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COURSE 962908

Weatherization Guide Chapters 3 & 4

Review Material

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PO Box 268 / Platteville, Wisconsin 53818 / 608.348.6688 / www.uscontractorlicense.com

Summary Of This Course

WEATHERIZATION GUIDE CHAPTERS 3 & 4

Approved by the

Wisconsin Department of Safety and Professional Services Safety and Buildings Division

Course Identification Number 962908

Educational Credit Hours: 6 Hours

Course Provider:

USCONTRACTORLICENSE LLC

P.O. Box 268

Platteville, WI 53818-0268

(608) 348-6688

www.uscontractorlicense.com

Chapters 3 and 4 of the Weatherization Field Guide emphasize improving energy efficiency, occupant safety, and equipment performance through proper installation, testing, and maintenance of heating systems and household appliances. Chapter 3 focuses on replacing, servicing, and diagnosing furnaces, boilers, heat pumps, and distribution systems. It stresses accurate equipment sizing, duct sealing and insulation, combustion safety testing, airflow verification, steady-state efficiency measurements, carbon monoxide testing, proper venting, condensate management, and compliance with manufacturer instructions and applicable codes. Regular maintenance, combustion analysis, and customer education are essential for safe, efficient operation.

Chapter 4 addresses electrical baseload measures that reduce household energy consumption. It covers the installation and replacement of high-efficiency refrigerators, freezers, lighting, and clothes washers using approved energy-efficient equipment. The chapter emphasizes proper removal and recycling of obsolete appliances, safe installation practices, verification of equipment performance, and maximizing long-term energy savings while maintaining customer safety, comfort, and reliable operation.

This Course is approved for the following electrical Registrations/Certifications or Licenses:

Dwelling Contractor Qualifier	6 Hours of Continuing Education	
Commercial Building Inspector	6 Hours of Continuing Education	
UDC HVAC Inspector	6 Hours of Continuing Education	

This course is a distance learning or e-learning course, which allows the attendee to complete the course on their time schedule.

Course Outline

This course is a distance learning or e-learning course, which allows the attendee to complete the course on their time schedule.

3.12 Replacing Space Heaters

3.13 Replacing Wood Stoves

3.14 Venting Combustion Gases

3.15 Combustion Air

- **3.15.1 Unconfined Space Combustion Air**
- **3.15.2 Confined Space Combustion Air**
- **3.15.3 Net -Free Area**
- **3.15.4 Sizing Combustion-Air Openings**

3.16 Thermostats

Chapter 4: Base Load Measures

Exam

180 questions related to the reference materials are used to test the attendee on their comprehension of the materials. A 70% score will need to be attained in order to pass this course.

Answer Sheet(s)

2 bubble style answer sheets are included. When you are finished with the exam, you may return the answer sheets for grading to:

By Mail: Uscontractorlicense LLC
PO Box 268
Platteville, Wisconsin 53818

By Email: michael@uscontractorlicense.com

By Fax: 608-571-0096

Once we get the answer sheets back, we will graded them, enter your hours into the attendance portal and email or mail you back your certificate of completion(s). You will be responsible for renewing your license with the DSPS at www.license.wi.gov website.

Any questions, please contact us at 608.348.6688

Foreword

The Wisconsin Weatherization Field Guide is a comprehensive guide to installing weatherization measures and verifying the quality of the work. The Field Guide is a tool for crew workers, energy auditors, and inspectors. The program's policies and administrative practices are identified in the Wisconsin Weatherization Program Manual.

The Field Guide started with dedicated weatherization crew workers determined to improve their trade and the services provided to their customers. It evolved from there to documenting those practices to share them with the rest of the weatherization network. The original Wisconsin Weatherization Field Guide was produced through a collaboration of the 2005 Weatherization Technical Advisory Group, Slipstream (*formerly Wisconsin Energy Conservation Corporation (WECC)*), and Saturn Resource Management.

Wisconsin is one of the national leaders in the Weatherization Assistance Program, and this guide represents the ongoing effort to continually improve our practices and procedures to deliver the best product to our customers.

Credits

Information in *Chapter 5 – Sections 5.15.1, 5.15.2, 5.15.3, 5.15.4, and 5.15.5* is used with permission from *the WAP Precautionary Radon Mitigation Field Guide* by Dick Kornbluth, Dick Kornbluth, LLC, Copyright 2018, Section 11 – Sumps; Pages – 18-22.

The original document was developed in 2005 through collaboration between Wisconsin Division of Energy Services, Slipstream (*formerly Wisconsin Energy Conservation Corporation (WECC)*), Saturn Resource Management, the Technical Assistance Group (TAG) and various technical consultants.

Weatherization Works

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homeenergy+

SATURN RESOURCE MANAGEMENT

slipstream

Chapter 3: Heating System Measures

3.1 Heating and Cooling Systems

This chapter covers improvements to heating and cooling systems. The improvements include the replacement or the modification and repair of the appliance. Complete combustion safety testing for all systems and steady-state efficiency (SSE) testing on gas and oil heating systems. All heating and cooling systems work shall be completed by qualified professionals.

3.2 General Heating System Replacement

All replacement heating systems, except for wood space heaters, shall meet the minimum efficiency standards as specified in the Wisconsin Weatherization Program Manual and listed in the AHRI Directory of Certified Product Performance. Wood heater installation shall conform to the requirement of NFPA 211. Observe the following standards for heating system replacement:

1. Disconnect refrigerant lines, plumbing, ducts, electric, control wires, vents, and fuel supply, when applicable.
2. Install heating systems in accordance with manufacturer's instructions and applicable state and local codes.
3. Use existing distribution system and fuel supply line, when possible.
4. Properly remove and dispose of existing unit.
5. Provide an owner's manual with heating system replacements on or near the heating system. The manual shall be attached in a durable device that allows for repeated customer access.
6. Properly size replacement heating systems units using an accurate analysis through REScheck, ACCA Manual J, or an equivalent industry-accepted sizing procedure by calculating the heating loads based on the post-retrofit dwelling characteristics.
    a. When sizing boiler systems, consider the capacity of the existing terminal devices and whether or not domestic hot water will be heated with the boiler.
7. Install gas pipe that is supported and electrically bonded (if required) in accordance with NFPA-54 and the WI Uniform Dwelling Code. Follow the manufacturer's specifications for installation. For more information see NFPA 54 and WI SPS 323.16.
    a. When CSST is already present in the building and not correctly bonded, bond the gas piping system to the electrical ground in accordance with NEC 250.94 and 250.104 when completing work on the fuel supply and/or the heating system.
8. New heating systems require a dedicated electrical circuit rated or fused to match the amperage of the system's requirements for overcurrent protection. Condensate pumps are allowed to be on the same circuit.
9. Verify and adjust, if necessary, so flue-gas oxygen, stack temperature, and carbon monoxide levels are within manufacturer's specifications. If manufacturer's specifications are not available, refer to *Table 3-2* or *Table 3-5*.

10. Verify and adjust, as needed, to ensure tested SSE meets or exceeds rated AFUE of heating system.
11. Install condensate tubing or piping to reach an appropriate drain. Utilize a hose protection ramp (trip strip) instead of a condensate pump where feasible.
12. Install a condensate pump when the condensate tubing will not drain adequately to an appropriate drain or may cause a tripping hazard. See *Condensate Removal in Chapter 3 – Section 3.8.2* for more information about condensate pumps.
13. Seal openings in chimneys where natural-draft or fan-assisted appliances are eliminated. Indicate with a written notice on the chimney, where sealed, that the chimney is no longer functional.
14. Ensure all remaining naturally vented combustion appliances are drafting properly.
15. Test the heating system's safety mechanisms to confirm they are operating properly and per the manufacturer's specifications (e.g., blower compartment's safety switch and emergency heat circuit are functioning, etc.).
16. Provide in-home operation and maintenance instructions, including a review of safety precautions to the customer.
17. Affix a tag, displayed prominently, identifying who the customer should call for service to the heating unit. The tag information shall contain the name, address, and telephone number of the service organization as well as the date of installation.
18. WHEN A HEATING SYSTEM IS LOCATED IN A CRAWL SPACE: Complete and inspect all heating system work before performing any other measures in the crawl space.

3.3 Forced-Air Furnace Replacement

Observe the following standards specific to forced-air furnace installation:

1. Set fan speed and fuel input for optimal occupant comfort within the manufacturer’s temperature rise limits.
2. Perform all required tests and document results.
3. Seal holes through the jacket of the air handler with mastic or foil tape that is UL181 listed.

3.4 Forced-Air Furnace Air Distribution

Forced-air duct systems present opportunities for saving energy in homes. Ducts waste energy through air flow problems, and from air leaks and lack of insulation when they pass through unconditioned spaces. This section addresses these forced-air distribution problems.

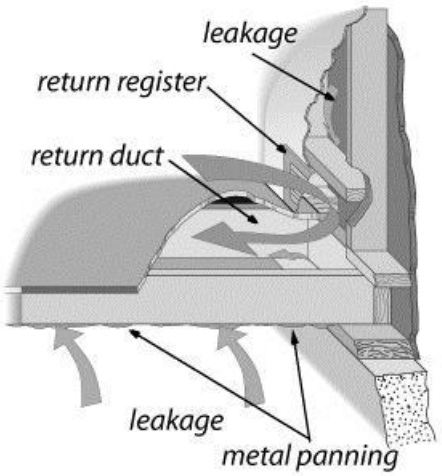
3.4.1 Duct System Modification

If adjusting the fan speed and gas pressure does not bring the furnace temperature rise within manufacturer's specifications, duct work modifications may be considered. Ductwork runs

installed to provide heat to individual spaces shall be as short as possible. The placement of a register shall be where it is least likely to be blocked by furniture or other obstacles.

If possible, a single return air grille shall be provided to a central location on the main floor that is heated, with the shortest ductwork run possible. If another floor is heated that can be closed off from the main floor, an additional return air grille may be installed with the shortest ductwork run possible to a central location. This may not apply to a basement when backdrafting or other health and safety risks or efficiency issues are present.

1. Design new ducts in accordance with ANSI/ACCA Manual D and manufacturer's specifications.
2. Design terminations in accordance with ANSI/ACCA Manual T and manufacturer's instruction.
3. Do not add supply registers to the combustion appliance zone (CAZ) unless it is an intentionally heated space. Consult with the customer about removing existing grilles in the CAZ. If grilles are removed, document the customer consultation in the file.
4. Do not add return grilles in the CAZ, and consult with the customer about removing existing return grilles in the CAZ.
5. Mechanically fasten supply and return ductwork with screws. Seal the ductwork to the furnace cabinet with mastic and fabric mesh tape, caulk, or other UL 181-approved material, to form an essentially airtight connection on all sides of these joints.
6. Do not install new ductwork in unconditioned spaces unless necessary. If ducts are located in unconditioned spaces, seal the joints and insulate the ducts to a minimum of R-8. Ductwork exposed to the exterior of the building shall be insulated to a minimum of R-12.
7. Connect new ducts to the existing distribution. Install a balancing damper in each new branch supply duct. Install registers to terminate each new supply or return branch duct.
8. Do not use building spaces, like basements or crawl spaces, as a plenum or duct.



Panned floor joists: These return ducts are often very leaky and may require removing the panning to seal the cavity.

3.4.2 Duct Leakage

Leaky ductwork poses multiple problems: it may affect the occupants' health and safety, comfort, and the home's energy consumption.

Seal all heating and cooling ductwork that runs outside the dwelling's heated envelope. These duct leaks waste energy and introduce health and safety hazards.
In the CAZ, return ductwork leakage causes depressurization and increases the possibility that natural-draft appliances will backdraft. Supply side leaks in the CAZ are less likely to cause

backdrafts; rather, they may aid the appliances' natural draft by adding positive pressure to the room.

Duct leakage that occurs inside the heated envelope is less likely to contribute to increased energy consumption. Supply duct leakage to outside can introduce excessive moisture into unheated spaces and depressurize the CAZ. Return duct leaks from unheated spaces can draw pollutants into the distributed air causing health issues for the occupants in the home.

Follow these instructions when sealing ductwork:

1. Seal all ducts located outside the pressure boundary. Test for leakage at each register or grille using a pressure pan with house at a 50-pascal pressure difference. Target goal is measured pressure of less than 1 pascal at each opening.
2. Seal the connection between the furnace and the supply plenum, as well as the connection between the furnace and the return drop.
3. Seal all gross holes in the supply and return ductwork. Repair/replace missing ducts in the return and supply systems.
4. Seal return and supply leaks as needed based on guidance in the Diagnostic Workbook.

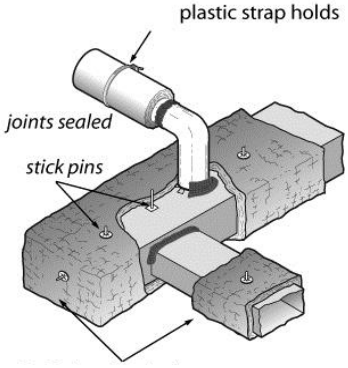
Materials for Duct Air Sealing

Duct mastic is the preferred duct-sealing material because of its superior durability and adhesion. Apply mastic at least $^{1}/_{16}$-inch thick and use reinforcing mesh or UL 181-approved tape for all joints wider than $^{1}/_{8}$ inch or joints that may experience some movement. Silicone or siliconized acrylic-latex caulk is acceptable for sealing wood-to-wood joints in panned joist spaces that function as return ducts.

Joints should rely on mechanical fasteners to prevent joint movement or separation. Tape alone will not hold a joint together, and it will not resist the force of compacted insulation or joint movement. Aluminum foil tape or cloth duct tape are not good materials for duct sealing because their adhesive often fails after a short time.

3.4.3 Duct Insulation

Insulate forced-air ducts that run through unconditioned areas with foil-faced duct insulation with a minimum value of R-8. Ductwork exposed to the exterior of the building shall be insulated to a minimum value of R-12. Ducts may be insulated with two-part foam products that meet the federal specification for duct insulation. If two-part foam is used, workers must ensure all duct seams are sealed to ensure the air stream does not come in contact with the foam. Aligning with SWS 5.0106.2 and 5.0107.2, the SPF must have a flame spread and smoke index of 25/450 or less tested in accordance with ASTM E84 or UL 723.



R-8 duct insulation fastened with stick pins.

Do not apply duct insulation to ducts that will be surrounded by R-8 or more of loose-fill insulation. Before installing the loose-fill insulation, make sure to seal these ducts.

Do not insulate ducts that run through conditioned areas unless they cause overheating in winter or condensation in summer.

Follow these steps when installing duct insulation:

1. Perform necessary duct sealing before insulating ducts.
2. Insulate all exposed forced-air ducts in unconditioned areas so no significant areas of bare duct are left uninsulated.
3. Fasten insulation mechanically, using stick pins, twine, plastic straps, or other appropriate materials. Tape the joints in the insulation to prevent air convection and apply mastic over the tape to increase the tape's longevity.

3.4.4 Measuring System Air Flow

Furnace air flow significantly affects the temperature rise. Excessive air flow (low supply air temperature) may cause customer-comfort issues. Low air flow is a more common problem in forced-air duct systems.

Insufficient air flow may cause short cycling or, in severe cases, failure of the heat exchanger. The most common causes of low air flow are an oversized furnace, a dirty filter, a dirty A-coil, registers or grilles that are blocked, fuel input set too high, fan speed set too low/too high, supply ducts that are too small or are restricted, and inadequate or restricted return ducts. *Table 3-1* shows recommended minimum air flow for various forced-air systems. When air flow is lower than the recommended minimum, the system is likely to have a temperature rise that is higher than the maximum specified by the manufacturer.

Table 3-1: Recommended Minimum Air flow *(in CFM)*

Furnace Size in kBTU	Natural Draft	Fan-Assisted Combustion	Sealed Combustion
40	400	520	600
50	500	650	750
60	600	780	900
75	750	975	1,125
100	1,000	1,300	1,500
	Multiplier		
kBTU	10	13	15
To calculate the estimated minimum air flow for a furnace, multiply the input kBTU by the multiplier for the type of furnace. (e.g., 40 x 15 = 600 CFM).			

Preparing to Measure Air Flow

Sophisticated test instruments are not necessary to discover that filters, air conditioning coils (A-coils), or blowers are packed with dirt or the branch duct to the master bedroom is disconnected. Diagnose these problems before measuring duct air flow. The following steps precede air flow measurements:

1. Ask the customer about comfort problems and temperature differences in various parts of the home.
2. Based on the customer's comments, look for disconnected or restricted ducts.
3. Inspect the filter(s), blower fan, and A-coil for dirt. Clean them if necessary. If the A-coil is not easily visible, a dirty blower fan is a fair indicator that the A-coil may also be dirty.

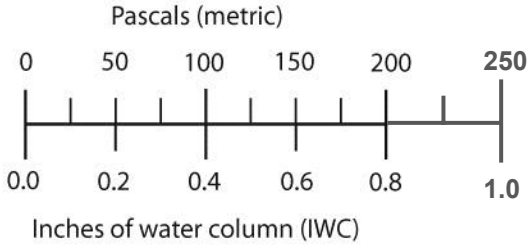
Flow-Plate Method for Measuring System Air Flow

The flow-plate meter is a plate with holes and sampling tubes that work in conjunction with a digital gauge to measure the velocity and static pressures inside the ductwork. The digital gauge then converts these values into an estimate of the distribution air flow.

The flow-plate meter will contain metering plates that can be configured to fit inside all standard-size filter slots. Whenever possible, make sure the plate is not bigger than the return cutout in the furnace. See the instruction manual for the flow-plate meter for specific directions on its use.

Measuring External Static Pressure

Perform this test if initial temperature rise and CO test results are outside of manufacturer's specifications and additional investigation is needed. External static pressure (ESP) is the difference between pressures in the supply and return ductwork. ESP is the air flow resistance caused by items external to the furnace cabinet. The ESP test can be used to identify existing ductwork issues such as insufficiently sized ductwork or obstructed cold air returns. Testing for ESP also allows for estimation of air flow if the furnace manufacturer's fan tables for static pressure and air flow are available.

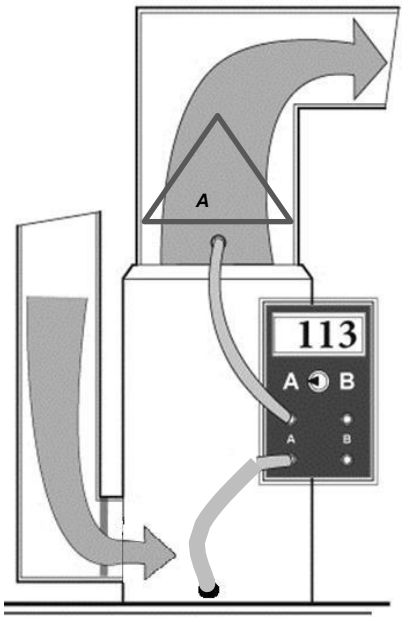


Pressure in two measurement systems: Technicians and engineers use both pascals (metric) and inches of water column to measure duct pressures.

ESP equals the sum of the absolute values of the static pressures in the supply and return sides. For example, a supply-side static pressure of +30 pascals and a return-side static pressure of -80 pascals indicate an ESP of 110 pascals (80 + 30 = 110). The supply-side static pressure will always be a positive number, and the return-side static pressure will always be a negative number. The larger the ESP, the lower the air flow at a given fan speed.

The ESP test requires a static-pressure probe, a pressure hose, and a digital gauge. Follow these steps to test the ESP of a forced-air heating system:

1. Install a clean furnace filter into the filter slot. If one is not available, remove the existing furnace filter if it is plugged or excessively dirty.
2. Drill one hole in the supply plenum, above the furnace cabinet and below the A-coil drain pan (if present). The hole must be large enough to accommodate a static-pressure probe. If the A-coil is mounted directly to the furnace, in order not to drill a hole in the coil or drain pan, drill a hole in the very top of the furnace cabinet. Be sure not to drill through a furnace baffle or heat exchanger. Ensure the hole goes through the insulation inside the furnace cabinet.
3. Drill one hole into the back of the blower cabinet. The hole must be large enough to accommodate a static-pressure probe. Be sure not to drill into wiring or other objects by removing the blower cabinet door to visually select a location free from obstacles. Ensure the hole goes through the insulation inside the blower cabinet.



External static pressure (ESP): The positive and negative pressures created by the resistance of the supply and return ducts produces ESP. The measurement shown here simply adds the two static pressures without regard for their signs. As ESP increases, air flow decreases. Numbers shown here are for example only.

External Static Pressure

ESP (IWC)	0.3	0.4	0.5	0.6	0.7	0.8
CFM	995	945	895	840	760	670

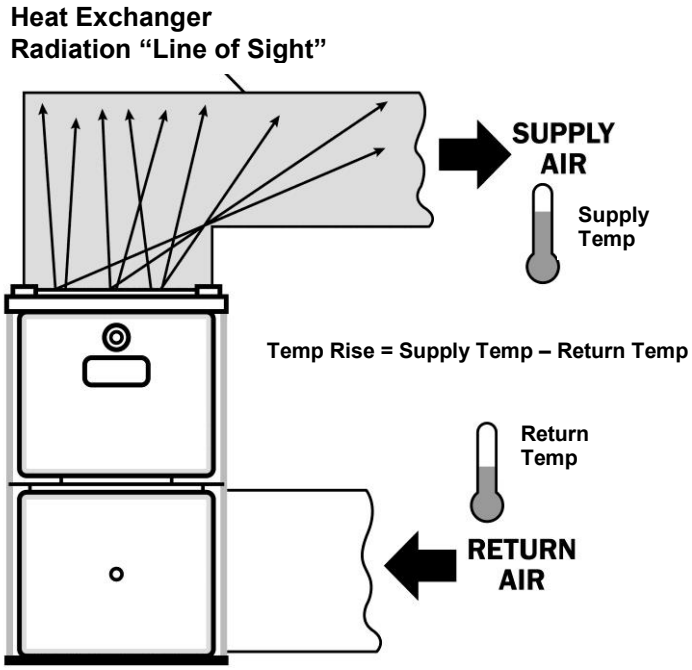
4. Set the digital gauge to “PR/PR” mode and attach a pressure hose to the Channel A input tap. (The “UNITS” button can be used on the gauge to measure inches of water column).
5. Attach the static-pressure probe to the hose. Insert the probe into each of the holes with the tip of the probe facing into the direction of the flow and record the test result for each hole.
6. Add the absolute values of the two test results, treating each result as if it were a positive number. This sum is the ESP for the heating system.
7. The higher the ESP measurement, the lower the air flow will be (assuming no change in the air handler’s speed setting). The manufacturers’ maximum recommended ESP is usually 0.50 IWC for standard air handlers. As ESP increases above 0.50 IWC, the likelihood of insufficient air flow increases. A very high ESP (over 1.0 IWC) may indicate an oversized furnace, the presence of constricted or insufficient ductwork, a plugged A-coil or furnace filter, or other distribution system issues.

Use the ESP test as a guide, along with customer conversations and the air flow and temperature-rise tests, in determining whether the heating system has sufficient air flow.

3.4.5 Measuring Temperature Rise

Temperature rise is the temperature difference between the supplied air and the return air. This test is critical in determining if the furnace is set up and operating properly. Perform the test after the furnace has reached steady-state and the ductwork has heated up.

Measure the return temperature by inserting the thermometer in the return drop prior to the filter. Measure the supply temperature in a main duct within 6 feet of the supply plenum without being in the line of sight of the heat exchanger. When there are multiple main ducts, measure the temperature in each branch and use the highest reading.



3.4.6 Filters

Observe the following standards related to furnace filter installation.

1. Supply the customer with MERV 6 or higher furnace filters. Provide either:
    a. Six 1- to 2-inch disposable filters (install one of them in the furnace); or
    b. One washable filter (installed); or
    c. One deep-pleated filter (installed).
2. Confirm filters are held firmly in place and provide complete coverage of the blower intake or the return register.
3. Ensure filters are easy to replace.
4. Confirm the heating system has a sealing filter cover and install a new one if none exists. Construct the new filter slot cover so it can be removed easily and safely. Confirm the filter is easy to access and replace. Magnetic filter covers are allowed only if they provide an adequate seal to the ductwork to prevent air leakage.

3.5 Boiler Replacement

Complete all tests on the Hot Water Boiler Replacement Check List and document results. Follow these specifications when replacing boilers:

1. To size a replacement system accurately, use an accurate analysis through REScheck, ACCA Manual J, or an equivalent industry-accepted sizing procedure by calculating the heating loads based on the post-retrofit dwelling characteristics. Consider the home's design temperature heat loss, the room-by-room heat loss, and the home's existing radiation capacity. In situations of insufficient radiation capacity, the home may need

more heat emitters to optimize the new system's efficiency and to heat all rooms adequately.

2. Flush the existing distribution system per manufacturer's instructions or until the water runs clean and is free of sediment. Verify proper pH and sediment values as provided by manufacturer. With a zoned system, flush each zone separately.
3. Install isolation valves at accessible points in the supply- and return-pipe connections and as near to the boiler as is convenient and practical to permit draining the boiler without emptying the system. These valves can also serve for filling the system and purging air from separate zones.
4. Locate new zone valves or zone circulating pumps near the boiler. Confirm each zone has its own shut-off valve.
5. Install a pressure relief valve (PRV) per manufacturer's instructions. Confirm the PRV is rated and sized correctly for the boiler BTU input and maximum operating pressure.
6. Install an automatic fill valve, if none is present.
7. The feed-water (inlet) side of the pressure-reducing feed valve shall have a backflow preventer, with a shut-off valve installed upstream from the backflow preventer, and the boiler (outlet) side of the pressure-reducing feed valve also shall have a shut-off valve to allow for maintenance or replacement without draining the boiler system.
8. The backflow preventer drain shall face the floor.
9. The system shall have an adequately sized expansion tank on the supply side of the boiler. Install an expansion tank or fill the existing expansion tank and the system to the correct level.
10. Install the circulator pump near the downstream side of the expansion tank to prevent the suction side of the pump from depressurizing the piping.
11. Verify return-water temperature is appropriate:
    a. For oil boilers, verify return-water temperature is above 150°F.
    b. For non-condensing gas boilers, verify return-water temperature is above 130°F to prevent acidic condensation within the boiler.
12. Install piping bypasses, mixing valves, primary-secondary piping, or other strategies as necessary to prevent condensation.
13. For condensing boilers, install condensation-resistant venting with condensation drains designed into the venting system per the manufacturer's specifications.
14. Insulate all pipes on the circulating loop between the boiler and an indirect domestic water heater.

15. When installed on a floor below grade, a new boiler shall be installed above known flood levels and as high as practical to avoid damage in case of flooding.
16. Inspect the chimney for deterioration and correct sizing. Repair and reline the chimney as necessary.
17. With standard-efficiency boilers, install a full-closure electric vent damper where feasible.

3.5.1 High-Efficiency (≥ 90%+) Boilers

High-efficiency boilers often present significant energy-saving opportunities as compared with standard-efficiency boilers. Similar to ≥90% efficient furnaces, high-efficiency boilers cause water vapor in the exhaust gases to condense, which releases extra heat and raises its efficiency potential above 90 percent. (High-efficiency systems are often referred to as “condensing” systems.)

To size a replacement system accurately, consider the home’s design temperature heat loss, the room-by-room heat loss, and the home’s existing radiation capacity. In situations of insufficient radiation capacity, the home may need more heat emitters to optimize the new system’s efficiency and to heat all rooms adequately.

With a high-efficiency boiler, the return water acts as a coolant for the exhaust gases. The lower the temperature of the return water, the more the exhaust gases cool — which in turn increases the amount of water that condenses out of the exhaust, and thus increases the boiler’s efficiency. For this reason, lower return-water temperatures correlate with increased efficiencies.

Outside air temperature sensors are installed with a boiler to allow the boiler controls to sense the actual outside temperature. Outdoor reset is a control function allowing the boiler to adjust the supply-water temperature to the minimum needed to heat the building at a given outside temperature. When the boiler limits its heat output to the dwelling’s actual need, the lower return-water temperature increases condensation and increases the boiler’s efficiency.

High-efficiency boilers require regular maintenance. Some high-efficiency boilers are especially vulnerable to problems with the distribution water – namely, dirt/debris/sediment/rust in the water and/or an improper pH level, both of which can lead to plugged heat exchangers and other issues. Educate customers and make sure they understand the maintenance requirements.

Follow these additional instructions when installing high-efficiency boilers:

1. Verify flue-gas O_2 percent or CO_2 and CO ppm are within the manufacturer's ranges for both high and low fire.
2. Equip the boiler with an outside air temperature sensor installed on a north-facing exterior wall. Determine the outdoor temperature above which the boiler should not operate and set high temperature shutoff to match.
3. Program the modulating boiler's heating curve in line with the dwelling's heat loss, outdoor design temperatures and radiation capacity.
4. Ensure the chemistry of the distribution water meets manufacturer's specifications. Testing may include pH, hardness/total dissolved solids (TDS), or inhibitor treatment.
5. Flush water distribution system using manufacturer recommended treatment chemicals designed to remove rust and debris from inside the system.

3.6 Hydronic Distribution Systems

Hydronic distribution systems consist of the supply and return piping, the circulator, expansion tank, air separator, air vents, and heat emitters. A properly designed and installed hydronic distribution system can operate for decades. Many systems, however, have installation flaws or need service.

Boiler piping and controls present many options for zoning, boiler staging, and energy-saving controls. Dividing homes into zones, with separate thermostats, can significantly improve energy efficiency over operating a single zone. Modern hydronic controls can provide hot water for heating to different zones at different times with varying heating loads in the zones.

Zone valves: A separate thermostat controls each zone valve. When a thermostat calls for heat, the boiler fires and the zone valve opens.

Follow these instructions for hydronic distribution systems:

1. Inspect radiators. Repair or replace as necessary.
2. Bleed air from radiators and from the entire system.
3. Confirm the distribution system has no leaks.
4. Modify the distribution system as necessary to work properly with the replacement boiler.
5. Install additional emitters (radiators or baseboard) as needed to allow for lower water temperatures to ensure new boilers will achieve rated AFUE (condensing of flue gases).
6. The system shall have automatic and manual air-bleed valves to eliminate air from all high points in the distribution-piping system.
7. Extend new piping and radiators to conditioned areas, like additions and finished basements currently heated by space heaters.

8. Install thermostatically controlled radiator valves on the major radiators or zone controls or outdoor reset and boiler controls to adjust supply-water temperature according to outdoor temperature. If feasible for the boiler system. Modulating pumps on multi- zoned systems may be considered.
9. Insulate all supply piping outside conditioned spaces. For hot-water systems, install 1½-inch fiberglass insulation on all pipes less than or equal to 1½ inches in diameter, and 2-inch fiberglass insulation on all pipes greater than 1½ inches in diameter. For steam systems, install 1½-inch fiberglass insulation on all pipes less than or equal to 1½ inches in diameter, and 3-inch fiberglass insulation on all pipes greater than 1½ inches in diameter.

3.7 Boiler Efficiency and Maintenance

Boilers can maintain good performance and efficiency for many years if they are regularly maintained and tuned up. Boiler performance and efficiency improve after effective maintenance and tune-up procedures.

Modern high-efficiency boilers require annual maintenance to achieve optimum performance and life expectancy. For information about boiler installation, see *Boiler Replacement in Chapter 3 – Section 3.5.*

Boiler performance and efficiency deteriorate in more ways than in forced-air furnaces. Specifically, these are:

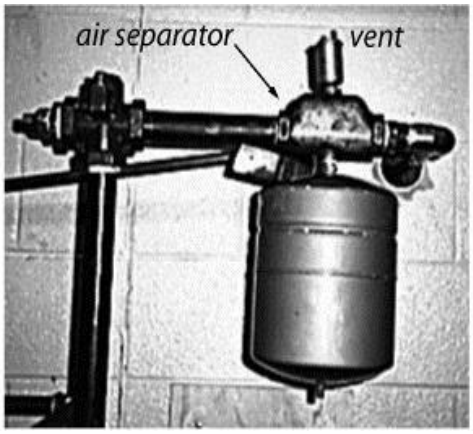
1. Corrosion, scaling, and dirt on the water side of the heat exchanger.
2. Corrosion, dust, and dirt on the fire side of the heat exchanger.
3. Excess air during combustion from air leaks and incorrect fuel-air mixture.
4. Off-cycle air circulation through the firebox and heat exchanger, removing heat from stored water.

Consider the following maintenance and efficiency improvements for both hot water and steam boilers:

1. Check for leaks on the boiler, around its fittings, or on any of the distribution piping connected to the boiler.
2. Install a magnetic filter on return piping just before boiler to prevent scaling on heat exchanger.
3. Install or replace old circulating pumps with electrically efficient ECM models.
4. On a steam boiler, inspect the water gauge glass for erosion, cracks, or drying. Replace damaged gauge glass on the boiler in accordance with manufacturer specifications. Remove, clean, and replace the gauge glass when dirt or sediment is coating it and making it difficult to observe the water level of the boiler.
5. Clean noticeable dirt from the fireside of the heat exchanger.

6. Check doors and cleanout covers for air leakage. Replace gaskets, warped doors, or warped cleanout covers.
7. Drain water from the boiler drain until the water flows clean.

Safety Checks and Improvements



Expansion tank, air separator, and vent: Preventing excessive pressure and eliminating air from the systems are important for hydronic distribution systems.

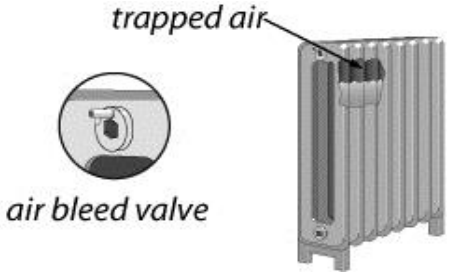
1. Confirm the existence of a 30 psi-rated pressure relief valve. Replace a malfunctioning valve or add one if none exists. Note signs of leakage or discharges and find out why the relief valve is discharging.
2. Make sure the expansion tank is not waterlogged or sized too small for the system. This could cause the pressure relief valve to discharge. Test expansion tank for acceptable air pressure — usually 12 to 22 psi.

   Note: A hot-water boiler is recognized by its expansion tank, located somewhere above the boiler. The expansion tank provides an air cushion to allow the system's water to expand and contract as it is heated and cooled without creating excessive pressure in the boiler piping and discharging through the pressure relief valve.
3. If rust is observed in the venting, verify return water temperature is above 130°F for gas and above 150°F for oil, to prevent acidic condensation.
4. Verify the system does not cycle on high limit.
5. Lubricate circulator pump(s) if necessary.

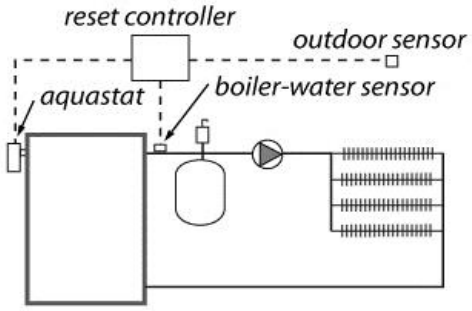
Efficiency Improvements

1. Repair water leaks in the system.
2. Remove corrosion, dust, and dirt on the fireside of the heat exchanger.
3. Check for excess air during combustion from air leaks and incorrect fuel-air mixture.
4. Confirm the boiler does not have low-limit control for maintaining a minimum boiler-water temperature unless the boiler is heating domestic water in addition to space heating.
5. Consider installing outdoor reset controllers on non-high-efficiency boilers to regulate water temperature, depending on outdoor temperature.

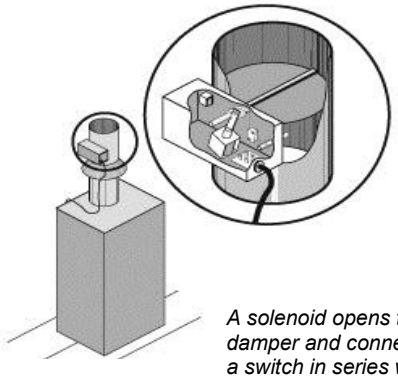
6. After control improvements like two-stage thermostats or reset controllers, verify return-water temperature is high enough to prevent condensation and corrosion in the chimney is noted previously.
7. Bleed air from radiators and piping through air vents on piping or radiators.
8. Vacuum and clean fins of fin-tube convectors if dust and dirt is present.
9. Consider installing full-closure electric vent dampers on natural-draft gas- and oil-fired high-mass boilers.



Purging air: Trapped air collects at the hot-water system's highest parts. Bleeding air from radiators fills the radiator and gives it more heating surface area.



Reset controller: The circulating water temperature is controlled by the reset controller according to the outdoor



A solenoid opens the damper and connects a switch in series with the burner.

Vent dampers: Electric vent dampers close the chimney when the burner is not firing, preventing circulating air from carrying the boiler's stored heat

3.8 Gas-Fired Heating Systems

3.8.1 Gas-Fired Heating System Installation

The general procedures outlined in *General Heating System Replacement in Chapter 3 – Section 3.2*, should be followed. Complete all tests on the Replacement Gas Furnace Check List and document results.

When replacing a gas-fired heating system:

1. Confirm the clearances to nearby combustibles of the heating unit and its vent connector conform to NFPA 54.
2. Clock the gas meter, if necessary, to troubleshoot oxygen, flue-gas temperature, carbon monoxide, or temperature-rise problems, and to verify the actual gas input matches with the nameplate input rating. Adjust gas input if necessary. See *Measuring BTU Input on Natural Gas Appliances in Chapter 3 – Section 3.8.3.*
3. Check the input gas pressure on the furnace when all gas-fired appliances are operating in the house to ensure no drop-off in required gas pressure. If the input is significantly different than the rating on the nameplate, all other variables above can be affected.

4. Measure manifold gas pressure to ensure it stays within the manufacturer's specified range. Adjust the fuel-air mixture for the lowest CO output and maximum SSE.
5. Follow manufacturer's venting instructions, along with the NFPA 54 to establish a proper venting system.
6. Follow manufacturer's instructions for proper removal of condensate. See *Condensate Removal in Chapter 3 – Section 3.8.2*.
7. Install a proper sediment trap on the gas line, if none exists.
8. When fuel switching from oil to gas, place the old oil tank out of service in accordance with Wisconsin Administrative Code ATCP 93.315.

3.8.2 Condensate Removal

Condensate is routed away from the furnace in one of two ways:

1. Running condensate tubing or piping directly from the furnace to an appropriate drain (Preferred Method); or
2. Pumping the condensate from the furnace to an appropriate drain using an electric condensate pump.

Whenever feasible, pipe directly from the furnace to the floor drain, without installing a condensate pump. Mechanically fasten the piping, either to the floor-drain strainer or to the floor itself. Ensure the piping will not pose a tripping hazard to the occupants. Installing a "trip strip," with the customer's approval, may be useful to prevent occupants from tripping over the piping.

Sometimes, a direct-piping strategy will not be feasible. There may not be a drain near the furnace, or perhaps the piping would pose a tripping hazard to the occupants. In these situations, installing a condensate pump is likely a better option. See the next section for information about condensate pumps.

Condensate Pumps

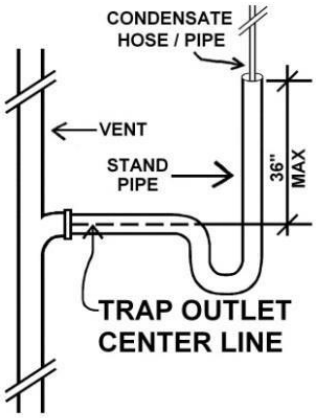
A condensate pump is installed when direct piping to an approved drain is not feasible. Condensate pumps may be installed using existing receptacles, new ground-fault circuit interrupter (GFCI) receptacles, or directly wired in accordance with pump manufacturer's requirements. Inspect the entire condensate system for leaks after installation. Insulate the condensate drain system when it is located in an unconditioned area or has the potential to form condensation. If a condensate pump is installed in or above a finished area, a secondary drain pan should be installed with a safety feature to disable the heating system if the pump fails.

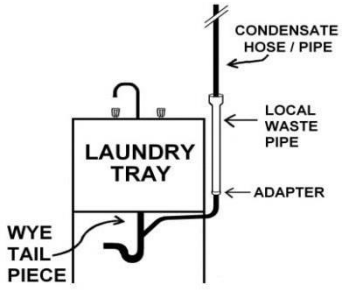
Condensate is a slightly acidic byproduct of combustion. Plumbing code requires it to be drained to the sanitary sewer system, and not to the ground or to a sump pump. Code allows condensate to go to a floor drain, a standpipe, or an indirect or local wastepipe served by a standpipe or the laundry tray tail piece. An air gap is required where the condensate line enters

the receptor. The condensate line cannot go directly into any drainpipe. See SPS 382.33 for Wisconsin code provisions regarding condensate drains.

Floor drain: The floor drain is the most common method for discharging condensate. Condensate lines that run to the drain must be secured to the floor to keep them in place. This method works best when the drain is not in a typical path of foot traffic.

Standpipe: The laundry standpipe is often the best place to discharge condensate. If the opening is not large enough for the washing machine hose and the condensate line, an adapter can be added to enlarge the top of the pipe. A standpipe cannot exceed 36 inches in height above the centerline of the horizontal drainpipe. If an existing standpipe is not an option, a new standpipe, trapped and vented, is acceptable. This option should be the last choice, as the trap can dry out if the heating system does not discharge condensate over an extended time. If a washing machine could be discharged into the standpipe, extend the standpipe at least 18 inches above the centerline of the horizontal drainpipe.



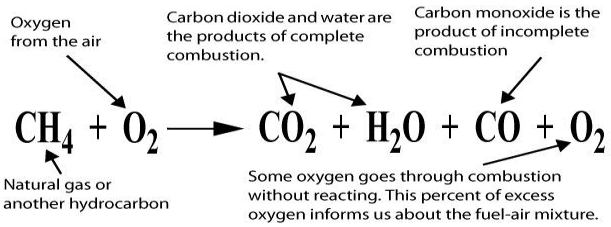


Indirect or local wastepipe: A vertical pipe that uses the trap of a standpipe or laundry tailpiece is considered an indirect or local wastepipe. It needs to be higher than the flood line of the laundry tray or standpipe. This method can also be used if the existing standpipe is full of other hoses.

3.8.3 Testing and Servicing Gas-Fired Systems

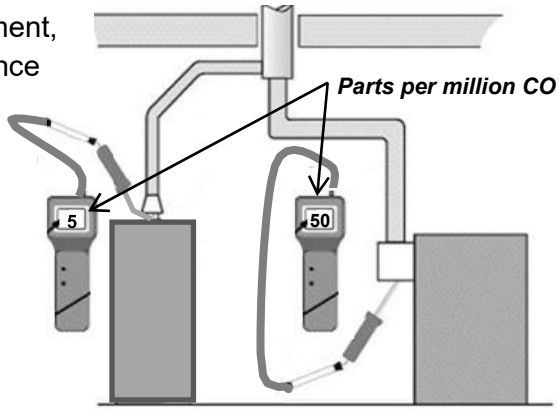
Gas burners should be cleaned and tuned every two to four years. Sometimes a maintenance schedule will be posted on an existing heating system, allowing assessment of the heating-system maintenance history (or lack thereof).

The goals of these service measures are to reduce CO, to optimize fuel-air mixture, and to confirm the operation of safety controls. Complete all tests on the Heating System Repair or Clean and Tune Check List and document results.



Perform the following inspection and maintenance procedures, as necessary, on gas-fired furnaces, boilers, water heaters, and space heaters:

1. Inspect for soot, melted wire insulation, melted grommets, and rust in the burner and manifold area outside the firebox. These all are indicators of flame rollout, combustion-gas spillage, and CO production.
2. Inspect the burners for dust, debris, misalignment, flame impingement, and other flame-interference problems. Clean, vacuum, and adjust as needed.
3. Inspect the heat exchanger for leaks.
4. Verify heating system wiring connections are enclosed in covered electrical boxes.
5. Determine the pilot is burning (if equipped) and main burner ignition is satisfactory.
6. Sample the undiluted combustion gases with a calibrated flue-gas analyzer and record steady-state efficiency, O_2 percentage, CO ppm (as-measured), and flue-gas temperature.

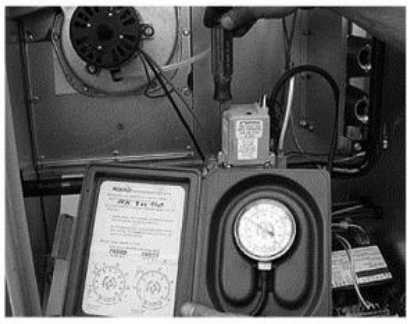


Sampling combustion gases: Sample combustion gases at the exhaust vent of the appliance before dilution air mixes with the gases.

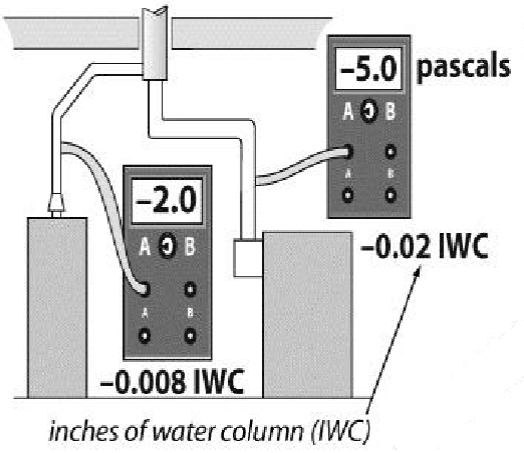
Testing older furnaces: Insert the probe into the draft diverter near the exhaust ports of the heat exchanger.

Testing 80+ furnaces: Drill a quarter-inch hole in the metal vent connector to sample combustion gases.

7. Clock the natural-gas meter, with all other gas appliances off, to confirm the input BTUs to the furnace or boiler match with the nameplate rating. Adjust gas pressure if necessary. See *Measuring BTU Input on Natural Gas Appliances in Chapter 3 – Section 3.8.3* for clocking the meter.
8. Clean the air handler ("squirrel cage") and the air- handler cabinet. Adjust the air handler's speed setting, if necessary, to ensure adequate air flow and to ensure temperature rise is within the manufacturer's specifications.
9. Test pilot safety control for complete gas valve shut-off when pilot is extinguished.
10. When testing is complete, seal all test holes.
11. Verify the thermostat's heat-anticipator setting matches the measured current in the 24-volt control circuit.
12. Check venting system for proper size and pitch.
13. Check venting system for obstructions, blockages, or leaks.
14. Measure chimney draft downstream of the draft diverter and check for spillage.
15. Measure gas input, and observe flame characteristics if soot, CO, or other combustion problems are present.



Adjusting gas pressure: Adjusting gas pressure is the only way to change the fuel-air mixture.



Measuring draft: Measuring chimney draft downstream from the draft diverter.

A common furnace-efficiency problem is low fuel input and high O_2 percentage, resulting in poor heat transfer. This condition will be detected by combustion testing and clocking the natural-gas meter. See the standards for O_2 percentage and flue-gas temperature in *Table 3-2*.

Flue-gas temperature is another important indicator of furnace performance. A low flue-gas temperature usually indicates efficient performance, since less of the heat is leaving the building. If the flue-gas temperature is too low in older furnaces or 80+ furnaces, acidic condensation will form in the vent. This acidic condensation can rust metal vents and damage masonry chimneys.

Adjust gas pressure and air flow in order to optimize gas input, O_2 percentage, flue-gas temperature, and SSE. These adjustments are best made while monitoring the exhaust gas with the combustion analyzer.

Table 3-2: Typical Ranges for Gas Burning Appliances

Performance Indicator	SSE 80+	SSE 90+
Carbon monoxide (CO) (ppm) air-free	≤ 400	≤ 400
Stack temperature (°F)	325° – 450°	90° – 120°
Temperature rise (°F)	40° – 70°	30° – 70°
Oxygen (O_2)	4 – 9%	4 – 9%
Gas pressure output at manifold - inches of water column (IWC)	3.2 – 3.9	3.2 – 3.9
Propane pressure output at manifold (IWC)	10 – 11	10 – 11
Steady-state efficiency (SSE)	82 – 86%	92 – 97%
Supply temperature (°F)	120° – 140°	95° – 140°

Proceed with burner maintenance and adjustment when any of the following are present:

1. When CO level exceeds the designated threshold for the specific gas burning appliance
2. Visual indicators of soot or flame rollout exist
3. Burners are visibly dirty

See *CO Corrective Actions in Chapter 5 – Table 5-2*.

Troubleshooting CO

CO Exceeds Limit in One Chamber

1. Open the primary air shutter of the burner where CO is above acceptable limits.
2. Clean that burner and/or pilot assemblies.
3. Align the burner and/or pilot assembly to eliminate impingement.
4. Check orifice size and alignment.
5. Check for flame movement and cracks in the heat exchanger.

CO Exceeds Limit in Two Chambers

1. Confirm combustion air source.
2. Check venting system and heat exchanger for blockages.
3. Open primary air shutter on each burner.
4. Clean burners and/or pilot assembly
5. Check orifice size and gas pressure.
6. Measure the appliance input and adjust if necessary.

Carbon Build-up in Heat Exchanger

1. Clean out carbon build-up.
2. Clean all other combustion surfaces including burners, pilot assembly, orifice, and baffles.
3. Inspect heat exchanger for cracks.
4. Reassemble the furnace:
   a. Set primary air openings.
   b. Check gas pressure and orifice size.
   c. Align, position, and level burners.
5. Check venting system and heat exchanger for blockages.
6. Measure the appliance input and adjust if necessary.

Procedures Fail to Reduce CO Below Limit

Re-check the Following Upon:

1. Primary air adjustment.
2. Burner level, alignment, and position.
3. Combustion air source.
4. Gas pressure is correct for type of fuel.
5. Appliance input is altitude adjusted.
6. Venting system is free of obstructions.
7. Heat exchanger is intact.
8. No flame impingement present

Table 3-3: Combustion Problems and Possible Solutions

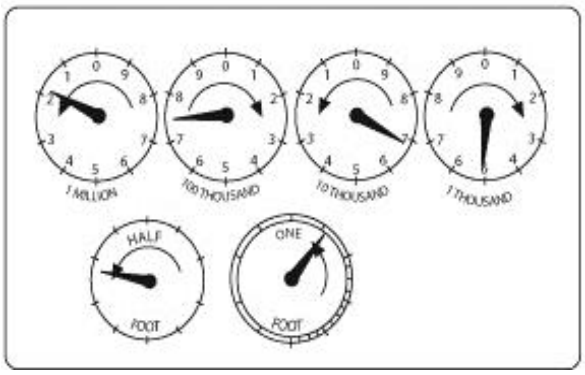
Problem	Possible Causes and Solutions
Weak draft with CAZ depressurization	Return duct leaks, clothes dryer, exhaust fans, other chimneys. Seal return leaks. Provide make-up air.
Weak draft with no CAZ depressurization	Chimney blocked or leaky or else CAZ is too airtight.
Carbon monoxide	Mixture too rich or too lean. Adjust gas pressure. Check chimney and combustion air for code compliance.
Stack temperature or temperature rise too high or low	Adjust fan speed or gas pressure. Improve ducts to increase air flow.
Oxygen too high or low	Adjust gas pressure, but do not increase CO level.

Gas burner maintenance includes the following measures:

1. Remedy the causes of CO and soot. These causes may include overfiring, closed primary air intake, flame impingement, and lack of combustion air.
2. Remove dirt, rust, and other debris that may be interfering with the burners. Clean the heat exchanger, if necessary.
3. Take action to improve draft if inadequate because of improper venting, obstructed chimney, leaky chimney, or depressurization. See *Improving Inadequate Draft in Chapter 3 – Section 3.14.1*.
4. Seal leaks in vent connectors and chimneys.
5. Adjust gas input if combustion testing or clocking the gas meter indicates overfiring or under-firing.

Measuring BTU Input on Natural Gas Appliances

1. Turn off gas supply to all gas-combustion appliances not being tested (such as heating systems, water heaters, dryers, cook stoves, space heaters, etc.) that are connected to the meter being timed.
2. Fire the appliance being tested and watch the dials of the gas meter.
3. Carefully count how long it takes for one revolution of the ½-, 1-, or 2-cubic-foot dial. Find that number of seconds in the columns marked “Seconds per Revolution” in *Table 3-4*. Follow that row across to the right to the correct column for the ½-, 1-, or 2-cubic foot dial. Multiply the number in the table by 1,000. Record the input in thousands of BTUs per hour. *For gauging a ¼-cubic-foot*



Gas meter dial: Use the number of seconds per revolution of the one-foot dial and the table on the following page to find the appliance’s input.

dial, count how long it takes for 4 revolutions. Then, use the 1-cubic-foot column to determine the input.

4. If the measured input is higher or lower than input on the nameplate by more than 10 percent, adjust gas pressure up or down, within the ranges in *Table 3-3*, until the approximately correct input is achieved. **CAUTION:** Consult with fuel supplier before adjusting pressure at meter.
5. For LP gas, determine the orifice size. From Table E.1.1 of the National Fuel Gas Code, find the input BTU value that corresponds with the orifice size. Multiply the listed BTU value by the number of orifices to get the input BTU for the heating system.
6. If the measured input is still out of range after adjusting gas pressure to these limits, replace the existing orifices with larger or smaller orifices sized to give the correct input. Any changes done to orifices must follow manufacturer's instructions.

Table 3-4: Input in Thousands of BTU/hr for 1000 BTU/cu. ft. Gas

Seconds per Revolution	Size of Meter Dial			Seconds per Revolution	Size of Meter Dial			Seconds per Revolution	Size of Meter Dial		
	½ cu. ft.	1 cu. ft.	2 cu. ft.		½ cu. ft.	1 cu. ft.	2 cu. ft.		½ cu. ft.	1 cu. ft.	2 cu. ft.
15	120	240	480	40	45	90	180	70	26	51	103
16	112	225	450	41	44	88	176	72	25	50	100
17	106	212	424	42	43	86	172	74	24	48	97
18	100	200	400	43	42	84	167	76	24	47	95
19	95	189	379	44	41	82	164	78	23	46	92
20	90	180	360	45	40	80	160	80	22	45	90
21	86	171	343	46	39	78	157	82	22	44	88
22	82	164	327	47	38	77	153	84	21	43	86
23	78	157	313	48	37	75	150	86	21	42	84
24	75	150	300	49	37	73	147	88	20	41	82
25	72	144	288	50	36	72	144	90	20	40	80
26	69	138	277	51	35	71	141	94	19	38	76
27	67	133	267	52	35	69	138	98	18	37	74
28	64	129	257	53	34	68	136	100	18	36	72
29	62	124	248	54	33	67	133	104	17	35	69
30	60	120	240	55	33	65	131	108	17	33	67
31	58	116	232	56	32	64	129	112	16	32	64
32	56	113	225	57	32	63	126	116	15	31	62
33	55	109	218	58	31	62	124	120	15	30	60
34	53	106	212	59	30	61	122	130	14	28	55
35	51	103	206	60	30	60	120	140	13	26	51
36	50	100	200	62	29	58	116	150	12	24	48
37	49	97	195	64	29	56	112	160	11	22	45
38	47	95	189	66	29	54	109	170	11	21	42
39	46	92	185	68	28	53	106	180	10	20	40

3.8.4 Leak-Testing Gas Piping

For information on leak-testing gas piping, *see Gas Piping Inspection in Chapter 5 – Section 5.8.1*.

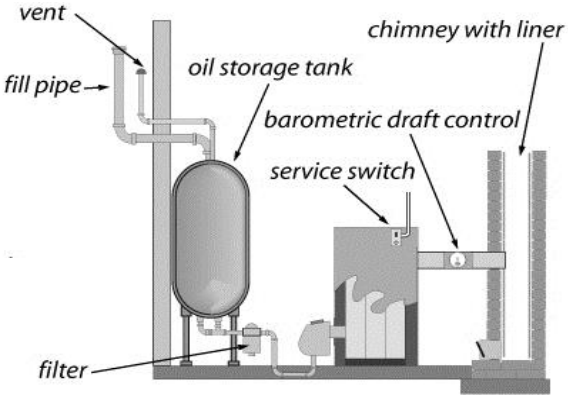
3.9 Oil-Fired Heating Systems

3.9.1 Oil-Fired Heating System Installation

The general procedures outlined in *General Heating System Replacement in Chapter 3 - Section 3.2* should be followed when replacing an oil heating system. Complete all tests on the Oil Replacement Furnace Check List and document results.

When replacing an oil furnace:

1. Properly size the nozzle based on the post-weatherization conditions using REScheck®, Manual J, or an equivalent industry-accepted sizing formula. Document the nozzle size on the inside of the furnace cabinet next to the furnace nameplate.
2. Examine the existing chimney and vent connector for suitability as venting for the new appliance. The vent connector may need to be resized, and the chimney may need to be relined.
3. Confirm the clearances to nearby combustibles of the heating unit and its vent connector conform to NFPA 31.



Oil heating system: Components of an oil heating system may need repair and cleaning during replacement of the furnace or boiler.

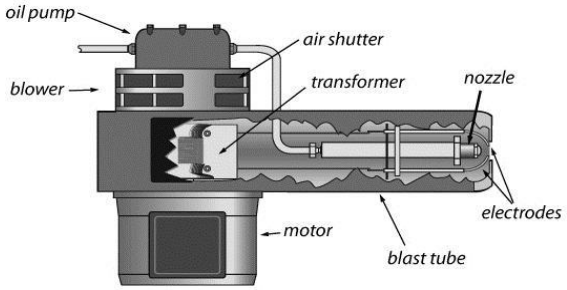
4. Test oil pressure, and verify it complies with the manufacturer's specifications.
5. Test control circuit amperage and adjust the thermostat's heat anticipator to match.
6. Test smoke number to confirm it meets manufacturer's specifications. See *Table 3-5.* Install a new fuel filter and purge the fuel lines.
7. Verify the chimney operates safely and in accordance with NFPA 211.
8. Confirm the tank and oil lines comply with NFPA 31.

3.9.2 Testing and Servicing Oil-Fired Systems

Oil burners require annual maintenance to retain their operational safety and combustion efficiency. Use results from steady-state efficiency, draft, carbon monoxide and smoke tests to guide and evaluate maintenance. These clean-and-tune procedures pertain to oil-fired furnaces, boilers, and water heaters.

Oil Burner Inspection and Testing

Evaluate oil burner operation by visually inspecting and combustion testing the system. An oil burner passing visual inspection with good test results may need minimal maintenance. If the test results are fair, adjustments may be necessary. Unsatisfactory test results may indicate the need to replace the burner or the entire heating unit.



Oil burner operation: For continual and complete burning of the oil, oil is pumped through the nozzle to create a specific spray pattern that is ignited by properly spaced electrodes carrying 10,000 volts from the transformer.

Follow these steps to improve oil burner safety and efficiency:

1. Inspect burner and appliance for signs of soot, overheating, fire hazards, corrosion, or wiring problems.
2. Equip all oil-fired heating systems with a barometric draft control.
3. Confirm the oil heating system has a dedicated electrical circuit.
4. Enclose all 120-volt wiring connections in covered electrical boxes.
5. Inspect fuel lines and storage tanks for leaks.
6. Inspect the heat exchanger and combustion chamber for cracks, corrosion, or soot buildup.
7. Check to see if the flame ignition is instantaneous or delayed. The flame ignition should be instantaneous, except for pre-purge units where the blower runs for a while before ignition.
8. Sample undiluted flue gases with a smoke tester, following the smoke tester instructions. Compare the smoke smudge left by the gases on the filter paper with the manufacturer's smoke-spot scale to determine smoke number. *With a smoke number of two or higher, do not use the electronic combustion analyzer.*

Table 3-5: Typical Ranges for Oil Burning Appliances

Performance Indicator	Non-Flame Retention	Flame Retention
Carbon monoxide (CO) (ppm) in flue gas	400 ppm air-free	400 ppm air-free
Stack temperature (°F)	325° - 550°	300° - 450°
Oxygen (O_2)	6-9%	5-9%
Smoke number (1-9)	≤ 2	≤ 1
Excess air (%)	≥ 80%	≥ 35%
Oil pressure pounds per square inch (psi)	≥ 100	100 -150
Overfire draft (inches of water column - IWC negative)	.02 IWC or 5 Pa	.02 IWC or 5 Pa
Flue draft (IWC negative)	.04 -.01 IWC or 10-15 Pa	.04 -.01 IWC or 10-15 Pa
Steady-state efficiency (SSE)	≥ 75%	≥ 80%

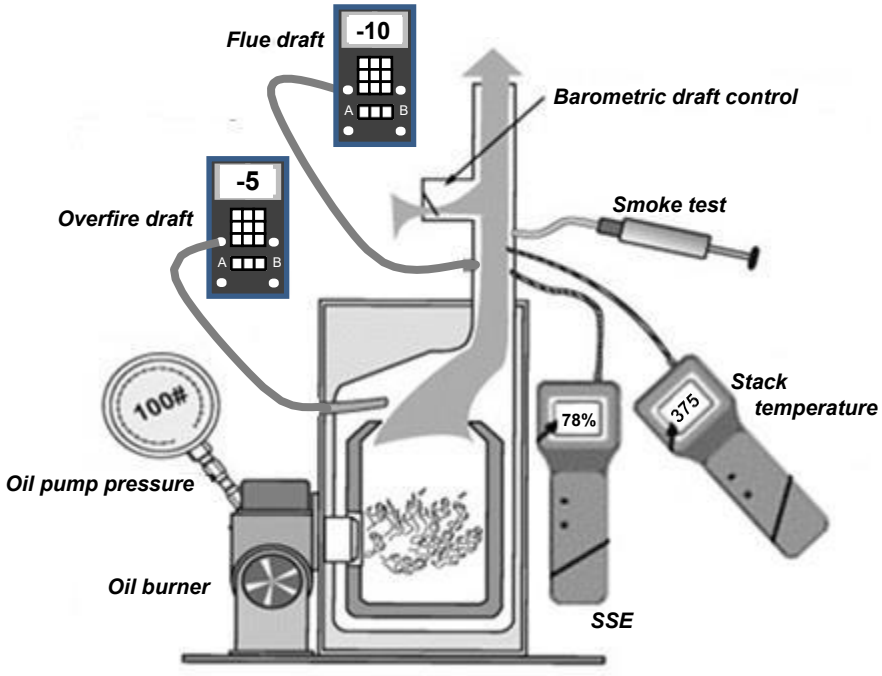
9. Analyze the flue gas for O_2 percentage, temperature, CO ppm, and steady-state efficiency (SSE). Sample undiluted flue gases between the barometric draft control and the appliance. Adjust fuel-air mixture and air flow to conform to standards in *Table 3-5*.
10. Measure flue draft between the appliance and barometric draft control and overfire draft at an opening to the firebox.
11. Measure high-limit shut-off temperature and adjust or replace the high-limit control if the shut-off temperature is more than 200°F for furnaces or 180°F for hot-water boilers.
12. Measure the oil-pump pressure and adjust to manufacturer's specifications if necessary.
13. Measure transformer voltage and replace transformer if not within the allowable range.
14. Ensure barometric draft controls are mounted plumb and level and the damper swings freely.
15. Time the CAD cell control or stack control to verify the burner will shut off within the time frame per manufacturer's specifications when the CAD cell is blocked from seeing the flame.

Oil Burner Maintenance and Adjustment

After evaluating the oil burner's initial operation, perform the following maintenance tasks as needed to optimize safety and efficiency:

1. Verify correct flame-sensor operation.
2. Replace the burner nozzle after matching the new nozzle's size to the home's post-weatherization heat load requirements.
3. Clean the burner's blower wheel.
4. Replace oil filter(s).
5. Clean or replace air filter. See *Filters in Chapter 3 – Section 3.4.6* for guidance on providing furnace filters.
6. Remove soot and sludge from combustion chamber.
7. Remove soot from heat exchanger surfaces.
8. Clean dust, dirt, and grease from the burner assembly.
9. Ensure the oil pump is set to the correct pressure.
10. Adjust barometric damper for a negative overfire draft of 5 pascals or 0.02 IWC, per manufacturer's specifications.
11. Adjust gap between electrodes and their position in burner tube, per manufacturer's specifications.
12. Repair the ceramic combustion chamber or replace it if necessary.
13. Inspect and clean the end of the burner-tube assembly. Replace flame retention head if damaged.
14. Inspect and clean the transformer contacts to remove any corrosion.

15. Adjust air shutter to achieve O_2 and smoke values, specified in *Table 3-5*.



Measuring oil burner performance: To measure oil-burning performance indicators, a manometer, flue-gas analyzer, smoke tester, and pressure gauge are required.

After these maintenance procedures, perform the diagnostic tests described previously to evaluate improvement made by the maintenance procedures and to determine if fine-tuning is required.

3.10 Electric Furnaces and Electric Baseboard Heat

In Wisconsin, electric baseboard heat is much more common than electric furnaces. Due to the high cost of electricity, these systems may be good candidates for fuel switching or converting to a heat pump.

Caution: Disconnect power from electric furnaces before performing any maintenance.

1. Check or clean and lubricate the following components: thermostat, blower, housing around electric element, and baseboard fins.
2. Clean or replace all filters.
3. Take extra care in duct sealing and in duct-air flow improvements for electric furnaces because of the high cost of electricity.
4. Verify safety limits and temperature rise conform to manufacturer's specifications.

3.10.1 Cold-Climate Air-Source Heat Pump Installations

Advances in heat pump technology allow systems to provide heat even at temperatures down to -20 degrees Fahrenheit. Replacing electric baseboard heat with a cold-climate air-source heat pump can result in significant savings.

When installing a cold-climate air-source heat pump:

1. Properly size the system based on 47ºF- and 5ºF-certified output capacities and determine the need for back-up heating when the new equipment will not be sufficient to meet hourly heat load demands.
2. Ensure that all components are compatible with each other for either a mini-split ductless system or a fully ducted system, including properly sized refrigerant lines.
3. Locate outdoor components in a location to provide access for maintenance and to allow for unrestricted airflow.
4. Locate indoor components of a mini-split system in location to provide adequate distribution of delivered warm air.
5. Install a dedicated electrical circuit rated or fused to match the amperage of the system's requirements for overcurrent protection.
6. Install system in accordance with manufacturer's instructions and applicable state and local codes. Follow manufacturer's instructions for the proper removal of condensate.
7. Confirm that the system has the correct amount of refrigerant to operate correctly and efficiently.

3.11 Cooling Systems

The use of air conditioning has become more common in homes across Wisconsin. In recent years, higher annual cooling degree days (CDD) along with higher electric costs results in greater savings. This in turn may result in cost effective replacements that meet the minimum savings-to-investment ratio (SIR).

All replacement cooling systems shall meet the minimum efficiency standards as specified in the Wisconsin Weatherization Program Manual and listed in the AHRI Directory of Certified Product Performance. Observe the following standards for all cooling system replacements:

1. Install cooling systems in accordance with manufacturer's instructions and applicable state and local codes.
2. Properly remove and dispose of the existing unit.
3. Provide an owner's manual with cooling system replacements.
4. Properly size replacement cooling systems units using an accurate analysis through REScheck, ACCA Manual J, or an equivalent industry-accepted sizing procedure based on post-weatherization cooling load.
5. Provide in-home operation and maintenance instructions, including a review of safety precautions to the customer.

3.11.1 Central Air Conditioner Installations

1. Use the existing distribution system, A-coil, and refrigerant lines, when possible.
2. Replacement A-coil must match or be paired with outside condenser unit.
3. Properly evacuate refrigerant from lines and recycle/dispose of old refrigerant if not used in the new system.
4. Locate outdoor unit to allow for dissipation of heat and to provide access for maintenance. The condenser shall be placed on a secure fabricated equipment pad or poured concrete pad.
5. Install a dedicated electrical circuit rated or fused to match the amperage of the system's requirements for overcurrent protection.
6. Install a weather-proof disconnect box within proximity of outdoor unit. Ensure safety disconnect is fused at manufacturer's recommended amperage. Install UL listed disconnect whip from box to AC unit.
7. Install condensate tubing or piping to reach an appropriate drain. Utilize a hose protection ramp (trip strip) instead of a condensate pump where feasible.
8. Install a condensate pump when the condensate tubing will not drain adequately to an appropriate drain or may cause a tripping hazard. See *Condensate Removal in Chapter 3 – Section 3.8.2* for more information about condensate pumps.
9. Confirm system setup meets manufacturer's recommendations for refrigerant level, room supply air temperature, super-heat, and sub-cooling temperatures.

3.11.2 Room/Window Air Conditioner Installations

Room or through the wall air conditioners can provide cooling to targeted sections of homes when the entire home is not cooled. Prior to the replacement of multiple room air conditioners consider the installation of central AC, if feasible.

1. Locate units in windows/areas that will provide adequate distribution of cool air to sections of home that are to be cooled.
2. Window model selection should consider ease of installation/removal as well as the weight of the unit.
3. Properly support windows units and seal around all openings not filled by units. Consider U-shaped models that provide proper support and allow the lower sash of window to be closed in a lower position.
4. Ensure opening/sleeves can be properly sealed during winter for room air conditioners.
5. Properly install unit to allow for drainage of condensate.
6. Ensure electrical outlet and circuit are rated for proper amperage of installed AC unit.

3.11.3 Air-Source Heat Pump Installations

Installing heat pumps rather than air conditioners can provide the needed cooling capacity and, in some homes, a significant portion of the needed heating capacity. Determine the most cost-effective outdoor temperature setting to switch to back-up heat, such as propane or oil forced air system. Provide customer education on the operating cost of the heat pump compared to the back-up heating system. Fully explain that additional electrical usage will be seen on bills when used for heating. Further explain that the cost of the electricity used by a heat pump can be lower than that of the back-up fuel when fossil fuel prices are higher.

3.11.3.1 Fully Ducted Installations

1. Use the existing distribution system, A-coil, and refrigerant lines, when possible.
2. Consider matching the inside coil and new refrigerant lines paired with condenser unit when existing will not meet needs or if new refrigerant requires updating.
3. Properly evacuate refrigerant from lines and recycle/dispose of old refrigerant where applicable.
4. Locate outdoor unit to allow for dissipation of heat and to provide access for maintenance. Condenser shall be placed on a secure fabricated equipment pad or platform to keep above the snow load, which can be mounted to the building or set on the ground.
5. Install a dedicated electrical circuit rated or fused to match the amperage of the system's requirements for overcurrent protection.
6. Install a weather-proof disconnect box within proximity of outdoor unit. Ensure safety disconnect is fused at manufacturer's recommended amperage. Install UL listed disconnect whip from box to AC unit.
7. Install condensate tubing or piping to reach an appropriate drain. Utilize a hose protection ramp (trip strip) instead of a condensate pump where feasible.
8. Install a condensate pump when the condensate tubing will not drain adequately to an appropriate drain or may cause a tripping hazard. See *Condensate Removal in Chapter 3 – Section 3.8.2* for more information about condensate pumps.
9. Confirm system setup meets manufacturer's recommendations for refrigerant level, room supply air temperature, super-heat, and sub-cooling temperatures.

3.11.3.2 Mini-Split Ductless Installations

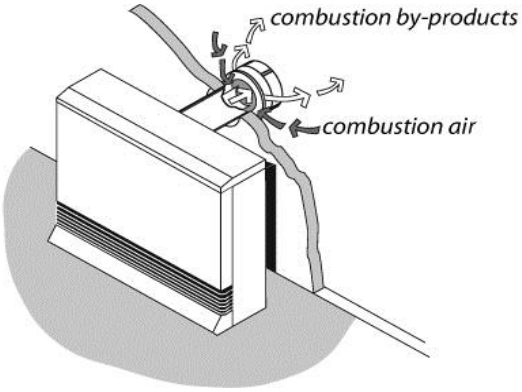
1. Locate outdoor components in a location to provide access for maintenance and to allow for un-restricted airflow. Place outdoor unit on a secure fabricated equipment pad or poured concrete pad.
2. Locate indoor components of a mini-split system in location to provide adequate distribution of delivered conditioned air.
3. Install a dedicated electrical circuit rated or fused to match the amperage of the system's requirements for overcurrent protection.

4. Follow manufacturer's instructions for the proper removal of condensate.
5. Confirm that the system has the correct amount of refrigerant to operate correctly and efficiently.

3.12 Replacing Space Heaters

When replacing a space heater:

1. Follow the manufacturer's venting instructions carefully. Do not vent sealed-combustion, induced-draft space heaters into naturally drafting chimneys.
2. If the space heater will sit on a carpeted floor, provide a fire-rated floor protector, sized to the width and length of the space heater, as a base.
3. Locate space heater away from traffic, draperies, and furniture.
4. Space heaters require a properly grounded duplex receptacle for electrical service.



Sealed combustion space heater: A sealed combustion space heater draws combustion air in and exhausts combustion by-products through a concentric vent system using a draft fan.

Inform the customer of the following operating instructions:

1. Do not store any objects near the space heater that would restrict air flow around it.
2. Do not use the space heater to dry clothes or for any purpose other than heating the home.
3. Do not allow anyone to lean or sit on the space heater.
4. Do not spray aerosols near the space heater. Many aerosols are flammable or can cause corrosion to the space heater's heat exchanger.

Space heater controls: Many modern energy-efficient space heaters have programmable thermostats as standard features.

3.13 Replacing Wood Stoves

Wood stoves with a crack or hole in the firebox and units that do not meet clearances and cannot be corrected shall be replaced for health and safety of the occupants. All replacement wood stoves must meet applicable local codes and EPA requirements. Installations must conform to NFPA 211.

When replacing a wood stove:

1. Install the stove to meet manufacturer's specifications.
2. Verify the replacement stove is certified to meet EPA emission standards or local standards, whichever are stricter.

3. Confirm the installed unit is certified and labeled by:
    a. National Fire Protection Association under 211-1996, or
    b. Other equivalent listing organization
4. Visually inspect the chimney for safe operation by referring to NFPA 211.
5. Seal all penetrations through the thermal-pressure boundary using appropriate high-temperature materials for the application in compliance with SWS 3.0102.2.
6. Provide all customers with in-home operation instructions, to include proper wood-burning practices, safety information, and education about proper maintenance, such as stack thermometers and the need for fire extinguishers.
7. Educate the customers about the potential impact of exhaust ventilation and/or forced-air distribution on the wood heater's operation.

Install make-up air if the building is tightened below the depressurization limit CFM_{50}.

3.14 Venting Combustion Gases

Proper venting is essential to the operation, efficiency, safety, and durability of combustion heaters. The National Fire Protection Association (NFPA) and the International Code Council (ICC) are the authorities on material choice, sizing, and clearances for chimneys and vent connectors, as well as for combustion air. The information in this venting section is based on the following NFPA and ICC documents:

- ✓ The International Fuel Gas Code (IFGC) (ICC)
- ✓ NFPA 31: Standard for the Installation of Oil-Burning Equipment
- ✓ NFPA 211: Standard for Chimneys, Fireplaces, Vents, and Solid-Fuel-Burning Appliances

Table 3-6: Guide to Venting Standards

Topic	Code Reference
Venting sizing	IFGC, Section 504
Clearances	IFGC, Section 308 and Tables 308.21 NFPA 31, Section 4-4.1.1 and Tables 4-4.1.1 and 4-4.1.2 NFPA 211, Sections 6.5, 4.3, 5
Combustion air	IFGC, Section 304 NFPA 31, Section 1-9 NFPA 211, Section 8.5 and 9.3

3.14.1 Improving Inadequate Draft

If spillage is detected, investigate the reason for the weak draft. Open a window, exterior door, or interior door that is below the level of the heating appliance to observe whether the addition of make-up air will improve draft. If the added air strengthens draft, then the problem is usually

depressurization. If opening a window has no effect, inspect the chimney. The chimney could be blocked or excessively leaky.

Chimney Improvements to Solve Draft Problems

Consider the following chimney improvements when attempting to improve worst-case draft:

1. Remove chimney obstructions.
2. Repair disconnections or leaks at joints and where the vent connector joins a masonry chimney.
3. Measure the size of the vent connector and chimney and compare with vent-sizing information listed in Section 504 of the International Fuel Gas Code. A vent connector or chimney liner, either too large or too small, can result in poor draft.
4. Increase the pitch of horizontal sections of vent, to facilitate the flue gases' movement toward the chimney.
5. Extend the flue's roof-jack. This option may be especially useful when the appliance's exhaust stack is short — for example, in a mobile home, or in a ranch home on a slab.
6. If wind is causing erratic draft, consider installing a wind-dampening chimney cap. If the masonry chimney is deteriorated, consider installing a new chimney liner.

Duct Improvements to Solve Draft Problems

Consider the following duct and air flow improvements when attempting to improve worst-case draft:

1. Seal/remove any return grilles in the CAZ.
2. Install a sealing filter cover.
3. Seal return-duct leaks in the CAZ, using the Diagnostic Workbook to guide duct-sealing decision-making.
4. Isolate the furnace from its return registers by air sealing.
5. Install make-up air to the CAZ. Open a nearby window, exterior door, or interior door to observe whether the addition of make-up air will improve draft. If the open window or door improves draft to an acceptable level, measure the size of the opening, and install make-up air accordingly.

See Table 3-7: Draft Problems and Solutions on next page.

Table 3-7: Draft Problems and Solutions

Problem	Possible Solutions
Adequate draft never established	Remove chimney blockage, seal chimney air leaks, or provide additional combustion air as necessary.
Blower activation weakens draft	Seal leaks in the furnace and in nearby return ducts. Isolate the furnace from nearby return registers.
Exhaust fans weaken draft	Provide make-up or combustion air if opening a door or window to outdoors strengthens draft during testing.
Closing interior doors during blower operation weakens draft	Add return ducts, grilles between rooms, or jumper ducts.

3.15 Combustion Air

A combustion appliance zone is classified as either an **unconfined space** or as a **confined space as defined by the IFGC**. An unconfined space is a CAZ connected to enough building air leakage to provide combustion air. A confined space is a CAZ with sheeted walls and ceiling and a closed door that form an air barrier between the appliance and other indoor spaces.

For confined spaces, the IFGC prescribes additional combustion air from outside the CAZ. Combustion air is supplied to the combustion appliance zone in four ways.

1. To an unconfined space through leaks within the building.
2. To a confined space through an intentional opening or openings between the CAZ and other indoor areas where air transfers in to replenish combustion air.
3. To a confined space through an intentional opening or openings between the CAZ and outdoors or ventilated intermediate zones like attics and crawl spaces.
4. Directly from the outdoors to the confined or airtight CAZ through a duct. Appliances with their own direct combustion-air ducts are called **sealed-combustion** or **direct-vent** appliances.

Table 3-8: CFM Air Requirements for Combustion Furnaces or Boilers

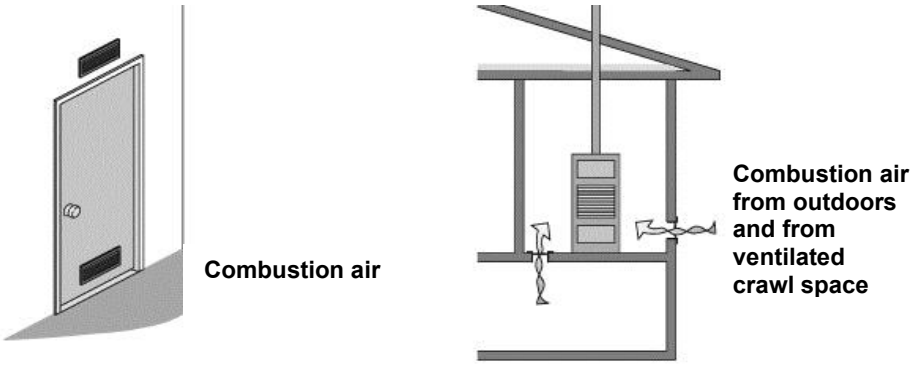
Appliance	Combustion Air (CFM)	Dilution Air (CFM)
Conventional Oil	38	195
Flame-Retention Oil	25	195
High-Efficiency Oil	22	-
Conventional Atmospheric Gas	30	143
Fan-Assisted Gas	26	-
Condensing Gas	17	-
Fireplace (no doors)	100-600	-
Airtight Wood Stove	10-50	-
A.C.S. Hayden, Residential Combustion Appliances: Venting and Indoor Air Quality Solid Fuels Encyclopedia		

3.15.1 Unconfined Space Combustion Air

Combustion appliances located in most basements, attics, and crawl spaces get adequate combustion air from leaks in the building shell. Even when a combustion appliance is located within the home's living space, it usually gets adequate combustion air from air leaks, unless the house is airtight or the combustion zone is depressurized.

3.15.2 Confined Space Combustion Air

A confined space is defined by the IFGC as a room containing one or more combustion appliances and which has less than 50 cubic feet of volume for every 1,000 BTUs per hour (BTU/hr) of appliance input.



Passive combustion-air options: Combustion air can be supplied from adjacent indoor spaces or from outdoors. Beware of passive combustion-air vents into the attic that could depressurize a combustion zone or allow moist air to travel into the attic.

If a small mechanical room is connected to adjacent spaces through large air passages like floor-joist spaces, however, the CAZ may not need additional combustion air, even with sheeted walls and a door separating it from other indoor spaces. The extent of the connection between the CAZ and other spaces can be confirmed by worst-case draft testing or blower door testing.

On the other hand, if the home is unusually airtight, the CAZ may not be able to obtain adequate combustion air, even when the CAZ is larger than the minimum confined-space room volume, defined above.

In confined spaces or airtight homes where outdoor combustion air is needed, the best strategy is a single-vent opening installed as low in the CAZ as is practical. A combustion-air vent into an attic may depressurize the combustion zone or dump warm, moist air into the attic. Instead, connect the combustion zone directly to the outdoors or to a ventilated crawl space through a single low vent, if possible.

Choose an outdoor location that is sheltered, where the wall containing the vent is not parallel to prevailing winds. Wind blowing parallel to an exterior wall or at a right angle to the vent opening tends to depressurize both the opening and the CAZ connected to it. Indoors, locate combustion-air vents away from water pipes to prevent the pipes from freezing.

3.15.3 Net-Free Area

Net-free area is the surface area of venting that remains open after subtracting for the blocking effect of louvers and grilles. Metal grilles and louvers are assumed to reduce the size of the vent opening to 75 percent of the original surface area. Wooden grilles and louvers are more restrictive, and they are assumed to reduce the net-free area to 25 percent of the original surface area.

Manufacturers often provide specifications about the net-free area through their grilles and louvers. When this information is available, use it to calculate the size of opening required to provide the net-free area necessary. When these specifications are not available, use the assumptions listed above.

For example, calculate a 10-inch by 10-inch opening (100 square inches) with a metal grille attached as having 75 square inches of net-free area. With a wooden louver installed, to calculate the same opening use 25 square inches of net-free area.

When sizing vent openings, always account for the reduction in the net-free area that will occur due to the installation of grilles and louvers.

3.15.4 Sizing Combustion-Air Openings

Table 3-9 summarizes the required ratios of combustion-air net-free area to appliance input (BTU/hr).

Here is an example of sizing two direct combustion-air openings to adjacent indoor space: The furnace and water heater are located in a confined space. The furnace has an input rating of 100,000 BTU/hr. The water heater has an input rating of 50,000 BTU/hr. Combined, the two appliances have an input rating of 150,000 BTU/hr. Therefore, each opening must have at least 150 square inches of net-free area of venting between the mechanical room and adjacent indoor space (150,000 ÷ 1,000 = 150 sq. in.). There are two openings, so the CAZ will have a total of 300 square inches of net-free area of venting.

If the same CAZ were ducted to the outdoors with a single opening, the requirement for the net-free area of venting would decrease to 50 square inches (150,000 ÷ 3,000 = 50 sq. in.).

When installing two combustion-air openings, the IFGC usually requires one opening commences 12 inches from the ceiling and one opening 12 inches from the floor. See IFGC 2012, Section 304.5 for a full breakdown of combustion-air requirements.

Table 3-9: Combustion Air Openings: Location and Size

Location	Dimensions
Two direct openings to adjacent indoor space	Minimum area each: 100 in^2 1 in^2 per 1000 BTU/hr each combined rooms volumes must be ≥S 50 ft^3 per 1000 BTU/hr
Two direct openings or vertical ducts to outdoors	Each vent should have 1 in^2 for each 4,000 BTU/hr
Two horizontal ducts to outdoors	Each vent should have 1 in^2 for each 2,000 BTU/hr
Single direct or ducted vent to outdoors	Single vent should have 1 in^2 for each 3,000 BTU/hr
From the *International Fuel Gas Code (IFCG).*	

3.16 Thermostats

Set the thermostat's heat anticipator to the amperage measured in the control circuit or follow the thermostat manufacturer's instructions for adjusting cycle length.

3.16.1 Programmable and Smart Thermostats

Programmable and smart thermostats may be big energy savers if the occupants understand how to operate the thermostat. If the existing thermostat will be replaced as a part of the weatherization work, discuss this option with the occupant. If the occupant is willing to use a programmable or smart thermostat, proceed with the installation. Educate the occupant on the use of the thermostat and leave a copy of manufacturer's directions with them.

Final Inspection and Quality Assurance Standards

Heating system work shall meet the following standards.

Required Outcomes		
	Replacements	**Clean and Tune**
All Fuels and Types	1. The carbon monoxide concentration in the undiluted flue gas does not exceed 400 ppm air-free *or* is within manufacturer's specifications.	1. The carbon monoxide concentration in the undiluted flue gas does not exceed 400 ppm air-free *or* is within manufacturer's specifications.
Gas Systems	2. Test and set the gas pressure within the manufacturer's specifications.	2. Test and set the gas pressure within the manufacturer's specifications.
Oil Systems	3. The smoke test: ≤ 1 for flame retention burner systems and ≤ 2 for non-flame retention burner systems using a smoke-spot scale.	3. The smoke test: ≤1 for flame retention burner systems and ≤2 for non-flame retention burner systems using a smoke-spot scale.
Forced-Air	4. The temperature rise is within the manufacturer's specification.	4. The temperature rise is within the manufacturer's specification.
All Boilers	5. O_2 and CO (or CO_2) values are within manufacturer's specified range. 6. Non-condensing boiler: The stack temperature is at least 300°F to minimize condensation in the chimney.	5. O_2 and CO (or CO_2) values are within manufacturer's specified range. 6. Non-condensing boiler: The stack temperature is at least 300°F to minimize condensation in the chimney.
≥ 90% Boilers	7. Outside air temperature sensor is installed on a north-facing exterior wall. 8. Heating curve is programmed in line with the dwelling's heat loss and radiation capacity.	7. Outside air temperature sensor is installed on a north-facing exterior wall. 8. Heating curve is programmed in line with the dwelling's heat loss and radiation capacity.

Heating Systems – General

1. Heating System Check List is complete in file.
2. Condensate line:
    a. Drains properly and is secured to floor drain.
    b. Does not present a tripping hazard.
    c. Pump installed only when needed.
3. No fuel leaks.
4. Oil systems have a new oil filter.
5. No pre-existing unvented space heaters located within the living space or pressure boundary remain in place.
6. Bonding of CSST gas lines meets NFPA 54 standards.

Required Testing		
	Replacements	**Clean and Tune**
All Fuels and Types	1. Measure the steady-state efficiency (SSE).	1. Measure the steady-state efficiency (SSE).
	2. Measure oxygen (O_2) levels. See *Table 3-2*, Typical Ranges for Gas-Burning Equipment.	2. Measure oxygen (O_2) levels. See *Table 3-2*, Typical Ranges for Gas-Burning Equipment.
	3. Measure the stack temperature (T-Stack).	3. Measure the stack temperature (T-Stack).
Forced-Air	4. Measure the air flow of the furnace air handler. Use a flow plate or the manufacturer's fan-flow tables to calculate air flow.	4. Measure the air flow of the furnace air handler. Use a flow plate or the manufacturer's fan-flow tables to calculate air flow.
All Boilers	5. Measure the supply and return water temperatures.	5. Measure the supply and return water temperatures.

New Heating Systems

1. Heating system is properly sized and adequately heats the building.
    a. Sizing calculation is in the customer file that accurately reflects the heat loss of the post-weatherization building.
    b. Distribution system is adequate for the properly sized furnace.
2. Heating system has proper venting.
    a. Meets manufacturer and code requirements.
    b. Proper clearances from windows, doors, and 3 feet from a gas meter, regulator, and vent outlet.
3. System is raised off the floor by durable materials.
    a. For basements with known water problems, the height is based on typical high-water marks noted in the CAZ or based on customer input.
4. Heating system equipment meets specification requirements.
5. Building permit obtained as required.
6. Installation meets code requirements.
7. System is on a dedicated electrical circuit.
    a. Service disconnect is present or within line-of-sight at service panel.
    b. Circuit is properly sized or a fuse or breaker is installed to protect the system.
8. The warranty and/or manual booklet is posted on or near the furnace.
9. Installed wood systems or stoves comply with NFPA 211 or EPA (per label).

Forced-Air Distribution

1. Filter/compartment:
    a. Is properly sealed, tight cover fit, and the filter seals to the filter rack.
    b. Allows for easy filter replacement.
    c. Filter is MERV 6 or better.
    d. One cleanable filter, six disposable 1- to 2-inch filters included, or one 3-inch filter installed.
2. Distribution within the CAZ and living areas are sealed based on worst-case depressurization testing. The distribution system does not excessively depressurize the CAZ, (>1 pascal, based on warnings in the Diagnostic Workbook when Category I appliances are present).
3. Adequate heat and return air are provided in the living areas.
4. New supply and return ducts are the proper size for efficient operation of the heating system.
5. Duct joints are properly attached and secured.

6. Ducts are properly supported.
7. Metal ducts are sealed with a UL181 rated material like mastic, tape, or caulk.
8. Distribution work in unheated areas is insulated to minimum of R-8.
9. Insulation meets material specifications and is not compressed.
10. Fiberglass insulation is installed with mechanical fasteners.
11. Registers are properly functioning for their intended purpose.
12. There are no return grilles in the CAZ.
13. New supply ducts have dampers.
14. Mobile home return air system is centralized through living space.
15. Backdraft dampers are installed between a wood furnace plenum and another forced air system.

Boilers

1. Boiler size is properly calculated and includes domestic hot water when applicable.
2. Existing radiators and other terminal devices are the appropriate size and quantity for the spaces they heat.
3. Heating System Check List is complete and in file.
4. Replacement units are rated for the application.
5. The existing feed water and distribution system works properly with a new boiler.
6. Distribution system was properly flushed.
7. Boiler controls, auto-fill valve, zone valve, and expansion tank are present and functioning as designed and outdoor air temperature sensor is installed on the most north facing exterior wall.
8. Existing boiler or distribution is adjusted or modified properly.
9. Radiators are bled and there no air is in the system.
10. Pressure relief valve has been documented as opened; closes without leaking.
11. Three- and four-unit buildings only. Boiler registration number is posted with current state certified inspection.

Hot Water Space Heating Distribution

1. Pipes are insulated in unheated areas.
2. Insulation seams are tightly fitted and secured.
3. No leaks in the system.

Thermostats

1. Installed thermostat functions properly with the installed heating system and meets household needs.
2. Customer is educated and understands how to operate thermostat.
3. Thermostat is in a location that allows the heating system to operate properly to heat the space.
4. Thermostat is installed on an interior wall and not near a supply register.

Additional Considerations

Under certain circumstances, the following items may be necessary to verify other tests results are correct or for troubleshooting various problems.

Air flow through the flow meter is consistent with flow rate listed in *Table 3-1* and the manufacturer's fan tables.

Required Testing		
	Replacements	**Clean and Tune**
All Fuels and Types	1. Measure the steady-state efficiency (SSE).	1. Measure the steady-state efficiency (SSE).
	2. Measure oxygen (O_2) levels. See *Table 3-2*, Typical Ranges for Gas-Burning Equipment.	2. Measure oxygen (O_2) levels. See *Table 3-2*, Typical Ranges for Gas-Burning Equipment.
	3. Measure the stack temperature (T-Stack).	3. Measure the stack temperature (T-Stack).
Forced-Air	4. Measure the air flow of the furnace air handler. Use a flow plate or the manufacturer's fan-flow tables to calculate air flow.	4. Measure the air flow of the furnace air handler. Use a flow plate or the manufacturer's fan-flow tables to calculate air flow.
All Boilers	5. Measure the supply and return water temperatures.	5. Measure the supply and return water temperatures.

Chapter 4: Base Load Measures

Base load measures are energy conservation measures that affect non-space heating energy usage. These measures may include, but are not limited to:

1. Water heater replacement
2. Domestic hot water treatments
3. Refrigerator and freezer replacement or removal
4. Lighting retrofits
5. Clothes washer replacement

4.1 Water Heater Replacement

Energy conservation replacements typically occur by completing conversions to natural gas from another fuel type, conversions to a hybrid heat pump from electric, or by replacing the existing inefficient water heater.

Observe the following standards for all water heater replacements or removals:

1. Remove existing water heater and dispose of properly.
2. Size the replacement water heater properly, based upon the number of people in the building.
3. Ensure height and space is acceptable for the water heater replacement.
4. Assess venting options for non-electric water heater replacements to ensure venting meets code requirements.

Observe the following standards for water heater installations:

1. Install water heater per manufacturer's instructions on a level and stable location. Provide strapping to secure the water heater, if needed.
2. Install a temperature and pressure relief (TPR) valve with piping as required by code or local jurisdiction.
3. Ensure venting meets NFPA 54 for gas units.
4. Install a dedicated shut-off valve for fuel supply.
5. Install a dedicated shut-off valve for both the hot and cold water lines to allow isolation of the tank, if none exist.
6. Ensure water lines do not leak after connection to water heater.
7. Fill tank with water before turning water heater on.
8. Measure and adjust temperature settings to 120°F. Check delivered temperature and adjust as necessary.
9. Affix a tag to the water heater identifying whom the customer should call for warranty

service. Display the tag prominently, and confirm that it includes the service provider's name, address, and telephone number.

10. If an existing outlet is not present, install an electrical outlet per manufacturer's instructions (pmi) and/or local codes. When a difference between the manufacturer specifications and code exists, the more restrictive requirement shall be applied.

4.1.1 Gas Water Heater Installations

Observe the following standards for all gas water heater installations:

1. Follow the manufacturer's instructions and NFPA 54 to ensure proper venting of the new water heater.
2. Confirm no gas leaks exist in any of the gas piping.
3. Install a proper sediment trap on gas line, if none exists.
4. Install an approved shut-off valve on the gas line, if none exists.
5. Install gas pipe that is supported and electrically bonded (if required) in accordance with NFPA 54 and the WI Uniform Dwelling Code. Follow the manufacturer's specifications for installation. For more information, see NFPA 54 and WI SPS 323.16.
    a. When CSST is already present in the building and not correctly bonded, bond the gas piping system to the electrical ground in accordance with NEC 250.94 and 250.104 when completing work on the fuel supply and/or the water heater.
6. Install properly sized gas piping.
7. A UL-listed appliance connector may be used to connect gas valve to gas piping.
8. Measure and adjust gas pressure to meet manufacturer's instructions.
9. Test for carbon monoxide (CO) level in the flue prior to the addition of dilution air, if possible, to confirm the CO level is less than 200 ppm air-free (or meets manufacturer's specifications, if different).
    a. If unable to test prior to the addition of dilution air, the test can be completed after the air dilution.

Observe the following standards for power-vented gas water heater installations:

1. If an existing outlet is not present, install an electrical outlet pmi and/or local codes. When a difference between the manufacturer specifications and code exists, the more restrictive requirement shall be applied.
2. Follow manufacturer's instructions for the proper removal of condensate.

4.1.2 Electric Water Heater Installations

Observe the following standards for all electric water heater installations:

1. Follow the manufacturer's instructions and current NEC code to ensure proper electrical connections.
2. Ensure circuit is protected by the correct fuse or breaker amperage.

Observe the following standards for heat pump water heater installations:

1. Follow the manufacturer's instructions for proper removal of condensate.
2. Educate the customer on how to change operational mode.
3. Educate the customer about how and when to change the filter.
4. Follow the manufacturer's instructions when venting cooler exhaust air to the outdoors.

4.2 Domestic Hot Water Treatments

4.2.1 Water Saving Showerheads and Aerators

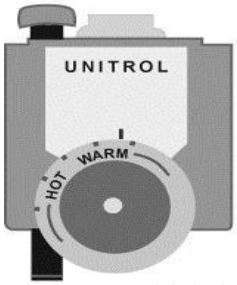
1. Remove and replace existing showerheads and aerators rated or tested above 1.5 gallons per minute with showerheads and aerators rated at 1.5 gallons per minute or less, and recycle replaced items appropriately.
2. Install new showerheads using thread-seal tape or other pipe sealant to prevent leakage. Avoid overtightening the new showerhead.
3. Protect the curved chrome showerhead nipple from damage during installation, using cloth or leather between the jaws of the pipe wrench or pliers.
4. When replacing faucet aerators, be careful to avoid scratching or deforming them.
5. Be cautious when significant deposits exist on the devices as this could lead to fixture damage and additional costs.

4.2.2 Water Heater Pipe Insulation

1. **FOR MOBILE HOMES ONLY:** For water heaters located in a closet with exterior access, insulate all water piping in the closet.
2. Insulate all pipes on the circulating loop between a boiler and an indirect domestic hot water storage tank.
3. Use properly sized pipe insulation rated at R-3 or better. Insulate elbows, unions, and other fittings to the same thickness the straight pipe runs are insulated.
4. Keep pipe insulation at least six inches away from combustion vent pipe, unless the insulation has a fire safety rating for closer clearance.
5. Secure seams, joints, and ends of pipe sleeves.

4.2.3 Setting or Reducing Water Temperature

1. Measure the hot water temperature at the faucet nearest to the water heater and set or reduce the water heater temperature to 120°F, with customer permission.
2. Mark the current setting on the thermostat and move the control to a lower temperature. Note the difference between electric and gas controls shown here.



Gas water heater control

Electric water heater control

3. On electric water heaters, set the upper thermostat and lower thermostat to the same temperature. Shut off power to the water heater before opening thermostat access panels.

4.3 Refrigerator or Freezer Replacement and Removal

Prior to installing a replacement unit:

1. Install replacement units only in locations allowed per manufacturer's instructions. Units can be installed in a non-conditioned space if allowed by the manufacturer.
2. Confirm the replacement unit will fit in the existing opening without modifications. Modify the opening only with agency and customer approval.
3. Verify door openings are wide enough to accommodate a new unit installation.
4. For units that do not meet Wisconsin Weatherization Program replacement guidelines, confirm the required waiver documentation is in the customer file.

When replacing a refrigerator or freezer:

1. Install the replacement unit level for proper operation. Raise the front of a refrigerator slightly to allow the doors to close slowly and without assistance or with limited assistance from the customer.
2. Unless limited by the existing installation space, install all the parts and trim per the manufacturer's instructions.
3. Plug the unit into the nearest receptacle to confirm the unit functions. Do not plug into an extension cord. The outlet should not be on a ground-fault interrupter circuit.
4. Change the swing on doors, if necessary, to meet the needs of the customer.
5. Verify the doors are properly aligned and seal tightly with a positive gasket seal.
6. De-manufacture and properly dispose of existing units being removed or replaced. Do not disable the existing unit until you install the replacement and confirm it works properly.

4.4 Lighting

Light Emitting Diode (LED) bulbs typically use 75 percent less electricity than a standard incandescent bulb. To prevent customer removal and promote efficiency, replacement LED bulbs should be selected to provide light output (lumen, efficacy, and color) equivalent to existing incandescent bulbs.

Globe-style LED

Halogen torchiere lamps pose a health and safety risk due to the heat generated by the halogen bulb. Replacing these lamps with an LED model eliminates the health and safety risk and reduces electrical usage.

When replacing lighting:

1. Demonstrate LED lighting. Explain the related electric savings potential for customers unsure about replacing incandescent bulbs with LEDs.
2. Select replacement LED bulbs with wattage that matches the lumen output and functionality of the existing incandescent bulb. Confirm customer satisfaction for task lighting and background lighting.
3. Install all LEDs. LEDs shall not be left for the customer to install.
4. Turn on each LED lighting replacement after installation to confirm it works properly.
5. Replace halogen torchiere lamps with LED torchiere lamps when appropriate and remove halogen torchiere lamps from residence. Properly dispose of halogen torchiere lamps.
6. Existing CFLs shall not be replaced with LEDs.
7. Provide CFL clean up instructions to customers.
8. Proper disposal is required.

If a CFL breaks, take care in cleaning up. Even though the amount of mercury is very small, EPA recommends the following steps:

1. Open nearby windows to disperse any vapors and leave the room for 15 minutes.
2. Carefully scoop up the fragments and powder with stiff paper or cardboard and seal them in a plastic bag.
3. Wipe the area clean with damp paper towels and place in the plastic bag.
4. Do not use a vacuum or broom to clean up the broken bulb on hard surfaces.
5. Place all clean-up materials in a sealed plastic bag.
6. Place the bag in a second sealed plastic bag and place it in an outdoor trash container. Note: Broken and unbroken CFLs should be taken to a recycling center if possible.
7. Wash your hands after disposing of the bag.

If a fluorescent bulb breaks on a rug or carpet, do your best to remove all visible materials using the steps above. Use sticky tape such as duct tape to help pick up the small pieces and powder. If you need to vacuum, once all visible materials have been removed, remove the vacuum bag (or empty and wipe the canister) and place the bag or vacuum debris in two sealed plastic bags and dispose of at your local hazardous waste site.

4.5 Clothes Washer

1. Make arrangements directly with the customer (as directed by the Agency) to schedule delivery and/or pick-up, or when needed to address any warranty/call back issues. Provide a minimum of 24 hours' notice when scheduling with customer.

2. Per work order specifications, deliver to intended address(es) in the dwelling. Deliver to and install in same location as the existing unit(s). This may include installation in individual apartments in multi-unit buildings.
3. Install with a drain pan/tray if the laundry room is on the second floor of the building, with finished living space on the level below the laundry room.
4. Install the replacement unit in place of the removed appliance, following manufacturer's specifications. Level unit, connect plumbing and accessories. Ensure the supply connections do not leak. Ensure the drain hose is installed to discharge to an appropriate outlet: a floor drain, standpipe, or laundry sink. Ensure the drain hose is secured as necessary.
5. Plug the unit into the nearest outlet and confirm the unit functions. Do not plug into an extension cord. Connect to a circuit with a ground-fault circuit interrupter (GFCI) if one is already installed and available.
6. Confirm the installed replacement unit works properly before disabling the existing unit.
7. Vendor is responsible for removal from premises and disposal of all debris, packing material, etc.
8. Remove the clothes washer identified for removal per the work order.
9. Vendor is responsible for any damage related to delivery, installation of new unit, or removal of old unit.
10. Appliances removed shall not be reused or resold. Disposal records shall be maintained sufficiently for vendor to provide verification to agency of proper disposal of any unit removed, upon agency request.

Final Inspection and Quality Assurance Standards

Acceptable installations shall meet the following standards.

Water Heater Replacement

1. Replacement is ENERGY STAR rated where applicable and meets the required Energy Factor (EF) or Uniform Energy Factor (UEF).
2. Follows Wisconsin Weatherization Program protocol for water heater replacement and was properly modeled with the energy audit.
3. Unit is properly sized for the household.
4. Follows manufacturer's instructions for installation including venting, pressure relief, drain tube, and electrical connection.
5. New outlet (receptacle) is properly installed pmi and/or local code.
6. Temperature measured is 120-125°F, unless an owner request for a higher temperature is documented. Do not set the water heater temperature below 120°F.
7. Replacement unit is not leaking or backdrafting.

Water Saving Devices

1. Installation follows Wisconsin Weatherization Program policies and protocol.
2. New aerators and showerheads do not leak.
3. Recycle or properly dispose of replaced showerheads and faucet aerators.

Refrigerators

1. Installation meets the manufacturer's instructions.
2. All parts and trim are present and installed as designed.
3. Unit is properly sized for the household.
4. Doors are properly aligned and there is a positive gasket seal.
5. The new refrigerator is installed as close to level as possible.
6. The unit consuming the most electricity (pre-weatherization) was replaced.
7. The refrigerator replaced was removed from the dwelling and disposed of properly.
8. Replacement refrigerator follows Wisconsin Weatherization Program policies and protocol.
9. The customer file contains a waiver for any unit that falls outside of replacement guidelines.

Freezers

1. Installation meets the manufacturer's instructions.
    a. Unit is not installed in a non-conditioned space (garage, porch) unless allowed by the manufacturer.
2. All parts and trim are present and installed as designed.
3. Replacement freezer size is equal to or less than unit or units replaced.
4. Lid is properly aligned and there is a positive gasket seal.
5. The unit consuming the most electricity (pre-weatherization) was replaced.
6. The freezer replaced was removed from the building and disposed of properly.
7. Replacement freezer follows Wisconsin Weatherization Program policies and protocol.
8. Additional functional units were removed and a bounty was offered per program policy with owner's permission.

Lighting: LEDs

1. Follows Wisconsin Weatherization Program protocol and policies.
2. Replacement bulbs are appropriate for the intended use.
3. No uninstalled LEDs were left at job site.
4. All halogen torchiere lamps were replaced.

Clothes Washer

1. Installation meets manufacture's specifications.
2. Unit installed in the same location of the existing appliance.
3. Unit leveled and plumbing connections are appropriately connected.
4. Drain hose is attached to appropriate termination.
5. Unit is plugged into closest outlet (no extension cords may be used).
6. Confirm new appliance is operable.
7. Replaced clothes washer was removed.