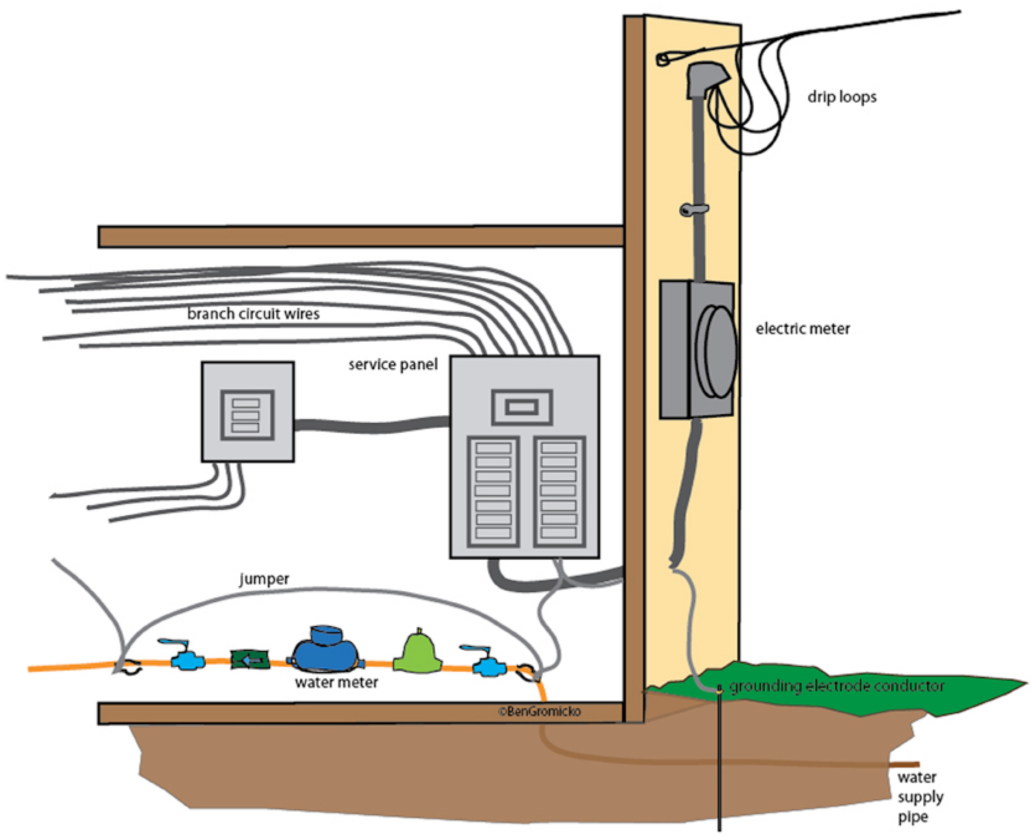
Chapter 8: Electrical System

Primary components are the service entry, service panel, and branch circuits. In unaltered buildings built since about 1940, the electrical system is likely to be intact and safe, although it may not provide the capacity required for the use of the building. Electrical capacity can be easily increased by bringing additional capacity in from the street and adding a larger service panel between the service entry and the existing panel. Existing circuits can continue to use the existing panel and new circuits can be fed through the new panel.

The electrical systems of residential buildings built prior to about 1940 may require overhaul or replacement, depending on the condition of the electrical system. Parts of these older systems may function adequately.

8.1 Service Entry

Service. Service is a term used to describe the conductors and equipment for delivering electricity from the utility company to the wiring system of the building served. Only one is typically installed for a dwelling. A minimum of 100-amp



service is needed for a single residential dwelling unit.

Service panel. It is typically referred to as the "panelboard" or "main electric panel." The first point of disconnect for the conductors from the utility company is at the "main panel."

Overhead wires. Overhead wires from the street should be greater than 10 feet above the ground, not in contact with tree branches or other obstacles, and not reachable from nearby windows or other accessible areas. The wires should be securely attached to the building and have drip loops where they enter the weatherhead. Wires should not be located over swimming pools.

Electric meter. The electric meter and its base should be weatherproof and securely fastened. Advise the utility company of any problems with the meter.

Service entrance conductor. The insulation of the service entrance conductor should be completely intact. If the main service panel is located inside the building, the conductor's passage through the wall should be sealed against moisture.

8.2 Main Electrical Service Panel (Breaker Box)

The main electrical service panel is the distribution center for electric service within the building. The primary function of the breakers or fuses (overcurrent protection devices) is to protect the house wiring from overloads.

All service panels must have covers or dead fronts. All openings should be closed.

Main disconnect. A means of disconnect for service must be located either outside or inside the dwelling unit nearest the point of entrance of the service conductors. No more than six hand movements or no more than six circuit breakers may be used to disconnect all service. Typically a main disconnect switch is required by the local authority. The main disconnect should be clearly marked to identify it as the service disconnect.

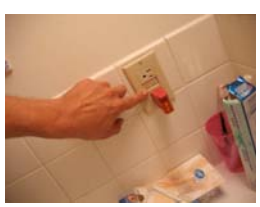
Condition and location. Water marks or rust on a service panel mounted inside the building may indicate water infiltration along the path of the service entrance conductor. Service panels mounted outdoors should be watertight. The service panel should have a workable space in front of it. The service panel should not be located inside a bathroom, over the stairs, or inside a clothes closet.

Amperage rating. The amperage rating of the main disconnect should not be less than 60-amps. It should be labeled or identified 100-amps or greater.

The ampacity of the service entry conductor may be determined by a building inspector by noting the markings (if any) on the conductor cable and finding the rating. If the service entry conductor is in a conduit, there may be markings on the conductor wires as they emerge from the conduit into the service panel. The ampere rating may be found on the service panel or service disconnect switch.

Grounding. A building inspector may be able to confirm that the service panel is properly grounded. Its grounding conductor should run to an exterior grounding electrode or be clamped to the metal water service inlet pipe between the exterior wall and the water meter.

Grounding electrode is a device that makes an electrical connection to the earth. A grounding electrode can be rebar in a footer, a metal underground water supply pipe within 10 feet of contact with the earth and a **grounding rod**.



GFCI. A GFCI (ground fault circuit interrupter) outlet is a device that adds a greater level of safety by reducing the risk of electric shock. Most building codes now require that GFCI protection be provided in wet locations such as the following: all kitchen counter receptacles; all bathroom receptacles; all exterior receptacles; receptacles in laundry and utility rooms; receptacles next to wet bar sinks; all garage and unfinished basement receptacles, except receptacles that are not readily accessible or single receptacles for appliances that are not easily moved; receptacles near a pool, spa, or hot tub and; light fixtures near water.

Downstream. A GFCI outlet may be wired in a branch circuit, which means other outlets and electrical devices may share the same circuit and breaker. When a properly wired GFCI trips, the other devices downstream from it will also lose power.

If you have an outlet that doesn't work, and the breaker is not tripped, look for a GFCI outlet that may have tripped. The non-working outlet may be downstream from a GFCI device. The “dead” outlets may not be located near the GFCI outlet; they may be several rooms away or even on a different floor.

GFCI outlets should be tested periodically - at least once a year. All GFCI devices have test buttons.

AFCI. All 15-amp and 20-amp 120-volt circuits for dining rooms, living rooms, bedrooms, sunrooms, closets, hallways, or similar areas must be AFCI protected. An arc fault circuit interrupter (AFCI) is a circuit breaker designed to prevent fires by detecting non-working electrical arcs and disconnect power before the arc starts a fire. The AFCI should distinguish between a working arc that may occur in the brushes of a vacuum sweeper, light switch, or other household devices and a non-working arc that can occur, for instance, in a lamp cord that has a broken conductor in the cord from overuse. Arc faults in a home are one of the leading causes for household fires.

AFCIs resemble a GFCI (Ground-Fault Circuit Interrupter) in that they both have a test button, though it is important to distinguish between the two. GFCIs are designed to protect against electrical shock, while AFCIs are primarily designed to protect against fire.

Overcurrent protection. A breaker or fuse is referred to as an overcurrent protection device. It is recommended that a homeowner should turn all circuit breakers on and off manually and make sure they are in functional condition.

The rating of the fuse or circuit breaker for each branch circuit may be checked by a building inspector or electrician. The amperage of the fuse or circuit breaker should not exceed the capacity of the wiring in the branch circuit it protects. Most household circuits use #14 copper wire, which should have 15-amp protection. There may be one or more circuits with #12 copper wire, which should have 20-amp protection. Large appliances, such as electric water heaters and central air conditioners, may require 30-amp service, which is normally supplied by #10 copper wire. If there were an electric range, it would require a 40-amp or 50-amp service with #6 copper wire.

Identification. Each circuit should be clearly and specifically identified as to its purpose. No two circuits should be labeled the same. No circuit should be identified in a way that may be subject to change with occupancy. For example, no breaker should be labeled “Ben’s room.”

8.3 Branch Circuits

The oldest wiring system that may still be acceptable, and one still found fairly often in houses built before 1930, is “**knob and tube**.” This system utilizes porcelain insulators (knobs) for running wires through unobstructed spaces, and porcelain tubes for running wires through building components such as studs and joists. Knob and tube wiring should be replaced during rehabilitation; but if it is properly installed, needs no modification, has adequate capacity, is properly grounded, has no failed insulation, and is otherwise in good condition, it can be an acceptable wiring system and is still allowed in many localities. Check with local building code officials. Also check the terms and conditions of the **home insurance policy** to see if "knob and tube" wiring is excluded. The greatest problem with such wiring is its insulation, which turns dry and brittle with age and often falls off on contact, leaving the wire exposed. Knob and tube wiring is known to have caused house fires.

Approved wire types include:

- NM (non-metallic) cable, often called by the trade name "Romex", a plastic covered-cable for use in dry locations (older NM cable may be cloth covered).
- NMC, similar to NM but rated for damp locations.
- UF (underground feeder), a plastic-covered waterproof cable for use underground.
- AC (armored cable), also called BX, a flexible metal-covered cable.
- MC (metal-clad cable), a flexible metal-covered cable with a green insulated ground conductor.
- EMT (electrical metallic tubing), also called "thinwall," a metal conduit through which the wires are run in areas where maximum protection is required.

Aluminum wire. Aluminum wire was used in residential buildings primarily during the 1960s and early 1970s, and is a potential fire hazard.

According to the U.S. Consumer Product Safety Commission, fires and even deaths have been caused by the use of aluminum wiring in residential homes. Problems due to expansion and arcing at the connections can cause overheating between the wire and the devices, or at wire splices. The connections can become hot enough to start a fire.

Aluminum wire should be attached only to approved devices (marked "CO-ALR" or "CU-AL") or with connectors.

Problems with aluminum wiring occur at connections, so feel cover plates for heat, smell for a distinctive odor in the vicinity of outlets and switches, and look for sparks and arcing in switches or outlets and for flickering lights. Whenever possible, aluminum wire and its devices should be replaced with copper wire and devices appropriate for copper. It is difficult to find aluminum branch wiring in a home during a visual inspection. For a thorough investigation, an electrician should be hired.

Smoke Detectors. After moving in, consider replacing all of the smoke/fire detectors in the entire house. The building should have functioning smoke detectors. Detectors should be wired to a power source and also should contain a battery. Smoke detectors do not last forever. Replace detectors according to manufacturer's recommendations. Test the detectors regularly.

Replace batteries when you change your clocks for daylight savings time changes.

8.4 Inspection Standards

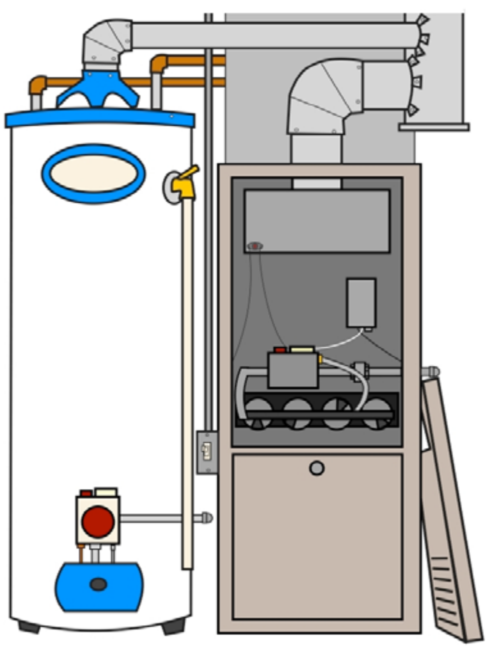
The inspector is required to inspect the service panel and overcurrent devices, but is not required to operate or reset overcurrent devices. During a home inspection, a representative number of switches, receptacles, lighting fixtures, and AFCI-protected receptacles are inspected - not each and every one.

The inspector shall report the presence of solid conductor aluminum branch circuit wiring ONLY if it is readily visible. The measurement of the amperage or voltage of the electrical service is not required by the SOP. Exterior accent wiring is not part of a home inspection.

Chapter 9: HVAC System

Most HVAC (heating, ventilating, air conditioning) systems in small residential buildings are relatively simple in design and operation. They consist of four components: controls, fuel supply, heating or cooling unit and distribution system. The **adequacy** of heating and cooling is often quite **subjective** and depends upon occupant perceptions that are affected by the distribution of air, the location of return air vents, air velocity, the sound of the system in operation and similar characteristics.

This chapter describes oil-fired and gas-fired warm air, hot water, and steam heating systems; electric resistance heaters; chilled air and evaporative systems; humidifiers; unit air conditioners; and attic fans.



9.1 Thermostatic Controls

Residential HVAC controls consist of one or more thermostats and a master shut-off switch for the heating or cooling unit.

Thermostats. Thermostats are temperature-sensitive switches that automatically control the heating or cooling system. Thermostats should be located in areas with average temperature conditions and away from heat sources such as windows, water pipes or ducts.

Once a year, take off the thermostat cover and check for dust on the spring coil and dirty or corroded electrical contact points. Plan to replace worn or defective thermostats. There may be more than one thermostat. Sometimes two thermostats separately control the heating and cooling system, and sometimes the living unit is divided into zones, each with its own thermostat.

Master (or service) shut-off switch. Every gas-burning and oil-burning system should have a master switch that serves as an emergency shutoff for the burner. Master shut-off switches are usually located near the burner unit or, if there is a basement, near the top of the stairs.

9.2 Fuel-Burning Units

Oil-fired or gas-fired furnaces and boilers provide heat to the majority of small residential buildings. Such fuel-burning units, whether they are part of a warm-air or a hot-water system, should be maintained regularly and continuously monitored.

No fuel-burning unit should be located directly off sleeping areas or close to combustible materials.

Seismic vulnerability. If the building is in a seismic zone, the HVAC unit should have seismic bracing to the structure.

Fuel supply. Gas supply lines should be made of black iron or steel pipe (some jurisdictions allow copper lines with brazed connections). Shutoff valves should be easily accessible. A gas shut-off valve should be next to the HVAC unit.

Oil tanks should be maintained in accordance with local regulations. All tanks must be vented to the outside and have an outside fill pipe. Buried tanks normally have a 550, 1000, or 1500 gallon (2080, 3785, or 5680L) capacity; basement tanks are usually sized to a 275-gallon (1040 L) capacity.

An oil filter should be installed on the oil supply line that runs from the storage tank to the oil burner. The filter needs to be maintained every year.

Ventilation and access. Make sure the fuel-burning unit has adequate combustion air and is easily accessible for servicing with at least three feet clear on each side of the unit requiring service.

Condition. On hot air furnaces, look for signs of rust on the furnace jacket from basement dampness or flooding, and, if an air conditioning evaporator coil is located over the furnace, look for rust caused by condensate over-flow. On hot water boilers, look for rust caused by dampness and by leaking water lines and fittings.

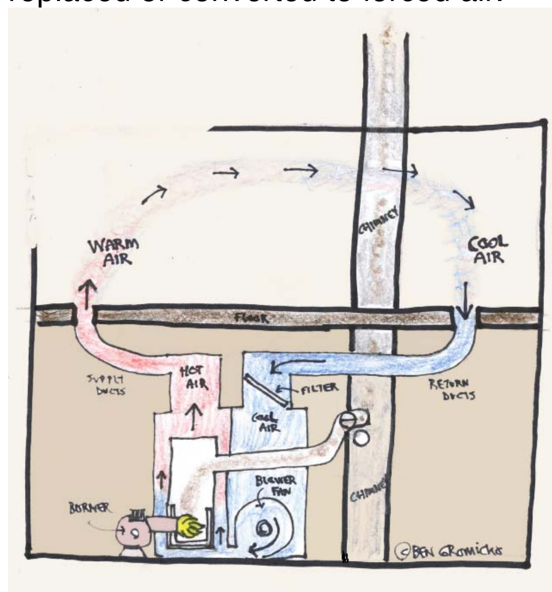
Flame. Once the unit has been activated, closely observe the combustion process. In oil-fired units, the **flame** should be clear and clean, and have minimal orange-yellow color. Flame height should be uniform.

Gas-fired units should have a **flame** that is primarily bluish in color. Check gas burners for rust and clogged ports. Soot or carbon build-up on the burners could be a sign of inefficient combustion. In oil-fired units, look for soot below the draft regulator, on top of the unit's housing and around the burner. The odor of smoke near the unit is another sign of poor combustion.

Have a service technician service and clean the system each and every year. Keep maintenance records up to date.

9.3 Forced Air Heating

Warm air heating systems are of two types, **forced air or gravity**. Gravity systems are occasionally still found in older single-family houses, but most gravity systems either have been replaced or converted to forced air.



Most forced warm air systems use natural gas or fuel oil as a heat source, but some systems use electric resistance heaters or heat pumps. The circulation blower and air distribution ductwork for electric resistance heating systems (and heat pumps) are identical to those of gas-fired and oil-fired warm air systems and should be regularly serviced and maintained.

Heat exchanger. The heat exchanger is located downstream of the burner in gas-fired and oil-fired furnaces and separates the products of combustion from the air to be heated. It is critical that the heat exchanger be intact and contains no cracks or other openings that could allow combustion products into the warm air distribution system. Visual detection of cracks, even by heating experts, is a difficult (if not impossible) process.

Monitor. Look for signs of soot at supply registers and smell for oil or gas fumes. Observe the burner flame as the furnace fan turns on; a disturbance or color change in the flame may indicate air leakage through a crack in the exchanger. A major cause of premature exchanger failure is water leakage from humidifiers or blocked air conditioner condensate lines. Check for signs of water leakage. The durability of the heat exchanger determines the service life of the furnace.

Circulation blower fan. If the fan is worn or misaligned, or has excessive dust and dirt on the fins, the fan may rumble or make sounds that are unwarranted or may actually shake the ductwork.

Distribution system. The distribution system is made up of supply and return ducts, filters, dampers and registers. Supply and return ducts may be made of sheet metal, glass fiber or other materials. Check ducts for open joints and air leakage wherever the ducts are exposed. Air ducts can be cleaned by an HVAC contractor or a professional duct-cleaning contractor. Ducts could be cleaned every 5 years. Cleaning ducts is part of maintaining a healthy home. There should be no openings in return ducts in the same room as a combustion furnace.

Check the air filter. Air filters are usually located on the return side of the furnace next to the blower, but they may be found anywhere in the distribution system. Check for their presence and examine their condition. Homeowners should check and replace the air filter every month (or according to the manufacturer's recommendations).

Humidifiers may be located in the *supply* air ducts. They should not be located in *return* air ducts because the moist air will pass through the heat exchanger and evaporator coil, rendering the humidification ineffective and corroding the heat exchanger. Humidifiers require regular maintenance.

9.4 Forced Hot Water or Hydronic

Hot water heating systems, like warm air systems, are of two types, forced or "hydronic" and gravity. Gravity systems are sometimes found in older single-family houses, but in most cases such systems have been replaced or converted to a forced hot water system. Gravity systems have no water pump and use larger piping. They tend to heat unevenly, are slow to respond and can only heat spaces above the level of their boiler. Like gravity warm air systems, they are considered inefficient. Forced hot water systems are usually heated by gas-fired or oil-fired boilers.

Boilers. Monitor all boilers for signs of corrosion and leakage. Most hot water and steam heating systems have steel boilers with a service life of about 20 years. Cast iron boilers have a service life of about 30 years. Water leaking from the exchanger of the boiler is likely an indication of a major defect requiring replacement.

Expansion tank. The expansion tank is usually located above the boiler and is connected to the hot water distribution piping. The pressure relief valve should discharge water from the system when the boiler pressure reaches 30 psi (207 kPa). Look for signs of water near the valve or below it on the floor. High-pressure conditions are usually due to a waterlogged expansion tank. If the boiler also generates domestic hot water, high pressure may be caused by cracks in the coils of the water heater, since the domestic water supply pressure usually exceeds 30 psi (207 kpa). Any water drips coming from the relief valve is unacceptable and may indicate a safety hazard.

Circulating pump and controls. The circulating pump forces hot water through the system at a constant flow rate, usually stated in gallons per minute (gpm). It should be located adjacent to the boiler on the return pipe near the boiler. Monitor the condition and operation of the pump itself. Listen for smooth operation. A loud pump may have bad bearings or a faulty motor. Look at the gasket seal between the motor and the pump housing for signs of leakage. Look for scorching at all electrical wiring and connections. Circulating pumps should be lubricated regularly (read manual).

Distribution piping. The forced hot water distribution system consists of distribution piping, radiators and control valves. Distribution piping may be one of three types: series-loop; one-pipe and; two-pipe.

In a **series-loop** system, radiators are connected by one pipe in a series. In a **one-pipe** system each radiator is separately attached to the water distribution pipe with a regulating, diverter fitting. A **two-pipe** system uses two pipes - one for *supply* water and one for *return*.


Monitor the distribution piping, valves, connections and radiators for water leaks.

Radiators and control valves. Radiators are of three types: cast iron (which in most cases are free standing but sometimes are hung from the ceiling or wall; convector (which may have a circulating fan) and; baseboard. Older residential buildings usually have cast iron radiators that are extremely durable. Baseboard radiators are considered the most desirable for residential use because they are the least conspicuous and distribute heat most evenly throughout the room. Monitor for water leaks. When a leak is detected, have the service technician flush the piping to check for galvanic corrosion.

9.5 Steam Heating

Steam heating systems are seldom installed now in small residential buildings but are still common in many older ones. They are simple in design and operation, but require a higher level of maintenance than modern residential heating systems. A homeowner should have plans to keep the system **maintained continuously**.

Steam boiler controls. Unlike hot water boilers, steam boilers operate only about three-fourths full of water and at much lower pressures, usually 2 to 5 psi. Steam boilers should be equipped with a water level gauge, a pressure gauge, a high-pressure limit switch, a low water cut-off and a safety valve.

Look at the water level gauge that indicates the level of the water in the steam boiler. The **gauge** should normally read about **half full**, though the actual level of the water is not critical as long as the level is showing. If the gauge is full of water, the boiler is flooded and water must be drained from the system. If the gauge is empty, the boiler water level is too low and must be filled (either manually through the fill valve or automatically through the automatic water feed valve, if the boiler has one). Unsteady, up and down motion of water in the gauge could mean the boiler is clogged with sediment or is otherwise operating incorrectly and must be repaired. The clarity of the boiler water should be checked when checking the gauge. If the gauge is too dirty to judge the water level, it needs to be removed and cleaned. Consider hiring a HVAC professional to maintain the system.

Steam distribution pipes. The steam distribution system consists of distribution piping, radiators and control valves. Distribution piping may have either a one-pipe or two-pipe configuration.

In a one-pipe system, steam from the boiler rises under pressure through the pipes to the radiators. There, it displaces air by evacuation through the radiator vent valves, condenses on the radiator's inner surface, and gives up heat. Steam condensate flows by gravity back through the same pipes to the boiler for reheating. The pipes, therefore, must be pitched no less than one inch in ten feet in the direction of the boiler to ensure that the condensate does not block the steam in any part of the system. All piping and radiators must be located above the boiler in a one-pipe system.

In a two-pipe steam system, steam flows to the radiators in one pipe and condensate returns in another. A steam trap on the condensate return line releases air displaced by the incoming steam. If the condensate return piping is located below the level of the boiler, it should be brought back up to the level of the boiler and vented to the supply piping in a "Hartford Loop." This prevents a leak in the condensate return from emptying the boiler.

Steam distribution piping should be checked for leaks at all valves and connections. Make sure all piping is properly pitched to drain toward the boiler. "Pounding" may occur when oncoming steam meets water trapped in the system by improperly pitched distribution piping or by shutoff valves that are not fully closed or fully open.

The valve to the steam radiator should NOT be turned on partway (it must be either completely on or completely off) or banging may occur. Variable sir vent valves are good because you can properly balance the system and turn down the heat, if need be.

9.6 Electric Resistance

Electric resistance heating elements commonly are used in heat pump systems, wall heaters, radiant wall or ceiling panels, and baseboard heaters. They are less frequently used as a heat source for central warm air or hot water systems. Such heating devices require some maintenance.

Electric resistance heaters. Electric resistance heaters are used in warm air and hot water systems and in heat pumps. They incorporate one or more heavy duty heating elements that are actuated by sequence relays on demand from the thermostat.

Electric wall heaters. These compact devices are often used as supplementary heating units. They may have one or more electric heating elements, depending on their size. Wall heaters often have a small circulation fan. Look for dirt build up on the fan blades and motor housing.

Radiant wall and ceiling panels. Electric heating panels that are embedded in wall or ceiling surfaces cannot be directly inspected, but all radiant surfaces should be monitored for signs of surface or structural damage.

Baseboard heaters. Baseboard heater heating fins can be damaged and become clogged with dust. Once a year remove heater covers and clean the unit. Bent heating fins can often be straightened by "combing." The thermostat may be on an adjacent wall or in the unit itself.

9.7 Central Air

Central air conditioning systems are defined here as electrically operated refrigerant-type systems used for cooling and dehumidification. Heat pumps are similar to central air conditioners, but are reversible and can also be used as heating devices. Air conditioning systems should be operated only when the outside air temperature is above 65 ºF (18 ºC); below that temperature, the systems will not operate properly, may shut down due to safety controls and could be damaged by operating in cool temperatures.

There are two types of central air conditioning systems: integral and split. In the integral system, all mechanized components—compressor, condenser, evaporator, and fans—are contained in a single unit. The unit may be located outside the building with its cold air ductwork extending into the interior, or it may be located somewhere inside the building with its exhaust air ducted to the outside.

In the split system, the compressor and condenser are located outside the building and are connected by refrigerant lines to an evaporator inside the building's air distribution ductwork. Split systems in buildings heated by forced warm air usually share the warm air system's circulating fan and ductwork. In such cases, the evaporator is placed either directly above or below the furnace, depending on the furnace design.

Compressor and condenser. The compressor pumps refrigerant gas under high pressure through a condenser coil. Compressors have a service life of 12 to 15 years and are the most critical component in the air conditioning system.

Pay attention to the compressor. It should start smoothly and run continuously; noisy start up and operation indicates a worn compressor. The condenser fan should start simultaneously with the compressor. After several minutes of operation, the air flowing over the condenser (the unit outside on a split system) should be warm. If it isn't, either the compressor may be faulty or there may not be enough refrigerant in the system.

3 feet of clearance. If the compressor, condenser, and condenser fan are part of a split system and are located in a separate unit outside, check the airflow around the outside unit to make sure it is unobstructed.

Look inside and check for dirt and debris, particularly on the condenser coils and fins, and look at the electrical wiring and connections. The unit **should be level** and supported well. Outdoor units often settle or slide. An **electrical disconnect switch** for use during maintenance and repairs should be located within sight of the exterior unit (not located behind the unit).

Refrigerant lines. Refrigerant lines form the link between the interior and exterior components of a split system. The larger of the two lines carries low-pressure (cold) refrigerant gas from the evaporator to the compressor. It is about the diameter of a broom handle and should be insulated along its entire length. The smaller line is not insulated and carries high pressure (warm) liquid refrigerant to the evaporator.

✔ **Touch the lines**. While the unit is operating, the smaller line should feel warm, and the larger should feel cool to the hand. You could check both lines for signs of damage and make sure the insulation is intact on the larger line. Sometimes a sight glass is provided on the smaller line; if so, the flow of refrigerant should look smooth through the glass. Bubbles in the flow indicate a deficiency of refrigerant in the system. Frost on any exposed parts of the larger line also indicates a refrigerant deficiency.

Evaporator. The evaporator is enclosed in the air distribution ductwork and can only be observed by removing a panel or part of the furnace plenum. High-pressure liquid refrigerant enters the evaporator and expands into a gas, absorbing heat from the surrounding air.

Air is pushed past the evaporator coil by the circulation blower; in the process, water vapor from the air condenses on the evaporator coil and drips into a drain pan. From there, it is directed to a condensate drain line that may sometimes include a condensate pump. The drain line could empty into a house drain or be discharged to the building's exterior.

Monitor the ductwork around the evaporator for signs of air leakage and check below the evaporator for signs of water leakage due to a blocked condensate drain line. Such leakage can present a serious problem if the evaporator is located above a warm air furnace, where dripping condensate water can cause rust to develop on the heat exchanger, or above a ceiling, where it can damage the building components below. Follow the condensate line and make sure that it terminates in a proper location.

In split systems where the evaporator is located in an attic or closet, the condensate drain pan should have an auxiliary condensate drain line located above the regular drain line, and that would drain into a water leak catch pan. The auxiliary drain pan that is separately drained should discharge to an area that is conspicuous. If you see this pipe leaking water, it is a sign of a water leak problem.

Geothermal heating and cooling systems. Geothermal systems are relatively new and operate similarly to air-to-air heat pump systems, but differ in design and installation. What might be considered the condenser are pipes buried in the ground in dry wells or other in-ground systems suitable for transferring or displacing heat. The system is closed and its piping is PVC so corrosion is not a potential problem. Geothermal systems are normally installed without a back-up or emergency heating system, and all their components (except the buried coils) are usually inside the house.

A geothermal heating and cooling system can be operated in a heating or cooling mode under any outside temperature. Although expensive to install, they normally are efficient and economical to operate.

9.8 Central Gas-Absorption Cooling Systems

Gas-absorption cooling systems occasionally may be found in older residential buildings. Such systems use the evaporation of a liquid, such as ammonia, as the cooling agent, and like a gas refrigerator, are powered by a natural gas or propane flame. It should start smoothly and run quietly.

9.9 Heat Pumps

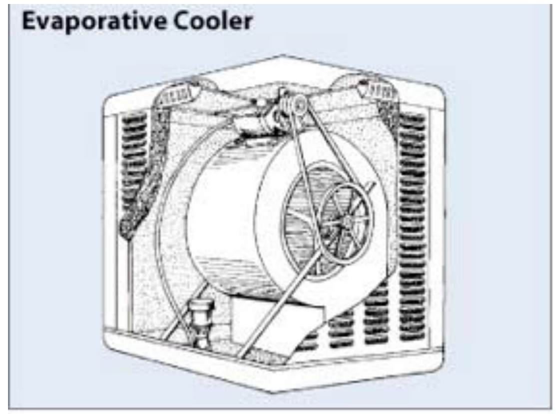
Heat pumps are like central air conditioners that can operate in reverse. Electric heat pumps are electrically operated, refrigerant-type air-conditioning systems that can be reversed to extract heat from outside air and transfer it indoors.

Cold temperatures. Do not operate air-to-air heat pumps in outdoor temperatures below 65 ºF (18 ºC) on the cooling cycle and above 55 ºF (13 ºC) on the heating cycle. Electric resistance auxiliary heaters are designed to activate when the outdoor temperature is around 30 ºF (-1 ºC), and the air-to-air heat pump cannot produce enough heat to satisfy the thermostat.

Improper defrosting. During cold, damp weather, frost or ice may form on the metal fins of the coil in an outdoor unit. Heat pumps are designed to defrost this build up by reversing modes either at preset intervals or upon activation by a pressure-sensing device.

9.10 Evaporative Cooling Systems (Swamp Coolers)

Evaporative cooling systems are simple and economical devices. They pass air through wetted pads or screens and cooling takes place by evaporation. Such systems can only be used in dry climates where evaporation readily takes place and where dehumidification is not required.



Evaporative coolers consist of evaporator pads or screens, a means to wet them, an air blower, and a water reservoir with a drain and float-operated water supply valve. These components are contained in a single housing, usually located on the roof, and connected to an interior air distribution system. In wetted-pad coolers, evaporator pads are wetted by a circulating pump that continually trickles water over them; in slinger coolers, evaporator pads are wetted by a spray; and in rotary coolers, evaporator screens are wetted by passing through a reservoir on a rotating drum.

The water in evaporative coolers often contains **algae** and **bacteria** that emit a characteristic **"swampy" odor**. These can be removed easily with bleach. Some systems counteract this pattern by treating the water or by continually adding a small amount of fresh water.

Monitor for signs of leakage and check the cleanliness and operation of the water reservoir, float-operated supply valve and drain. Listen for unusual sounds or vibrations.

9.11 Humidifiers

Humidifiers require consistent maintenance. Do not delay cleaning the humidifier, because a dirty humidifier can cause air quality problems.

A humidifier should only operate when the furnace fan is on, the system is in the heating mode and the indoor humidity is lower than the humidistat setting.

Humidifiers are sometimes added to warm-air heating systems to reduce interior dryness during the heating season. They are installed with the air distribution system and are controlled by a humidistat that is usually located in the return air duct near the humidifier housing.

Types of humidifiers:

Stationary pad: air is drawn from the furnace plenum or supply air duct by a fan, blown over an evaporator pad, and returned to the air distribution system.

Revolving drum: water from a small reservoir is picked up by a revolving pad and exposed to an air stream from the furnace plenum or supply ductwork.

Atomizer: water is broken into small particles by an atomizing device and released into the supply air ductwork.

Steam: water is heated to temperatures above boiling and then injected into the supply air duct.

Monitor for mineral build up on the drum or pad. Examine the humidifier's water supply and look for signs of leakage, especially at its connection with the house water supply. Check all electrical wiring and connections.

9.12 Unit (Window) Air Conditioners

Unit air conditioners are portable, integral air conditioning systems without ductwork. Look at the seal around each unit and its attachment to the window or wall. It should be adequately supported. It should not be obstructed. Look for proper condensate drainage. After several minutes, the air from the unit should feel quite cool. It should start smoothly and run quietly. Check for water dripping from the condensate discharge on the exterior side of the unit.

9.13 Whole House Fans

Whole house fan. The louvers of the whole house fan should open completely when the fan is running. Clean the louvers when they are dirty. Be sure to cover the fan opening when the unit is not being used, especially during the winter in cold climates. The fan thermostat should be set at around 95 ºF (35 ºC). The fan should start and run smoothly.

9.14 Inspection Standards

The HVAC (heating, ventilating, air conditioning) system is inspected using normal operating controls. The inspector is not required to inspect the flues or chimneys, fire chambers, heat exchangers, humidifiers, electronic air filters or geothermal systems. Underground or concealed fuel storage systems are beyond the visual scope of a home inspector. The inspector is not required to check uniformity, BTU, temperature, flow, balance, distribution, or adequacy of the HVAC system. The inspector is not required to activate a system that has been shutdown. An inspector is not required to operate the cooling system when the weather is cold, or operate the heating system when the weather is hot.

Chapter 10: Making Your Home Energy Efficient

Sealing and **insulating** your home is one of the most cost-effective ways to make a home more comfortable and energy efficient—and you can do it yourself.

In this chapter, you will learn how to find and seal hidden attic and basement air leaks; determine if your attic insulation is adequate and learn how to add more; make sure your improvements are done safely; and reduce energy bills and help protect the environment.

You will notice your home's air leaks in the winter more than any other time of year. Most people call these air leaks "drafts." You may feel these drafts around windows and doors and think these leaks are your major source of wasted energy. In most homes, however, the most significant air leaks are hidden in the attic and basement. These are the leaks that significantly raise your energy bill and make your house uncomfortable.

In cold weather, warm air rises in your house, just like it does in a chimney. This air, which you have paid to heat, is just wasted as it rises up into your attic and sucks cold air in all around your home—around windows, doors, and through holes into the basement. Locating these leaks can be difficult because they are often hidden under your insulation. This chapter will help you find these leaks and seal them with appropriate materials.
An inspector who is certified in the thermography and building science can help find these air leaks. To find a certified inspector go to www.inspectorseek.com. Ask the inspector if they are infrared-certified and look for the infrared-certified logo.

10.1 Getting started

Sealing attic air leaks will enhance the performance of your insulation and make for a much more comfortable home.

Attic air sealing and adding insulation are do-it-yourself projects if your attic is accessible and not too difficult to move around in. The projects in this chapter can usually be completed in two days and will provide rewards for years to come.

If you find any major problems in the attic space such as roof leaks, mold, unsafe working conditions, inadequate flooring, inadequate ventilation, knob-and-tube wiring, recessed “can” lights, we recommend hiring a contractor to help you and/or correct these problems before proceeding.

Look around your house for any dropped-ceiling areas, dropped soffits over kitchen cabinets, slanted ceilings over stairways, and where walls (interior and exterior) meet the ceiling. These areas may have open spaces that could be huge sources of air leaks.

10.2 Working in the Attic

Be sure to use a work light to make sure that your work area is lit adequately.

Use personal protective equipment. To work in an attic, you need kneepads, coveralls, gloves and a hat to keep itchy and irritating insulation off your skin. Use an OSHA-approved particulate respirator or a high-quality dust mask.

Be safe. Do not work in the attic area if you feel that it is dangerous in any way. It’s not worth risking life or property. Simply hire a qualified contractor to perform the work you need to get done. If you work in a hot attic, drink plenty of water.

Watch your step. Walk on joists or truss chords. Watch your head - there will be sharp nails and things sticking out above you and all around your head.

10.3 What You Will Need

- Reflective foil insulation or other blocking material such as drywall or pieces of rigid foam insulation to cover soffits, open walls, and larger holes
- Unfaced fiberglass insulation and large garbage bags
- Silicone or acrylic latex caulk for sealing small holes (1/4 inch or less)
- Expanding spray foam insulation for filling larger gaps (1/4 inch to 3 inches)
- Special high-temperature (heat-resistant) caulk to seal around flues and chimneys
- Roll of aluminum flashing to keep insulation away from the flue pipe
- Tape measure
- Utility knife and sheet metal scissors
- Staple gun (or hammer and nails) to hold covering materials in place
- Plastic garbage bag

10.4 Plug the Large Holes

The biggest savings will come from sealing the large holes. Locate the areas from the attic where leakage is likely to be greatest: where walls (interior and exterior) meet the attic floor; dropped soffits (dropped-ceiling areas) and; behind or under attic knee walls. **Look for dirty insulation**. Dirty insulation (black/brown stains on the underside of the insulation) indicates that air is moving through it. Push back the insulation or pull it out of the soffits. You will place this insulation back over the soffit once the stud cavities have been plugged and the soffits covered.

Dropped soffit. After removing insulation from a dropped soffit, cut a length of reflective foil or other blocking material (rigid foam board works well). Apply a bead of caulk or adhesive around the opening. Seal the foil to the frame with the caulk/adhesive and staple or nail it in place, if needed.

Under a wall. Cut a 24-inch long piece from a batt of fiberglass insulation and place it at the bottom of a 13-gallon plastic garbage bag. Fold the bag over and stuff it into the open joist spaces under the wall (a piece of rigid foam board sealed with spray foam also works well for covering open joist cavities). Cover with insulation when you're done.

Finished rooms built into attics often have open cavities in the floor framing under the sidewalls or knee walls. Even though insulation may be piled against or stuffed into these spaces, they can still leak air. Again, look for signs of dirty insulation to indicate air is moving through. You need to plug these cavities in order to stop air from traveling under the floor of the finished space.

Flue. The opening around the flue or chimney of a furnace or water heater can be a major source of warm air moving in the attic. Because the pipe gets hot, building codes usually require 1-inch of clearance from metal flues (2 inches from masonry chimneys) to any combustible material, including insulation. This gap can be sealed with lightweight aluminum flashing and special high-temperature (heat-resistant) caulk. Before you push the insulation back into place, build a barrier out of the metal aluminum to keep the insulation away from the pipe.

10.5 Seal the Small Holes

Look for areas where the insulation is darkened. This is the result of dusty air coming from the house interior, and moving into and being filtered by the insulation. In cold weather, you may also see frosty areas in the insulation caused by warm, moist air condensing and then freezing as it hits the cold attic air. In warmer weather, you'll find water staining in these same areas. Use expanding foam or caulk to seal the **openings around plumbing vent pipes and electrical wires**. When the foam or caulk is dry, cover the area again with insulation. After sealing the areas, just push the insulation back into place. If you have blown insulation, a small hand tool can be helpful to level it back into place.

10.6 Attic Access

Seal up the attic access panel with weather stripping. Cut a piece of fiberglass or rigid foam board insulation the same size as the attic hatch and glue it to the back of the attic access panel.

If you have pull-down attic stairs or an attic door, these should be sealed in a similar manner using weather stripping and insulating the back of the door. Treat the attic door like an exterior door to the outside.

10.7 Ducts

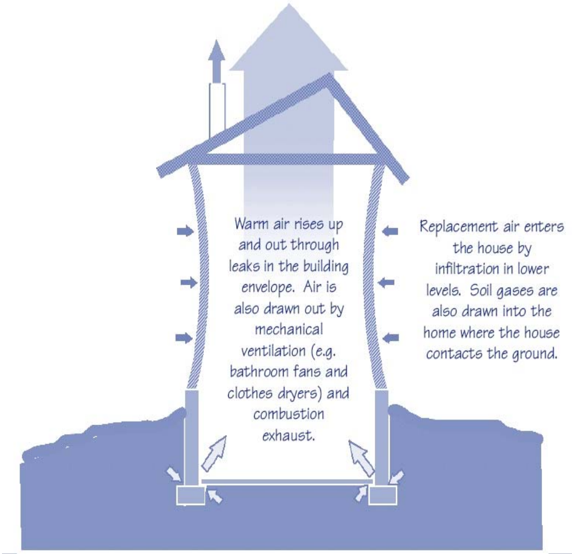
Sealing and insulating your ducts can increase the efficiency of your HVAC system. Leaky ducts waste an incredible amount of energy. Check the duct connections for leaks - seal the joints with mastic or foil tape (household duct tape should not be used). Pay special attention to all the duct penetrations going through the attic floor. Seal these with foam.

HVAC ducts should also be insulated—if your ducts are uninsulated or poorly insulated, seal them first, then add insulation. Use duct insulation material rated at least R-6. Duct sealant, also known as duct mastic, is a paste, which is more durable than foil duct tape. It is available at home improvement centers.

10.8 “Can” Lights

Recessed “can” lights (also called high-hats or recessed lights) can make your home less energy-efficient. These recessed lights can create open holes that allow unwanted airflow from conditioned spaces to unconditioned spaces. In cold climates, the heat from the airflow can melt snow on the roof and cause the development of ice dams. Recessed “can” lights in bathrooms also cause problems when warm, moist air leaks into the attic and causes moisture damage.

Warning: You can create a fire hazard if the “can” light is not insulated or sealed properly. It may be best to consult a professional before sealing “can” lights or coming in contact with any electrical components.



10.9 Stack Effect

Like a chimney. Outside air drawn in through open holes and gaps in the basement is drawn in by a chimney stack effect created by air leaks in the attic. As hot air generated by the furnace rises up through the house and into the attic through open holes, cold outside air gets drawn in through open holes in the basement to replace the displaced air. This makes a home feel drafty and contributes to higher energy bills. After sealing attic air leaks, complete the job by sealing basement leaks, to stop the stack effect.

Basement air leaks. Along the top of the basement wall where floor system meets the top of the foundation wall is a good area to look for open holes and gaps. Since the top of the wall is above ground, outside air can be drawn in through cracks and gaps where the house framing sits on top of the foundation.

Sealant or caulk is best for sealing gaps or cracks that are 1/4 inch or less. Use spray foam to fill gaps from 1/4 inch to about 3 inches. We also recommend you seal penetrations that go through the basement ceiling to the floor above. These are holes for wires, water supply pipes, water drainpipes, the plumbing vent stack, and the furnace flue.

Attic and basement air sealing will go a long way to improve your comfort because your house will no longer act **like an open chimney**.

10.10 Attic Insulation Thickness

Look. One quick way to determine if you need more insulation on the floor of your attic is to simply look across the floor of your attic. If the insulation is level with or below your floor joists, more insulation is needed. If the insulation is well above the joists, you may have enough. There should be no low spots.

R-Value. Insulation levels are specified by R-Value. R-Value is a measure of insulation's ability to resist heat flow. The higher the R-Value, the better the thermal performance of the insulation. The recommended level for most attic floors is R-38 or about 10 to 14 inches (depending on the type of insulation and your climate).

When adding insulation, you do not have to use the same type of insulation that currently exists in your attic. You can add loose fill on top of fiberglass batts or blankets, and vice-versa. If you use fiberglass over loose fill, make sure the fiberglass batt has no paper or foil vapor barrier. The insulation needs to be "unfaced."

Laying out or spreading fiberglass rolls is easy. If you have any type of insulation between the rafters, install the second layer over and perpendicular to the first. This will help cover the tops of the joists and reduce heat loss or gain through the frame.

NEVER! Never lay insulation over recessed light fixtures or soffit vents. Keep all insulation at least 3 inches away from "can" lights, unless they are rated IC (Insulated Ceiling). If you are using loose fill insulation, use sheet metal to create barriers around the openings. If using fiberglass, wire mesh can be used to create a barrier.

Rafter vent trays. To completely cover your attic floor with insulation out to the eaves you need to install rafter vents or trays (also called insulation baffles). Rafter vents ensure the soffit vents are clear and there is a clear opening for outside air to move into the attic at the soffits and out through the gable or ridge vent for proper ventilation.

10.11 Additional Information

For additional information on Indoor Air Quality (IAQ) issues related to homes such as combustion safety, indoor air contaminants, and proper ventilation, visit: http://www.epa.gov/iaq/homes/hip-front.html.

ENERGY STAR is a government-backed program helping businesses and individuals protect the environment through superior energy efficiency. To learn more about the wide variety of energy-efficient ENERGY STAR products and processes visit http://www.energystar.gov.

Chapter 11: Checklists for the Seasons

These are checklists that you can use and incorporate into your regular maintenance program for your house. They are broken up into seasons.

In the Spring:

- Check for damage to your roof
- Check all the fascia and trim for deterioration
- Have a professional air conditioning contractor inspect and maintain your system as recommended by the manufacturer
- Check your water heater
- Replace all extension cords that have become brittle, worn or damaged
- Check your fire extinguishers
- Clean the kitchen exhaust hood and air filter
- Review your fire escape plan with your family
- Repair all cracked, broken or uneven driveways and walks to help provide a level walking surface
- Check the shutoff valve at each plumbing fixture to make sure they function
- Clean clothes dryer exhaust duct, damper, and space under the dryer
- Inspect and clean dust from the covers of your smoke and carbon monoxide alarms

In the Summer:

- Check kids playing equipment
- Check your wood deck or concrete patio for deterioration
- Check the nightlights at the top and bottom of all stairs
- Check exterior siding
- Check all window and door locks
- Check your home for water leaks
- Check the water hoses on the clothes washer, refrigerator icemaker and dishwasher for cracks and bubbles

In the Fall:

- Check your home for water leaks
- Have a heating professional check your heating system every year
- Protect your home from frozen pipes
- Run all gas-powered lawn equipment until the fuel is gone
- Test your emergency generator
- Have a certified chimney sweep inspect and clean the flues and check your fireplace damper
- Remove bird nests from chimney flues and outdoor electrical fixtures

- Inspect and clean dust from the covers of your smoke and carbon monoxide alarms
- Make sure the caulking around doors and windows is adequate to reduce heat/cooling loss
- Make sure that the caulking around your bathroom fixtures is adequate to prevent water from seeping into the sub-flooring

In the Winter:
- Clean the gutters and downspouts
- Confirm firewood at least 20 feet away from your home
- Remove screens from windows and install storm windows
- Familiarize responsible family members with the gas main valve and other appliance valves
- Clean the clothes dryer exhaust duct, damper and space under the dryer
- Make sure all electrical holiday decorations have tight connections
- Clean the kitchen exhaust hood and air filter
- Check the water hoses on the clothes washer, refrigerator icemaker and dishwasher for cracks and bubbles
- Check your water heater
- Test all AFCI and GFCI devices

Chapter 12: Service Life Expectancies

Appliance
Life Expectancy in Years

Air conditioner compressor
12-15
Asphalt, wood shingles & shakes
15–40
Asphalt composition shingle
15–40
Asphalt driveways
8-12
Baseboard systems
15-25
Boilers, hot water or steam
25-35
Brick and concrete patios
15-25
Brick and stonewalls
100+
Built-up roofing, asphalt
10–26
Central air conditioning unit
12-15
Compactors
6-10
Concrete block foundations
100+
Concrete walks
10-20
Dishwashers
8-10
Dryers
8-14
Disposal
8-10
Electric ranges
14-18
Electric water heater
5-12
Exhaust fans
5-10
Faucets
10-15
Fences
10-15
Forced air furnaces, heat pump
12-18
Freezers, standard
10-20
Furnaces, gas- or oil-fired
15-20
Garage door opener
8-12
Garage doors
20 to 25
Gas ovens
10-18
Gas ranges
12-20
Gas water heater
6-12
Gravel walks
4-6
Gutters and downspouts
25-30
Heat Exchangers, shell-and-tube
10-15
Humidifier
5-7
Microwave ovens
9-13
Poured concrete foundations
100+
Pumps, sump and well
5-12
Refrigerators
10-18
Rooftop air conditioners
14-18

Sheet metal
20-50
Siding, aluminum
20-40
Siding, steel
30-50
Siding, vinyl
30-45
Siding, wood
12–100
Sinks, china
15-20
Sinks, enamel cast iron
20-30
Sinks, enamel steel
5-10
Slate
40-100
Smoke detectors
5-10
Sprinkler systems
10-14
Stucco
20-40+
Swimming pools
10-20
Termite proofing
5-7
Tile
30-40+
Washers, clothes
12-16

Waste piping, cast iron
50-100
Window a/c unit
5-8
Wooden decks
12-20

Chapter 13: Consumer Resources

Septic and Wastewater
National Onsite Wastewater Recycling Association. The National Onsite Wastewater Recycling Association (NOWRA) is the largest organization within the U.S. dedicated solely to educating and representing members within the onsite and decentralized industry. http://www.nowra.org/

Home Security
Brinks Home Security. Brink's Home Security installs state-of-the-art monitored home alarm systems, including burglar alarms, carbon monoxide and smoke detectors that are easy to use AND affordable!
http://www.brinkshomesecurity.com/

House Painters
Your source for house painters and painting contractors.
http://www.certapro.com/

Handyman Services
Our mission is to offer our residential and business customers a professional and reliable maintenance and repair service. http://www.mrhandyman.com/

Home Improvement Contractors
Get matched to prescreened home improvement contractors.
http://www.servicemagic.com/

Gutters and Downspouts.
Innovative, affordable, invisible and effective gutter protection.
http://www.gutterstuff.com/

Moving Services.
Whether you're moving to the next block or across the nation, we can help you organize and simplify your move. Get mover quotes, change your address and set up your utilities, phone, high-speed Internet, television services and so much more all on one site. It's fast, easy and free!
http://www.whitefence.com/

Angie's List
Looking for the best service? More than 750,000 consumers use Angie's List to find high quality contractors, service companies and health care providers.
http://www.angieslist.com/Angieslist/

Inspectors
The world's biggest and best professional association of home and commercial property inspectors.
http://www.internachi.org/