or no insulation in the walls, floors and ceilings,
- No vapor barrier in the ceiling,
- Uninsulated ducts in the floor or ceiling, and
- Jalousie windows.

It should come as no surprise that pre-1976 mobile homes suffer from poor thermal performance given the above characteristics. Thermal performance improved as a result of the HUD Code, but some minimum requirements still lagged behind what was typically found in site-built homes. Mobile homes built after 1976 may be identified by the following minimum characteristics.

- 2”x 4” sidewall studs,
- Minimum R7 sidewall and floor insulation and R11 ceiling insulation,
- Ceiling vapor barrier,
- Insulated ducts or ducts intended to be located within the conditioned space, and
- Single-hung or slider windows.

The HUD code was further modified again in 1985 and 1994. These changes improved both the indoor air quality and thermal performance of mobile homes. In addition, the term “manufactured home” started to replace “mobile home”. In fact, it is often difficult to distinguish between new double-wide manufactured homes and site-built homes. Construction techniques and thermal performance between the two housing types are now comparable.

This section addresses mobile homes built prior to 1985. It is in these homes where the thermal resistance of the floors, walls and roof cavity is poor and additional insulation may save significant energy. Duct leakage is often a significant problem that can also provide significant energy savings. Air leakage and poor heating system efficiency are also common problems in these older mobile homes.

310 Air Leakage

A Building Tightness Limit (BTL) should be established for mobile homes per Section 1113, “Building Tightness Limit”. See section 1115 for determining air sealing guidelines.

Because insulating mobile home floors, walls and roof cavities often make a mobile home tighter, it is recommended that air sealing be limited to sealing ductwork and large holes needed to hold insulation in place until all insulation measures have been completed and a blower door test has been conducted. Additional air sealing may then be done if the existing air leakage rate is above the mobile home’s BTL.

3101 Air Leakage Locations

The following are common air leakage problems in mobile homes.

- Plumbing penetrations in floors, walls, and ceilings.
- Water heater closets with exterior doors having large openings into the bathroom and other areas.
- Torn or missing underbelly, exposing flaws in the floor to the space beneath the mobile home.
- Gaps around the electrical service panel box, light fixtures, fans, and flue pipes.
- Joints between the halves of double-wide mobile homes and between the main dwelling and additions.
- Under bath sinks, around dryer vents, furnace flues and return air registers.

320 Mobile Home Insulation

Effective methods for insulating mobile home floors, walls and roof cavities have been developed over the past 25 years. Insulation should not be installed if moisture problems found in wall and roof cavities cannot be corrected. Mobile home floors should not be insulated if a plumbing leak cannot be repaired. Note, however, that insulating mobile home floors may help keep exterior moisture from moving-up into the mobile home. See section 133, “Moisture Assessment”, for additional information regarding moisture problems.

3201 Floor Insulation

Mobile home floor insulation is a beneficial measure for heating climates. Existing insulation was fastened to the bottom of the floor joists during assembly leaving the cavity uninsulated and subject to convection currents. The floor cavity may be blown with fiberglass insulation.

32011 Preparing for Mobile Home Floor Insulation

The belly material of the mobile home should be inspected prior to blowing floor insulation. Crawling under the mobile home to inspect the belly may be a problem, but is necessary to ensure that problems with the belly can be corrected prior to or as part of the floor insulation job.

Ensure that floor cavity is not being used as a belly-return air plenum. The belly-return must be converted to central return[31] before floor cavity is insulated. See section 34043, "Converting Belly-Return Systems".

Test ducts to ensure that they are tight (see section 3404, "Ductwork"). Seal all holes in the duct system before insulating floor cavity. Ensure that duct boots are securely fastened to sub-floor and main trunk.

Determine location of water pipes in the floor cavity. There must be a minimum of 3 inches between the belly material and pipes for floor insulation. If it is not possible to get 3 inches of floor insulation between the belly material and pipes, the pipes must be insulated or moved closer to the floor above. Otherwise, the floor cavity should not be insulated.

Tightly seal all holes in the floor to prevent loose insulation from blowing into the living space.

Seal large holes in the belly material and ensure that all plumbing problems are solved before insulating. Patch holes with insulated foam board, fiberboard or belly-paper (nylon reinforced material specially manufactured for mobile homes). Secure patches with stitch-staples and caulk, screws or lath strips.

Install a ground moisture barrier if there are signs of ground moisture problems. The ground barrier also makes it easier and cleaner for crews to work under the mobile home.

32012 Insulating the Floor

Floor cavities should be insulated with blown fiberglass installed to a density of 1.25 lbs/ft^3 to 1.75 lbs/ft^3. Cellulose is not to be used because of weight. Dense-packing cellulose may also damage the belly material. Carefully estimate number of bags needed to insulate floor cavity so as to avoid putting excessive pressure on belly material.

Blowing a mobile home floor

[31] A central return is defined as a return air system with one return air grille. Return air may be ducted to the furnace or, as in the case of mobile homes, air returns to the furnace through louvered doors to the furnace closet.

There are two favored methods of insulating mobile home floors. The side-blow method involves drilling through the rim joist and blowing insulation through a grey PVC fill tube to reduce static electricity. The belly-board method involves blowing fiberglass insulation with a flexible fill tube through holes cut in the belly material.

During the insulation process, periodically inspect interior of mobile home and ducts to ensure that loose insulation is not getting into the home or ducts.

320121 Side Blow Method

Each joist cavity in the floor is insulated through holes cut in the rim joist. Remove trim pieces to expose the rim joist. Drill carefully to avoid wiring located adjacent to rim joists. Block drilled holes with wood plugs following insulation. Seal plugs with adhesive prior to replacing trim.

Ducts running Crosswise to the Mobile Home

Drill two 2-9/16 inch holes into adjacent joist cavities on opposite sides of the mobile home to avoid excessive weakening of the rim joist. The belly-board may have sags in it where it dropped down from the joists, especially near the center where the duct is located. It may be necessary to push the belly-board up and secure to the joists to avoid installing unnecessary amounts of insulation. Leave a minimum 3 inch space between the belly material and bottom of duct and pipes for insulation.

Ducts running the Length of the Mobile Home

The rim joists on the short sides of the mobile home are non-structural. Drill two 2-9/16 inch holes into each cavity at the front and rear of the home as it may be difficult to insulate the entire joist run from one side. Insulate half the cavity from each end of the home.

Attach sections of rigid fill tubes as needed to fill each cavity.

320122 Belly-Board Method

For crosswise joists, use existing holes or cut slits near the center of the home. Extend a flexible fill-tube out to the rim joist. Fill cavity from edge back towards hole. Repeat procedure on other side of joist cavity.

Secure sections of belly-board to floor joists where sags are present to avoid blowing an unnecessary amount of insulation into the cavity. Leave a minimum 3 inch space between the belly-board and bottom of duct and water pipes for insulation.

For ducts that run the length of the mobile home, cut holes into each joist cavity. Space holes along the floor cavity at approximately the same length as the fill-tube.

3202 Sidewall Insulation

Mobile home walls are usually partially insulated. It is common for the existing insulation to fill only half of the wall cavity's thickness. The cost effectiveness of installing mobile home sidewall insulation should always be determined.

Sidewalls should not be dense-packed or over-filled. Inspect exterior siding and interior panels and repair or reinforce sections as necessary before insulating. Seal holes and cracks in interior wall panels to keep loose insulation from getting into the home.

32021 Electrical Assessment

The client should be asked about any known existing electrical problems. Assess type and condition of electrical wiring. Electrical #12 aluminum or #14 copper wiring must be protected with 15 amp fuses or breakers. Cavities should not be insulated if excessive movement of the wires will occur. Each outlet, switch, or light fixture should be checked for proper operation with a receptacle tester before and immediately following the completion of the insulation work.

If aluminum wiring is present, an electrician should check that the wiring is safe both prior to and after installing sidewall insulation. If an electrician cannot certify the safety of the wiring, wall cavities containing aluminum wiring are not to be insulated.

32022 Insulation Methods

Access to mobile home walls is from the bottom of the siding. If horizontal siding is present, the bottom section of siding is removed. If vertical siding is present, the siding is loosened by removing the bottom row of screws. Joints in the vertical siding pieces may need to be secured with short sheet-metal screws.

Fiberglass batts or blown fiberglass insulation should be used. Cellulose should not be used because of moisture absorption, density and weight. Areas above windows and doors are difficult to access and probably not worth insulating.

The client should remove wall hangings where the nail is in the cavity before the walls are insulated.

Walls may be insulated using the batt-stuffer method or may be blown.

320221 Batt-stuffing Mobile Home Walls

This method works on about 50 percent of metal-sided mobile homes. It is faster than blowing the wall and works well for partially insulated walls or wall cavities with obstructions. Poly encased or vinyl faced fiberglass insulation is preferred for this application, however kraft-faced and unfaced batts will also work.

- Use a batt stuffer made of quarter-

Batt-stuffing a mobile home wall cavity

inch Lexan® (polycarbonate plastic), 10 or 11 inches wide and 96 inches long.

- On the ground, lay a piece of plastic sheeting, measuring approximately the same size as the unfaced batt and the stuffer.
- Cut batts approximately 8 inches longer than the wall cavity height.
- Lay the batt on the plastic and the batt-stuffer on the batt.
- Lap a few inches of the batt and plastic sheeting over the top of the batt-stuffer. Stuff the batt up into the wall between existing insulation and the interior paneling, with the plastic sheeting against the wall paneling. The plastic sheeting may remain in place.

320222 Blowing Mobile Home Walls

Blowing mobile home wall cavities is recommended for cavities that cannot be stuffed with batts. Additional insulation is blown between existing insulation and interior paneling with a flexible fill tube with a 1-1/4 inch inside diameter. The end of the hose should be cut on a 45 degree angle to facilitate movement up the wall cavity. Use the natural curvature of the tube to help push the tube up the wall cavity. Ensure that interior paneling is sound.

- Remove screws from bottom of exterior siding.
- Pull siding and existing insulation away from studs.
- Insert tube to the top of the wall cavity with tip sliding against interior paneling.
- Avoid overfilling the cavity and bulging the exterior siding.

To prevent over-filling the wall cavity, loose blow the bottom of the cavity with an unfaced batt stuffed in the bottom of the cavity to prevent insulation from blowing out of the wall cavity.

3203 Roof Cavity Insulation

Blowing a closed mobile home roof cavity is similar to blowing a closed wall cavity, only the insulation does not have to be as dense. Fiberglass blowing insulation is preferred. Cellulose should not be used because of moisture absorption, density and weight.

Venting mobile home roofs is optional. Vent installation may be considered part of an overall strategy to keep moisture out of the roof cavity.

Ensure that electrical problems do not exist in roof cavity before insulating (see section 32021, “Electrical Assessment”).

Occupants of mobile homes in heavy snow load areas should be advised that snow loads will likely increase due to roof cavity insulation. Occupants should be advised not to shovel snow off of the roof, but rather use a push broom if there are concerns.

There are two common methods for blowing mobile home roof cavities. The first is cutting a square hole in the metal roof and blowing fiberglass through a flexible fill-tube. The second is disconnecting the metal roof at its edge and blowing fiberglass through a rigid fill-tube.

32031 Preparing to Blow a Mobile Home Roof

See section 21211, "Heat Producing Devices", for information with respect to insulation clearances. Generally, insulation should be kept a minimum of 3 inches from heat producing devices such as non-Type-IC rated recessed lights.

- Inspect the ceiling and seal all penetrations.
- Reinforce weak areas in the ceiling.
- Inspect seams and joints on the roof. Seal open seams and joints before or during insulation installation.
- Take steps to maintain safe clearances between insulation and recessed electrical fixtures.
- Assemble patching materials such as metal patches, sheet-metal screws, putty tape, and roof coating.

32032 Blowing a Mobile Home Roof from the Edge

This procedure requires a scaffold to be performed safely and efficiently. The roof cavity may have to be accessed from both sides of the mobile home if a "strongback"[32] is present in the roof assembly and the fill tube won't fit under it. Mobile home metal roofs are usually fastened only at the edge, where the roof joins the wall.

- Remove the screws from the metal j-rail at the roof edge. Also remove staples or other fasteners. Scrape off putty tape.
- Pry the metal roof up far enough to insert a 2 inch diameter, 14 foot long rigid fill tube.
- Blow insulation through the fill-tube into the cavity. Loose blow the last few feet (nearest installer) to prevent insulation from blowing out. Stuff the last foot or two with unfaced fiberglass batts.
- Re-attach roof edge to the wall using new putty tape and larger screws. Re-attach rain gutter.

32033 Blowing Through the Top

This procedure is not recommended for metal roofs in heavy snow load areas. Instead, install insulation from the roof edge (section 32032) in these areas.

- Cut 10 inch square holes at the roof's apex on top of every second truss. Each square hole allows access to two truss cavities.
- Existing aluminum roof coating around hole must be removed before new patch is installed. The coating must be heated and then may be scraped-off.
- Use a 2 inch or 2 ½ inch diameter fill-tube. Insert the fill-tube and push it out toward the

Blowing a mobile home roof from the edge

[32] A beam used as a stiffener in some mobile home roofs and floors.

edge of the cavity.

- Blow fiberglass insulation into each cavity. Install insulation to a density between 1.25 lbs/ft^3 and 1.75 lbs/ft^3. Do not overfill cavity.
- Stuff the area under each square hole with a piece of unfaced fiberglass batt so that the finished patch will stand a little higher than the surrounding roof.
- Patch the hole with a 14 inch square, 26 gauge galvanized steel. Seal with roof cement and screw into the existing metal roof.
- Cover the patch with a second 18 inch square patch of *Peal and Seal*.

330 Windows and Doors

3301 Window Replacement

Replacing windows and doors should only be done if determined to be cost-effective.

New jalousie or awning type windows are not acceptable as replacements. Replacement windows are to be double glazed with a thermal break. Cost effectiveness of low-E double glazed replacement windows should also be checked. Replacement windows with an emergency release are available and should be considered for replacement windows in bedrooms.

Inspect the condition of rough opening members when replacing windows. Replace deteriorated, weak or rotted framing members.

Prepare replacement window by lining the perimeter of the inner lip with 1/8 inch thick putty tape or 100% silicone caulk. Caulk exterior window frame perimeter to wall after installing window.

3302 Mobile Home Storm Windows

Interior storm windows are an allowable measure if determined to be cost-effective. Replacement of existing storm windows is not allowed unless the existing storm windows cannot be re-glazed or repaired.

Two kinds of interior storm windows are common in mobile homes. RDG storm windows clip into a frame that is then screwed into the wall. RDG storms are installed over awning and jalousie windows. Interior sliding storm windows are used with sliding windows.

3303 Mobile Home Doors

Mobile-home doors are available in two basic types: the mobile-home door and the site-built house door. Mobile home doors swing outward and site-built house doors swing inward.

Door replacement is an allowable expense only when the existing door is damaged beyond repair and constitutes a severe air leakage problem.

340 Mobile Home Furnaces

A great majority of mobile homes are equipped with downflow furnaces, designed specifically for mobile homes. Mobile home furnaces are different from conventional furnaces found in site-built homes in the following ways:

- Mobile home furnaces are sealed combustion units that use outdoor combustion air vented directly to the unit.
- Gas-fired furnaces contain kits that allow the use of either propane or gas as fuel.
- Return air to the furnace usually passes through a large opening in the furnace rather than a ducted return. Supply air is returned to the furnace through the living space. The furnace closet door must have louvers or grilles that allow the air back to the furnace return air opening.

3401 Furnace Replacement

Mobile home furnaces must be replaced by furnaces designed and listed for use in mobile homes. See section 223, "Heating System Replacement Standards", for heating system replacement guidelines.

3402 Furnace Maintenance

Mobile home furnaces should comply with the combustion safety and efficiency standards as discussed in sections 2211 and 2212, "Gas Burner Servicing Requirements" and "Oil Burner Maintenance and Adjustment".

3403 Furnace Venting

Mobile home furnaces often use manufactured chimneys that include a concentric passageway for combustion air. When replacing a mobile home furnace, note any differences between the old and new furnace supply air paths. Follow manufacturer's instructions exactly.

Inspect the vent for signs of rust, cracks, holes or unsealed or disconnected sections. Repair or replace if necessary.

3404 Ductwork

34041 Duct Leakage Locations

The following locations have been identified as the most serious duct problems in mobile homes.

- Floor cavities used as return-air plenums. Plenum return systems should be eliminated and replaced with central return systems through the living space back to the furnace (see section 34043, "Converting Belly-Return Systems").
- The joint between the furnace and the main duct. The main duct may need to be cut open to access and seal these leaks.
- Joints between the main duct and its boots – the short duct sections joining the main duct to the floor register.
- Joints between duct boots and

Using metal and mastic to seal mobile home duct boots

floor.

- Disconnected, damaged or poorly joined crossover ducts, end of duct runs.

34042 Duct Leakage Standards

See section 113, “Duct Leakage Tests” for discussion regarding duct leakage. See section 11353, “Pressure-Pan Test Procedures” for recommended testing procedures.

Pressure pan readings must be adjusted based on a zone pressure in the floor cavity. Measure the pressure difference between the floor and living space alongside the boot cavity. Adjust pressure pan readings accordingly. See Table 1 for Pressure Pan Multipliers in section 113, “Duct Leakage Tests”.

The following duct leakage standards should be applied to mobile homes.

- For a central return system, all pressure pan readings should be 0 while a blower door is depressurizing the dwelling to -50 Pascals.
- For a central return system, a sum of 3 Pascals for the pressure pan readings is acceptable if:
  - The floor boots are sealed with mastic, as necessary; and
  - The ends of the supply trunk ducts are sealed.

  Goal: Attempt to reduce the sum of the pressure pan readings to zero Pascals.

- For a central return system, a sum of 5 Pascals for the pressure pan readings is acceptable if:
  - The floor boots are sealed with mastic, as necessary;
  - The end of the supply trunk ducts are sealed;
  - Any crossover ducts are visually inspected, repaired and sealed, as necessary (make sure these ducts are supported properly); and
  - The furnace plenum is sealed with mastic.

  Goal: Attempt to reduce the sum of the pressure pan readings to zero to 3 Pascals.

If difficulty is experienced meeting the goals, use a “pillow” (fiberglass insulation inside of a plastic bag) to block and segment sections of the ducted system to assist in finding leaks. Additionally, the duct may be inspected with a mirror and a strong flashlight.

34043 Converting Belly-Return Systems

Belly-return systems in mobile homes are notoriously leaky. Leaky return systems can significantly increase space heating costs and lead to thermal discomfort and indoor air quality problems.

When converting a belly-return system in a mobile home to a central return, follow the following procedures.

1. Add a grill with at least 200 in^2 of net free area to the furnace closet door.

2. Block all floor return registers with a durable material to keep floor insulation from being blown into the home. Look carefully to find hidden registers under built-ins, behind furniture, and in kitchen toe-kick spaces.
3. Completely block and seal all floor openings in the furnace closet using a fire retardant air barrier, being careful to not seal the combustion air inlet.
4. Check the temperature rise of the furnace to ensure that the airflow is not restricted after floor insulation has been installed. The temperature rise should be within the range specified on the manufacturer's label or between 40^{o} and 80^{o} F.
    a. Inspect the plenum/furnace joint at the floor before measuring the temperature rise. Repair this joint, if needed, before measuring temperature rise.
    b. Make sure all interior doors are open, except the furnace closet door which should be completely closed.
    c. Turn on the furnace and allow the temperature of the supply air to stabilize. Measure the temperature at the register closest to the furnace, making sure that the airflow to this register is not blocked and that there is no significant duct leakage between the furnace and the thermometer.
    d. Subtract the house air temperature – the return air – from the supply air temperature. The difference is the temperature rise.
    e. If the temperature rise is greater than the recommended range the airflow is restricted by an:
        i. Undersized opening in the furnace closet door, or
        ii. Another restriction in the ductwork
    f. If the temperature rise is less than the recommended range, there might be:
        i. Significant leakage at the furnace/plenum joint, or
        ii. Significant leakage in the duct between the furnace and the supply air register where the temperature was measured.
5. Once the temperature rise is within the recommended range, measure room-to-room pressure differences and relieve pressure differences that are greater than 3 Pascals. Additional information on this test may be found in section 1142, "Duct Induced Pressures".
    a. Close all interior doors. Measure the pressure difference across all interior doors. Pressure test and record measurements for all rooms with reference to the main body of the house.
    b. Take action if room pressure difference exceeds 3 Pascals. Provide pressure relief by:
        i. Opening the door slightly while measuring the pressure difference across the door. Open the door until the pressure difference is 3 Pascals or less and measure the square inches of opening. This is the number of square inches:

            - The door must be undercut, or

            - A direct grille, offset grilles, or jump duct must be installed properly relieve the pressure imbalance caused by the distribution system when the door is closed.

34044 Crossover Ducts

Crossover ducts are generally made with flex duct. Inspect crossover ducts for the following conditions and correct as necessary.

- Ducts should not be compressed nor should sharp bends be present.
- Ducts should be insulated to a minimum R8.
- Sags in crossover ducts should be limited to 12 inches over an eight foot span.
- Ducts should be mechanically secured to belly of mobile home.
- Joints should be sealed with mastic or aluminum foil-backed butyl tape.

Damaged crossover duct work should be replaced. Cut-out damaged sections. Insert and secure metal sleeve between remaining pieces of duct. Seal joints with mastic or aluminum foil-backed butyl tape.

34045 Duct Sealing

Any portion of the duct work that extends beyond the last register or grille may be sealed.

Trunk end blocks are only allowed if it is determined that duct air leakage reduction will result from installation. End blocks should be made from sheet metal or aluminum flashing. A fire rated two-part foam may also be used. Any metal end blocks must be mechanically attached to the duct system. Gaps between the end block and the duct must be sealed with mastic. If possible, install the trunk end block at least one foot beyond the last register location. Duct "sweeps" or sloped end blocks are not to be used.

See sections 2271, "Duct Sealing" and 2273, "Improving Duct System Airflow" for additional information regarding duct sealing procedures and methods for improving airflow.

350 Mobile Home Water Heaters

3501 Water Heater Replacement

Water heaters installed at the time of mobile home assembly were HUD approved for mobile home installation. Consider the following when replacing mobile home water heaters:

- Become familiar with the HUD code for water heaters and apply those standards when advising about, working on, or replacing water heaters in manufactured homes.
- Water heaters, whether gas or electric, should be installed to discourage storage of combustibles around these heat producing appliances. Clearances around water heaters should be minimized to avoid this problem, but must be in accordance with manufacturer's instructions.
- Installation of gas- or propane-fired water heaters must provide for the complete separation of the combustion air and the conditioned space[33]. Replacement water heaters should be HUD approved for mobile homes.
- Water heaters should be installed with a drain pan.

[33] HUD Code, #3280.709(d)

3502 Water Heater Closets

At a minimum, water heater closets with an exterior wall must be treated as follows:

- The exterior access door and adjacent exterior walls of closets containing water heaters should be insulated. If the door and adjacent wall can be insulated, the water heater should not be wrapped with insulation.
  - Cover any air vents in the door or adjacent exterior wall.
  - Bring combustion air from underneath the belly or through the skirting by installing an appropriately sized metal chute with a rodent barrier. If the mobile home is skirted, this metal chute must extend to the outside of the skirting.
- If it is not possible to insulate the closet door and adjacent wall area:
  - The tank should be wrapped with an insulation blanket (see section 22422, "Tank Insulation").
  - Large holes in the closet walls that allow air leakage into the interior must be sealed.
  - All plumbing within the closet that is susceptible to freezing must be insulated.
  - An adequate amount of combustion air must be provided to gas- and propane-fired water heaters.

Mobile home water heater closet with gas-fired water heater

360 Water Supply Systems

Water pipes that have not been covered by floor insulation should be insulated to a minimum of R3.5. Piping should be free from water leaks and properly secured to support the weight of the piping and insulation. Pipe insulation should be preformed to fit standard pipe diameters. Pre-formed dimensions should be appropriate for the pipe size. If the insulation is exposed to the weather, it should be resistant to degradation from moisture and ultraviolet light. If the insulation cannot provide this protection, a jacket or facing should be installed that protects the insulation from these conditions.

To prevent freezing, box the individual water supply system pressure tank with 2 inches of extruded polystyrene insulation. Ensure the outer surface of this insulation is protected from direct sunlight.