CHAPTER TITLE: HEATING SYSTEM SPECIFICATIONS

PA will elect to use the parameters set forth in its published set of PA Field Standards for Heating System Improvements. Combustion heating systems heat most homes and their operation generates many important topics. Combustion safety and efficiency lead off this chapter because they are the primary tests performed by an auditor. Chimneys, venting, and combustion air are the topics of the middle part of this chapter. Distribution systems, furnaces and boilers, and installation issues follow the sections on combustion.

Gas and oil combustion efficiency and safety are discussed in separate sections. Natural gas and propane systems are basically the same appliances, differing from one another only in operating pressure and the orifice sizes of their burners. The word "gas" used here means either natural gas or propane.

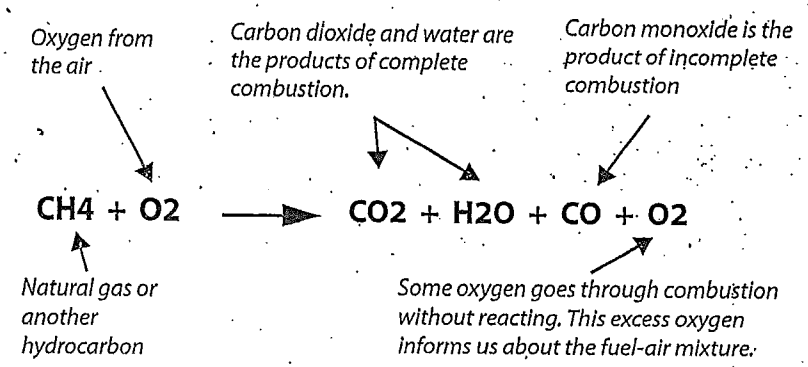
Oil-fired appliances often operate significantly below their maximum fuel-burning efficiency. Adjusting fuel-air mixture, draft, as well as, cleaning the burner and heat exchanger can often boost efficiency noticeably.

Gas furnaces and boilers burn cleanly in comparison to heaters powered by other fuels. The fuel-burning efficiency of gas appliances is difficult to improve, although removing carbon monoxide (CO) from their combustion gases makes them operate more safely.

Forced-air furnaces are the most common type of heating system. Leaky ducts and airflow problems are common problems with furnaces and ducts. This chapter discusses furnaces and ducts in sections: *"Furnace operating standards" on page 133*, *"Duct air-tightness standards" on page 135*, and *"Improving duct-system airflow" on page 139*.

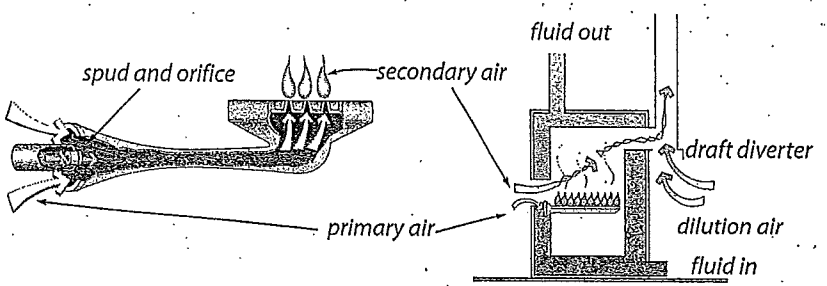
TITLE.1 COMBUSTION SAFETY AND EFFICIENCY TESTING

For both oil and gas, safety-testing is extremely important. Combustion systems with their burners, heat exchangers, and chimneys are often neglected for decades.



Title.1.1 Gas burner safety and efficiency testing

These following specifications apply to gas furnaces, boilers, water heaters, and space heaters.



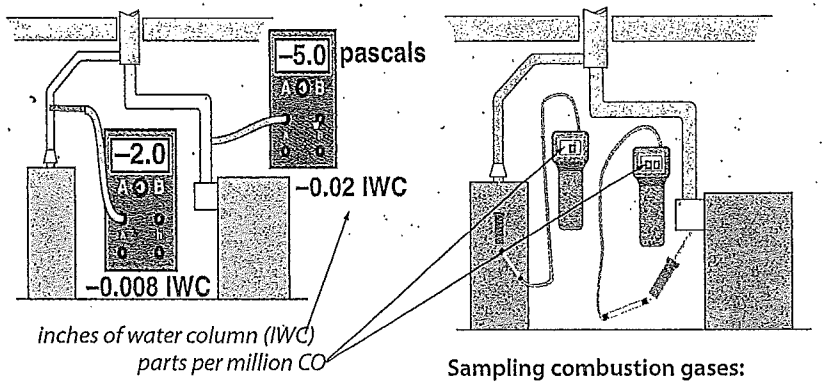
Atmospheric gas burners: These burners use the heat of the flame to pull combustion air into the burner. Dilution air, entering at the draft diverter, limits excess air and reduces the likelihood of condensation in the chimney.

Gas-burner inspection and testing

Perform the following inspection procedures and maintenance practices on all gas-fired furnaces, boilers, water heaters, and space heaters. The goal of these measures is to reduce carbon monoxide (CO), stabilize flame, and test safety controls. For information on the effects of CO, see "Carbon monoxide" on page 64.

- ✓ Look for soot, burned wires, and other evidence of flame roll-out.
- ✓ Inspect the burners for dust, debris, misalignment, and other flame-interference problems. Clean, vacuum, and adjust as needed.
- ✓ Inspect the heat exchanger for leaks. See "Inspecting furnace heat exchangers" on page 132.
- ✓ Assure that all 120-volt wiring connections are enclosed in covered electrical boxes. Furnaces and boilers should have dedicated circuits.
- ✓ Determine that pilot is burning (if equipped) and that main burner ignition is satisfactory.
- ✓ Sample the undiluted combustion gases with a calibrated flue-gas analyzer during operation.
- ✓ Test pilot-safety control for complete gas valve shutoff when pilot is extinguished.
- ✓ Check the thermostat's heat-anticipator setting. The thermostat's heat anticipator setting should match the measured current in the 24-volt control circuit.
- ✓ Check venting system for proper size and pitch.
- ✓ Check venting system for obstructions, blockages, or leaks.
- ✓ Measure chimney draft downstream of the draft diverter.
- ✓ Drill and non-corrosive plug in PVC vent for sampling hole on Category IV vent.

- ✓ High temperature silicone and lag bolt in B-vent and concentric flue in manufactured home heating appliances.
- ✓ Test to ensure that the high-limit control extinguishes flame when the furnace temperature rises within 10% of 200° F.
- ✓ Measure gas input, and observe flame characteristics if soot, CO, or other combustion problems are present.



Measuring draft: Measure chimney draft downstream of the draft diverter.

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

Proceed with burner maintenance and adjustment when:

- CO is greater than 100 ppm.
- Visual indicators of soot or flame roll-out exist.
- Burners are visibly dirty.
- Measured draft is low or nonexistent.
- The appliance doesn't conform to the combustion specifications above.

Gas-burner maintenance includes the following measures.

- ✓ Remove causes of CO and soot, such as over-firing, closed primary air intake, and flame impingement.

- ✓ Remove dirt, rust, and other debris that may be interfering with the burners.
- ✓ Take action to improve draft, if inadequate because of improper venting, obstructed chimney, etc.
- ✓ Seal leaks in vent connectors and chimneys.
- ✓ Adjust gas input if combustion testing indicates overfiring or underfiring.

Table Title-1:Combustion Standards for Gas Furnaces

Performance Indicator	70+	80+	90+
Carbon monoxide (CO) (ppm)	≤ 100 ppm	≤ 100 ppm	≤ 100 ppm
Gross stack temperature (°F)	400°–575°	275°–450°	90°
Temperature rise (°F)	pmi	pmi	pmi
Oxygen (%O^2)	4–10%	4–10%	4–10%
Nat gas pressure (IWC)[a]	3.2–3.9	3.2–3.9	3.2–3.9
Prop gas pressure (IWC)	10-12	10-12	10-12
Draft (IWC)	–5 Pa. or -0.02 IWC	–5 Pa. or -0.02 IWC	25–100 Pa. or +0.1 to +0.4 IWC
Venting	B-Vent	B-Vent	Sched.40 PVC–Red lettering only

a. IWC = inches water column
b. as per manufacturer instructions.
#. 40-90 degrees temperature rise as a fall back measure.

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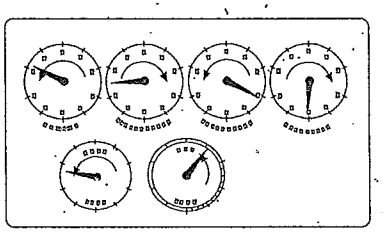
Measuring BTU input on natural gas appliances

Use the following procedure when it's necessary to measure the input of a natural gas appliance.



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.

1. Turn off all gas combustion appliances such as water heaters, dryers, cook stoves, and space heaters that are connected to the meter you are timing, except for the appliance you wish to test.
2. Fire the unit being tested, and watch the dials of the gas meter.
3. Carefully count how long it takes for one revolution of $^1/_2$, 1, or 2 cubic-foot dial. Refer to *Table Title-2 on page 93* and find that number of seconds in the columns marked "Seconds per Revolution." Follow that row across to the right to the correct column for the $^1/_2$, 1, or 2 cubic-foot dial. Note that you must multiply the number in the table by 1000. Record the input in thousands of BTUs per hour
4. If the measured input is higher or lower than input on the name plate by more than 10%, adjust gas pressure up or down within a range of 3.2 to 3.9 IWC.
5. If the measured input is still out of range, replace the existing orifices with orifices sized to give the correct input.

Table Title-2: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		
	1/2 cu. ft.	1 cu. ft.	2 cu. ft.		1/2 cu. ft.	1 cu. ft.	2 cu. ft.		1/2 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

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Title.1.2 Leak-testing gas piping

Natural gas and propane piping systems may leak at their joints and valves. Find gas leaks with an electronic combustible-gas detector, often called a gas sniffer. A gas sniffer will find all significant gas leaks if used carefully. Remember that natural gas rises from a leak and propane falls, so position the sensor accordingly.

- ✓ Sniff all valves and joints with the gas sniffer.
- ✓ Accurately locate leaks using a non-corrosive bubbling liquid, designed for finding gas leaks.
- ✓ All gas leaks should be repaired.

Title.1.3 Oil-burner safety and efficiency

Oil burners require annual maintenance to retain their operational safety and combustion efficiency. Testing for combustion efficiency (steady-state efficiency), draft, carbon monoxide, and smoke should be used to guide and evaluate maintenance. These procedures pertain to oil-fired furnaces, boilers, and water heaters.

Oil-burner inspection and testing

Use visual inspection and combustion testing to evaluate oil burner operation. An oil burner passing visual inspection and giving good test results may need no maintenance. If the test results are outside of weatherization specifications, adjustments may be necessary (i.e. air band adjustments or retention head adjustments).

Follow these steps to achieve a minimum standard for oil-burner safety and efficiency:

- ✓ Inspect burner and appliance for signs of soot, overheating, fire hazards, or wiring problems.

- ✓ Verify that all oil-fired heaters are equipped with a barometric draft control, unless they have high-static burners or are manufactured house furnaces.
- ✓ Assure that all 120-volt wiring connections are enclosed in covered electrical boxes. Each oil furnace or boiler should have a dedicated electrical circuit.
- ✓ Inspect fuel lines and storage tanks for leaks.
- ✓ Inspect heat exchanger and combustion chamber for cracks, corrosion, or soot buildup.
- ✓ Check to see if flame ignition is instantaneous or delayed. Flame ignition should be instantaneous, except for pre-purge units where the burner blower runs for a while before ignition.
- ✓ Sample undiluted flue gases with a smoke tester, following the smoke-tester instructions. Compare the smoke spot left by the gases on the filter paper with the manufacturer's smoke-spot scale to determine smoke number. If the smoke number is above 2, clean and tune. Perform a combustion analysis test.
- ✓ Analyze the flue gas for O_2 or CO_2, temperature, CO, and steady-state efficiency (SSE). Sample undiluted flue gases between the barometric draft control and the appliance.
- ✓ Measure flue draft between the appliance and barometric draft control and over-fire draft over the fire inside the firebox.
- ✓ 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 without a domestic coil. For hot-water boilers with a domestic coil, set the shut-off temperature as needed for domestic hot-water needs.
- ✓ Measure transformer voltage, and replace if under specification (check input voltage first).

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- ✓ Assure that barometric draft controls are mounted plumb and level and that the damper swings freely with weight in the correct position (H or V).
- ✓ Time the CAD cell control or stack control to verify that the burner will shut off, within the time stated on the control body, when the CAD cell is blocked from seeing the flame.

Table Title-3:Combustion Standards for Oil-Burning Appliances

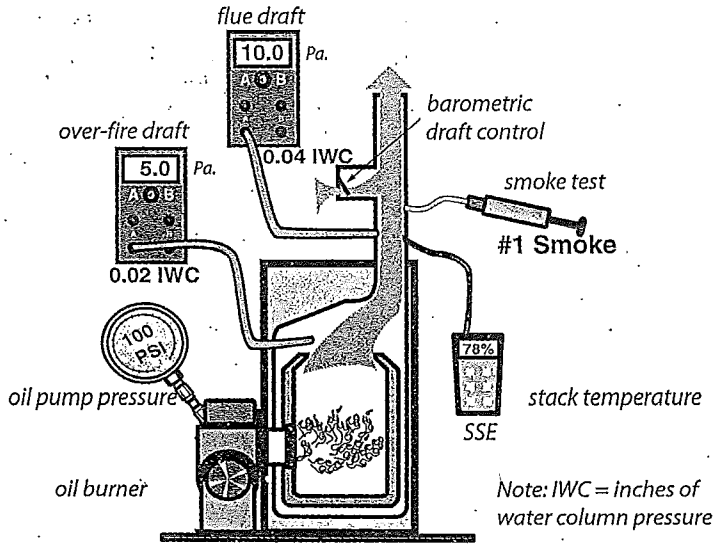
Oil Combustion Performance Indicator	Non-Flame Retention	Flame Retention
Oxygen (% O_2)	4–9%	4–7%
Gross Stack temperature (°F)	325°–600°	300°–500°
Carbon monoxide (CO) parts per million (ppm)	≤ 100 ppm	≤ 100 ppm
Steady-state efficiency (SSE) (%)	≥ 75%	≥ 80%
Smoke number (1–9)	≤ 2	0
Excess air (%)	≤ 100%	≤ 25%
Oil pressure pounds per square inch (psi)	≥ 100 psi	≥ 100-150 psi (pmi)*
Over-fire draft (IWC)	5 Pa. or -.02 IWC	5 Pa. or -.02 IWC
Flue draft (IWC)	10–25 Pa. or -0.04–-0.1IWC	10–25 Pa. or -0.04–-0.1IWC

Gross stack temperature (GST) is as measured in the breech of the heating appliance. Net stack temperature is GST minus combustion air temperature.
* pmi = per manufacturer's specifications

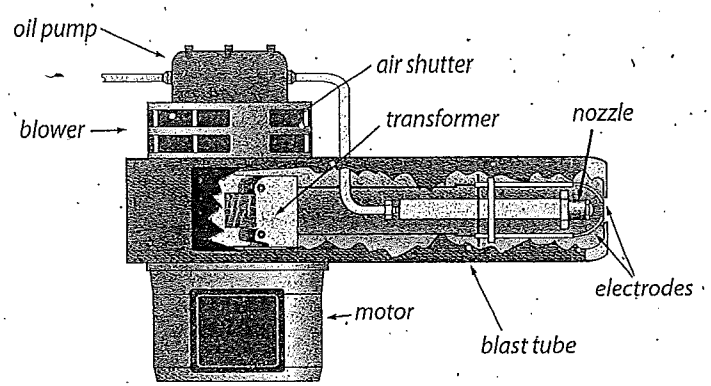
Oil burner maintenance and adjustment

After evaluating the oil burner's initial operation, if it falls outside the weatherization specifications, a Clean and Tune (C&T) may be recommended. The following should be considered as minimum tasks to ensure efficiency and safety of the heating appliance.

- ✓ Verify correct flame-sensor operation.
- ✓ Units may be derated to the maximum allowed by the manufacturer, or no lower than 350 degrees stack temperature. This applies only to Category I vent.
- ✓ Replace nozzle.
- ✓ Clean the burner's blower wheel.
- ✓ Replace oil filter(s).
- ✓ Clean or replace air filter.



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



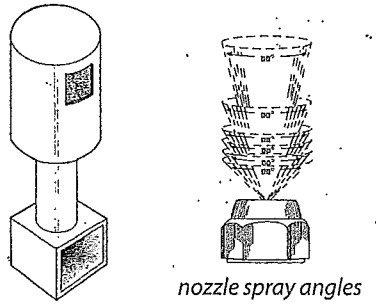
Oil-burner: Performance and efficiency will deteriorate over time if neglected. Annual maintenance is recommended.

- ✓ Remove soot, ash, carbon, and sulfer accumulations from combustion chamber.
- ✓ Remove soot, ash, and sulfer from heat exchanger surfaces.
- ✓ Clean dust, dirt, and oily deposits from the burner assembly.
- ✓ Set oil pump to correct pressure (PMI).
- ✓ Adjust air shutter and retention head clearances (PMI) to achieve oxygen and smoke values, specified in *Table Title-3, "Combustion Standards for Oil-Burning Appliances," on page 96.*
- ✓ Adjust barometric damper for flue draft of -5–10 pascals or -0.02-to-0.04 IWC (before barometric damper).
- ✓ Adjust gap between electrodes to manufacturer's specifications.
- ✓ Repair the combustion chamber, or replace it if necessary.

After these maintenance procedures, the technician performs the diagnostic tests described previously to evaluate improvement made by the maintenance procedures and assure peak efficiency.

Burner replacement with flame-retention burner

A flame-retention burner is a newer type of oil burner that gives a higher combustion efficiency by swirling the mist or oil and air to produce better mixing. Modern flame-retention burners improve combustion efficiency and have steady-state efficiency (SSE) of 80% or slightly more. Replacing an old-style burner with a flame-retention model may be cost-effective if 75% SSE cannot be achieved. Flame-retention-burner motors run at 3450 rpm and older oil burners run at 1725 rpm motor speed. Looking for the nameplate motor or pump speed can help you discriminate between the flame-retention burners and non-retention conventional burners.



Oil spray pattern and combustion chamber: Matching the burner's spray pattern to the combustion chamber is important to retrofit applications.

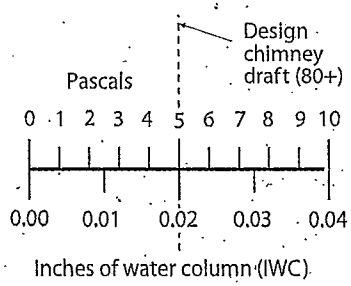
If a high-mass furnace or boiler has a sound heat exchanger but the oil burner is inefficient or unserviceable, the burner may be replaced by a newer flame-retention burner. The higher heat from a flame-retention burner may crack the heat exchanger of a low-mass furnace or boiler that had been previously fired by a lower temperature non-retention burner. The new burner must be tested for efficient and safe operation as described previously.

- Units may only be derated by a maximum of 15% from the manufacturer's specifications, or no lower than 350 degrees stack temperature.
- Install a new combustion chamber, choosing one that fits the size and shape of the burner flame. Or, change nozzles on the new burner to produce a flame that fits an existing combustion chamber that is still in good condition. Either way, the flame must fill the combustion chamber without impingement.

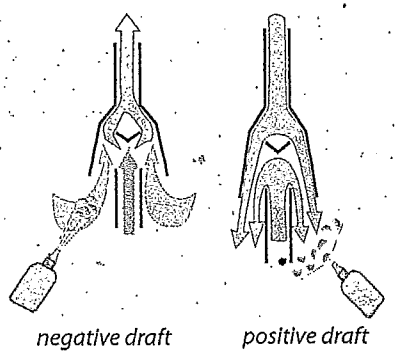
TITLE.2 MEASURING DRAFT AND HOUSE PRESSURES

The main purpose of measuring draft is to insure that the combustion gases are being vented from a dwelling. Draft is measured in inches of water column (IWC) or Pascals. House pressure affects draft and must be measured and controlled.

Technicians create worst-case conditions for naturally drafting appliances in order to insure that appliances will draft even in worst-case conditions of house depressurization. Depressurization is among the leading cause of backdrafting and flame roll-out. Testing for adequate draft of all combustion appliances is required before final inspection. Category I Venting must be negative pressure in the flue. Category IV will be positive pressure in flue.



Title.2.1 Draft characteristics in combustion appliances



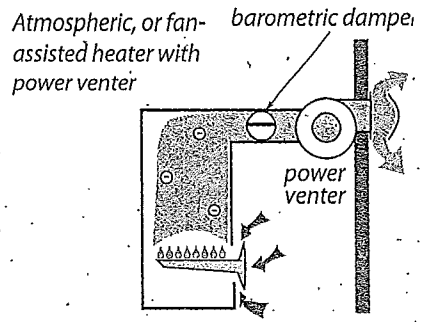
Negative versus positive draft: With positive draft air flows down the chimney and out the draft diverter. A smoke bottle helps distinguish between positive and negative draft.

There are several different classifications of combustion appliances based on the type of draft they employ to exhaust their flue gases. Most existing appliances exhaust their gases into an atmospheric chimney. An atmospheric chimney produces negative draft—a slight vacuum. The strength of this draft is determined by the chimney's height, its cross-sectional area, and the temperature difference between the flue gases and outdoor air. Atmospheric draft should always be negative.

Most existing gas and oil appliances are designed to operate with at least negative 0.02 inches of water column (IWC) or –5 pascals chimney draft. Tall chimneys located indoors can produce strong drafts and short chimneys or outdoor chimneys typically produce weaker drafts. Wind and house pressures also affect draft.

Atmospheric combustion appliances exhaust combustion gases solely by their buoyancy. Fan-assisted appliances have the help of a small fan near the exhaust of their heat exchanger that regulates airflow through the heat exchanger.

Power burners have fans at the intake of the combustion chamber to mix combustion air with fuel and inject the mixture into the combustion chamber. The standard power oil burner is the most common type of power burner. Most appliances with draft-assisting fans and power burners vent into atmospheric chimneys.



Power-vent draft: A power venter is an external draft-inducing fan that helps atmospheric, and fan-assisted furnaces, boilers, and water heaters vent through sidewall vents.

Positive-draft appliances, which are either condensing or non-condensing, vent either horizontally or vertically and require airtight chimneys. Most positive-draft appliances are condensing furnaces and boilers. Most non-condensing positive-draft appliances are boilers, although some furnaces and newer water heaters are also designed to vent through positive-draft, sidewall vents. These appliances have draft in the range of +0.05 to +0.35 IWC or 12 to 85 pascals and are much less influenced by indoor and outdoor pressures.

Power venters with sidewall vents are a good alternative, when a vertical chimney is inadequate or non-existent. The power venter is located near the end of the vent and creates a negative draft. See "Manufactured House furnace venting" on page 123.

Title.2.2 Worst-case combustion appliance zone tests

This test uses the home's exhaust fans, air handler, and chimneys to create worst-case depressurization in the combustion-appliance zone (CAZ). A combustion appliance zone (CAZ) is an area containing one or more combustion appliances. During this worst-case testing, you measure chimney draft. Draft is the pressure difference between the chimney and combustion zone.

The reason for this test is that worst-case conditions do occur, and chimneys should vent their combustion gases even under these extreme conditions. The three main influences on worst-cast draft scenario are depressurization, chimney characteristics, and tightness of the home. This worst-case draft test will discover whether or not the venting system will exhaust the combustion gases when the combustion-zone pressure is as negative as you can make it. A sensitive manometer is usually used for accurate and reliable readings of chimney draft.

Title.2.3 CAZ Combustion Safety Test

1. Record outdoor ambient air temperature
2. Zero gas leak detector and Carbon Monoxide Meter to outdoor ambient air conditions
3. Check all gas and or fuel lines to all appliances for leaks and make required repairs before performing test.
4. Using a manometer measure the base pressure of the CAZ with reference to outside, start with all exterior doors, windows and fireplace damper(s) closed or sealed, if possible. Set all combustion appliances to the pilot setting or turn off the service disconnect, including: Boiler, furnace, space heaters, water heater, and/or any device that will exhaust air from the structure. With the structure in this configuration, measure and record the base pressure of the combustion appliance zone With Reference To (WRT) outside.
5. Establish the worst case CAZ by turning on the dryer, all exhaust fans and exhaust devices, and the air handler fan, if present. If a fireplace is present and cannot be sealed off, turn on blower door and exhaust 300CFM. Check the CAZ pressure before and after closing each interior door, one door at a time. If the CAZ pressure is more negative with the door open, leave the door open. If the CAZ pressure is more negative with the door closed, leave it closed. Always measure the pressure With Reference To (WRT) the CAZ, so make sure the hose is long enough (the DG-700 manometer comes with 30' of hose). Close any interior doors that make the CAZ pressure more negative. Turn on the air handler fan, if present and leave on if the pressure in the CAZ becomes more negative, and then recheck the door positions. Measure the net change in pressure from the CAZ to outside, corrected for the base pressure. Record the "worst case depressurization".
6. Compare to chart (CAZ depressurization Limits). If CAZ does not meet CAZ depressurization limits, recommend outside air to CAZ. Locate what is depressurizing the CAZ (i.e. whole house fan). Recommend that the device not be used until the depressurization problem is corrected.
7. Before and during the Spillage, draft and Carbon Monoxide tests, monitor the ambient CO in the breathing zone. Abort the test if the ambient CO level exceeds 35ppm. Turn off the appliance, ventilate the space and evacuate the structure. The structure may be reentered once ambient CO levels have gone below 35ppm. The appliance must be repaired and the problem corrected prior to completing the combustion safety diagnostics.

CAZ Depressurization Limits

Venting Conditions	LImit (Pascals)
Orphan natural draft water heater (including outside chimneys)	-2
Natural draft boiler or furnace commonly vented with water heater	-3
Natural draft boiler or furnace with vent damper commonly vented with water heater	-5
Individual natural draft boiler or furnace	-5
Mechanically assisted draft boiler or furnace commonly vented with water heater	-5
Mechanically assisted draft boiler or furnace alone, or fan assisted DHW alone	-15
Exhaust to chimney-top draft inducer (fan at chimney top); High static pressure flame retention head oil burner; Sealed combustion appliances;	-50

8. While under worst case CAZ start the heating appliance, beginning with the smallest BTU rated appliance first and using a smoke bottle, test for Spillage at the draft diverter, the appliance should not spill more than 60 seconds. If spillage ends within 60 seconds test draft.

9. Follow the **Protocol for Draft Testing*** (Check draft after the draft diverter for gas, and before the barometric draft damper on oil, compare to Table 3-4: "Minimum Worst-Case Draft" on outdoor temperature).

10. Once the appliance has reached Steady State measure the CO level at the flue, the CO level should never exceed 100ppm or the Manufacturers specifications. If CO exceeds these levels a clean and tune is required.

Table Title-4:Minimum Worst-Case Draft

	Outdoor Temperature (Degrees F)				
Appliance	**<20**	**21-40**	**41-60**	**61-80**	**>80**
Gas-fired furnace, boiler, or water heater with atmospheric chimney	-5 Pa. -0.02 IWC	-4 Pa. -0.016 IWC	-3 Pa. -0.012 IWC	-2Pa. -0.008 IWC	-1 Pa. -0.004 IWC
Oil-fired furnace, boiler, or water heater with atmospheric chimney	-15 Pa. -0.06 IWC	-13 Pa. -0.053 IWC	-11 Pa. -0.045 IWC	-9 Pa. -0.038 IWC	-7 Pa. -0.030 IWC

11. Repeat steps 8, 9 and 10 for each heating appliance located in the combustion appliance zone

12. Perform steps 8, 9 and 10 with all appliances operating at the same time

13. If Spillage, draft and CO PASS under Worst case skip to line 15

14. If Spillage, and or draft FAIL under worst case turn off the appliance, exhaust fans and exhaust devices, open interior doors and allow the vent to cool before re-testing. Test for CO, spillage and draft under "natural conditions". Measure the worst case depressurization taken in step 5. Repeat for each appliance, and then with all appliances operating, allowing the vent to cool between each test

15. Make recommendations or complete work order for repairs based on test results.

Note: Documentation of a chimney safety performance test must be included in the client file.

Title.2.4 * Protocol for Draft Testing

Measure flue pressure at steady-state operating conditions of all heating and hot water combustion appliances.

Gas appliances

1. Atmospheric or Natural Draft (70%): Draft testing shall be done in the center of the longest, straightest, accessible section of the vent connector after the draft diverter. Holes made for the purpose of measuring draft shall be drilled using 5/16th bit. Once test is complete, seal hole with High Temperature RTV silicone caulk, cover with aluminum tape or metal plug.
2. Induced Draft (80%) furnaces: Draft testing shall be done downstream of the inducer motor. The preferred location for CO testing is the same hole used for draft testing. Holes made for Draft and CO testing shall be drilled using a 5/16th bit. Once test is complete, seal hole with High Temperature RTV silicone caulk, cover with aluminum tape or metal plug. If using B-vent completely seal the inner liner with High Temperature RTV silicone caulk and a 3/8 inch tap bolt made of stainless steel or seal interior hole with RTV silicone and cover exterior hole with aluminum tape.
3. Sealed Combustion or Power Vented appliances or water heaters (90% +): No draft measurement required, unless venting issues are suspected.

Oil appliances

Natural draft oil fired hot air, hot water, steam boilers and oil fired water heaters, measure draft at or *in the breech* or at the stack pipe (properly, just above the flue vent connector) measured just a few inches above the boiler or furnace top, and *before* the barometric damper itself and no closer than 2 pipe sizes in diameter from any elbow. Drill a 5/16" hole in the flue gas exhaust pipe and seal hole with High Temperature RTV silicone caulk, cover with aluminum tape or metal plug.

Heating System Specifications

Title.2.5 Improving inadequate draft

If measured draft is below minimum draft pressures, investigate the reason for the weak draft. Open a window or door to observe whether the addition of combustion air will improve draft. If this added air strengthens draft, the problem usually is depressurization. If opening a window has no effect, inspect the chimney. The chimney could be blocked or excessively leaky. Consider implementing the following improvements in order to solve draft problems.

Chimney improvements

- ✓ Repair or remove chimney obstructions, disconnections, or leaks, which can weaken draft.
- ✓ Measure the size of the vent connector and chimney and compare to vent-sizing information listed in Section 504 of the *International Fuel Gas Code*. A vent connector or chimney liner that is either too large or too small can result in poor draft.
- ✓ If wind is causing erratic draft, consider a wind-dampening chimney cap.
- ✓ If the masonry chimney is deteriorated, consider installing a new chimney liner. See "Metal liners for masonry chimneys" on page 115.

Duct improvements

- ✓ Repair and seal return-duct leaks near furnace.
- ✓ Isolate furnace from return registers by air-sealing.
- ✓ Improve balance between supply and return air by installing new return ducts, transfer grills, or jumper ducts. See"Improving duct-system airflow" on page 139.

Reducing depressurization from exhaust devices

- ✓ Isolate furnace from exhaust fans and clothes dryers by air-sealing between the combustion zone and zones containing these depressurizing forces.
- ✓ Reduce capacity of large exhaust fans.

Combustion and make-up air

- ✓ Provide make-up air for dryers and exhaust fans.
- ✓ Provide combustion-air inlet to combustion zone. See "Combustion air" on page 126.

TITLE.3 VENTING COMBUSTION GASES

Proper venting is essential to the operation, efficiency, safety and durability of combustion heaters. Reference the most stringent code. The National Fire Protection Association (NFPA) and the International Code Council (ICC) are the authoritative information sources 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 *National Fuel Gas Code* (NFPA 54) (ANSI Z223.1) *2006 Edition*
- NFPA 31: *Standard for the Installation of Oil-Burning Equipment 2006 Edition*
- NFPA 211: *Standard for Chimneys, Fireplaces, Vents, and Solid-Fuel-Burning Appliances 2006 Edition*
- The *International Mechanical Code* (IMC) 2009 edition
- The *International Residential Code* (IRC) 2009 edition

Title.3.1 General venting requirements

Combustion gases are vented through vertical chimneys or other types of approved horizontal or vertical vent piping. Identifying the type of existing venting material, verifying the correct size of vent piping, and making sure the venting conforms to the applicable codes are important tasks in inspecting and repairing venting systems. Too large a vent often leads to condensation and corrosion. Too small a vent can result in spillage. The wrong vent materials can corrode or deteriorate from heat.

Table Title-5:Venting and Combustion Air Standards

Topic	Standard and Section
Chimneys, Vents, and Sizing	NFPA 54 2006, Chapter 13 IRC 2009, Chapter 24 IMC 2009, Chapter 8
Clearances	NFPA 54 2006, Section12.8.4.4 IMC 2009, Section 801.18.4 NFPA 31 2006, Chapter 10 NFPA 211 2006, Many sections
Combustion Air	NFPA 54 2006, Section9.3 IMC 2009, Chapter 7 IRC 2009, Chapter 24 NFPA 31 2006, Section 1-9; NFPA 211 2006, Section 8.5 and 9.3

Title.3.2 Vent connectors

A vent connector connects the appliance's venting outlet or appliance breach with the chimney's inlet or chimney breach. Approved vent connectors for gas- and oil-fired units are made from the following materials.

1. Type-B vent, consisting of a galvanized-steel outer pipe and aluminum inner pipe ($\geq$ 0.027 inch thick)
2. Type-L vent connector with a stainless-steel inner pipe and either galvanized or black-steel outer pipe.
3. Galvanized-steel pipe ($\geq$ 0.018 inch thick)
4. Aluminum pipe (0.027 inch thick)

5. Stainless-steel pipe ($\geq$ 0.012 inch thick)
6. Various manufactured vent connectors

Double-wall vent connectors are the best option, especially for appliances with horizontal sections of vent connector. A double-wall vent connector helps maintain flue-gas temperature and prevent condensation. Gas appliances with draft hoods, installed in attics or crawl spaces must use a Type-B vent connector. Type-L vent pipe is commonly used for vent connectors for oil and solid fuels but can also be used for gas.

Observe the following general specifications, concerning vent connectors.

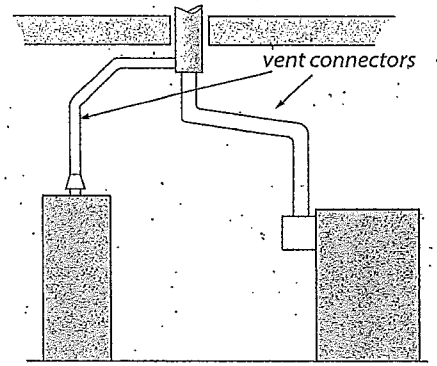
- A vent connector is almost always the same size as the vent collar on the appliance it vents.
- Vent-pipe sections should be fastened together with 3 screws or rivets.
- The vent connector should be sealed where it enters the chimney.
- Vent connectors should be free of rust, corrosion and holes.
- The chimney combining two vent connectors should have a cross-sectional area equal to the area of the larger vent connector plus half the area of the smaller vent connector. The common vent should be no larger than 7 times the area of the smallest vent. For specific vent sizes, see NFPA codes themselves listed in "Venting and Combustion Air Standards" on page 110.

Table Title-6:Areas of Round Vents

Vent diameter	4"	5"	6"	7"	8"
Vent area (square inches)	12.6	19.6	28.3	38.5	50.2

Heating System Specifications

- The horizontal length of vent connectors shouldn't be more than 75% of the chimney's vertical height or have more than 18 inches horizontal run per inch of vent diameter.



Two vent connectors joining chimney: The water heater's vent connector enters the chimney above the furnace because the water heater has a smaller input.

- Vent connectors must have upward slope to their connection with the chimney. A slope of $^1/_4$ inch of rise per foot of horizontal run along their entire length is recommended to prevent condensation from pooling and rusting the vent.

Table Title-7:Vent Connector Diam (in.) and Max Horiz Length (ft.)

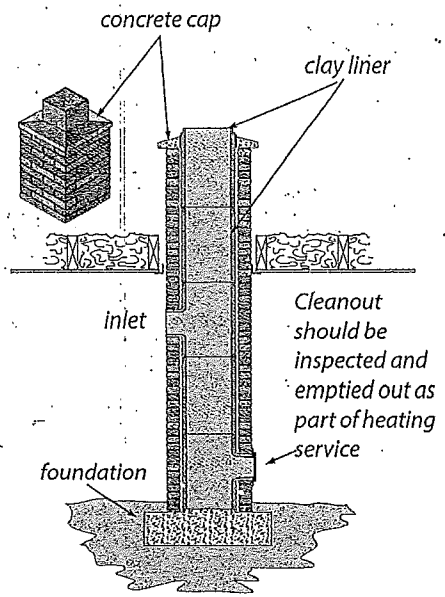
3"	4"	5"	6"	7"	8"	9"	10"	12"	14"
4.5'	6'	7.5'	9'	10.5'	12'	13.5'	15'	18'	21'

From International Fuel Gas Code 2000

- When two vent connectors connect to a single chimney, the vent connector servicing the smaller appliance should enter the chimney above the vent for the larger appliance.
- Maintain minimum clearances from combustibles as specified by the connector's manufacturer.

Title.3.3 Chimneys

There are two common types of vertical chimneys for venting combustion fuels that satisfy NFPA and ICC codes. First there are masonry chimneys lined with fire-clay tile, and second there are manufactured metal chimneys, including all-fuel metal chimneys and Type-B vent chimneys for gas appliances.



Masonry chimneys: Remain a very common vent for all fuels.

Masonry chimneys

Observe the following general specifications for inspecting, repairing, and retrofitting masonry chimneys.

- Masonry chimneys should be supported by their own masonry foundation.
- Existing masonry chimneys should be lined with a fireclay flue liner. There should be a $^1/_2$-inch to 1-inch air gap between the clay liner and the chimney's masonry to insulate the liner. The liner shouldn't be bonded structurally to the outer masonry because it needs to expand and contract independently of the chimney's masonry structure. The clay liner can be sealed to the chimney cap with a flexible high-temperature sealant.
- The chimney's penetrations through floors and ceilings should be sealed with metal as a firestop and air barrier.
- Deteriorated or unlined masonry chimneys may be rebuilt as specified above or relined as part of a heating-system replacement or a venting-safety upgrade. As an alternative, the vertical chimney may be replaced by a sidewall vent, equipped with a power venter mounted on the exterior wall.
- Maintain minimum clearances from combustibles as specified by the chimney's equipment manufacturer.
- Masonry chimneys should have a cleanout 12 inches or more below the lowest inlet. Mortar and brick dust should be cleaned out of the bottom of the chimney through the clean-out door, so that this debris won't eventually interfere with venting.

Manufactured chimneys

Manufactured metal chimneys have engineered parts that fit together in a prescribed way. Metal chimneys have all manufactured components from the vent connector to the termination fitting on the roof. Parts include: metal pipe, weight-supporting hardware, insulation shields, roof jacks, and chimney caps. One manufacturer's chimney may not be compatible with another's connecting fittings.

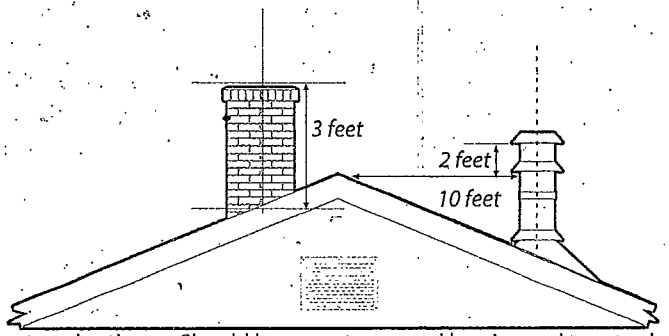
All-fuel metal chimneys come in two types: insulated double wall metal pipe and triple-wall metal pipe. Install them strictly observing the manufacturer's specifications.

All-fuel metal chimney: These chimney systems include transition fittings, support brackets, roof jacks, and chimney caps. The pipe is double-wall insulated or triple wall.

Type-B vent pipe is permitted as a chimney for Category I gas appliances, but adhere to manufacturer's instructions. Some older manufactured gas chimneys were made of metal-reinforced asbestos cement.

Chimney termination

Masonry chimneys and all-fuel metal chimneys should terminate at least three feet above the roof penetration and two feet above any obstacle within ten feet of the chimney outlet. Chimneys should have a cap to prevent rain and strong downdrafts from entering.



Chimney terminations: Should have vent caps and be given adequate clearance height from nearby building parts. These requirements are for masonry chimneys and manufactured all-fuel chimneys.

B-vent chimneys can terminate as close as one foot above flat roofs and pitched roofs up to a $^{6}/_{12}$ roof pitch. As the pitch increases, the minimum termination height rises as shown in the table.

Table Title-8:Roof Slope and B-Vent Chimney Height Above Roof

flat-6/12	6/12-7/12	7/12-8/12	8/12-9/12	9/12-10/12	10/12-11/12	11/12-12/12	12/12-14/12	14/12-16/12	16/12-18/12
1'	1' 3"	1' 6"	2'	2' 6"	3' 3"	4'	5'	6'	7'

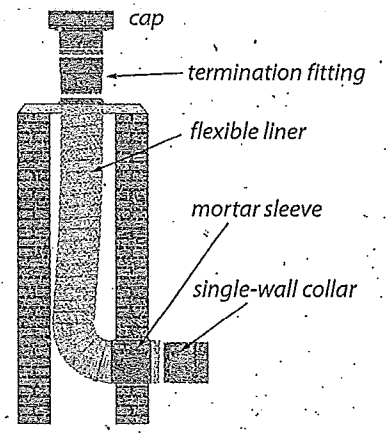
From International Fuel Gas Code 2000

Metal liners for masonry chimneys

Unlined masonry chimneys or chimneys with deteriorated liners should be relined as part of heating system replacement. For gas applications use either Type-B vent, or a flexible stainless-steel or aluminum liner. For oil applications use Type-L or flexible stainless liner. See also *"Manufactured House furnace venting" on page 123.*

Heating System Specifications

Flexible liners require careful installation to avoid a low spot at the bottom, where the liner turns a right angle to pass through the wall of the chimney breach. Follow the manufacturer's instructions, which usually prescribe stretching the liner and fastening it securely at both ends, to prevent it from sagging and thereby creating such a low spot.



Flexible metal chimney liners: The most important installation issues are sizing the liner correctly along with fastening and supporting the ends to prevent sagging.

To reduce condensation, flexible liners should be insulated—especially when installed in exterior chimneys. Insulate all rigid and flexible metal chimney liners with Pearlite or suitable material. Follow manufacturer's installation instructions.

Sizing flexible chimney liners correctly is very important. Oversizing is common and can lead to condensation and corrosion. The manufacturers of the liners include vent-sizing tables in their instructions. Liners should bear the label of a testing lab like Underwriters Laboratories (UL).

Title.3.4 Special venting considerations for gas

The American Gas Association (AGA) has devised a classification system for venting systems serving natural gas and propane appliances. This classification system assigns Roman numerals to four categories of venting based on whether there is positive or negative pressure in the vent and whether condensation is likely to occur in the vent.

	Negative-pressure Venting	Positive-pressure Venting
Non-condensing	I Combustion Efficiency 83% or less Use standard venting: masonry or Type B vent	III Combustion Efficiency 83% or less Use only pressurizable vent as specified by manufacturer
Condensing	II Combustion Efficiency over 83% Use only special condensing-service vent as specified by manufacturer	IV Combustion Efficiency over 83% Use only pressurizable condensing-service vent as specified by manufacturer

American Gas Association Vent Categories

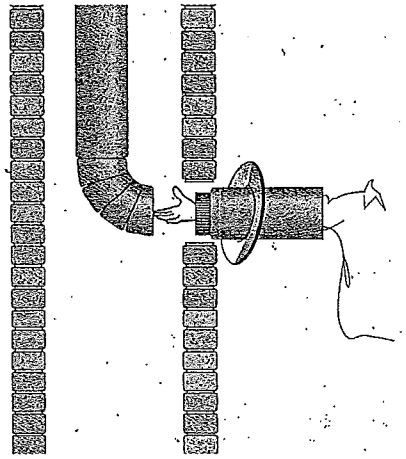
AGA venting categories: The AGA classifies venting by whether there is positive or negative pressure in the vent and whether condensation is likely.

A great majority of appliances found in homes and multi-family buildings are Category I, which have negative pressure in vertical chimneys with no condensation expected in the vent connector or chimney. Condensing furnaces are usually Category IV with positive pressure in their vent and condensation occurring in both the appliance and vent.

Venting fan-assisted furnaces and boilers

Newer gas-fired fan-assisted heating appliances control flue-gas flow and excess air better than atmospheric heaters, resulting in higher efficiency. These are non-condensing Category I heating appliances in the 80%-plus Annual Fuel Utilization Efficiency (AFUE) range. Because these units eliminate dilution air and have slightly cooler flue gases, chimneys should be carefully inspected to ensure that they are suitable for a possibly more corrosive flue-gas flow. The chimney should be relined when any of the following three conditions are present.

1. When the existing masonry chimney is unlined.
2. When the old clay or metal chimney liner is deteriorated.
3. When the new heater has a smaller input than the old one. In this case the new chimney should be sized to the new furnace or boiler and the existing water heater.



B-vent chimney liner: Double-wall Type B vent is the most commonly available chimney liner and is recommended over flexible liners. Rigid stainless-steel single-wall liners are also a permanent solution to deteriorated chimneys.

For gas-fired 80+ AFUE furnaces, a chimney liner should consist of:

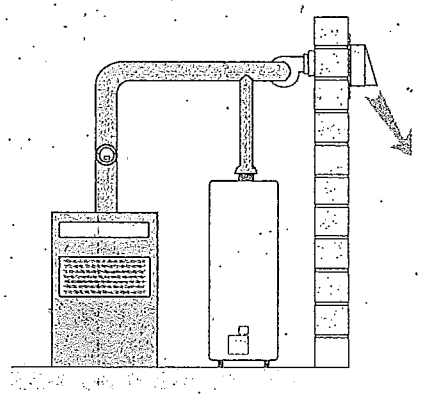
- Type-B vent
- A rigid or flexible stainless steel or aluminum liner
- A poured masonry liner

Power venters for sidewall venting

Power venters are installed just inside or outside an exterior wall and are used for sidewall venting. Power venters create a stable negative draft.

Many power venters allow precise control of draft through air controls on the their fans. Barometric draft controls can also provide good draft control when installed either on the common vent for two-appliances or on the vent connector for each appliance.

This more precise draft control, provided by the power venter and/or barometric damper, minimizes excess combustion and dilution air. Flue gas temperatures for power venters can be cooler than temperatures needed to power vertical atmospheric chimneys. Less excess air and cooler flue gases can improve combustion efficiency in many cases. However, the power venter must be installed by a technician familiar with adjusting the draft to each appliance.



Power venters: Sidewall venting with a power venter is an excellent option when the chimney is dilapidated or when no chimney exists.

A single power venter can vent both a furnace or boiler and also a water heater. Types B or L vent are good choices for horizontal vent piping. Use Type B for gas only.

Power venters should be considered as a venting option when:

- Wind, internal house pressures, or nearby buildings have created a stubborn drafting problem that other options can't solve.
- An existing horizontally vented appliance has weak draft and/or condensation problems.
- The cost of lining an unlined or deteriorated chimney exceeds the cost of installing a power venter with its horizontal vent.
- A floor furnace or other appliance with a long horizontal vent connector has backdrafting problems.

Table Title-9:Characteristics of Gas Furnaces and Boilers

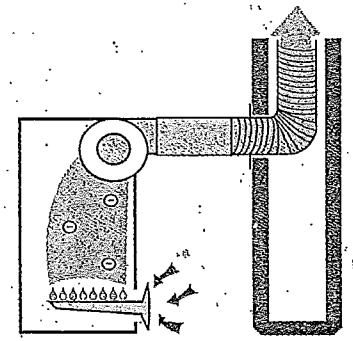
AFUE	Operating characteristics
70+	Category I, draft diverter, no draft fan, standing pilot, non-condensing, indoor combustion and dilution air
80+	Category I, no draft diverter, draft fan, electronic ignition, indoor combustion air
90+	Category IV, no draft diverter, draft fan, low-temperature plastic venting, positive draft, electronic ignition, condensing heat exchanger, outdoor combustion air is to be provided

Pressurized sidewall vents

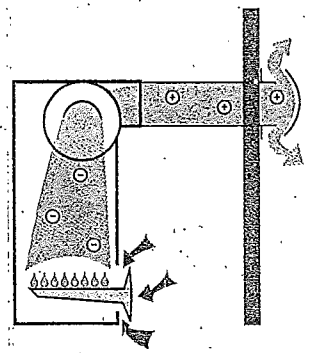
Sometimes, the manufacturer gives the installer a venting choice of whether to install a fan-assisted furnace or boiler into a vertical chimney (Category I) or as a positive-draft appliance (Category III), vented through a sidewall vent. Sidewall-vented fan-assisted furnaces and boilers may vent through B-vent or stainless-steel single-wall vent pipe. Pressurized sidewall vents must be airtight at the operating pressure. B-vent must be sealed with high-temperature silicone caulking or other approved means to air-seal its joints.

Some high-temperature positive-draft plastic vent pipe, used in horizontal installations, was recalled by manufacturers because of deterioration from heat and condensation. Deteriorated high-temperature plastic vent must be replaced by airtight stainless-steel vent piping or B-vent.

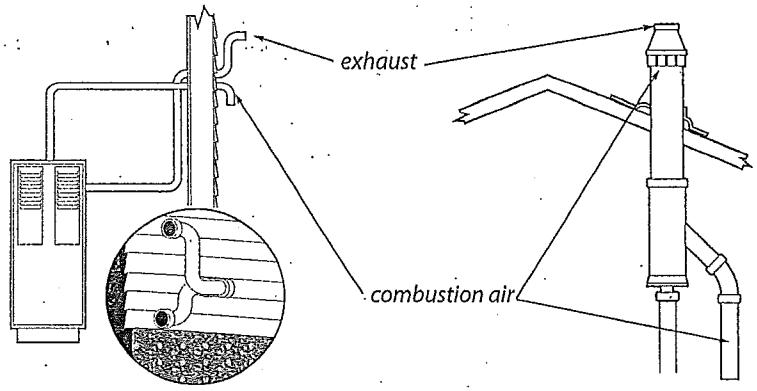
Existing fan-assisted appliances may have problems with weak draft and condensation when vented horizontally. Horizontally vented, fan-assisted furnaces and boilers may require a power venter to create adequate draft.



Fan-assisted gas heaters with vertical chimneys: These 80% AFUE central heaters are almost always vented into atmospheric chimneys, which may need to be relined.



Fan assisted heaters with sidewall vents: Sometimes these appliances are vented through a side wall through airtight plastic or stainless-steel vent pipe.



Condensing furnace venting: The two common types of termination for plastic condensing vents are separate pipes or a concentric fitting. Vents going through the roof are preferred for their being more resistant to tampering and damage.

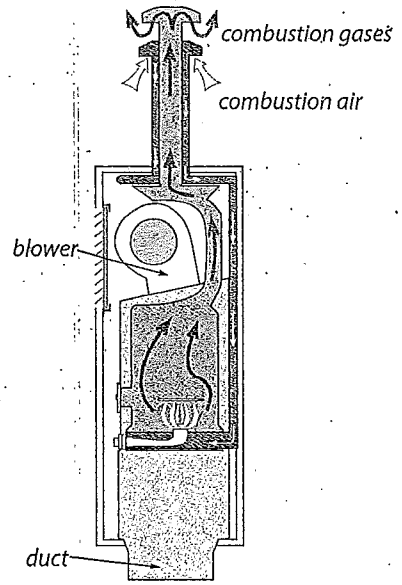
Condensing-furnace venting

Condensing furnaces with 90+ AFUE are vented horizontally or vertically through non-cellular PVC Schedule 40 pipe. The vent is pressurized, making it Category IV. Vent piping should be sloped back toward the appliance, so the condensate can be drained and treated if necessary.

Combustion air is supplied from outdoors through a sealed plastic pipe or from indoors. Outdoor combustion air is required, and most condensing furnaces are equipped for outdoor combustion air through a dedicated inlet pipe. This combined combustion-air and venting system is referred to as direct-vent or sealed-combustion.

Title.3.5 Manufactured House furnace venting

Manufactured houses require furnaces designed and approved for use in manufactured houses. Manufactured House furnaces are direct-vented, sealed-combustion units that require an outdoor source of combustion air. Manufactured House furnaces may be atmospheric (no draft fan) or fan-assisted. The fan may draw combustion air from a concentric space created by the double-wall chimney or from a duct connected to the ventilated crawl space. Manufactured House furnaces often have a manufactured chimney that includes a passageway for admitting outdoor combustion air supply.



Manufactured house furnace venting: Manufactured house chimneys and chimney caps must be installed perfectly vertical and the cap must be securely attached to avoid venting problems and tripping of the pressure switch.

When replacing standard manufactured houseanufactured house furnaces, note the differences between the old furnace and new in the way each supplies itself with combustion air, and follow manufacturer's installation instructions exactly. The chimney assembly must often be replaced when the furnace is replaced. The roof jack may need to be replaced, and the hole for the chimney moved. It is essential that the chimney be vertical and that the chimney cap not be tipped. Many callbacks are caused by chimney and chimney-cap alignment. See "Heating appliance replacement" on page 230.

Manufacturers now produce condensing furnaces that are HUD-approved for use in manufactured housing. These positive-draft furnaces may eliminate venting and combustion-air problems, common to manufactured house furnaces, because of their robust positive draft and negatively pressurized combustion-air vent.

Title.3.6 Wood-heating venting and safety

Wood heating is a popular and effective auxiliary heating source for homes. However, wood stoves and fireplaces can cause indoor-air-pollution and fire hazards. As part of health and safety work, it's important to inspect wood stoves to assess potential hazards.

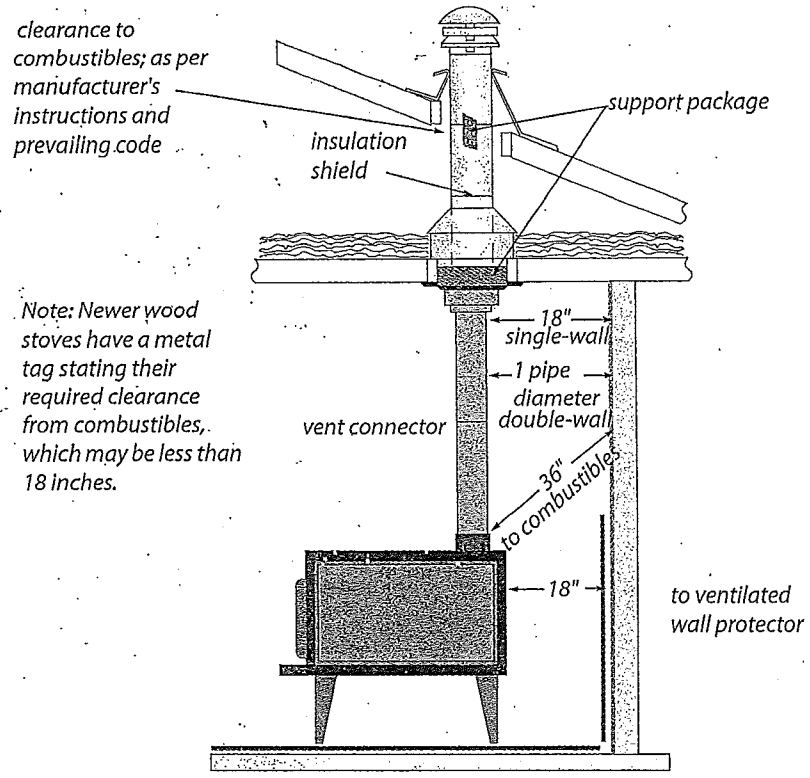
Stoves that are listed by a testing agency like Underwriters Laboratory have a tag stating their clearance from combustibles. Unlisted stoves should conform to the minimum clearances shown here. Ventilated wall protectors, described in NFPA codes and standards, generally allow the listed clearance to be reduced by half. See "Venting combustion gases" on page 109.

All components of wood-stove venting systems should be approved for use with wood stoves. Chimney sections penetrating floor, ceiling, or roof should have approved thimbles, support packages, and ventilated shields to protect combustible materials from high temperatures.

- ✓ Inspect stove, vent connector, and chimney for correct clearances from combustible materials as listed in NFPA 211. Ensure that stove is sitting on a noncombustible floor.
- ✓ Inspect vent connector and chimney for leaks, and seal leaks with a high-temperature sealant designed for use with metal or masonry.
- ✓ Inspect chimney and vent connector for creosote build-up, and clean chimney if creosote build-up exists.
- ✓ Inspect the house for soot on seldom-cleaned horizontal surfaces. If soot is present or if the blower door indicates leakage, inspect and replace the gasket on the wood-stove door if appropriate. Seal other air leaks, and take steps to

improve draft as necessary, to reduce indoor smoke emissions.

- ✓ Inspect and clean stack damper and/or combustion air intake if necessary.
- ✓ Check catalytic combustor for repair or replacement if the wood stove has one.
- ✓ Assure that heat exchanger surfaces and flue passages within the wood stove are free of accumulations of soot or debris.



Wood-stove installation: Wood-stove venting and clearances are vitally important to wood-burning safety. Read and follow all manufacturer's instructions for the stove and its venting components.

TITLE.4 COMBUSTION AIR

Combustion appliances need a source of combustion air while they are operating. The exception to this rule is sealed-combustion or direct-vent appliances, which bring in their own outdoor air through a dedicated pipe. Common combustion-air and venting problems, combined with the complexity of codes and recommendations on combustion air argue strongly in favor of installing direct-vent appliances.

A combustion-air source must deliver between 17 cfm and 600 cfm. The lower end of this scale represents small furnaces and space heaters, and the upper end represents wood-burning fireplaces or large boilers in multifamily buildings.

Table Title-10:CFM 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

The goal of assessing combustion air is to verify that there is an adequate supply, and to ensure that a combustion-air problem isn't creating CO or interfering with combustion.

A combustion appliance zone (CAZ) is an area containing one or more combustion appliances. Combustion appliance zones are classified as either un-confined spaces or confined spaces. Un-confined spaces are open or connected to enough building volume and air leakage to provide combustion air. For un-confined spaces, combustion air comes from leaks within the combustion zone. Confined spaces are combustion zones with a closed door and sheeted walls and ceiling that create an air barrier between the appliance and other indoor spaces. For confined spaces, combustion air must come from outside the combustion zone. A relatively airtight home is itself a confined space and must bring combustion air in from outdoors.

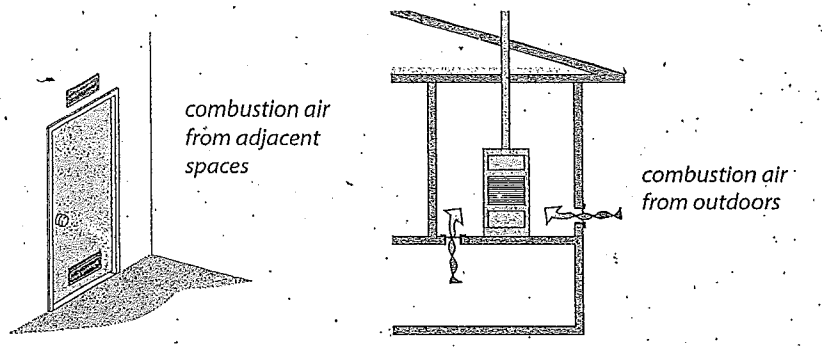
Combustion air is supplied to the combustion appliance in four ways.

1. To an un-confined space through leaks in the building.
2. To a confined space through an intentional opening or openings between the CAZ and other indoor areas where air leaks 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 combustion appliance through a duct. Appliances with direct combustion-air ducts are called sealed-combustion or direct-vent appliances.

Title.4.1 Un-confined-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. See "CAZ Combustion Safety Test" on page 103.

Heating System Specifications



Passive combustion-air options: Combustion air can be supplied from adjacent indoor spaces or from outdoors. Two openings into the combustion zone are preferred

Title.4.2 Confined-space combustion air

A combustion appliance located in a confined space, surrounded by materials that are relatively effective air barriers, may need a vent connecting it to an adjacent indoor area, a crawl space, or outdoors. A confined space is defined by the IFGC as a room containing one or more combustion appliances that has less than 50 cubic feet of volume for every 1000 Btu per hour of appliance input.

However, the code definition aside, if the mechanical room is connected to adjacent spaces through large air passages like floor-joist spaces, the combustion appliance zone is not actually a confined space even though it has a door separating it from other indoor spaces. This connection between the combustion zone and other spaces could be confirmed by pressure testing. See "Very simple pressure tests" on page 214. On the other hand, if the home is unusually airtight, the combustion zone may be unable to provide adequate combustion air, even when the combustion zone is larger than the minimum confined-space room volume, defined earlier.

Combustion air from adjacent indoor spaces is usually preferred over outdoor combustion air because of the possibility of wind

depressurizing the combustion zone. However, if there is a sheltered outdoor space from which to draw combustion air, this can be a superior choice. Outdoor air is generally cleaner and dryer than indoor air, and a connection to the outdoors makes the confined space less affected by indoor pressure fluctuations.

For every 1,000 Btu/hour input, a combustion-air vent to another indoor space should have a total of 2 square inches (in^2) of net free area. Net free area is smaller than actual vent area and takes the blocking effect of louvers into account. Metal grills and louvers provide 60% to 75% of their area as net free area while wood louvers provide only 20% to 25%.

Here is an example of sizing combustion air to another indoor area. The furnace and water heater are located in a confined space. The furnace has an input rating of 100,000 Btu/hour. The water heater has an input rating of 40,000 Btu/hour. Therefore, there should be 280 in^2 of net free area of vent between the mechanical room and other rooms in the home. ([100,000 + 40,000] ÷ 1,000 = 140 x 2 in^2 = 280 in^2).

Combustion-air vent location

In confined spaces or airtight homes where outdoor combustion air is needed, prefer low vents to high ones. A combustion-air vent into an attic may depressurize the combustion zone in some cases because the attic tends to be a depressurized zone where air is being exhausted. Instead, connect the combustion zone to a ventilated crawl space or directly to outdoors. The vent opening should have one square inch (1 in^2) of net free area for each 3000 Btu/hour of appliance input.

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

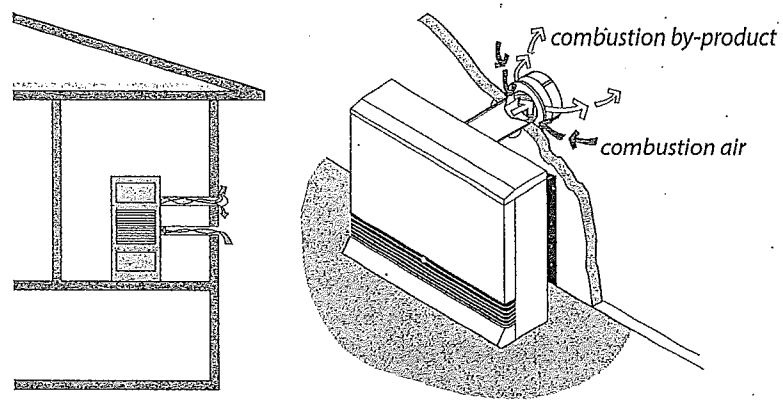
Heating System Specifications

Title.4.3 Proprietary combustion-air systems

Any passive combustion-air inlet can potentially depressurize the combustion zone because pressure from wind or stack effect can extract air from the combustion zone instead of supplying air. Several proprietary systems are available that offer superior assurance of adequate combustion air compared to passive vents. These systems are particularly appropriate in confined areas suffering from: stubborn draft problems, combustion-zone depressurization, inadequate combustion-air, or a combination of these problems.

Direct combustion-air supply

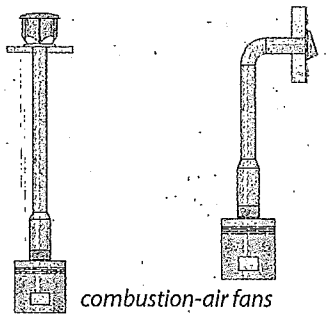
Many new combustion appliances are designed for direct outdoor-air supply to the burner. These include most condensing furnaces, manufactured house furnaces, manufactured house water heaters, many space heaters, and some non-condensing furnaces and boilers. Some appliances give installers a choice between indoor and outdoor combustion air. Outdoor combustion air is usually preferable in order to prevent the depressurization problems, combustion-air deficiencies, and draft problems.



Sealed combustion: Sealed combustion appliances draw combustion air in and exhaust combustion by-products, either using a draft fan or by pressure difference created by the fire.

Fan-powered combustion air

At least one company manufactures a proprietary combustion-air system that introduces outdoor air through a fan that sits on the floor and attaches to a combustion-air duct to outdoors.



Fan-powered combustion air: Fans for supplying combustion air can help solve stubborn combustion air and drafting problems.

Direct combustion air supply to oil-fired heaters

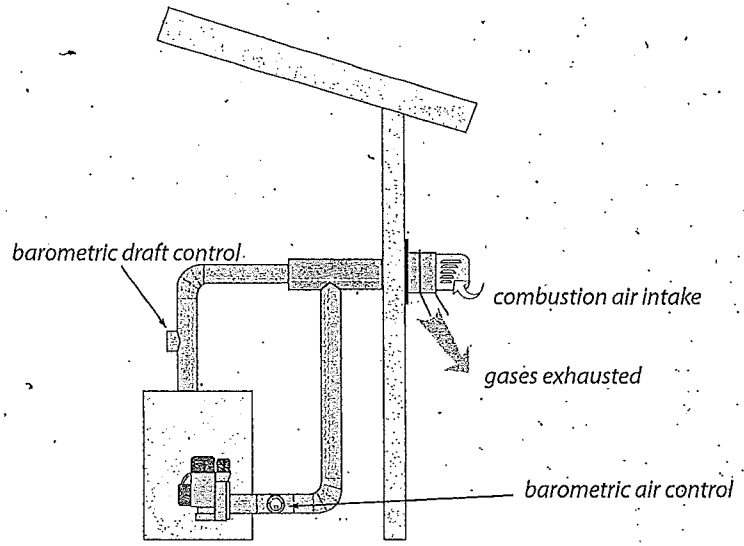
Oil furnaces and boilers can be either purchased new or may be retrofitted with a sealed combustion-air and venting system. The burner fan is fitted with an air boot that feeds the burner with outdoor air. The amount of outdoor air fed to the burner is usually regulated by a barometric draft control.

Combustion air combined with power venting

Both gas- and oil-fired heating systems can be supplied with combustion air by proprietary systems that combine power venting with powered combustion-air supply. The combustion air simply flows into the combustion zone from outdoors, powered by the power venter. If the appliance has a power burner, like a gun-type oil burner, a boot may be available to supply combustion air directly to the burner as shown here.

TITLE.5 FORCED-AIR SYSTEM STANDARDS

The overall system efficiency of an oil or gas forced-air heating system is affected by blower operation, duct leakage, balance between supply and return air, and duct insulation levels. Retrofits to the forced-air system generally are more cost-effective than retrofits to the heating unit itself.



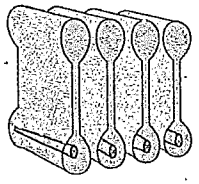
Sealed-combustion, oil-heating retrofit: Direct supply of combustion air to gun-type oil burners is a good option for shielding the oil burner from house pressures.

Title.5.1 Inspecting furnace heat exchangers

Leaks in heat exchangers are a common problem, causing the flue gases to mix with house air. Ask clients about respiratory problems, flue-like symptoms, and smells in the house when the heat is on. Also, check around supply registers for signs of soot, especially with oil heating. All furnace heat exchangers should be inspected as part of weatherization. Consider using one or more of the following 7 general options for evaluating heat exchangers.

1. Look for rust at exhaust ports and vent connector.
2. Look for flame impingement on the heat exchanger during firing.
3. Observe flame movement, change in chimney draft, or change in CO reading as blower is turned on and off.
4. Look for flame-damaged areas near the burner flame.

5. Measure the flue-gas oxygen concentration before the blower starts and just after it has started. There should be no more than a 1% change in the oxygen concentration.
6. Examine the heat exchanger, shining a bright light on one side and looking for light traces on the other using a mirror to peer into tight locations.
7. Employ chemical detection techniques, following manufacturer's instructions.



Furnace heat exchangers: Although no heat exchanger is completely airtight, it should not leak enough to display the warning signs described here.

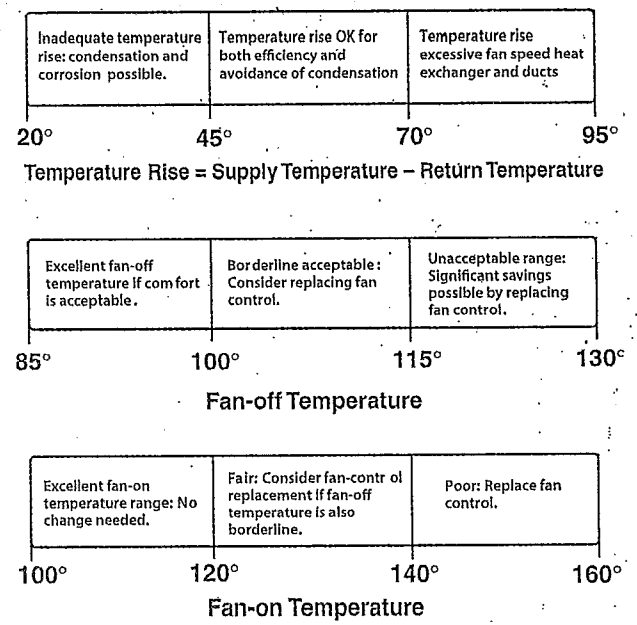
Heat exchangers with either rust through penetrations or cracks are to be considered non-serviceable and defective.

Title.5.2 Furnace operating standards

The effectiveness of a furnace depends on its temperature rise and flue-gas temperature. For efficiency you want a low temperature rise and low flue-gas temperature. However, you must maintain a minimum flue-gas temperature to prevent corrosion in the venting. Apply the following furnace-operation standards to maximize the heating system's seasonal efficiency and safety.

- Check temperature rise after 5 minutes of operation. Refer to manufacturer's nameplate for acceptable temperature rise (supply temperature minus return temperature). The temperature rise should be between 40°F and 90°F (or PMI) with the lower end of this scale being preferable for energy efficiency.
- All forced-air heating systems must deliver supply air and collect return air only within the intentionally heated portion of the house. Taking return air from an un-heated area of the house such as an unoccupied basement is not acceptable.

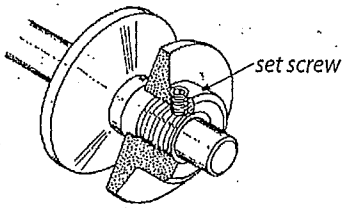
Table Title-11:Furnace Operating Parameters



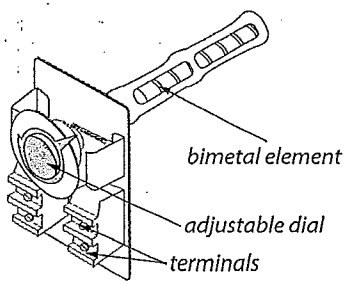
- The fan-off temperature should be between 90° and 100° F, with the lower end of the scale being preferable for maximum efficiency.
- The fan-on temperature should be no less than 120° F.
- The high-limit controller should shut the burner off before the furnace temperature reaches 200°F.
- On time-activated fan controls, verify that the fan is switched on within two minutes of burner ignition and is switched off within 2.5 minutes of the end of the combustion cycle.

If the heating system does not conform to these standards, consider the following improvements.

- ✓ Clean or change dirty filters
- ✓ Clean the blower, increase fan speed, and improve ducted air circulation. See "Improving duct-system airflow" on page 139.
- ✓ Adjust fan control to conform to the above standards, or replace the fan control if adjustment fails. Many fan controls on modern furnaces aren't adjustable.
- ✓ Adjust the high-limit control to conform to the above standards, or replace the high-limit control.



Adjustable drive pulley: This adjustable pulley moves back and forth allowing the belt to ride higher or lower, adjusting the blower's speed.



Fan/limit control: Turns the furnace blower on and off, according to temperature. Also turns the burner off if the heat exchanger gets too hot (high limit).

Title.5.3 Duct air-tightness standards

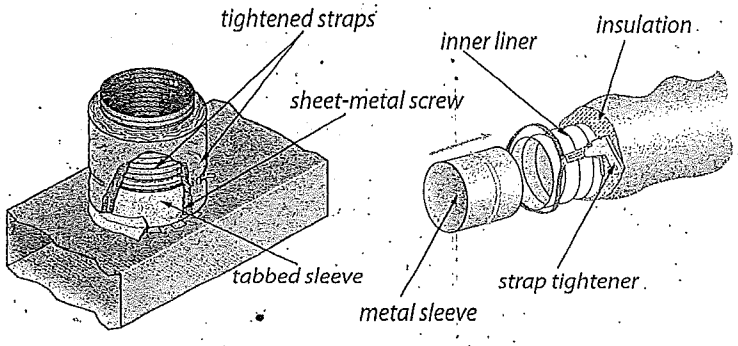
Duct air leakage is a major energy-waster in homes where the ducts are located outside the home's thermal boundary in a crawl space, attic, attached garage, or leaky basement. When the weatherization job will leave these intermediate zones outside the thermal boundary, duct air-sealing is cost-effective.

Ducts should be tested to determine how much they leak before any duct air sealing is performed. For information on duct testing, see "Duct airtightness testing" on page 221.

Duct leakage sites

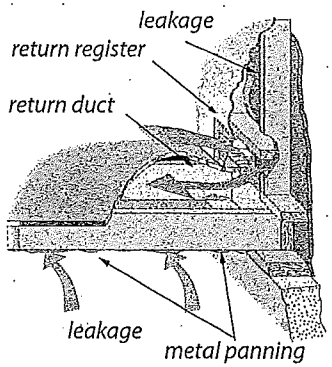
Ducts located outside the thermal boundary or in an intermediate zone like a ventilated attic or crawl space should be sealed. The following is a list of duct-leak locations in order of their relative importance. Leaks nearer to the air handler see higher pressure and are more important than leaks further away.

- ✓ First, seal all return leaks within the combustion zone to prevent this leakage from depressurizing the combustion zone and causing backdrafting.
- ✓ Plenum joint at air handler: These joints may have been difficult to fasten and seal because of tight access. Go the extra mile to seal them airtight by caulking this important joint even if it requires cutting an access hole in the plenum. (Avoid mastic and fabric mesh here for future access—furnace replacement, for example.)
- ✓ Joints at branch takeoffs: These important joints should be sealed with a thick layer of mastic. Fabric mesh tape is a plus for new installations or when access is easy.
- ✓ Joints in sectioned elbows: Known as gores, these are usually leaky.
- ✓ Tabbed sleeves: Attach the sleeve to the main duct with 3-to-5 screws and apply mastic plentifully.
- ✓ Flexduct-to-metal joints: Apply mastic to the metal sleeve. Clamp the flexduct's inner liner over this strip of mastic with a plastic strap, using a strap tensioner. Clamp the insulation and outer liner with another strap.
- ✓ Support ducts and duct joints with duct hangers where needed.
- ✓ Seal leaky joints between building materials composing cavity-return ducts, like panned floor cavities and furnace return platforms.



Flexduct joints: Flexduct itself is usually fairly airtight, but joints, sealed improperly with tape, can be very leaky. Use methods shown here to make flexduct joints airtight.

- ✓ Seal leaky joints between supply and return registers and the floor, wall, and ceiling to which they are attached.
- ✓ Consider sealing off supply and return registers in unoccupied basements.
- ✓ Seal penetrations made by wires or pipes traveling through ducts. Even better: move the pipes and wires and patch the holes.

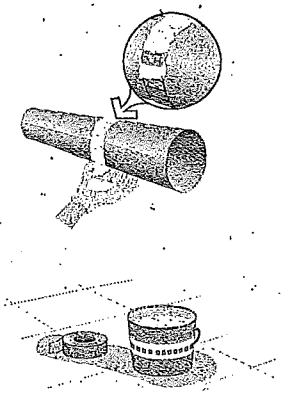


Panned floor joists: These return ducts are often very leaky and may require removing the panning to seal the cavity.

Materials for duct air-sealing

Duct mastic is the preferred duct-sealing material because of its superior durability and adhesion. Apply at least $^1/_{16}$-inch thick and use reinforcing mesh for all joints wider than $^1/_8$ inch or joints that may experience some movement.

Siliconized acrylic-latex caulk is acceptable for sealing joints in panned joist spaces, used for return ducts.



Duct mastic: Mastic, reinforced with fabric webbing, is the best choice for sealing ducts.

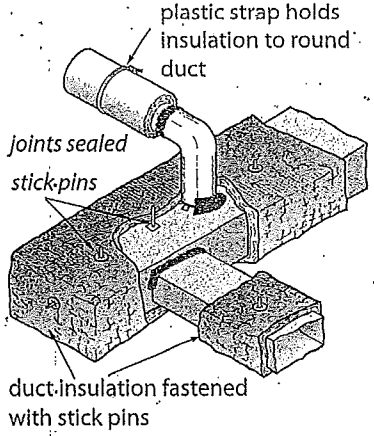
Joints should rely on mechanical fasteners to prevent joint movement or separation. Tape should never be expected to hold a joint together nor expected to resist the force of compacted insulation or joint movement. Aluminum foil or cloth duct tape are not good materials for duct sealing because their adhesive often fails after a short time.

Title.5.4 Duct insulation

Insulate supply ducts that run through unconditioned areas outside the thermal boundary such as crawl spaces, attics, and attached garages with a minimum of R-11 vinyl- or foil-faced duct insulation. Don't insulate ducts that run through conditioned areas unless they cause overheating in winter or condensation in summer. Follow the best practices listed below for installing insulation.

- Always perform necessary duct sealing before insulating ducts.
- Insulation should cover all exposed supply ducts, without significant areas of bare duct left uninsulated.

- Insulation should be fastened by mechanical means such as stick pins, twine, or plastic straps: Tape can be effective for covering joints in the insulation to prevent air convection, but tape will usually fail if expected to resist the force of the insulation's compression or weight.



Duct insulation: Supply ducts, located in unheated areas, should be insulated to the current standard as stated in the Priority List.

Title.5.5 Improving duct-system airflow

Inadequate airflow is a common cause of comfort complaints. The airflow capacity of the air handler may be evaluated in relationship to the capacity of the furnace or air conditioner. For combustion furnaces, the heat exchanger air flow should be adjusted to manufacturer's specifications. Central air conditioners and heat pumps should deliver 400 cfm of airflow per ton of cooling capacity. See "Furnace replacement" on page 144 for more information about evaluating airflow.

When the air handler is on there should be a strong flow of air out of each supply register, providing its balancing damper is properly adjusted. Low airflow may mean that a branch is blocked or separated, or that return air is not sufficient. When low airflow is a problem, consider the following obvious improvements.

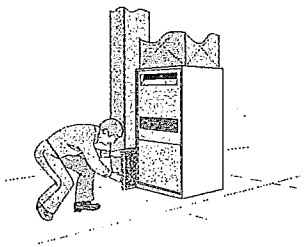
- ✓ Clean or change filter.
- ✓ Clean furnace blower.
- ✓ Clean air-conditioning or heat pump coil. (If the blower is dirty, the coil is probably also dirty).
- ✓ Increase blower speed.

- ✓ Lubricate blower motor (PMI), and check tension and condition of drive belt and the condition of motor and blower pulleys.
- ✓ Repair or replace bent, damaged, or restricted registers.

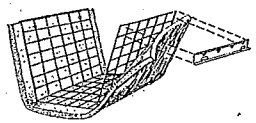
Filter and blower maintenance

A dirty filter can reduce airflow significantly. Take action to prevent filter-caused airflow restriction by the following steps:

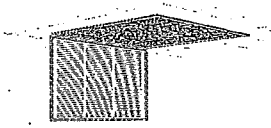
- Insure that filters are easy to change or clean.
- Stress to the client the importance of changing or cleaning filters, and suggest to the client a regular filter-maintenance schedule.
- Clean the blower. This task involves removing the blower and removing dirt completely with a brush or water spray.
- Special air-cleaning filters offer more resistance than standard filters, especially when saturated with dust. Avoid using them, unless you test for airflow after installation.



Panel filter installed in filter slot in return plenum



Washable filter installed on a rack inside the blower compartment



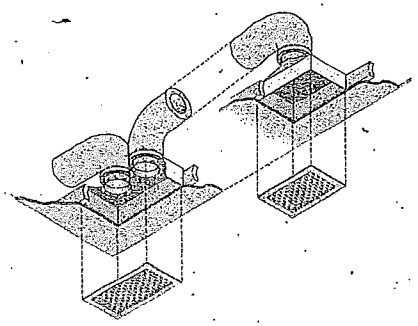
Panel filter installed in return register

Furnace filter location: Filters are installed on the return-air side of forced air systems. Look for them in one or more of the following places.

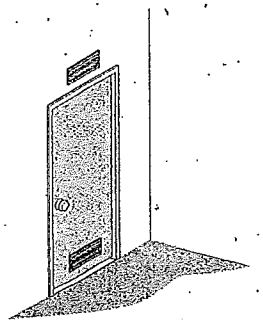
Duct improvements to increase airflow and improve comfort

Consider the following improvements in response to customer complaints and conditions you observe during a thorough duct inspection. Unbalanced airflow through ducts can pressurize or depressurize rooms, leading to increased air leakage through the building shell. For information on how to test these room pressures, see "Measuring duct-induced pressures" on page 223. Consider the following duct changes to increase system airflow and reduce the imbalance between supply and return.

- Remove obstructions to registers and ducts such as rugs, furniture, and objects placed inside ducts, like children's toys and water pans for humidification.
- Remove kinks from flex duct, and replace collapsed flex duct and fiberglass duct board.
- Install additional supply ducts and return ducts as needed to provide conditioned air throughout the building, especially into additions to the building.
- Undercut bedroom doors, especially in homes with single return registers.
- Install a transfer grille between the bedroom and main body of house to improve airflow.
- Retrofit jumper ducts, composed of one register in the bedroom, one register in the central return-air zone, and a duct in between (usually running through an attic or crawl space).
- Install registers and grilles where missing.



Jumper ducts can bring air from a restricted area of the home back to a main return register.



Installing grills in doors or through walls allows return air to escape from bedrooms

Restricted return air: Return air is often restricted, requiring a variety of strategies to relieve the resulting house pressures and low system airflow. Installing an additional return duct directly into the air handler is a preferred strategy.

New ducts

New ducts should not be installed in unconditioned spaces unless absolutely necessary. If ducts are located in unconditioned spaces, joints should be sealed and the ducts insulated as described previously. See "Duct air-tightness standards" on page 135 and "Duct insulation" on page 138.

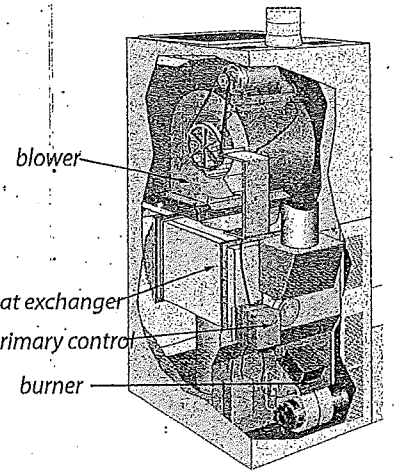
New ducts must be physically connected to the existing distribution system or to the furnace. Install balancing damper in each new branch duct. Registers should terminate each new supply or return branch duct.

TITLE.6 HEATING-SYSTEM REPLACEMENT SPECIFICATIONS

All heating replacement systems must have dedicated combustion air whenever possible. Don't assume that older furnaces and boilers are inefficient until testing them. During testing, make appropriate efforts to repair and adjust the existing fur-

nace or boiler, before deciding to replace it. Replacement parts like gas valves and controls for older heating units are commonly available.

Heating appliances are often replaced when the cost of repairs and retrofits exceeds one half of estimated replacement costs. Estimate the repair and retrofit costs and compare them to replacement cost before deciding between retrofit and replacement.



Oil-fired downflow furnaces: Their design hasn't changed much in recent years except for the flame-retention burner.

Replacements should only be considered if repairs are impractical or expensive or if a replacement shows a savings to investment ratio (SIR) of 1.0 or better as modeled by NEAT. Replacement should be considered if existing furnace falls outside of the PA parameters for health, safety and efficiency."

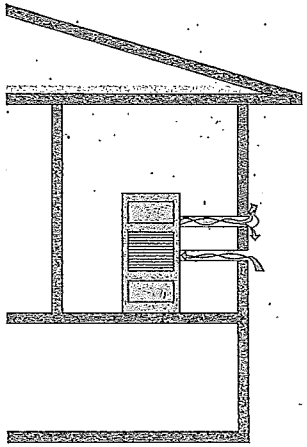
New heating appliances must be installed to manufacturer's specifications or current code requirements, whichever is more stringent, and follow all applicable building and fire codes. Replacement gas heating appliances should have a minimum Annual Fuel Utilization Efficiency (AFUE) of 90% and be installed as a two-pipe direct-vent or concentric flue system for exhaust and combustion air. Combustion air must be derived from outdoors. These high-efficiency furnaces are direct-vent, sealed-combustion units with health and safety benefits in addition to their superior efficiency and significantly lower fuel usage. Boilers and oil-fired units must have a minimum AFUE of 82%.

Heat load calculations, used to size the new heater, should account for reduced heating loads, resulting from insulation and air-sealing work. Heat load calculations should follow Manual J procedures.

Specifications are presented here first according to fuel-type—oil or gas—then by distribution type: forced air, hot water, or steam.

Title.6.1 Furnace replacement

The overall goal of furnace replacement is to provide a forced-air heating system in virtually new condition, even though existing supply and return ducts may remain. Any design flaws in the ducts and registers should be diagnosed and corrected during the furnace replacement.



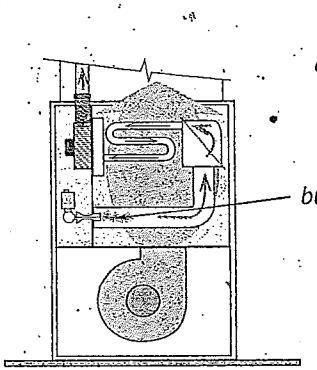
Sealed combustion heaters: Sealed combustion furnaces and boilers prevent the air pollution and house depressurization caused by some open-combustion heating units.

Observe the following standards in furnace installation.

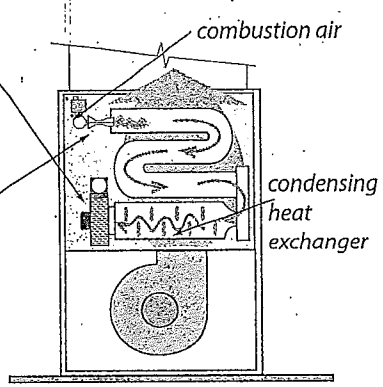
Furnace should be sized to the approximate heating load of the home, accounting for post-weatherization heat-loss reductions.

- ✓ Installer should add return ducts or supply ducts as part of furnace replacement to improve air distribution, to eliminate duct-induced house pressures, and to establish acceptable values for static pressure and temperature rise.
- ✓ Supply and return plenums should be mechanically fastened with screws and sealed to air handler with mastic and fabric mesh tape to form an essentially airtight connection on all sides of these important joints.
- ✓ All ducts should be sealed as described in *"Duct air-tightness standards" on page 135.*

- ✓ Temperature rise (supply temperature minus return temperature) must be within manufacturer's specifications or no higher than 90° F.
- ✓ High limit should stop burner operation within 10% of manufacturer's high limit. Furnace must not cycle on high limit.



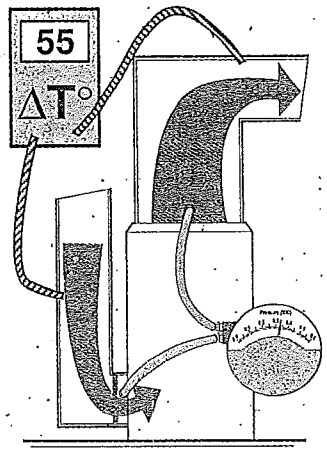
80+ gas furnace: An 80+ furnace has a restrictive heat exchanger, an inducer, and has no draft diverter or standing pilot.



90+ gas furnace: A 90+ furnace has a condensing heat exchanger and an inducer for pulling combustion gases through its more restrictive heat exchange system and establishing a strong positive draft.

- ✓ Fan control should be set to activate fan at no less than 120° F and deactivate it at 90° to 100° F. Slightly higher settings are acceptable if these recommended settings cause a comfort complaint.

- ✓ Static pressure, measured in both supply and return plenums should be within manufacturer's specifications.
- ✓ Blower should not be set to operate continuously.
- ✓ Seal holes through the jacket of the air handler with mastic or foil tape.
- ✓ Filters should be held firmly in place and provide complete coverage of blower intake or return register. Filters should be easy to replace.



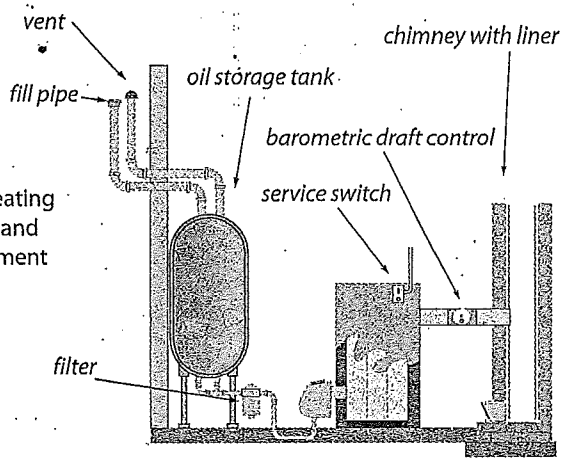
Static pressure and temperature rise: Testing static pressure and temperature rise across the new furnace should verify that the duct system isn't restricted. The temperature rise is specified by the manufacturer on the name plate of the Furnace.

Title.6.2 Oil-fired heating installation

The overall goal of the system replacement is to provide an oil-fired heating system in virtually new condition, even though components like the oil tank, chimney, piping, or ducts may remain. Any maintenance or repair on these remaining components should be considered part of the job. Any design flaws related to the original system should be diagnosed and corrected during the heating-system replacement.

- ✓ Examine existing chimney and vent connector for suitability as venting for new appliance. The vent connector may need to be re-sized and the chimney may need to be re-lined.
- ✓ Check clearances of heating unit and its vent connector to nearby combustibles, by referring to NFPA 31.

- ✓ Check for the presence of a control that will interrupt power to the burner in the event of a fire.
- ✓ Test oil pressure to verify compliance with manufacturer's specifications.
- ✓ Test transformer voltage to verify compliance with manufacturer's specifications.



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

- ✓ Install digital double set-back thermostat, if possible.
- ✓ Adjust oxygen, flue-gas temperature, and smoke number to match manufacturer's specifications.
- ✓ Install new fuel filter and purge fuel lines as part of new installation.
- ✓ Bring tank and oil lines into compliance with NFPA 31, Chapters 2 and 3.
- ✓ Check for emergency shut-off, installed in the living space.
- ✓ See *"Combustion Standards for Oil-Burning Appliances" on page 96.*

Title.6.3 Gas-fired heating installation

The overall goal of the system replacement is to provide a gas-fired heating system in virtually new condition, even though existing components like the gas lines, chimney, water piping, or ducts may remain. Any necessary maintenance or repair on these remaining components should be considered part of the installation. Any design flaws in the original system should be diagnosed and corrected during the heating-system replacement.

The new furnace should have an Annual Fuel Utilization Efficiency (AFUE) of at least 90%.

- ✓ Check clearances of heating unit and its vent connector to nearby combustibles, according to the International Fuel Gas Code (IFGC). See"Venting and Combustion Air Standards" on page 110 for more information about National Fire Protection Association (NFPA) Standards.
- ✓ Clock gas meter to insure correct gas input. See "Measuring BTU input on natural gas appliances" on page 92.
- ✓ If necessary, measure gas pressure, and increase or decrease gas pressure to obtain proper gas input.
- ✓ Test gas water heater to insure that it vents properly after installation of a sealed-combustion, 90+ AFUE furnace. If necessary power vent, reline chimney, move or replace water heater to assure proper venting.
- ✓ Install digital double set-back thermostat, if possible.
- ✓ Follow manufacturer's venting instructions along with the IFGC to establish a proper venting system.
- ✓ Ensure proper sediment trap (drip leg) on gas line.
- ✓ Ensure that the new heating appliance meets specifications on page 91.
- ✓ Ensure that the new unit is properly sized as per ACCA Manual J protocols.

Title.6.4 Electric-furnaces and electric baseboard heat

The purpose of servicing electric furnaces and electric baseboard heat is to clean the heat exchangers and blower. Sealing ducts is also very important.

- ✓ Check and clean thermostat.
- ✓ Clean and lubricate blower if appropriate.
- ✓ Clean or replace all filters.
- ✓ Vacuum and clean housing around electric elements, if dirty.
- ✓ Clean fins on electric-baseboard systems, if applicable.
- ✓ Take extra care in duct sealing and duct airflow improvements for electric furnaces because of the high cost of electricity. See "Duct air-tightness standards" on page 135 and "Improving duct-system airflow" on page 139.
- ✓ Verify that safety limits, temperature rise, and static pressure conform to manufacturer's specifications.

TITLE.7 HOT-WATER AND STEAM STANDARDS

The following standards refer to hot-water and steam systems commonly found in single-family homes. Hot-water and steam systems found in multifamily buildings are generally more complex and should be tested and evaluated by professionals experienced in their operation.

Title.7.1 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. There are more ways for performance and efficiency to deteriorate in boilers compared to furnaces.

Specifically these are:

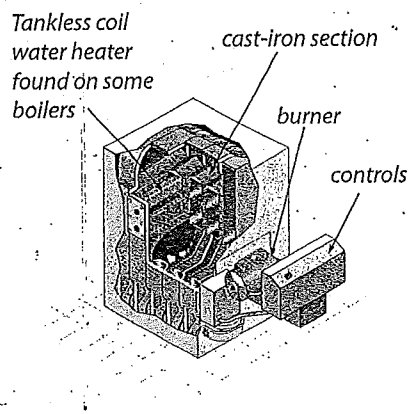
- Corrosion, scaling, and dirt on the water side of the heat exchanger.
- Corrosion, dust, and dirt on the fire side of the heat exchanger.
- Excess air during combustion from air leaks and incorrect fuel-air mixture.
- Off-cycle air circulation through the firebox and heat exchanger, removing heat from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

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

- ✓ Check for leaks on the boiler, around its fittings, or on any of the distribution piping connected to the boiler.
- ✓ Clean fire side of heat exchanger of noticeable dirt.
- ✓ Check doors and cleanout covers for air leakage. Replace gaskets or replace warped doors or warped cleanout covers.
- ✓ Drain water from the boiler drain until the water flows clean on steam boilers only!

Title.7.2 Hot-water space-heating

Hot-water heating is generally a little more efficient than forced-air heating and considerably more efficient than steam heating. The most significant energy problems in hot-water systems are poor steady-state efficiency, off-cycle flue losses robbing heat from stored water, and boilers operating at too high a water temperature.



Cast-iron sectional boilers: The most common boiler type for residential applications.

Consider the following safety checks and improvements.

- ✓ Confirm the existence of a 30-psi-rated pressure-relief valve for hot-water, and a 15-psi-rated pressure relief valve for steam boilers. 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.

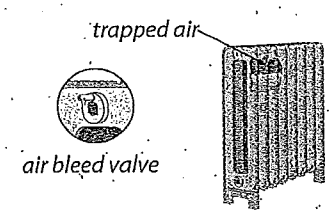
Note: You can recognize a hot-water boiler by its expansion tank, located somewhere near the boiler. This cylindrical tank provides an air cushion to allow the system's water to expand and contract as it is heated and cooled without discharging through the relief valve.

- ✓ Make sure that the expansion tank isn't waterlogged or sized too small for the system.
- ✓ If rust is observed in venting, verify that return water temperature is above 130° F for gas and above 150° F for oil, to prevent acidic condensation.
- ✓ High-limit control should deactivate burner between 180° 200° F on boilers without a domestic coil.

- ✓ Lubricate circulator pump(s) if necessary.

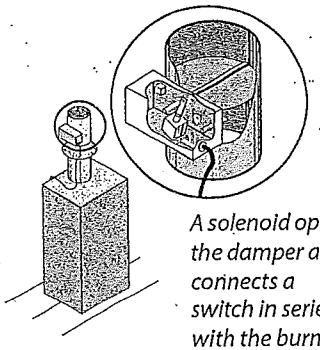
Consider the following efficiency improvements.

- ✓ Repair water leaks in the system.
- ✓ Boiler should not have low-limit control for maintaining a minimum boiler-water temperature, unless the boiler is heating domestic water in addition to space heating.
- ✓ Bleed air from radiators and piping through air vents on piping or radiators on hot water systems. Most systems have an automatic fill valve. If there is a manual fill valve for refilling system with water, it should be open to push water in and air out, during air purging on hot water systems.



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.

- ✓ Consider installing outdoor reset controllers on larger boilers to regulate water temperature, depending on outdoor temperature.
- ✓ After control improvements like two-stage thermostats or reset controllers, verify that return water temperature is high enough to prevent condensation and corrosion in the boiler and flue as noted previously.
- ✓ Vacuum and clean fins of fin-tube convectors if you notice dust and dirt there.
- ✓ Insulate all supply piping, passing through unheated



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

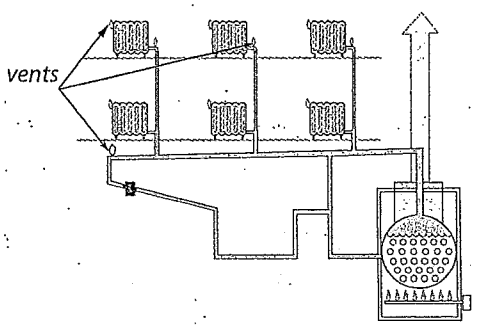
Vent dampers: Electric vent dampers close the chimney when the burner isn't firing, preventing circulating air from carrying the boiler's stored heat up the chimney.

areas, with foam pipe insulation, at least one-inch thick, rated for temperatures up to 200° F.

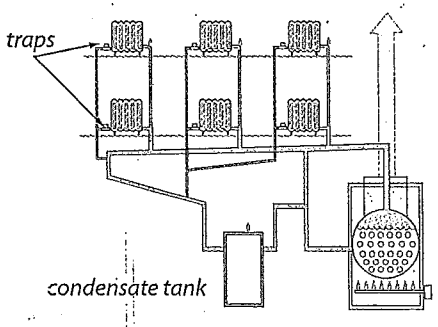
- ✓ Consider installing electric vent dampers on atmospheric gas- and oil-fired high-mass boilers.

Title.7.3 Steam heating

Steam heating systems should operate at the lowest steam pressure that will heat the building. This may be considerably less than 1 psi on the boiler pressure gauge. Large buildings may need higher steam pressures, but smaller structures or buildings can operate at lower steam pressures. Traps and air vents are crucial to operating at a low steam pressure. Electric vent dampers will reduce off-cycle losses for both gas- and oil-fired systems.



One-pipe and two-pipe steam systems: Still common in multifamily buildings, one-pipe steam works best when very low pressure steam can drive air out of the piping and radiators quickly through plentiful vents. Vents are located on each radiator and also on main steam lines.



Two-pipe steam systems: Radiator traps keep steam inside radiators until it condenses. No steam should be present at the receiver or receiver and pump if the system is so equipped.

Note: You can recognize a steam boiler by its sight glass, which will indicate the boiler's water level. Notice that the water doesn't completely fill the boiler, but instead allows a space for the steam to form above the boiler's water.

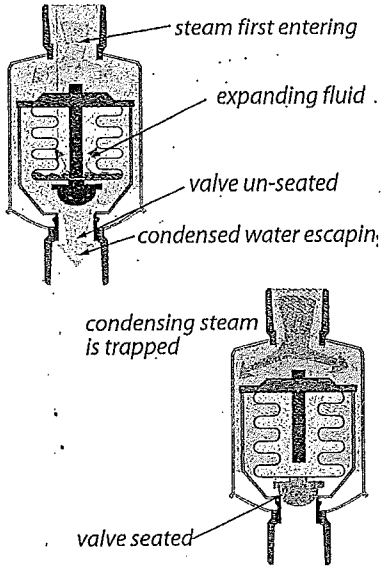
Perform the following for safety and maintenance checks on steam systems.

- ✓ Verify that steam boilers are equipped with high-pressure limits and low-water cut-off controls.
- ✓ Verify that flush valves on low water cutoffs are operable and do not leak.
- ✓ On steam boilers with externally mounted low water cut-offs, verify the function of the control by flushing the low water cutoff with the burner operating. Combustion must cease when the water level in the boiler drops below the level of the float.
- ✓ Drain water out of blow-down valve until water runs clear.
- ✓ Check with owner about chemicals added to boiler water to prevent corrosion and mineral deposits. Add chemicals if necessary.
- ✓ Ask owner about instituting a schedule of blow-down and chemical-level checks.

Consider the following efficiency checks and improvements for steam systems.

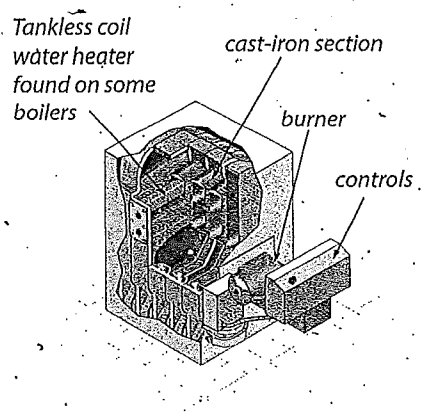
- ✓ Verify that high-pressure limit control is set at or below 1 (one) psi.
- ✓ Verify steam vents are operable and that all steam radiators receive steam during every cycle. Replace vents as necessary. Add vents to steam lines and radiators as needed to achieve this goal.

- ✓ Check steam traps with a digital thermometer or listening device to detect any steam escaping from radiators through the condensate return. Replace leaking steam traps or their thermostatic elements.
- ✓ Repair leaks on the steam supply piping or on condensate return piping.
- ✓ Consider a flame-retention burner and electric vent damper as retrofits for steam boilers.
- ✓ Clean fire side of heat exchanger of noticeable dirt.
- ✓ All steam piping, passing through unconditioned areas, should be insulated to at least R-3 with fiberglass or specially designed foam pipe insulation rated for steam piping.



Steam traps: Steam enters the steam trap heating its element and expanding the fluid inside. The expanded element plugs the steam's escape with a valve.

Title.7.4 Boiler replacement



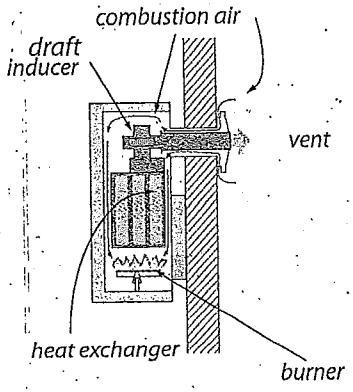
Cast-iron sectional boilers: Are the most common boilers for residential applications.

Don't assume that a boiler replacement will save much energy unless the boiler's steady-state efficiency can't be raised to around 80%. The overall goal of boiler replacement is to provide a hydronic heating system in virtually new condition, even though existing supply and return piping may remain. Any design flaws in the venting, piping, and controls should be diagnosed and corrected during the boiler replacement.

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

The new gas boiler should have an AFUE of at least 80%. The new boiler should be equipped with electronic ignition and a draft-assisting or power-draft fan. It should not have a draft diverter.

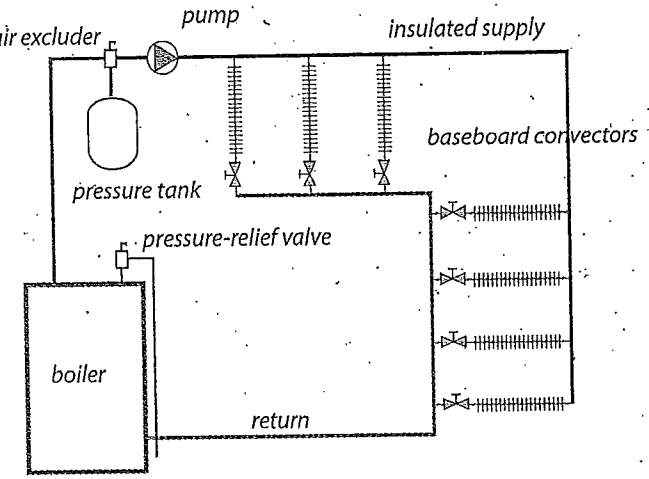
Boiler seasonal efficiency is more sensitive to proper sizing than is furnace efficiency. A boiler should be sized to the load of the structure. Consider the following specifications when replacing boilers.



Wall-hung boiler: Energy-efficient wall-hung boilers require less space of standard boilers.

- ✓ Inspect chimney for deterioration and correct sizing. Repair and re-line the chimney as necessary.
- ✓ An effective air-eliminating device or devices must be part of the new hydronic system.
- ✓ Install the pump near the downstream side of the pressure tank to prevent the suction side of the pump from depressurizing the piping, which can pull air into the piping.
- ✓ The expansion tank should be replaced, unless it is verified to be the proper size for the new system and tested for correct pressure during boiler installation.
- ✓ Verify that return water temperature is above 130° F for gas and above 150° F for oil, to prevent acidic condensation within the boiler, unless the boiler is designed for condensing. Install piping bypasses, mixing valves, primary-secondary piping, or other strategies, as necessary, to prevent condensation within a non-condensing boiler.
- ✓ Recognize the boiler installation's potential for causing condensation in the vent connector and chimney. If the boiler's steady-state efficiency is expected to be more than 83%, condensation-resistant venting and condensation drains should be designed into the venting system. These custom venting systems are provided or specified by the manufacturer.

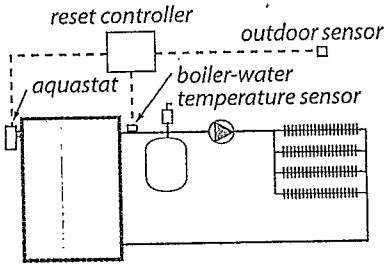
- ✓ A pressure-relief valve must be installed with the new boiler and connected to a discharge pipe, terminating at a location approved by code.



Simple reverse-return hot-water system: The reverse-return method of piping is the simplest way of balancing flow among heat emitters.

- ✓ Maintaining a low-limit boiler-water temperature is wasteful. Boilers should be controlled for a cold start, unless the boiler is used for domestic water heating.
- ✓ Insulate all supply piping, outside conditioned spaces, with foam or fiberglass pipe insulation.

- ✓ Extend new piping and radiators to conditioned areas like additions and finished basements, currently heated by space heaters.
- ✓ For large boilers, consider installing outdoor reset controllers to adjust supply water temperature according to outdoor temperature.

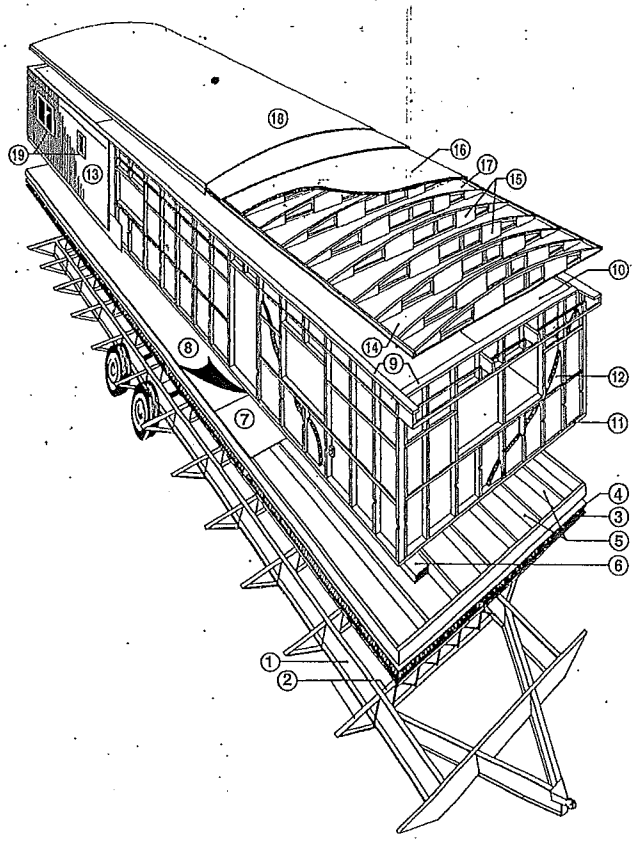


Reset controller: The circulating water is controlled by the reset controller according to the outdoor temperature.

- ✓ For large boilers, consider installing a cutout controller that prevents the boiler from firing when the outdoor temperature is above a certain setpoint where heat is not needed.

CHAPTER TITLE: MANUFACTURED HOUSING SPECIFICATIONS

Manufactured houses typically use more energy per square foot than site-built homes, but their consistent construction makes them more straightforward to weatherize.



Typical Components of a Manufactured House: 1–Steel chassis. 2–Steel outriggers and cross members. 3–Underbelly. 4–Fiberglass insulation. 5–Floor joists. 6–Heating/air conditioning duct. 7–Decking. 8–Floor covering. 9–Top plate. 10–Interior paneling. 11–Bottom plate. 12–Fiberglass insulation. 13–Metal siding. 14–Ceiling board. 15–Bowstring trusses. 16–Fiberglass insulation. 17–Vapor barrier. 18–Galvanized steel one-piece roof. 19–Metal windows.

Insulation upgrades save the most energy in manufactured houses, though sealing shell and duct air leaks presents good opportunities, too. Manufactured house heating retrofit and replacement are often cost-effective when a customer's energy usage is high. See "PA WAP Manufactured Home, Measure Selection Priority List (MHEA)" on page 19.

TITLE.1 MANUFACTURED HOUSE HEATING

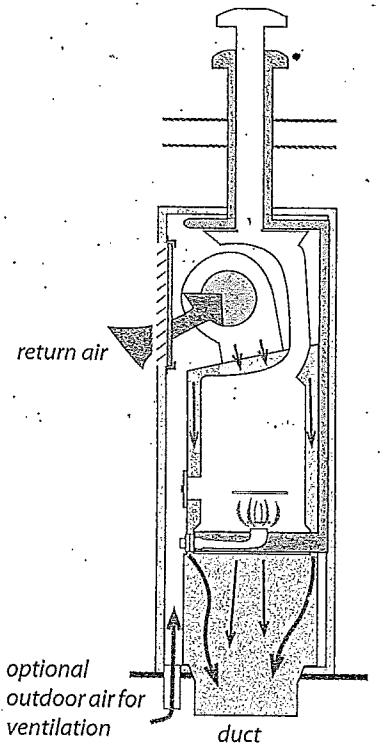
Manufactured house furnaces are different from conventional furnaces in the following ways:

- A great majority of manufactured houses are equipped with downflow furnaces, designed specifically for manufactured houses.
- Manufactured house combustion furnaces are sealed-combustion units that use outdoor combustion air, unlike most furnaces in site-built homes. They don't have draft diverters or barometric draft controls.
- Manufactured house furnaces require an outdoor source of combustion air.
- Manufactured house furnaces have either a manufactured chimney that includes a passageway for combustion air or a combustion-air chute connecting the burner with the crawl space.
- Gas-fired furnaces have kits attached, containing alternative orifices, to burn either propane or gas.
- Return air is supplied to the furnace through a large opening in the furnace cabinet, rather than through ducts connected to the blower compartment.

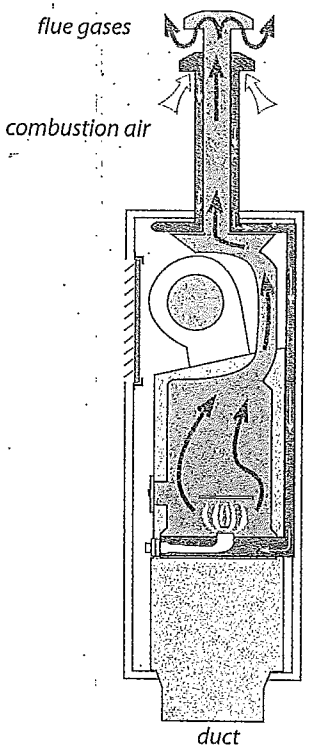
Manufactured house furnaces have been sealed-combustion since the early 1970s. Gas furnaces are either the old atmospheric sealed-combustion type or the newer fan-assisted mid-efficiency type. Some older sealed-combustion furnaces had

draft inducers also. For information on electric furnaces, see "Electric-furnaces and electric baseboard heat" on page 149.

Manufactured house oil furnaces are a close relative to oil furnaces in site-built homes. However, they should have a housing that fits around the burner's air shutter and provides outdoor air directly to the burner. See "Oil-burner safety and efficiency" on page 94 and "Direct combustion air supply to oil-fired heaters" on page 131.



Manufactured house furnace airflow: Return air flows from the hallway through the furnace grille. The air is heated and distributed through the ducts.



Manufactured house furnace combustion: Combustion air enters through the flue assembly on the roof and feeds the flame through a sealed passageway.

Important Note: Install only furnaces designed for manufactured houses. The installation should include the complete chimney and roof jack assembly.

Manufactured Housing Specifications

Title.1.1 Furnace maintenance and energy efficiency

Manufactured house furnaces should comply with this guidebook's combustion safety and efficiency standards. See "Gas burner safety and efficiency testing" on page 88 and "Oil-burner safety and efficiency" on page 94.

Title.1.2 Heating appliance replacement

Manufactured house furnaces must be replaced by furnaces designed and listed for use in manufactured houses. If a heat exchanger is available to replace the existing cracked heat exchanger, consider heat-exchanger replacement as a repair priority instead of replacing the furnace.

Consider replacing the existing furnace with a sealed-combustion, downflow, condensing furnace. Manufacturers make condensing furnaces, approved for manufactured houses. In any case replacement furnaces must fall within the specifications for HUD and Pennsylvania Combustion Efficiency Standards.

Manufactured house furnaces may be replaced when any of the following 3 conditions is observed.

1. The furnace has a cracked heat exchanger.
2. Repair and retrofit exceed half of the replacement cost.
3. The furnace is not operating and not repairable.

Follow these procedures when installing new manufactured house furnaces.

- ✓ Install a new furnace base.
- ✓ Attach the furnace base firmly to the duct, and seal all seams between the base and duct with mastic and fabric tape before installing the furnace.
- ✓ Support the main duct underneath the furnace with additional strapping if necessary.

- ✓ When replacing manufactured house furnaces, note the differences between old furnace and new, in the way each supplies itself with combustion air.
- ✓ Install a new chimney that is manufactured specifically for the new furnace. Install to manufacturer's specifications.

Manufactured house furnaces have short chimneys, and their combustion process depends on a delicate balance between combustion air entering and combustion gases leaving. The furnace demands a vertical, leak-free chimney, and a properly installed chimney cap. Follow manufacturer's installation instructions exactly.

surize the home's attic and draw moist outdoor air into the cavity. This moist air will condense during some seasons and cause moisture damage.

- Severely deteriorated floors in water heater compartments.
- Gaps around the electrical service panel box, light fixtures, and fans.
- Joints between the halves of double-wide manufactured houses and between the main dwelling and additions.

Table Title-1:Air Leak Locations and Typical CFM_{50} Reductions

Air Sealing Procedure	Typical CFM_{50} Reduction
Patching large air leaks in the floor, walls and ceiling	200–900
Sealing floor as return-air plenum	300–900
Sealing leaky water-heater closet	200–600
Sealing leaky supply ducts	100–500
Installing tight interior storm windows	100–250
Caulking and weatherstripping	50–150

Title.2.2 Duct-leak locations

The following locations have been identified by technicians using blower doors and duct testers as the most serious energy problems.

- Floor and ceiling cavities used as return-air plenums. These return systems should be eliminated in favor of return-air through the hall or a large grille in the furnace-closet door.

CHAPTER TITLE: HEALTH AND SAFETY INFORMATION

This chapter explains some of the most pressing hazards that your clients face in their homes, as well as those you face at work as a weatherization specialist.

The most common home health hazards that are related to weatherization are:

1. Carbon monoxide
2. Moisture problems
3. Lead-based paint dust
4. Gas leaks

When a weatherization agency finds serious safety problems in a customer's home, the agency should inform the customer in writing about the hazards and make suggestions about how to eliminate them.

The home is second only to the automobile as a dangerous place to be: household accidents kill 24,000 Americans and injure 3,500,000 each year. Children may be at a greater risk because they spend more time at home and are less aware of danger than adults. There are three major causes of non-workplace injuries.

1. Falls
2. Poisoning by solids and liquids
3. Smoke inhalation and burns from fires

See "Health and Safety Standards" on page 28.

TITLE.1 CLIENT HEALTH AND SAFETY

Carbon monoxide, moisture problems, lead-paint dust, and gas leaks are the most important health and safety problems related to weatherization work. When these are detected, inform the customer verbally and in writing as appropriate. Addressing these problems should be a top priority.

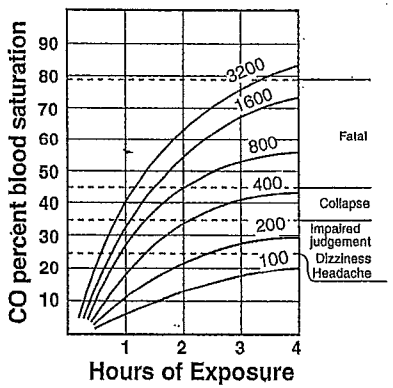
1. Test heating systems and homes for carbon monoxide and solve problems causing CO.
2. Find moisture problems and discuss them with the client. Never make moisture problems worse. See *"Gas range and oven safety" on page 66.*
3. Practice lead-safe weatherization. See *"Lead-safe weatherization" on page 76.*

"Client Health and Safety" on page 29 discusses standards for this topic.

Health and Safety

Title.1.1 Carbon monoxide

Carbon monoxide (CO) is released by combustion appliances, automobiles, and cigarettes as a product of incomplete combustion. CO is the largest cause of injury and death in the U.S. from gas poisoning, resulting in more than 500 deaths per year. Many more people are injured by high concentrations of the gas, or temporarily sickened by lower concentrations of 5-to-50 parts per million (ppm). The symptoms of low-level CO exposure are similar to the flu, and may go unnoticed.



CO blocks the oxygen-carrying capacity of the blood's hemoglobin, which carries vital oxygen to the tissues. At low concentrations (5-to-50 ppm), CO reduces nerve reaction time and causes mild drowsiness, nausea, and headaches. Higher concentrations (50-to-3000 ppm) lead to severe headaches, vomiting, and even death if the high concentration persists. The effects of CO poisoning are usually

reversible, except for exposure to very high levels, which can cause brain damage.

The EPA's suggested maximum 8-hour exposure is 9 ppm in room air. Room levels of CO at or above 9 ppm are usually associated with the use of malfunctioning combustion appliances within the living space, although cigarette smoking or automobile exhaust are also common CO sources.

CO is a common problem in low-income housing, affecting 20% or more of residential buildings in some regions. Offending appliances include: unvented gas space heaters, kerosene space heaters, backdrafting vented space heaters, gas ranges, leaky wood stoves, and automobiles idling in attached garages or near the home. Backdrafting furnaces and boilers may also lead to high levels of CO.

The most common CO-testing instruments are electronic sensors with a digital readouts in parts per million (ppm). Follow the manufacturer's recommendations on zeroing the meter—usually by exposing the meter to clean air. CO testers usually need re-calibration every 6 months or so, using factory-specified procedures.

CO is normally tested near the flame or in the flue of vented appliances. See "Combustion safety and efficiency testing" on page 88. CO is usually caused by one of the following:

- Overfiring
- Backdrafting of combustion gases smothering the flame
- Flame interference by an object (a pan over a gas burner on a range top, for example)
- Inadequate combustion air
- Flame interference by moving air
- Misalignment of the burner

Health and Safety

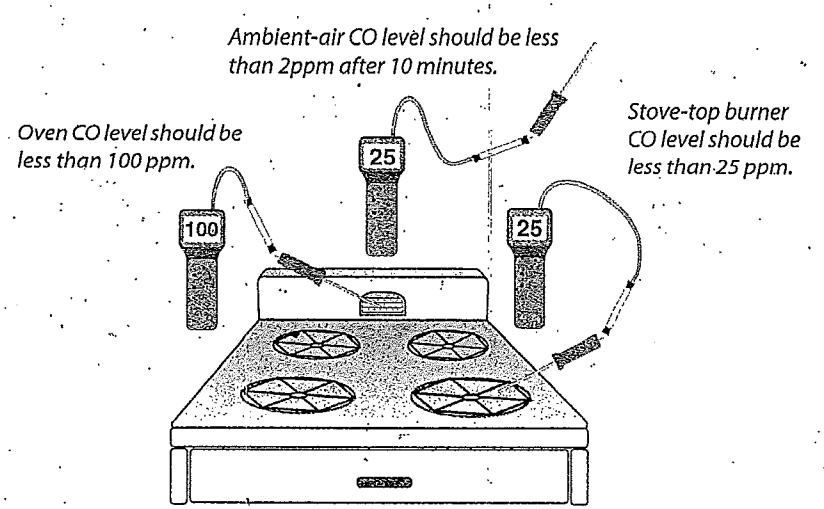
Title.1.2 Gas range and oven safety

Gas ranges and ovens can produce significant quantities of CO in a kitchen. Overfiring, dirt buildup, and foil installed around burners are frequent causes of CO. Oven burners are likely to produce CO even when not obstructed by dirt or foil. Test the range and oven for safety following these steps and take the recommended actions before or during weatherization.

1. Test each stove-top burner separately, using a digital combustion analyzer or CO meter and holding the probe about 8 inches above the flame for 2 minutes. Desired CO level is under 25 parts per million (ppm).
2. Turn on the oven to bake at high temperature. Sample the CO level in exhaust gases at the oven vent and in the ambient air after 10 minutes.
3. If the CO reading is over 100 ppm or if the ambient-air reading rises to 35 ppm or more during the test, take action to reduce these levels. Actions include cleaning the oven, removing aluminum foil, or adjusting the burner's adjustable gas control.

Advise the client of the following important operating practices.

- ✓ Never install aluminum foil around a range burner or oven burner.
- ✓ Never use a range burner or gas oven as a space heater.
- ✓ Open a window and turn on the kitchen exhaust fan when using the range or oven.
- ✓ Keep range burners and ovens clean to prevent dirt from interfering with combustion.
- ✓ Burners should display hard blue flames. Yellow or white flames, wavering flames, or noisy flames should be investigated by a trained gas technician.



Title.1.3 Moisture problems

Moisture causes billions of dollars worth of property damage and high energy bills each year in American homes. Water damages building materials by dissolving glues and mortar, corroding metal, and nurturing pests like mildew, mold and dust mites. These pests, in turn, cause many cases of respiratory distress. Water also reduces the thermal resistance of insulation and other building materials. High humidity also increases air conditioning costs because the air conditioner must remove the moisture from the air to improve comfort.

Relative humidity (rh) is the percentage of the maximum moisture that air at a given temperature can hold. Rh is 100% when the air is saturated with moisture. Add more moisture to saturated air, and water condenses on cool objects. Relative humidity is 50% when the air at a particular temperature is only half saturated with water vapor. Building materials' moisture content is directly related to the relative humidity of the surrounding air.

High relative humidity in indoor air can cause comfort problems in summer, and condensation problems in both summer

Health and Safety

and winter. Experts on cooling say the air should be less than 60% relative humidity for adequate indoor comfort in summer. Experts on winter conditions say that indoor relative humidity in cold climates should be less than 40% to avoid moisture condensation problems.

Moisture enters buildings and moves through them in the forms of liquid water and water vapor. The four categories of water movement are:

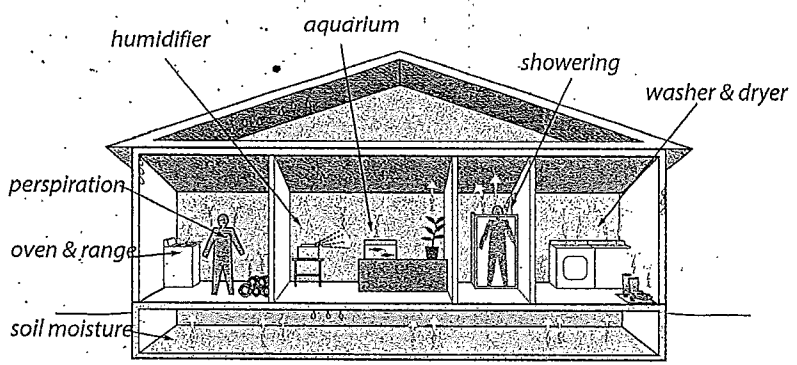
- *Liquid flow.* Driven by gravity or air-pressure differences, water flows into a building's holes and cracks. Roof leaks and plumbing leaks can deposit large amounts of water in a home.
- *Capillary seepage.* Liquid water creates a suction of its own as it moves through tiny spaces within and between building materials. This capillary suction draws water seepage from the ground. Seepage also redistributes water from leaks, spills, and condensation.
- *Air movement.* Air movement carries water vapor into and out of the building and its cavities. Air pressure difference is the driving force for this air movement, and holes in the shell are the leakage paths. If the air reaches saturation (also called the dew point), condensation will occur.
- *Vapor diffusion.* Water vapor will move through solid objects depending on their permeability and the vapor pressure.

Liquid flow is the most serious water threat, because it moves large amounts of water rapidly. Capillary seepage can also move liquid water rapidly into a home through damp soil and a porous foundation.

Water vapor movement by air leakage and diffusion occurs mainly when heating or cooling systems are operating. Winter air leakage tends to carry moist indoor air outdoors—drying the indoor air. Summer air leakage tends to bring moist, hotter air into the home— increasing humidity.

Vapor diffusion is the slowest form of moisture movement and creates fewer problems than the others. However, vapor diffusion can cause condensation inside relatively cool building cavities during both the heating and cooling seasons.

Moisture moves into a building during wet seasons and out during drier seasons. Moisture is a problem when it reaches a level that encourages pests—termites, dust mites, dry rot, and fungus.



Moisture sources: Moisture sources abound in typical homes.

The most common sources of moisture are leaky roofs and damp foundations. Other critical moisture sources include dryers vented to indoors, showers, cooking appliances, hanging wet laundry indoors, drying fire wood supply indoors, and unvented gas appliances like ranges or decorative fireplaces. Climate is also a major contributor to moisture problems. The more rain, extreme temperatures, and humid weather a region has, the more its homes are vulnerable to moisture problems.

Reducing sources of moisture is the first priority for solving moisture problems. Next most important are air and vapor barriers to prevent water-vapor from migrating through building cavities. Relatively airtight homes may need mechanical ventilation to remove accumulating water vapor. Also, see "Moisture Problems" on page 30.

Health and Safety

Table Title-1:Typical Household Moisture Sources

Moisture Source	Potential Amount Pints
Ground moisture	0–105 per day
Unvented combustion space heater	0.5 –20 per hour
Seasonal evaporation from materials	6–19 per day
Dryers venting indoors	4–6 per load
Dishwashing	1–2 per day
Cooking (meals for four)	2–4 per day
Showering	0.5 per shower
Hanging laundry to dry indoors	8-12 per day
Drying/seasoning fire wood indoors (one cord)	32 pints

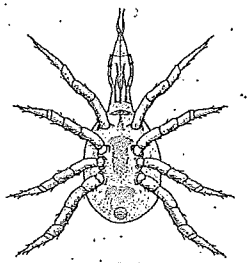
Symptoms of moisture problems

Condensation on windows, walls, and other surfaces signals high relative humidity and the need to find and reduce moisture sources. During very cold weather or rapid weather changes, condensation may occur. This occasional condensation isn't a major problem. However, if window condensation is a persistent problem, reduce moisture sources, add insulation, or consider other remedies that lead to warmer interior surfaces. The colder the outdoor temperature, the more likely condensation is to occur. Adding insulation helps eliminate cold areas where water vapor condenses.

Moisture problems arise when the moisture content of building materials reaches a threshold where pests like termites, dust mites, rot, and fungus can thrive. Asthma, bronchitis and other respiratory ailments can be exacerbated by moisture problems because mold, mildew, and dust mites' protein and feces are potent allergens.

Rot and wood decay indicate advanced moisture damage. Unlike surface mold and mildew, wood decay fungi penetrate, soften, and weaken wood.

Peeling, blistering or cracking paint may indicate that moisture is moving through a wall, damaging the paint and possibly the building materials underneath.

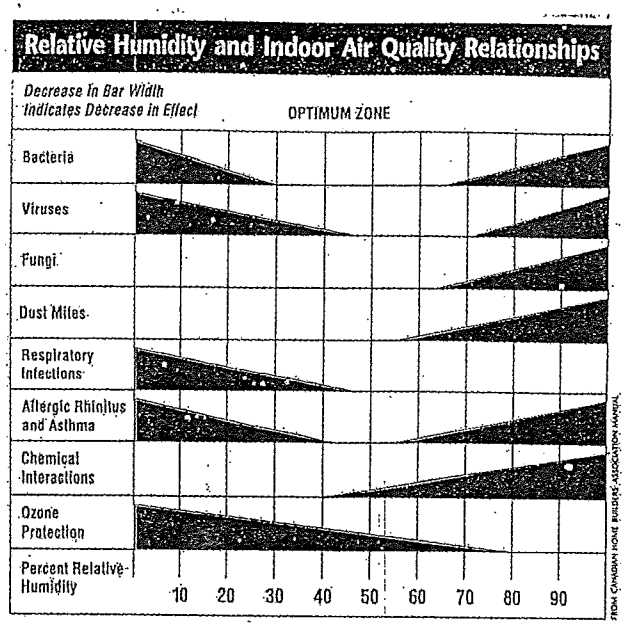


Fungus and dust mites: Biological pests create bioaerosols that can cause allergies and asthma.

Corrosion, oxidation and rust on metal are unmistakable signs that moisture is at work. Deformed wooden surfaces may appear as damp wood swells and then warps and cracks as it dries.

Concrete and masonry efflorescence is a white, powdery deposit left by water moving through a masonry wall, leaving minerals from mortar or the soil behind as it evaporates.

The Pennsylvania Department of Community and Economic Development uses the following form for assessing the presence of moisture in a home.



Health and Safety

pennsylvania
DEPARTMENT OF COMMUNITY & ECONOMIC DEVELOPMENT

Department of Community and Economic Development
Office of Energy Conservation and Weatherization

Whole House Moisture Assessment

Date: _____ Client: _____
Job Number: _____ Auditor: _____
Agency Name _____
Weather conditions at the time of the audit: _____

Attic access is best described as: ☐ Hatch ☐ Door ☐ None
Attic Ventilation: ☐ Yes ☐ No ☐ Other
Description: _____

Mechanical ventilation: ☐ Dryer ☐ Range hood ☐ Bath fan ☐ Other
Are the mechanical vents properly extended: ☐ Yes ☐ No
(if no, explain) _____

Water Moisture Symptoms:
☐ Efflorescence ☐ Stains ☐ Rotted wood ☐ Damp floor/walls
☐ Visible mold growth ☐ Mildew/odor ☐ Rust stains on appliances, etc. ☐ Other
(If so, where do they appear in the home) _____

Pictures Taken for Client File: ☐ **Yes** ☐ **No**

Moisture Contributing Factors: ☐ Wet basement ☐ Roof leaks ☐ Plumbing leaks ☐ Other
(If other, explain) _____

Comments:
_____
_____
_____

Do any children or elderly reside or frequently visit? ☐ Yes ☐ No
Does anyone residing in the home have health issues? ☐ Yes ☐ No
(if yes, explain) _____

Repairs recommended prior to weatherization? ☐ Yes ☐ No
(Repair description) _____
_____
_____

Repairs to be completed by: ☐ Landlord ☐ Homeowner ☐ Other
Repair completion verified by: _____

The above statement regarding moisture history of this dwelling is true and correct to the best of my knowledge.
Recommended repairs must be completed prior to any measures being installed in the home.

Client Signature: X _____ Date: _____
Auditor Signature: _____ Date: _____
Reviewed By: Name: _____ Entity: _____

Sample Weatherization Mold Assessment and Release Form

Mold can be a problem in any home, but especially in those where there is an excessive amount of moisture or humidity present. In addition, if there are several pets, plants, or fish aquariums present, conditions may exist for mold to grow. An assessment of your home included a visual check for mold. This is not a mold inspection and the person making this assessment is not a mold inspector. Testing and identification of specific molds is beyond the scope of this program and we are not liable for mold that was not found during this inspection.

During an energy audit on *(date)* _____ our personnel identified mold growth in the following room(s) of your home located at: _____

☐ Living/Bedroom Areas ☐ Bathroom Areas ☐ Laundry Areas ☐ Combustion Areas

☐ Crawlspace Areas ☐ Attic Areas ☐ Basement Areas ☐ Other Location

(Other location) _____

Moldy or musty odors are an indicator that there may be hidden mold growth.

Moldy or Musty Odors: ☐ Are present ☐ Are not present

The U.S. Department of Energy generally does not allow Weatherization agencies to remedy mold problems, but some actions associated with a cost effective energy saving measure may be taken to reduce moisture problems. We will take the following measures that may help to resolve existing moisture problems:

_____

_____

_____

Check and Sign One of the Following Disclaimers:

☐ **Moisture/Mold Disclaimer:** By signing below, I acknowledge that I have received information concerning moisture and mold conditions in my home prior to any weatherization work being done and I will take steps to reduce excessive moisture. I agree to hold the agency performing weatherization harmless for any future moisture or mold problems that are not associated with the weatherization work.

Weatherization Client: _____ Date: _____

Agency Auditor/Estimator: _____ Date: _____

☐ **Deferral Disclaimer:** By signing below, I acknowledge that I have been notified there is existing mold in the home prior to any weatherization work being done. I have been advised that the agency performing weatherization cannot cost effectively resolve the identified mold or moisture and that weatherization work must be deferred until the mold or moisture is remedied.

Weatherization Client: _____ Date: _____

Agency Auditor/Estimator: _____ Date: _____

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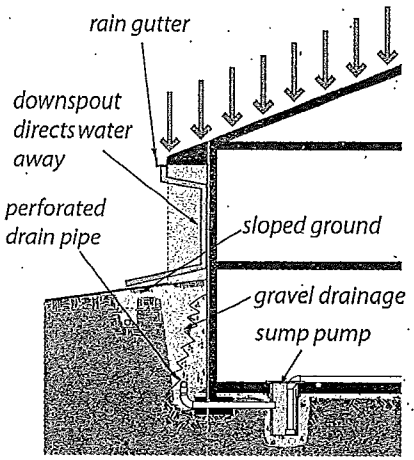
Solutions to moisture problems

Water moves easily as a liquid or vapor from the ground through porous building materials like concrete and wood. Auditors should be aware of how occupant behavior and site conditions affect the moisture problems they see. A high ground-water table can channel moisture into a home faster than anything short of a big roof leak. The most common ground-moisture source is water vapor rising through the soil or liquid water moving up through the soil by capillary action. To prevent this, all crawl spaces should have ground moisture barriers.

A ground moisture barrier is simply a piece of heavy plastic sheeting laid on the ground. Black or clear heavy plastic film works well, but tough cross-linked polyethylene is more durable.



Stopping water leakage: Choose from a variety of measures to protect homes from water leakage.

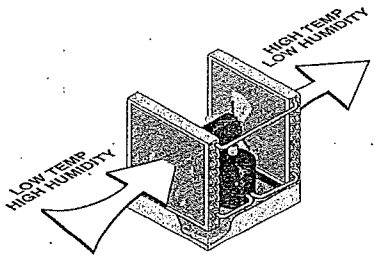
A sump pump is the most effective remedy, when ground water continually seeps into a basement or crawl space and collects there as standing water. Serious ground-water problems may require excavating and installing drain pipe and gravel—to disperse accumulations of groundwater between a home and nearby hillside, for example.

Rainwater flowing from roofs often plays a major role in dampening foundations. In rainy climates, install rain gutters with downspouts that drain roof water away from the foundation.

Preventing moisture problems is the best way to guarantee a building's durability and its occupant's respiratory health.

Besides the all-important source-reduction strategies listed above, consider the following additional moisture solutions.

- Installing or improving air barriers and vapor barriers to prevent air leakage and vapor diffusion from transporting moisture into building cavities. See "Sealing bypasses" on page 163.
- Adding insulation to the walls, floor, and ceiling of a home to keep the indoor surfaces warmer and less prone to condensation. During cold weather, well-insulated homes can tolerate higher humidity without condensation than can poorly insulated homes.
- Ventilating the home with drier outdoor air to dilute the more humid indoor air. However, passive ventilation is only effective when the outdoor air is drier than the inside air.
- Removing moisture from indoor air by cooling the air to below its dew point, with refrigerated air conditioning systems (summer) and dehumidifiers (winter).



Dehumidifiers: In damp climates, dehumidifiers protect many homes from excessive moisture.

Mechanical ventilation

Ventilation is an important health and safety concern in very airtight homes. These homes have a blower-door-measured air-leakage rate lower than the building airflow standard discussed in *"Building Airflow Standard (BAS)" on page 211.* Ventilation is also important in homes with pollutant sources: smoking, new furniture, new carpet, etc. Homes with a natural air-change rate lower than the BAS should have mechanical ventilation systems.

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The choice comes down to ventilating the whole house or providing spot-ventilation in the kitchen and bathroom where most moisture and odors are generated. Kitchen and bath fans must be vented outdoors, never into crawl spaces or attics.

High quality exhaust fans should have tight-sealing backdraft dampers. Backdraft dampers are located in the fan housing, in the vent duct, or in the termination fitting in the roof or wall.

A low noise level (rated in sones) is important in encouraging occupants to use exhaust fans. The sone rating varies from about 5 sones for the noisiest residential exhaust fans to about 0.5 sones for the quietest fans. The success of spot ventilation and whole-house ventilation depends on how much noise the fan makes. Occupants may not use the fans or may disconnect automatic controls if the fans are too noisy.

Exhaust fans can also provide whole-house ventilation. Make-up air comes from outdoors through the home's air leaks. Manual switches, dehumidistats, and timers are used to control exhaust fans for whole-house ventilation. Exhaust fans typically run from 2 to 6 hours per day, when providing whole-house ventilation.

Title.1.4 Lead-safe weatherization

All dust is dangerous, but lead dust is particularly dangerous because lead is a poison. Children are more vulnerable than adults because of their greater hand-to-mouth behavior. Take all necessary steps, outlined here, to protect customers and their children from lead dust.

Lead-safe weatherization (LSW) is a group of safe practices used by weatherization technicians. LSW practices are little more than very careful dust-prevention and housekeeping precautions. Lead-safe weatherization is required when workers will disturb painted surfaces by cutting, scraping, drilling, or other dust-creating activities.

Technicians should assume the presence of lead based paints in any site built home constructed prior to 1978. Weatherization activities that could disturb lead paint and create lead dust include the following:

- Glazing, weatherstripping, or replacing windows
- Weatherstripping, repairing, or replacing doors
- Drilling holes in the interior or the exterior of the home for installing insulation
- Removing trim or cutting through walls or ceilings to seal air leaks, install ducts, replace windows etc.
- Removing painted siding for installing insulation

When engaging in these activities, follow DOE and EPA lead safe protocols.

Also, see "Lead-Based Paint Hazards" on page 32 and "Unvented Space Heaters" on page 25.

TITLE.2 WORKER HEALTH AND SAFETY

Injuries are the fourth leading cause of death in the United States. Long-term exposure to toxic materials contributes to sickness, absenteeism, and death of workers.

The personal health and safety of each employee is vitally important. Preventing injuries on the job is weatherization's highest priority. Workplace safety standards established by the Occupational Safety and Health Administration (OSHA) as well as other standards established by the construction trade must be observed by weatherization staff and their contractors. Safety always has priority over other factors affecting weatherization operations. The following hazards merit special attention of weatherization agencies and their contractors because of their statistical importance.

1. Driving
2. Falls

Health and Safety

3. Back injuries
4. Hazardous materials
5. Electrical and tool hazards
6. Repetitive stress injuries

"Crew or Contractor Health and Safety" on page 28 discusses standards for this topic.

Title.2.1 Commitment to safety

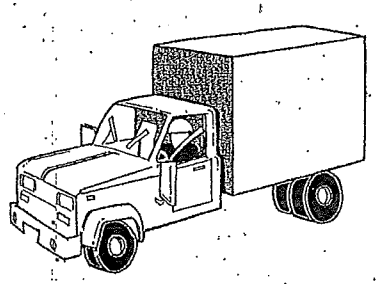
Workers tend to become complacent about their health and safety if its importance is not continually stressed. Weatherization agencies should do the following to encourage safety.

Safety meetings: Safety education and safety meetings are essential parts of a successful safety program.

- Arrange regular health and safety training,
- Conduct regular safety meetings,
- Keep equipment in good condition, and
- Observe all state and federal standards relating to worker health and safety.

Safety requires communication and action. To protect themselves from injury and illness, workers are encouraged to recognize hazards, communicate with co-workers and supervisors, and take action to reduce or eliminate hazards.

Title.2.2 Driving



Safe vehicles: Maintain vehicles in good repair. Drivers and passengers should always wear seat belts.

According to the Bureau of Labor Statistics (BLS), one-third of all occupational fatalities in the United States occur in motor-vehicle accidents. Supervisors and workers should plan and organize their errands and commuting to the job site to minimize vehicular travel. Vehicles should be kept in good repair. Brakes, horns, steering gear, headlights, directional signals, backup lights, and backup signals (when present) should be regularly inspected and repaired if necessary. Workers should always wear seat belts, which should be kept in working order.

Title.2.3 New employees

New hire: New hires are several times more likely to be injured, compared to experienced workers.

New employees are more likely to injure themselves on the job compared to experienced workers. Before their first day on the job, new employees should learn about safety basics such as proper lifting, safe ladder usage, and safe operation of the power tools they will use on the job. New employees should be taught how to use safety equipment such as respirators, safety glasses, hearing protection, and gloves. They should also be instructed in proper dress for the job—shorts, sandals, and tank tops are not appropriate.

Supervisors must inform new employees about hazardous materials they may encounter on the job, and teach them to read the

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Material Safety Data Sheets (MSDS) required by OSHA for each material.

Alcohol and drugs are prohibited on the job. Encourage staff and coworkers to refrain from smoking and to stay physically fit.

Title.2.4 Lifting and back injuries

Awkward loads: Ask for help when moving heavy or awkward loads.

Back injuries account for one out of every five workplace injuries. Four out of five back injuries are to the lower back; three out of four are the result of improper lifting.

Workers often injure their backs by lifting heavy or awkward loads improperly or without help.

Workers should be instructed in proper lifting techniques—lifting with their legs and keeping a straight back whenever possible. To avoid back injury, employees are encouraged to get help before trying to lift heavy or awkward loads, to stay in good physical condition, and to control their weight through proper diet and exercise. Supervisors should identify workers with limited lifting abilities because of weakness or prior injury and instruct them to avoid heavy lifting.

Other approaches for prevention also include:

1. Redesigning work activities: adapting equipment and minimizing awkward movement on the job site.
2. Administrative controls: strength-testing workers, setting lifting limits, and providing training for all workers on the causes and prevention of back injuries.

Title.2.5 Respiratory health

Common household construction and insulation dust can be full of toxins including lead, asbestos, and chemicals. Drilling, cutting, scraping can stir up toxic dust, which may then be inhaled. Workers are also exposed to dust from the insulation they install. Dust that clings to clothes worn on the job travels home, where it may be inhaled by family members.

Employees are encouraged to wear a respirator when working in a dusty environment. Workers with beards, facial scars, and thick temple bars on eyeglasses must take special care to get a good seal when putting on a respirator. The seal can be tested by putting on the respirator, closing the exhalation valve, and exhaling gently. There should be no leakage of air around the face. Refer to NIOSH for proper type and use of dust mask.

Workers are encouraged to wear coveralls when entering attics or crawl spaces. Coveralls should be disposable or laundered professionally. Workers should be taught how to recognize asbestos insulation that may be installed around older furnaces and boilers. The danger of carrying dust into their own home on their clothing should be stressed. Weatherization contractors and agency staff should be taught how to keep dust out of client's homes by erecting temporary barriers when they are doing work that may release toxic dust into a client's home.

Workers should be instructed about the dangers of dust, gases, smoke, vapors, and oxygen-deficient environments. Workers spraying two-part urethane foam should use a respirator canister designed to filter organic vapors and ventilate the area where the foam is being sprayed. For areas, like crawl spaces that are difficult to ventilate, workers should use a supplied-air, positive-pressure respirator.

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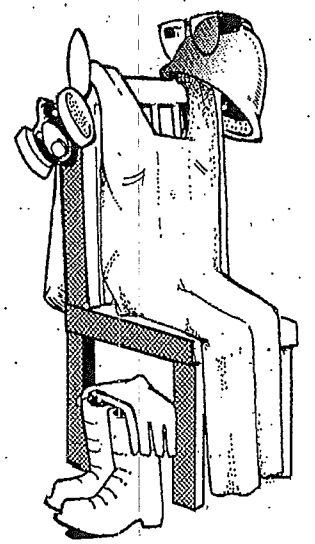
Title.2.6 Hazardous materials

Workers' health and safety can be threatened by hazardous materials used on the job. Workers often fail to protect themselves from hazardous materials because they don't recognize them and understand their health effects. Breathing hazardous materials, absorbing them through the skin, and eye contact with hazardous materials are common ways workers are affected.



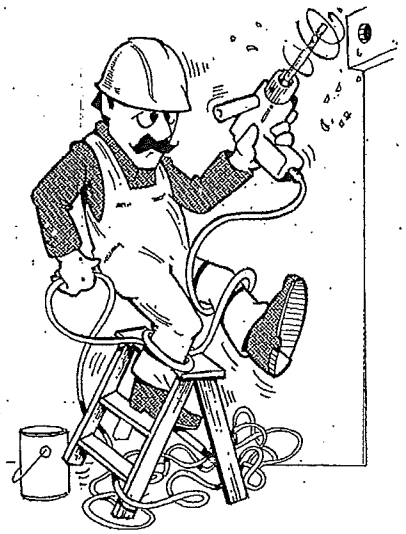
Personal protective equipment: Employees should own and maintain protective equipment to protect themselves from hazardous materials.

OSHA regulations say employers must notify and train employees about hazardous materials used on the job. OSHA requires that a Material Safety Data Sheet (MSDS) for every workplace hazardous material be readily available to employees. Copies of MSDSs are obtained from manufacturers or their distributors.

- Employees should know where MSDSs are kept and how to interpret them.
- Employees should know how to avoid exposure to hazardous materials used on the job and how to clean up chemical spills.
- Employees should be instructed on appropriate protective equipment.
- Employees should wear appropriate protective equipment recommended by the MSDS, while working with any hazardous material.

Title.2.7 Falls

Falls off ladders and stairs cause 13% of workplace injuries according to the National Safety Council. Falls from the same elevation such as slips and trips account for approximately 7% of workplace injuries. Any change in elevation greater than 19 inches must be served by a ladder or stairway.



Ladders: Ladders are the most dangerous tools workers use.

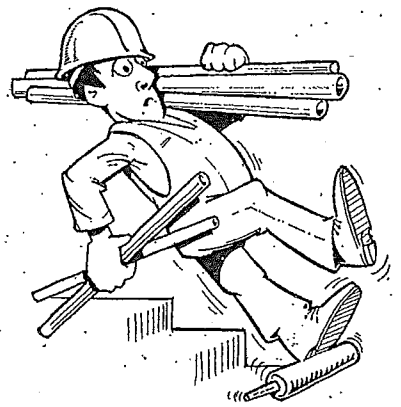
Broken ladders and ladders that slip because they haven't been anchored properly are both major causes of on-the-job falls. Worker carelessness and using the wrong ladder for a particular job is also a common cause of falls. Step ladders, for instance, are often used for work that is too far off the ground, forcing workers to stand on the top step or to reach too far.

OSHA regulations say extension ladders should extend at least three feet above the roof or landing they access and shouldn't have a pitch steeper than four feet of rise for each foot the base is away from the building. Ladders must be blocked or tied firmly in place at the top and bottom when the above rule cannot be observed.

All ladders should be kept in good repair, and should be replaced if they have missing steps or cracked side-rails. Broken ladders should be removed from the equipment storage area. Portable metal ladders should not be used where they may come in contact with electrical conductors.

Ladders must be maintained free of oil, grease, and other slipping hazards. They must not be loaded beyond the maximum intended load for which they were built. Workers should avoid carrying heavy loads up ladders and operating power tools from ladders.

Scaffolding must be used when working above-ground for sustained time periods. Scaffolds should be built plumb and level. Each leg should be stabilized so that it supports equal weight as other legs. This is especially important on unlevel ground. Planks should be secured to the structure and handrails provided on the sides and ends of the walkway.



Good housekeeping: Good housekeeping is essential to protect workers and clients alike from falls.

Workplaces should be policed regularly to remove slipping and tripping hazards. Workers carrying loads should establish a debris-free walkway.

Title.2.8 Repetitive Stress Injuries

Ergonomics establish good work habits in your office or on the job by the proper posture, hand and arm coordination in the use of tools or office equipment. It has been found that long term injuries can be avoided by stretching just a few minutes a day. As a result new designs are being made in hand and power tools, office equipment as well as every day home equipment uses. Your safety committee should have their ergonomics standard included for your own personal safety.

Title.2.9 Tool safety

The tools used in construction work are dangerous if used improperly. About 90,000 people hurt themselves with hand tools each year. One moment of inattention can cause an injury that can change a worker's life permanently.

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Six basic safety rules can reduce hazards associated with the use of hand and power tools:

1. Keep all tools in good condition with regular maintenance.
2. Use the right tool for the job.
3. Inspect tools for damage before using them.
4. Operate tools according to the manufacturer's instructions.
5. Provide and use appropriate personal protective equipment.
6. Use ground-fault interrupter extension cords.

Electrical safety: Cords should be maintained in good condition. Special ground-fault-interrupter cords or outlets should be used in wet conditions.

APPENDIX A—STANDARDS FOR WEATHERIZATION MATERIALS

If the standards listed in this appendix conflict with those required by current local codes, the local code shall have precedence and a copy of the applicable section will be retained with procurement records.

The following Government standards are produced by the Consumer Product Safety Commission and are published in title 16, Code of Federal Regulations:

Thermal Insulating Materials for Building Elements Including Walls, Floors, Ceilings, Attics, and Roofs Insulation—organic fiber—conformance to Interim Safety Standard in 16 CFR part 1209;

Fire Safety Requirements for Thermal Insulating Materials According to Insulation Use—Attic Floor—insulation materials intended for exposed use in attic floors shall be capable of meeting the same flammability requirements given for cellulose insulation in 16 CFR part 1209;

Enclosed spaces—insulation materials intended for use within enclosed stud or joist spaces shall be capable of meeting smoldering combustion requirements in 16 CFR part 1209.

The following standards which are not otherwise set forth in part 440 are incorporated by reference and made part of part 440. The following standards have been approved for incorporation by reference by the Director of the Federal Register in accordance with 5 U.S.C. 552(a) and 1 CFR part 51. These materials are incorporated as they exist on January 3, 2002 and a notice of any change in these materials will be published in the FEDERAL REGISTER. The standards incorporated by reference are available for inspection at the Office of the Federal Register Information Center, 800 North Capitol Street, Suite 700, Washington, DC 20001.

The standards incorporated by reference in part 440 can be obtained from the following sources:

Air Conditioning and Refrigeration Institute, 4301 N. Fairfax Drive, Suite 425, Arlington, VA 22203; (703) 524-8800.

American Architectural Manufacturers Association, 1827 Walden Office Square, Suite 104, Schaumburg, Illinois 60173-4268; (847) 303-5664.

American Gas Association, 400 N. Capitol Street, NW, Washington, DC 20001; (202) 824-7000.

American National Standards Institute, Inc., 11 West 42nd Street, New York, NY 10036; (212) 642-4900.

American Society of Mechanical Engineers, Three Park Avenue, New York, NY 10016-5990; (212) 591-7722.

American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959; (610) 832-9585.

Association of Home Appliance Manufacturers, 1111 19th Street, NW, Suite 402, Washington DC, 20036; (202) 872-5955.

Federal Specifications, General Services Administration, General Services Administration, Federal Supply Service, Office of the CIO and Marketing Division, Room 800, 1941 Jefferson Davis Hwy., Arlington, VA 22202; (703) 305-6288.

Gas Appliance Manufacturers Association, 2107 Wilson Boulevard, Suite 600, Arlington, Virginia 22201; (703) 525-7060.

National Electrical Manufacturers Association, 1300 North 17th Street, Suite 1847, Rosslyn, VA 22209; (703) 841-3200.

National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101; (617) 770-3000.

Sheet Metal and Air Conditioning Contractors Association, 4201 Lafayette Center Drive, Chantilly, Virginia 20151-1209; (703) 803-2980.

Solar Rating and Certification Corporation, c/o FSEC, 1679 Clearlake Road, Cocoa, FL 32922-5703; (321) 638-1537.

Steel Door Institute, 30200 Detroit Road, Cleveland, OH 44145-1967; (440) 899-0010.

Steel Window Institute, 1300 Sumner Avenue, Cleveland, OH 44115-2851; (216) 241-7333.

Tubular Exchanger Manufacturers Association, 25 North Broadway, Tarrytown, NY 10591; (914) 322-0040.

Underwriters Laboratories, Inc., 333 Pfingsten Road, Northbrook, IL 60062-2096; (847) 272-8800.

Window & Door Manufacturers Association, 1400 East Touhy Avenue, Suite 470, Des Plaines, IL 60018; (800) 223-2301.

More information regarding the standards in this reference can be obtained from the following sources:

Environmental Protection Agency, 401 M Street, NW, Washington, DC 20006; (202) 554-1080.

National Institute of Standards and Technology, U.S. Department of Commerce, Gaithersburg, MD 20899; (301) 975-2000.

Weatherization Assistance Program, Office of Building Technology Assistance, Energy Efficiency and Renewable Energy, 1000 Independence Avenue, SW, EE-42, Washington, DC 20585-0121; (202) 586-4074.

Fire Safety Requirements for Insulating Materials According to Insulation Use

[Standards for conformance]

Attic floor	Insulation materials intended for exposed use in attic floors shall be capable of meeting the same smoldering combustion requirements given for cellulose insulation in ASTM[1] C739-00.
Enclosed space	Insulation materials intended for use within enclosed stud or joist spaces shall be capable of meeting the same smoldering combustion requirements given for cellulose insulation in ASTM C739-00.
Exposed interior walls and ceilings	Insulation materials, including those with combustible facings, which remain exposed and serve as wall or ceiling interior finish, shall have a flame spread classification not to exceed 150 (per ASTM E84-00a).
Exterior envelope walls and roofs	Exterior envelope walls and roofs containing thermal insulation shall meet applicable local government building code requirements for the complete wall or roof assembly.
Pipes, ducts, and equipment	Insulation materials intended for use on pipes, ducts, and equipment shall be capable of meeting a flame spread classification not to exceed 150 (per ASTM E84-00a).

[1] ASTM indicates American Society for Testing and Materials.

Storm Windows

[Standards for conformance]

Storm windows:	
All storm windows . .	AAMA/NWWDA[1] 101/I.S. 2-97.
Aluminum frame storm windows	AAMA[2] 1002.10-93.
Rigid vinyl frame storm windows	ASTM[3] D4726-00.
Frameless plastic glazing storm	Required minimum thickness for windows is 6 mil (0.006 inches).
Movable insulation systems for windows	Commercially available.

[1] AAMA/NWWDA indicates American Architectural Manufacturers Association/National Wood Window & Door Association (now the Window & Door Manufacturers Association).

[2] AAMA indicates American Architectural Manufacturers Association.

[3] ASTM indicates American Society for Testing and Materials.

Replacement Windows

[Standards for conformance]

Replacement windows:	
All windows	AAMA/NWWDA[1] 101/I.S. 2-97.
Steel frame windows	Steel Window Institute recommended specifications for steel windows, 1990.
Rigid vinyl frame windows	ASTM[2] D4726-00.

[1] AAMA/NWWDA indicates American Architectural Manufacturers Association/National Wood Window & Door Association (now the Window & Door Manufacturers Association).

[2] ASTM indicates American Society for Testing and Materials.

WEATHERSTRIPPING

[Standards for conformance]

Weatherstripping	Commercially available.
Vapor retarders	Selected according to the provisions cited in ASTM[1] C755-97. Permeance not greater than 1 perm when determined according to the desiccant method described in ASTM E96-00.
Items to improve attic ventilation	Commercially available.

[1] ASTM indicates American Society for Testing and Materials.

HEAT EXCHANGERS

[Standards for conformance]

Heat exchangers, water-to-water and steam-to-water	ASME[1] Boiler and Pressure Vessel Code, 1998, Sections II, V, VIII, IX, and X, as applicable to pressure vessels. Standards of Tubular Exchanger Manufacturers Association, Eighth Edition, 1999.
Heat exchangers with gas-fired appliances[2]	ANSI/UL[3] 462, Ninth Edition, approved by ANSI February 28, 1997.

[1] ASME indicates American Society for Mechanical Engineers.

[2] The heat reclaimer is for installation in a section of the vent connector from appliances equipped with draft hoods or appliances equipped with powered burners or induced draft and not equipped with a draft hood.

[3] ANSI/UL indicates American National Standards Institute/Underwriters Laboratories.

BOILER/FURNACE CONTROL SYSTEMS

[Standards for conformance]

Automatic set back thermostats	Listed by UL[1]. Conformance to NEMA[2] DC3-1989 (R1996).
Line voltage or low voltage room thermostats	Listed by UL. Conformance to NEMA DC3-1989 (R1996).
Clock thermostats	Listed by UL. Conformance to NEMA DC3-1989 (R1996).
Automatic gas ignition systems	ANSI[3] Z21.21-2000. AGA[4] Laboratories Certification Seal.
Energy management systems	Listed by UL.
Hydronic boiler controls	Listed by UL.
Other burner controls	Listed by UL.

[1] UL indicates Underwriters Laboratories.

[2] NEMA indicates National Electrical Manufacturers Association.

[3] ANSI indicates American National Standards Institute.

[4] AGA indicates American Gas Association.

Install gas conversation burners	ANSI[1] Z21.8-1994 (for gas- or oil-fired systems), ANSI Z21.17-1998, and ANSI Z223.1-1999 (same as NFPA 54-1999). AGA[2] Laboratories Certification Seal.
Replace oil burner	UL[3] 296, Ninth Edition, 1994 and NFPA 31-2001.
Install burners (oil/gas)	ANSI Z223.1-1999 for gas equipment and NFPA[4] 31-2001 for oil equipment.
Re-adjust boiler water temperature or install automatic boiler temperature reset control	ASME[5] CSD-1-1998, ANSI Z223.1-1999, and NFPA 31-2001.
Replace/modify boilers	ASME Boiler and Pressure Vessel Code, 1998, Section II, IV, V, VI, VIII, IX, and X. Boilers must be Hydronics Institute Division of GAMA equipment.
Clean heat exchanger, adjust burner air shutter(s), check smoke no. on oil-fueled equipment. Check operation of pump(s) and replacement filters.	Per manufacturers' instructions.
Replace combustion chambers	Refractory linings may be required for conversions.

BOILER REPAIR AND MODIFICATIONS/EFFICIENCY IMPROVEMENTS—Continued

[Standards for conformance]

Replace heat exchangers, tubes	Protection from flame contact with conversion burners by refractory shield.
Install/replace thermostatic radiator valves	Commercially available. One-pipe steam systems require air vents on each radiator; see manufacturers' requirements.
Install boiler duty cycle control system	Commercially available. ANSI/NFPA 70-1999 (same as IEEE National Electrical Code) and local electrical code provisions for wiring.

[1] ANSI indicates American National Standards Institute.
[2] AGA indicates American Gas Association.
[3] UL indicates Underwriters Laboratories.
[4] NFPA indicates National Fire Prevention Association.
[5] ASME indicates American Society for Mechanical Engineers.

Replacement Furnaces, Boilers, and Wood Stoves

[Standards for conformance]

Chimneys, fireplaces, vents and solid fuel burning appliances	NFPA[1] 211-2000 (same as ANSI[2] A52.1).
Gas-fired furnaces	ANSI Z21.47-1998 and ANSI Z223.1-1999 (same as NFPA 54-1999).
Oil-fired furnaces	UL[3] 727, Eighth Edition, 1994 and NFPA 31-2001.
Liquefied petroleum gas storage	NFPA 58-2001.
Ventilation fans:	
Including electric attic, ceiling, and whole-house fans	UL 507, Ninth Edition, 1999.

[1] NFPA indicates National Fire Prevention Association.
[2] ANSI indicates American National Standards Institute.
[3] UL indicates Underwriters Laboratories.

Air Conditioners and Cooling Equipment

[Standards for conformance]

Air conditioners:	
Central air conditioners	ARI[1] 210/240-1994.
Room size units	ANSI/AHAM[2] RAC 1-1992.
Other cooling equipment:	
Including evaporative coolers, heat pumps, and other equipment	UL[3] 1995, Second Edition; 1995.

[1] ARI indicates Air Conditioning and Refrigeration Institute.
[2] ANSI/AHAM indicates American National Standards Institute/Association of Home Appliance Manufacturers.
[3] UL indicates Underwriters Laboratories.

Screens, Window Films, and Reflective Materials

[Standards for conformance]

Insect screens	Commercially available.
Window films	Commercially available.
Shade screens:	
Fiberglass shade screens	Commercially available.
Polyester shade screens	Commercially available.
Rigid awnings:	
Wood rigid awnings	Commercially available.
Metal rigid awnings .	Commercially available.
Louver systems:	
Wood louver awnings	Commercially available.
Metal louver awnings	Commercially available.
Industrial-grade white paint used as a heat-reflective measure on roofs, awnings, window louvers, doors, and exterior duct work (exposed)	Commercially available.

Refrigerators

[Standards for conformance]

Refrigerator/freezers (does not include freezer-only units)	UL[1] 250. Replaced units must be disposed of properly per Clean Air Act 1990, Section 608, as amended by 40 CFR[2] 82, May 14, 1993.

[1] UL indicates Underwriters Laboratories.
[2] CFR indicates Code of Federal Regulations.

Fluorescent Lamps and Fixtures

[Standards for conformance]

Compact fluorescent lamps	ANSI/UL[1] 542, Seventh Edition, February 6, 1997 and UL 1993, First Edition, 1993.
Fluorescent lighting fixtures	UL 1570, Fourth Edition, 1995.

[1] ANSI/UL indicates American National Standards Institute/Underwriters Laboratories.