

ESSENTIAL KNOWLEDGE

A critically important aspect of an HVAC system's ability to efficiently maintain comfort is its controls. Today, nearly all heating and/or cooling systems are controlled by a thermostat. Even factory-built wood fireplaces are available with thermostat control. The sophistication of thermostats and other HVAC system controls has evolved dramatically over the last decade with the advancement of electronic controls. As controls for residential systems are relatively inexpensive, and their technology has advanced significantly in the past few years, it is cost effective to replace older controls that may not be operating properly.

A thermostat senses the room air temperature and controls the heating system via an electrical switch according to an occupant-selected setpoint temperature. Line voltage thermostats are typically used for zonal electric resistance heating systems and low voltage thermostats are used for central systems. Thermostats should be located about 5' above the floor where they will sense an air temperature representative of the room or area being controlled. Location near a heat source such as the supply register or heat sink such as a window will result in poor comfort control.

Old-style electromechanical thermostats found in many rehab projects employ either a mercury or snap-action switch, a bimetallic coil, and an anticipator (Fig. 1). The bimetallic coil expands and contracts as it heats and cools, activating and deactivating the switch that controls furnace or boiler operation. The anticipator is a tiny heater that heats the bimetallic coil to compensate for its slow response to changing air temperature. Adjustment of the thermostat dial establishes the angle or the tension of the bimetallic coil to the contacts. There are versions of these thermostats that include an electric clock to switch the thermostat between two temperature settings to achieve an energy-saving setback condition. An eight-hour overnight setback during the heating season saves 1% to 2% per degree of setback. An eight-hour midday setup during the cooling season saves 1% to 3% per degree of setup.

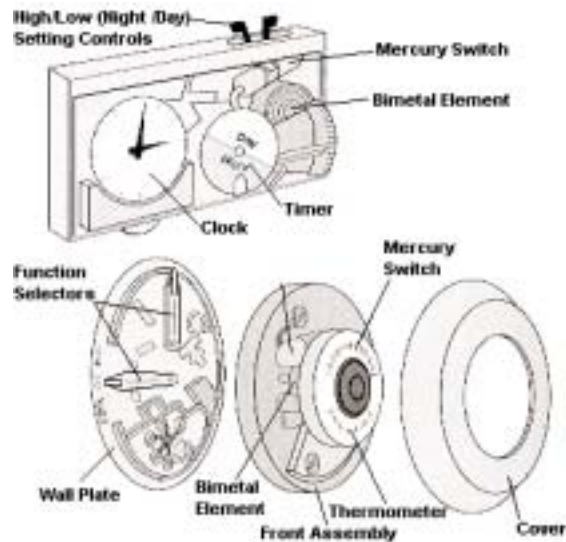


FIGURE 1

ELECTRICAL THERMOSTAT

1. REPLACE THE BIMETAL THERMOSTAT WITH AN ELECTRONIC PROGRAMMABLE THERMOSTAT.

While electromechanical thermostats (Fig. 2) are lower in cost than electronic programmable thermostats, their performance in terms of “deadband” and “droop” is poorer as well. Deadband is an indicator of the swing in room temperature between heating/cooling system cycles. Droop is an indicator of how well the anticipator is functioning. Thermostats also degrade over time as calibration slips and mechanical parts stick. An old electromechanical thermostat can be cleaned and recalibrated, but a better solution is to simply replace it with a new electronic thermostat. Electronic thermostats employ a thermistor rather than a bimetallic coil for sensing the room air temperature. It is more sensitive and fast responding. Microprocessor programming allows for several different temperature settings throughout the day and for different days of the week. Some units provide for different settings for weekdays and weekends or weekdays, Saturdays, and Sundays. The Lightstat thermostat has the ability to adjust the thermostat setting using the light level in the room as an indicator of whether people are in the room. Honeywell has a thermostat that senses lighting levels and occupancy. Thermostats are also now available as wireless remote control devices. They may be placed on the coffee table in the center of the room next to the television remote. Home Automation manufactures a line of thermostats that can communicate with home automation systems, personal computers, and utility demand-side management programs. In a region with real-time pricing, the RC-91 model has the ability to display the real-time energy price and the user can then set the thermostat accordingly.

ADVANTAGES: Energy savings through more capability to set back temperature during unoccupied or night time hours. More accurate and responsive for better comfort control.

DISADVANTAGES: Somewhat higher cost. Just like VCRs, there may be some homeowners that have difficulty following the sequential steps to program them properly. Some types of heat distribution systems such as radiant and hydronic baseboard systems are not as responsive as forced air and the time required to recover from a thermostat setback may be unacceptable.



FIGURE 2

ELECTRONIC PROGRAMMABLE THERMOSTAT

2. INSTALL A HUMIDISTAT.

Typically, heating and cooling systems are designed to maintain comfort in terms of temperature only. Humidity is allowed to fluctuate. In warm humid climates, it may be desirable to control the air conditioning system to maintain comfort humidity as well as temperature conditions. In colder climates, a humidifier may be installed to maintain higher and more comfortable indoor humidity levels. In either sit-

uation, the installation of a humidistat (or dehumidistat, depending on the situation) is appropriate. The location of the humidistat can vary. It can be in the room next to, or integral with, the thermostat or in the return air duct. The humidistat works in a similar manner to the thermostat. It senses humidity and turns the air conditioner or humidifier on or off based upon a humidity setpoint. For two-speed air conditioners, the dehumidistat may trigger the system to go to low speed for enhanced dehumidification capability.

ADVANTAGES: Better control of humidity for improved comfort and air quality.

DISADVANTAGES: Calibration needs to be checked periodically. When controlling an air conditioning system in humid climates, can cause over-cooling.

3. INSTALL A CONTROL SYSTEM THAT SENSES OUTDOOR CONDITIONS AND ADJUSTS ACCORDINGLY.

More sophisticated control systems incorporate outdoor temperature sensors as well as indoor sensors for better control and operating efficiency. For heat pump systems equipped with auxiliary electric resistance heat, an outside temperature sensor is used to lock out the resistance heat when the outdoor temperature is above a specific setting. This prevents the resistance heat from unnecessarily coming on to quickly recover from a nighttime setback. Outdoor temperature sensors are also used to adjust the water temperature in hydronic systems to the lowest temperature necessary to meet the home's heating load. For the control of humidifiers in cold climates, Honeywell Comfort Center's winter humidity control senses outdoor temperature and resets the indoor humidity setting accordingly to prevent condensation on windows. The Honeywell system can be customized for the insulating value of the home's windows. Aprilaire also has a humidistat that controls according to outdoor temperature but does not have the window customization capability.

ADVANTAGES: Reduced operating costs for the heat pump auxiliary heat lock out control.

DISADVANTAGES: Higher initial cost.



FIGURE 3

VENTILATION CONTROLLER

MOTORIZED OUTSIDE AIR DAMPER

4. INSTALL VENTILATION SYSTEM CONTROLS.

There is a variety of methods for controlling mechanical ventilation systems. On the simple, low cost end of the spectrum are the manual controls. These include a simple on/off switch. Additional features might be a timer that shuts the fan off automatically after a certain period of time or a speed control that allows the user to select the ventilation air flow. The manual controls rely upon the user recognizing when ventilation is needed and taking the appropriate control action. The average human nose is more sensitive to air pollutants than most sophisticated electronic sensors. Another set of control options that are more sophisticated and more expensive are automatic. These include time clocks programmed by the user. Trol-A-Temp's Timed Make-Up Air Control (TMAC) or Timed Ventilation Control (TVC) are simple timers that control a motorized damper that allows outside air into the central HVAC system (Fig. 3). The unit will turn on the HVAC blower if it is not already running. Automatic controls also include a variety of demand-controlled ventilation (DCV) strategies. The DCV methods rely upon a sensor in the space or return duct to detect when additional ventilation air is needed. The sensing parameter can be motion, humidity, car-

bon dioxide, or a mixture of gaseous pollutants such as tobacco smoke, cooking odors, and VOCs. For the most part, the manual controls tend to be most appropriate for local exhaust fans and the more sophisticated automatic controls are appropriate for whole-house ventilation systems.

ADVANTAGES: Manual controls are relatively inexpensive and reliable. Automatic controls do not rely upon the user.

DISADVANTAGES: Manual controls rely upon the user for proper control. Automatic controls are more expensive and can fall out of calibration resulting in either insufficient or excessive ventilation air quantities.

5. INSTALL A FORCED-AIR ZONING SYSTEM.

Forced-air zoning systems utilize thermostats in conjunction with motorized dampers in individual supply ducts to different control zones (Fig. 4). By varying the air flow in response to the zone thermostat, a single air conditioning and/or heating system can be used to meet the varying needs of multiple zones. These systems are most easily installed in a new installation, but can be retrofitted into an existing system. Care must be taken to either bypass extra air or oversize the ductwork to assure that central system air flow does not drop below the design minimum when only one or two zones are calling for air and all other zones are closed. There are several manufacturers of this type of system including Research Products Corporation, Carrier, Honeywell/Trol-A-Temp and Durazone.

ADVANTAGES: Achieves the energy saving and improved comfort benefits of zoning with a central forced-air system.

DISADVANTAGES: High initial cost. Systems need to be carefully designed to assure that minimum air flow requirements are met under all operating conditions.

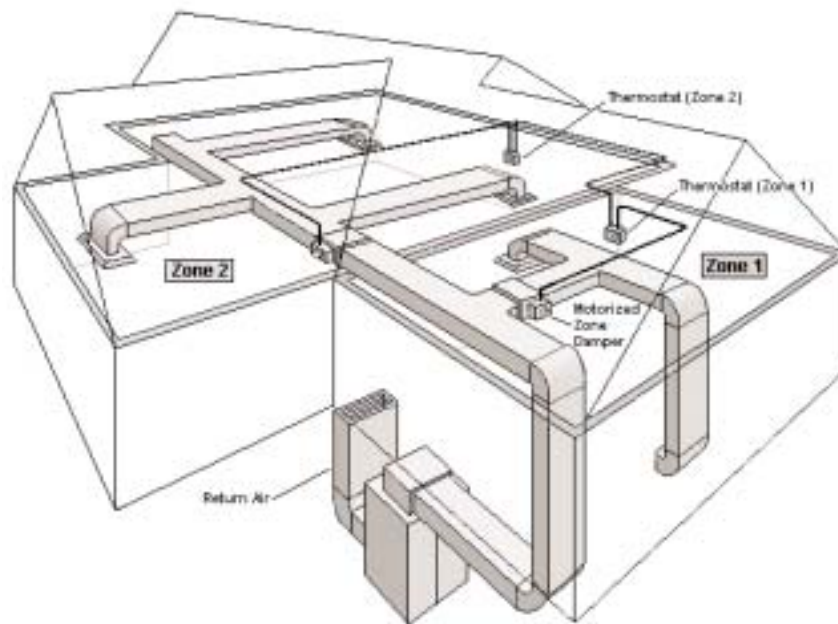


FIGURE 4

FORCED-AIR ZONING SYSTEM

FURTHER READING

Comfort, Air Quality, and Efficiency by Design, Manual RS, Air Conditioning Contractors Association, 1997.

Understanding Ventilation, John Bower, The Healthy House Institute, 1995.

PRODUCT INFORMATION

Broan Mfg. Co., Inc., P.O. Box 140, Hartford, WI 53027; 800-548-0790; www.broan.com.

Carrier North American Operations, P.O. Box 4808, Carrier Parkway, Syracuse, NY 13221; 315-432-6000; www.carrier.com.

Home Automation, Inc., 2709 Ridgelake Drive, Metairie, LA 70002; 800-229-7256.

Honeywell, Inc., 1985 Douglas Dr. North, Golden Valley, MN 55422; 800-328-5111; www.honeywell.com.

Lightstat, Inc., 22 W. West Hill Road, Winsted, CT 06098; 800-292-2444; www.lightstat.com.

Robertshaw, Uni-Line North America, Division of Siebe Climate Control, P.O. Box 2000, Corona, CA 91719; 909-734-2600; www.robertshaw.com.

Tamarack Technologies, Inc., 11 Patterson's Brook Rd., West Wareham, MA 02576; 800-222-5932; www.tamtech.com.

Trol-A-Temp, Division of Trolex Corp., 57 Bushes Lane, Elmwood Park, NJ 07407; 800-828-8367; www.trolatemp.com.

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FIREPLACES & CHIMNEYS

ESSENTIAL KNOWLEDGE

In recent years fireplaces have captured a renewed interest as a supplemental heating source for the home. In a rehabilitation project, rehabilitating an existing fireplace or installing a new fireplace may be under consideration. The rehabilitation of an existing fireplace cannot only add to the appearance of the room, but also provide for safe and efficient space heating. The installation of a new, efficient fireplace to supplement an existing system, which may be inefficient and/or undersized, may be an attractive alternative to replacing the existing system.

Traditional wood-burning fireplace designs are not efficient, can produce emissions that are harmful to the environment, and, if poorly designed or maintained, can be dangerous. In fact, some Western municipalities in the U.S. have passed ordinances prohibiting the installation of a conventional fireplace for environmental reasons. EPA-approved, factory-built wood and gas fireplaces, wood stoves, or gas-fired logs are acceptable alternatives which should be considered during a rehabilitation project.

If constructing or significantly reconstructing a fireplace or installing a stove, building codes should be carefully reviewed for minimum requirements for materials, heights, and clearances. Local code requirements apply even if the existing chimney is used. If an old unused fireplace is found encased in plaster during the course of a rehabilitation project, it can be reconstructed by a competent mason who knows and follows recommended design practices. Many early fireplaces and chimneys smoked too much due to flaws in their design. This poor performance may be the reason that the fireplace had been abandoned. If an old, closed-off chimney is to be rehabilitated, make sure that it still runs through the roof to an appropriate height and that openings for other stove pipes have not been cut into it. Old chimneys were often used to serve multiple stoves with a single flue.

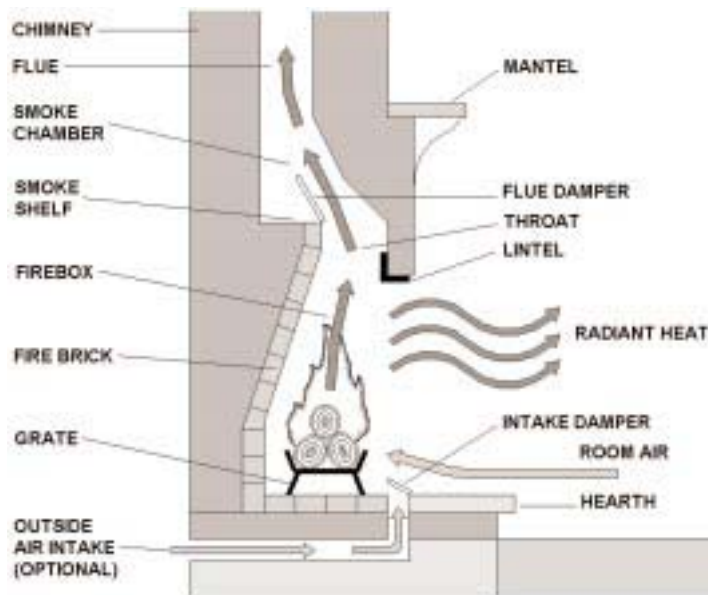


FIGURE 1

CONVENTIONAL WOOD-BURNING FIREPLACE

Conventional fireplaces (Fig. 1) provide heat primarily by radiation. Thus, the amount of brick masonry, surface area exposed to the fire, its distance from the fire and the size of the fire determine the amount of heat provided. Rumford-style fireplaces feature angled side walls, a shallow depth, and a high opening. These fireplaces tend to be more efficient than conventional designs because they radiate more heat and draw less room air up the chimney. Air-circulating fireplaces (Fig. 2) capture heat from the back of the firebox by circulating room air through brick baffles or steel plates. This warmed air can then be circulated by a fan to spaces to provide heat by convection.

The primary function of a chimney flue is to exhaust combustion wastes - carbon dioxide, nitrogen, sulfur dioxide, water vapor, and carbon monoxide. A second function is to create a draft that pulls the air over the fire. For a wood-burning fire, the draft must be strong. To accomplish this, the fireplace has a sloped back and a stepped throat controlled by a damper. Each combustion heat source (e.g., furnace and fireplace) needs its own flue, but a single chimney can contain several flues from multiple fireplaces and/or a furnace. (Fig. 3) Two combustion appliances such as a water heater and a furnace can share a flue. In this instance, problems can arise if one of those appliances is replaced with a direct-vent unit because the flue is too large for the remaining appliance. Condensation of combustion gases can occur in the chimney, resulting in corrosion. This can also occur with the installation of a higher efficiency chimney-vented combustion appliance, particularly in a cold climate.

Beyond replacing the brick and mortar of an old disintegrating chimney, clearing several inches of debris from above the damper, and clearing other blockages in the chimney flue, several additional steps may be necessary to assure that an old fireplace and chimney are in safe working condition. Alternatives or enhancements to the fireplace such as stoves and inserts can also improve the efficiency of the system.

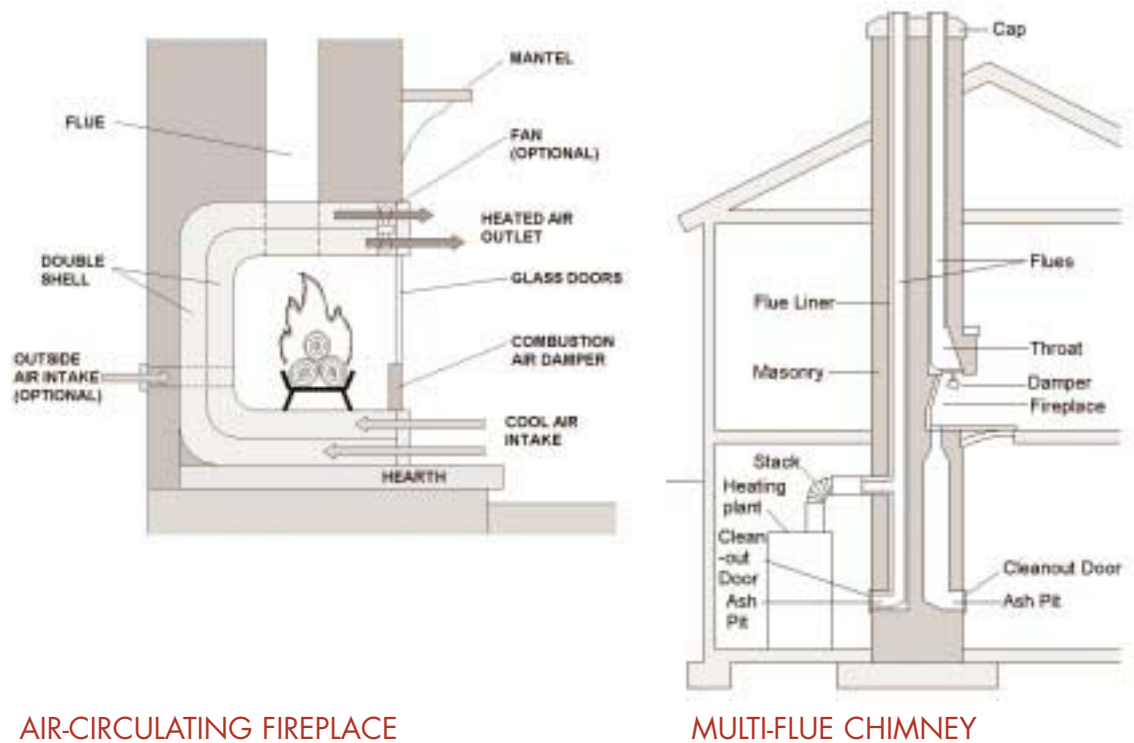


FIGURE 2, 3

AIR-CIRCULATING FIREPLACE

MULTI-FLUE CHIMNEY

TECHNIQUES, MATERIALS, TOOLS

1. REBUILD OR REPOINT THE CHIMNEY.

The mortar between the bricks of an old chimney is likely to be in need of renewal. It was not intended to last as long as the bricks. The replacement process is known as repointing or tucking. Whatever kind

of mortar was used initially should be used for repointing so as to have the same expansion and compression characteristics under varying weather conditions. In some instances, the condition of the chimney may have deteriorated to a point beyond repair by repointing and relining. When the mortar crumbles easily and/or bricks are loose, removal and replacement should be considered. It may be possible to reuse the original bricks. Creosote is a carcinogen so a respirator should be worn when rehabilitating an old chimney and the work area should be enclosed in plastic sheeting to protect the rest of the house.

ADVANTAGES: Improved safety and integrity of the chimney.

DISADVANTAGES: Can be expensive because it is a time consuming process that requires the expertise of a mason.

2. INSTALL A CHIMNEY CAP.

Rain mixing with soot and fireplace gases produces a destructive acid. Thus, all chimneys should have a rain cap to prevent this deterioration (Fig. 4). Rain caps can also minimize downdrafts.

ADVANTAGES: Fairly inexpensive. Extends the life of the chimney.

DISADVANTAGES: Difficult to install on high chimneys.



FIGURE 4

CHIMNEY CAP

3. RELINE THE CHIMNEY.

Liners, which are now required by code, prevent the heat from a chimney fire from causing a house fire. Older chimneys may be unlined (pre-1910), lined with mortar that has deteriorated, or have old tile liners that are cracked. They also often served more than one fireplace and had more than one flue in them with a wall of brick as a divider. This brick divider is likely to be in very poor condition and tumbling bricks from this divider can block the flue.

The solution to all of these problems is to reline the chimney. There are different methods for relining a chimney.

■ Install a metal pipe available in 3 ft. sections from local heating suppliers. Stainless steel should be used if the flue will be used for furnace gases, which are very corrosive. Seal around the pipe at the bottom and top of the chimney with lightweight mortar. Flexible pipe is also available for non-straight chimneys. Caution is advised if the chimney has a weak draft. Reducing the cross-section area of the flue with a metal pipe will only worsen the situation.

■ Install a tile lining. This is required by code in some areas if the chimney is to be used with wood fires. Although more expensive, a tile liner is more resistant to corrosion and the high temperatures of a chimney fire due to creosote build up.

■ Use a patented process, which is only available through franchised dealers, to line the chimney with a cementitious mix. A vinyl or rubber hose can be inserted and inflated (Fig. 5). Lightweight concrete is then poured around the hose, which is deflated and removed after the concrete sets.

ADVANTAGES: Improved safety and integrity of the chimney.

DISADVANTAGES: Can reduce the size of the flue and thus the draft to an insufficient level.

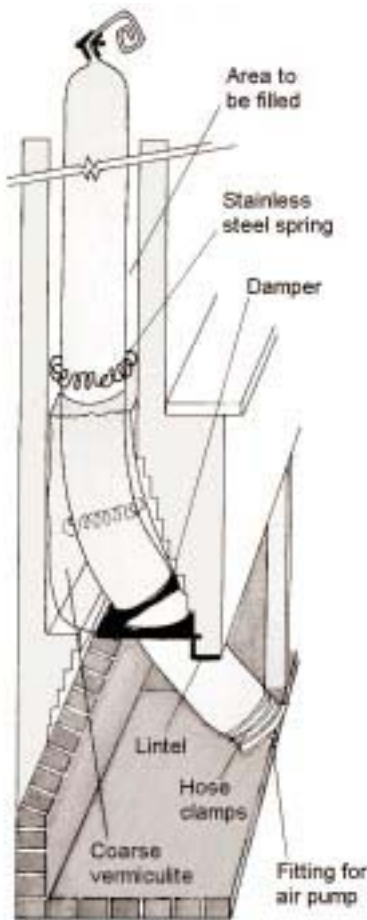


FIGURE 5

CHIMNEY RELINING

4. INSTALL AN EXTERIOR AIR SUPPLY FOR COMBUSTION AND DRAFT AIR.

Conventional fireplaces draw room air that has been heated by the home's primary heating system and exhaust it out the chimney. This air is replaced by infiltration of cold outside air through cracks and openings in the building envelope. In tightly constructed homes or homes that are already exhausting air with fans and dryers, the fireplace may be starved for air and dumping smoke into the room because of insufficient draft. A solution to these problems is to provide a means for using outside air for combustion.

There are three basic components to an exterior supply air system for a fireplace: intake, passageway, and inlet (Fig. 1). The intake is typically located on an outside wall or the back of the fireplace, but can be in a crawl space, attic, or other unheated space. Many codes will not allow location of an inlet within a garage because of the potential presence of fuel fumes. A passageway or duct connects the intake to the inlet. It is usually insulated to reduce heat loss. The inlet introduces the outside air to the firebox. A damper is necessary to control the volume and direction of air flow.

Glass doors are typically installed to prevent indoor air from entering the firebox and going up the chimney. Unfortunately, the tempered glass that is so often used is not a good transmitter of infrared radiation so the radiant heat from the fire itself is significantly reduced.

ADVANTAGES: Minimizes the exfiltration of heated conditioned-space air.

DISADVANTAGES: May be difficult to install in an existing fireplace.

5. INSTALL AN ENVIRONMENTALLY FRIENDLY GRATE.

The specially designed EcoFire Super-Grate, marketed by Andiron Technologies, can be installed to reduce the harmful emissions of a conventional fireplace. This stainless steel grate replaces the wrought-iron grate that holds wood logs. It is attached to a fan which blows air through holes in the tubes of the grate. This air results in an extremely hot fire which has lower emission levels. The heat-reflecting shield which is attached improves heating efficiency by increasing the radiant heat output.

ADVANTAGES: Easily retrofit to existing fireplaces.

DISADVANTAGES: Relatively expensive and still subject to wood-burning bans.

6. INSTALL A GAS LOG SET OR FIREPLACE.

A gas log set is primarily a decorative appliance. It includes a grate holding ceramic logs, simulated embers, a gas burner, and a variable flame controller. These sets can be installed in most existing fireplaces. There are two principal types: vented and unvented. Vented types require a chimney flue for exhausting the gases. They are only 20% to 30% efficient and most codes require that the flue be welded open, which results in an easy exfiltration path for heated room air. Unvented types operate like the burner on a gas stove and the combustion products are emitted into the room. They are more efficient because no heat is lost up the flue and most are equipped with oxygen depletion sensors, but they are banned in some states, including Massachusetts and California.

Gas fireplaces incorporate a gas log set into a complete firebox unit with a glass door (Fig. 6). Some have built-in dampers, smoke shelves, and heat circulating features that give them the capability to provide both radiant and convective heat. Units can have push-button ignition, remote control, variable heat controls, and thermostats. Gas fireplaces are more efficient than gas logs with efficiencies of 60% to 80%. Many draw combustion air in from the outside and are direct vented, eliminating the need for a chimney (Fig. 7). Some of these units are wall furnace rated.

There are also electric fireplaces which provide the ambience of a fire and, if desired, a small amount of resistance heat. These units have no venting requirements.

ADVANTAGES: No ashes or flying sparks that occur with wood-burning fireplaces. Not affected by wood burning bans imposed in some areas when air quality standards are not met. Direct-vented gas or electric models eliminate the need for a chimney.

DISADVANTAGES: Cost for equipment and running the gas line can be high. Cannot use existing masonry chimney with a gas fireplace.



FIGURE 6

GAS FIREPLACE

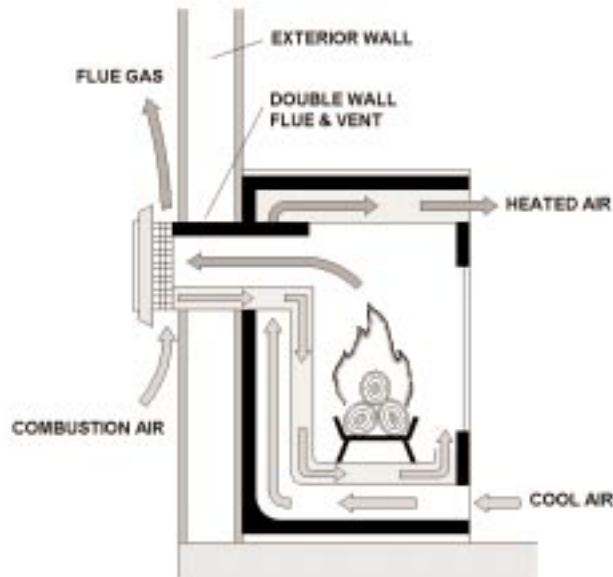


FIGURE 7

DIRECT-VENT GAS FIREPLACE

7. INSTALL A WOOD STOVE, FIREPLACE INSERT, OR ADVANCED FIREPLACE.

There are wood-burning equipment alternatives that offer an improvement over a conventional wood-burning fireplace that may only be 10% efficient. These include wood stoves, fireplace inserts, and advanced fireplace cores. The performance of wood-burning systems varies dramatically with the type of equipment, the type of wood being burned, the wood's moisture content, and the way it is maintained and operated.

Wood stoves without air controls, such as Franklin stoves, have efficiencies of 20% to 30%. Stoves with controlled air inlets into primary and secondary combustion areas can have efficiencies as high as 55%. Advanced designs can have efficiencies as high as 75%. The more efficient systems require much less excess air for combustion and produce lower levels of incomplete combustion products which produce creosote.

Wood-burning fireplace inserts are designed to fit into existing fireplaces to improve their heating performance. Some stoves sit on an existing fireplace hearth and vent up the chimney.

In response to some Western-state ordinances banning the installation of a traditional fireplace, manufacturers responded with fireplaces that meet the Environmental Protection Agency's (EPA) standards for wood stoves. These units are as efficient as the advanced wood stoves. They are air-tight with gasketed doors and a pyro-ceramic glass window that allows the infrared heat from the flame into the room. The advanced fireplace has an insulated casing to reduce heat loss through the outside wall of the house. A squirrel-cage fan is used to draw room air in and around the casing to pick up additional convective heat and supply it to the room. Heat output is controlled by the amount of outside air intake for combustion. Some even allow for short duct runs to distribute heat via natural convection to isolated rooms. RSF Energy produces a fireplace system that can supply a whole-house duct system with an in-line blower and thermostats (Fig. 8).

The Rumford-style fireplace designed by Jim Buckley is one of the only masonry fireplaces that meets most air quality standards. A fireplace kit is available for the construction of a masonry fireplace based upon the traditional Rumford design. The kit includes a one-piece curved clay throat, a clay flue tile liner, a smoke chamber, a stainless-steel damper, and optional glass doors.

ADVANTAGES: Higher efficiency than a conventional wood-burning fireplace.

DISADVANTAGES: Can be subject to wood-burning bans when local air quality standards are not met. Requires maintenance to prevent the dangerous build up of creosote.

FURTHER READING

"Back to the Future Fireplace," *This Old House*, January/February 1997, pp.74-79.

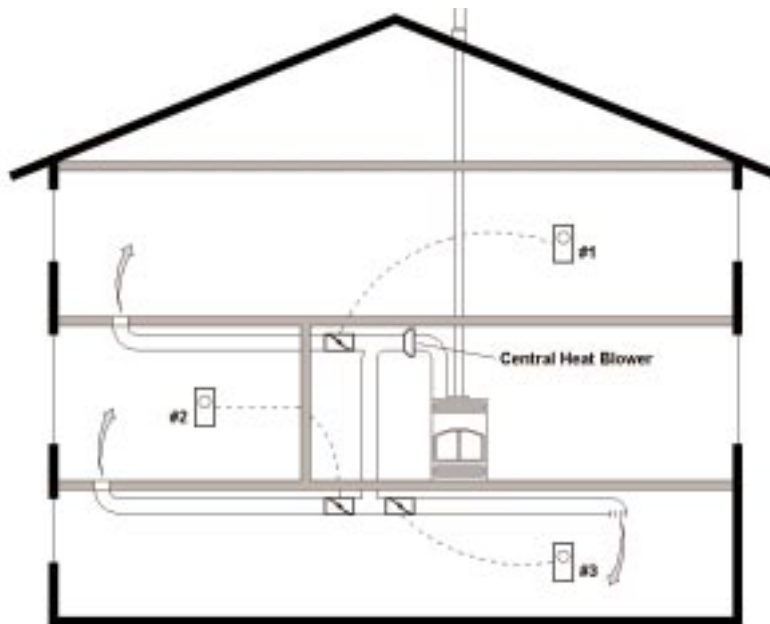


FIGURE 8

DUCTED FIREPLACE

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Technical Note 19A – Residential Fireplaces, Details and Construction, May 1980.

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Sunset Fireplaces & Wood Stoves, Lane Publishing Co., 1989.

The Fireplace Book, The Aberdeen Group, 1992.

The Old-House Journal Compendium, Clem Labine and Carolyn Flaherty, The Overlook Press, 1980.

The Stanley Complete Step-by-Step Book of Home Repair and Improvement, James A. Hufnagel, New York: Simon & Schuster, 1993.

PRODUCT INFORMATION

Andiron Technolgies, Inc., 2995 Woodside Road, Suite 400, Woodside, CA; 888-4-EcoFire; www.EcoFire.com.

Buckley Rumford, 710 Foster Street, Port Townsend, WA; 800-447-7788; www.rumford.com

Heat-N-Glo Fireplace Products, 6665 West Hwy 13, Minneapolis, MN; 888-743-2887; www.heatnglo.com

Heatilator, Inc., 1915 West Saunders Street, Mt. Pleasant, IA; 319-385-9211; www.heatilator.com

Industrial Chimney Company/RSF Energy, 801 St. Nicholas, St. Jerome, Quebec, Canada; 450-565-6336; www.icc-rsf.com

Majestic Products Company, 1000 E. Market Street, Huntington, IN; 800-525-1898; www.majesticproducts.com

Temco Fireplace Products, 301 S. Perimeter Park Drive, Suite 227, Nashville, TN; 615-831-9393.

DOMESTIC HOT WATER HEATING

ESSENTIAL KNOWLEDGE

Depending on whether the home is air conditioned or not, water heating is the second or third largest energy expense in the home. Traditionally, water heating accounts for approximately 14% of the utility bill. As space heating and cooling loads decrease and system efficiencies increase, water heating represents a greater portion of the home's energy bill.

The predominant design for water heaters is the storage type (Fig.1). These units hold heated water in a thermostatically controlled storage tank. Tanks in residential applications usually have storage capacities ranging from 30 to 80 gallons. The tank may have a combustion burner in the bottom with a flue running up through the center of the tank, electric resistance heating elements immersed in the water, or a heat exchanger circulating fluid heated by another source such as a boiler.

When deciding whether or not the domestic water heating system needs rehabilitation, the following questions should be answered:

- Does the present system have several years left on its expected life?
- Is the time it takes to deliver hot water to faucets acceptable?
- Is there sufficient hot water?

In a rehabilitation situation, the answer to any of these questions could be no. Poor maintenance can shorten the life of water heaters. Bathrooms added over the years may be remote from the tank location or the addition of clothes and dish washers may have increased hot water demands beyond the original design.

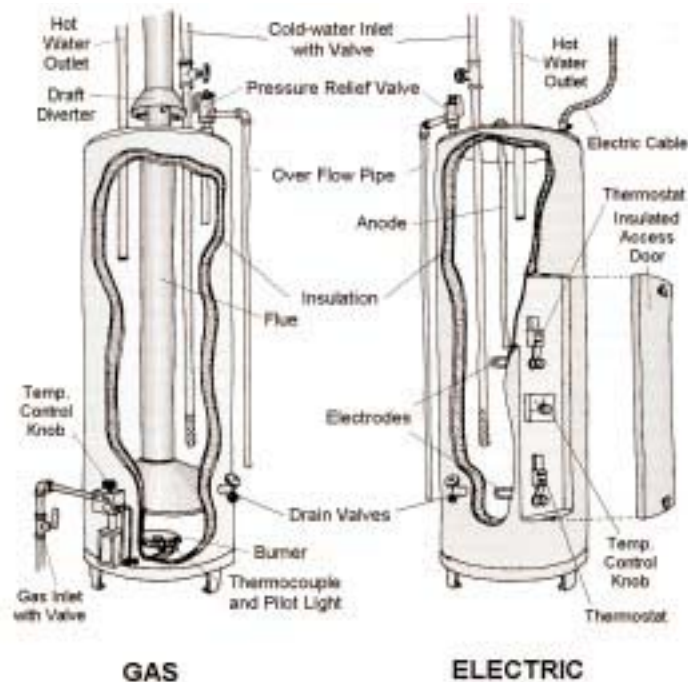


FIGURE 1

STORAGE-TYPE WATER HEATERS

The life of storage-type water heaters is typically 10 to 15 years due to the corrosion of the tank. Maintenance, such as replacing the anode and cleaning sediment from the bottom of the tank, can extend its life, but this is rarely done. Thus, if the storage tank is more than 10 years old, it should probably be replaced. The month and year that the tank was built is usually encoded in its serial number.

Demand, or instantaneous-type water heaters can be located closer to the fixture to minimize the waiting time for hot water. These units eliminate the tank and its associated losses altogether.

If purchasing a new water heater, selecting a system of the proper size and recovery rate is important to ensure that all hot water demands are met. A water heater of insufficient capacity will result in cold showers, but a water heater that is too large wastes energy. The water heater size is determined by the First Hour Rating (FHR), which is the amount of hot water (in gallons) that can be produced in one hour. The FHR is not only a function of tank size, but also recovery rate, which is a measure of how quickly the incoming cold water can be heated. Gas water heaters have higher recovery rates than electric units. Thus, for the same FHR, the gas water heater requires a smaller tank than an electric water heater.

In addition to the FHR, storage-type water heaters are given an Energy Factor (EF) rating. This is a seasonal efficiency rating that takes into account the water heater's recovery efficiency, standby losses, and energy input. Recovery efficiency is the ratio of the amount of heat that is absorbed by the water to the amount of heat input.

TECHNIQUES, MATERIALS, TOOLS

1. IMPROVE THE EFFICIENCY OF THE EXISTING STORAGE-TYPE WATER HEATER.

In lieu of purchasing a new, more-efficient water heater, there are a few relatively easy and inexpensive ways to improve the efficiency of the existing system. These are essentially the same methods that manufacturers have used to improve the efficiency of today's tank water heaters.

Insulate the tank and pipes. Older storage-type water heaters can benefit from the simple installation of an insulating jacket or blanket. This reduces the heat loss from the tank to the surrounding area. Be careful not to cover thermostats, drains, flues, or combustion air inlets. Insulating the pipes reduces the losses from the hot water as it flows through the pipes to the faucet. The split foam rubber type of insulation is effective and easy to install.

Install anti-convection valves or loops. These devices are installed on the hot water inlet and outlet pipes to prevent the convection of hot water up the pipes from the tank when in the standby mode. There are numerous types. Some are based on a simple ball-type check valve. A loop in the piping serves the same purpose (Fig. 2).

ADVANTAGES: Inexpensive and easy to do.

DISADVANTAGES: Tank blankets are not as effective as internal insulation because certain areas must be left exposed for access and venting purposes. The useful life of these measures is limited to the remaining life of the water heater. They will not be necessary for most new water heaters because high levels of internal tank insulation and anti-convection devices are standard features.

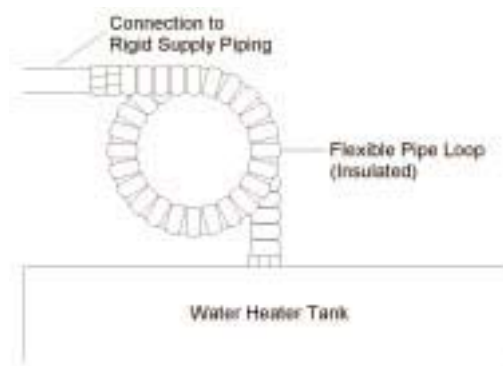


FIGURE 2

ANTI-CONVECTION LOOP

2. INSTALL AN INDIRECT STORAGE WATER HEATER.

In an older home with a hydronic heating system supplied by a boiler, a tankless coil may be the method for heating domestic hot water. This is a coil located within the boiler. There is no storage of hot water. This approach is suitable in the winter when the boiler is operating for space heating, but is inefficient in the summer because the boiler must start and stop frequently just to provide domestic hot water. An alternative is to install an indirect storage water heater (Fig. 3). Heating fluid from the boiler is circulated through a coil inside the storage tank. The boiler is still used throughout the year for domestic hot water, but it comes on less frequently in the summer because it responds to a drop in storage tank temperature and not every demand for hot water.

ADVANTAGES: Improves system efficiency.

DISADVANTAGES: Requires additional floor space for the storage tank.

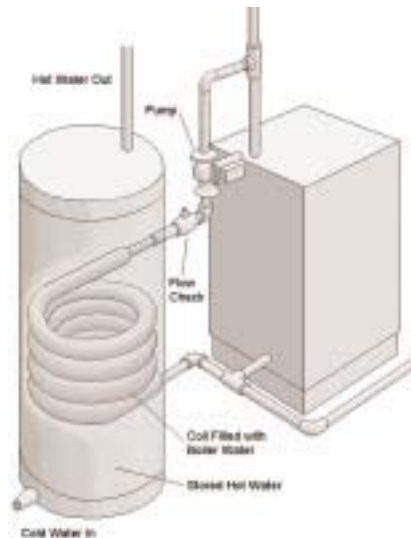


FIGURE 3

INDIRECT STORAGE WATER HEATER

3. INSTALL A NEW ELECTRIC RESISTANCE STORAGE WATER HEATER.

Although this is usually the most expensive method for heating water, it is the second most common type of water heater after gas storage units. If hot water requirements are relatively low, this may be the most practical choice. New electric storage water heaters have higher levels of insulation than the old versions. Some are all-plastic, which do not need anodes and come with lifetime, never-leak warranties. Electric storage water heaters can be located almost anywhere because there are no combustion air and venting issues. Time clocks can be used to prevent the resistance elements from operating during peak electric charge periods where time-of-use rates are in effect.

ADVANTAGES: Lower initial cost than gas storage water heaters. Installation location flexibility.

DISADVANTAGES: High operating costs.

4. INSTALL A NEW GAS STORAGE WATER HEATER.

New gas storage water heaters have better tank insulation, improved baffle designs, lower pilot burner inputs, and new combustion chamber configurations than older versions. Baffles regulate the flow of combustion air up through the flue and new designs increase the transfer of heat from the flue gases to the water, increasing system efficiency. They also reduce convective air movement and heat loss up the flue during standby periods.

As with gas furnaces, there are several venting options. Standard units are atmospheric vented

with the vertical flue that is often tied into the same chimney flue as the gas furnace. Power-vented units use a fan to assist the venting of the combustion gases. These provide more location flexibility because longer vertical or horizontal vent pipes can be used. They also cannot backdraft while the burner is operating. However, they still use indoor air for combustion and now require electricity to operate. Direct-vented units are also available that draw outside air in for combustion and vent directly out the wall.

A gas water heater that avoids the problems of venting entirely is the Seahorse by Gas-Fired Products Incorporated. This unit is a gas-fired heat exchanger with a pump that is placed in an insulated box on the outside wall of the home and plumbed into a storage tank inside the home which may be the old electric water heater (Fig.4). Going a step further is the Weather-Pro by American Water Heater. This is a gas water heater that can be installed outside, including the 50-gallon tank. Its distribution is currently limited to Southern states where freeze protection is not an issue.

ADVANTAGES: Low operating cost.

DISADVANTAGES: Higher initial cost than electric resistance storage-type water heaters. Venting requirements restrict location flexibility. Power-vented units require electricity to operate and have had occasional problems with nuisance shutdowns when their pressure safety switches have mistaken windy conditions for blocked vents.

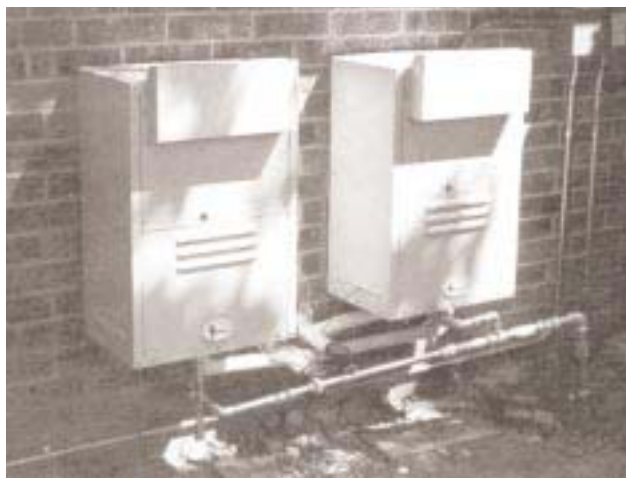


FIGURE 4

SEAHORSE OUTSIDE GAS-FIRED WATER HEAT EXCHANGER

5. INSTALL A DEMAND WATER HEATER.

In situations where space for a 20 to 50 gallon storage tank is limited or the wait for hot water to a tap remote from the storage tank is excessive, the installation of a demand water heater may be appropriate. Also called tankless, instantaneous, and point-of-use, demand water heaters heat the water as it is called for. There is no storage tank. Some point-of-use units may not be truly instantaneous or tankless because they employ a small 2- to 4-gallon storage tank (Fig. 5).

Electric demand water heaters heat the water as it passes over a resistance element. The power requirements limit these units to water flow rates for a single sink or low-flow shower. One of the largest electric demand water heaters is the Seisco RA-28. Rated at 28 kW, it is capable of supplying 2.5 gallons per minute at a 78°F temperature rise. Electric demand water heaters typically modulate their output by using multiple heating elements. Less expensive, fixed output units do not allow for much variation in water flow.

Gas demand water heaters employ a modulating burner to supply hot water at a specific pre-set temperature. Their output is sufficient to satisfy the hot water demands of an entire home. They must be mounted on an external wall for venting purposes.

ADVANTAGES: Location flexibility due to their small size. Reduced standby losses. Longer life because the

tank corrosion issue is eliminated. When located near the point of use, they are water conserving because there is less cold water to go down the drain prior to the arrival of hot water.

DISADVANTAGES: While they can deliver hot water for an indefinite period of time, the flow rate (gallons per minute) may not be sufficient. Most units cannot serve multiple tap requirements simultaneously. Initial costs are higher than storage-type units. Require larger gas lines or power requirements than storage-type units. Service support may be less than for the more-common storage-type units.



FIGURE 5

POINT-OF-USE WATER HEATER

6. SUPPLEMENT THE WATER HEATER WITH A PREHEATING OR HEAT RECOVERY SYSTEM.

The heating requirements of the water heater can sometimes be supplemented by recovering waste heat from other processes or capturing solar energy. One of the simplest approaches is a tempering tank. This is a second uninsulated tank located in a warm or sunny area and connected in series with the primary water heater tank. Cold water first enters the tempering tank where it warms up to the surrounding air temperature. Solar water heating, both passive and active systems, can be used to preheat water and during some times of the year can meet all of the water heating needs.

Hot water desuperheaters, such as the HotTap unit by Addison Products, are hot refrigerant-to-water heat exchangers on the refrigerant line of an air conditioner or heat pump. Such a unit is installed after the compressor, but before the condenser, to remove the superheat from the refrigerant vapor and transfer it to the domestic hot water (Fig. 6). The amount of water heating provided by these systems is a function of the air conditioning usage since they only provide heat when the air conditioner or heat pump is operating.

Another method of heat recovery is the GFX (gravity film exchange). This is a heat exchanger between the water waste pipe and the DHW tank cold water inlet (Fig. 7). It consists of a section of 3" or 4" copper drainpipe with a coil of 1/2" or 3/4" tubing wrapped around it. At times of high hot water use such as showering, the water going down the drain is still hot. This device recovers some of that heat and preheats the cold water flowing into the tank. There are no controls or moving parts.

ADVANTAGES: Relatively inexpensive and require little or no maintenance. Capture heat energy that would otherwise be wasted. Desuperheaters can improve the HVAC system cooling efficiency slightly.

DISADVANTAGES: Desuperheaters only provide a benefit when the heat pump or air conditioner is operating and they can decrease the heating capacity of a heat pump system. GFX devices only recover heat when water is draining out at the same time that make-up water is flowing into the tank (e.g., water is flowing directly from the spigot or showerhead down the drain). Building codes or building officials in some areas do not allow GFX devices.

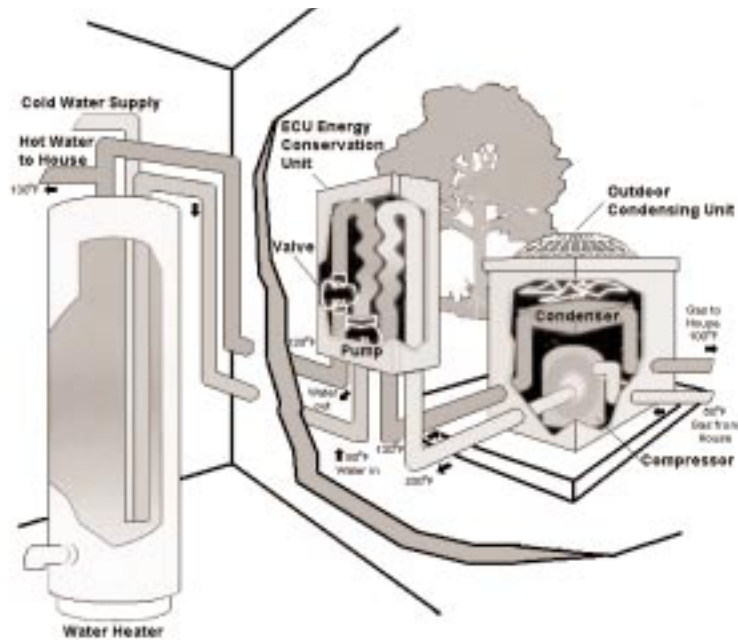


FIGURE 6

HOT WATER DESUPERHEATER

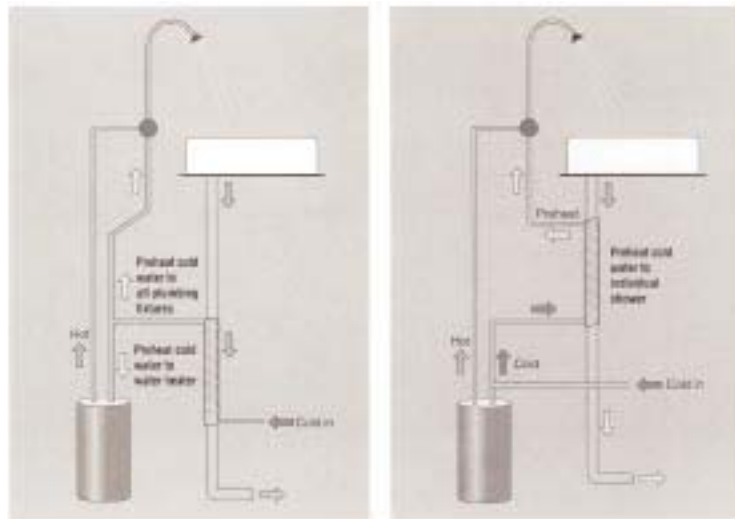


FIGURE 7

GFX HEAT RECOVERY SYSTEM

7. INSTALL A HEAT PUMP WATER HEATER (HPWH).

If electricity is the only water heating fuel alternative and the domestic hot water requirements are relatively high (e.g., four or more occupants) a heat pump water heater can be considered to reduce operating costs. It can typically provide hot water at one-half to one-third the energy use of an electric resistance water heater. Rather than heating the water directly by electric resistance, these heat pumps use electricity to drive a vapor compression cycle that moves heat from the surrounding air to the tank water. HPWHs can be integral systems with the compressor/evaporator unit sitting on top of the storage tank or as separate units requiring a pump and flow loop (Fig. 8). Integral units avoid the need for a pump and control loop but the separate unit design can be retrofitted to the home's existing tank.

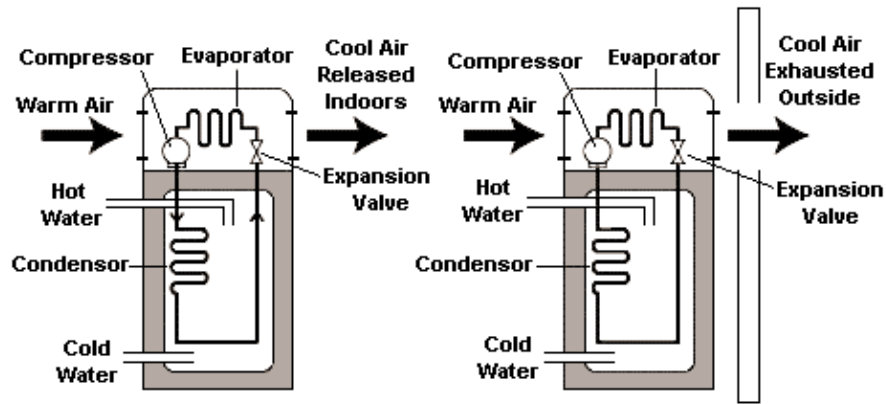


FIGURE 8

HEAT PUMP WATER HEATER

HPWHs are most appropriate in warm climates because they are typically located in basements and garages, where freeze damage is not a concern. The efficiency of the heat pump also drops at low air temperatures. HPWHs cool and dehumidify the air surrounding the evaporator section like an air conditioner. This can be beneficial in a conditioned space in the summer, but detrimental in the winter. The evaporator section cannot be in a confined space where the surrounding air is not mixed with warmer air.

HPWHs do not have the quick recovery of standard water heaters. A larger tank could be used to meet peak demands, but the more common solution is to install an electric resistance heating element in the tank to handle the peak demand periods. This defeats some of the efficiency benefits of the HPWH.

In cooler climates or where a ventilation system is employed, an exhaust air heat pump water heater (EAHPWH) may be appropriate. This system, manufactured by DEC/Therma-Stor, captures heat from the air before it is exhausted.

ADVANTAGES: Lower operating cost than an electric resistance system.

DISADVANTAGES: Higher initial cost. There are currently only a few U.S. manufacturers and there is little market infrastructure in place. Finding qualified, experienced installation and service technicians may be difficult. Their installation requires expertise in water heater service as well as refrigerant handling regulations. HPWHs need to be located where the compressor noise will not be a problem. They require regular maintenance similar to that for an air conditioner.

FURTHER READING

Residential Heat Pump Water Heaters, Federal Technology Alert, www.pnl.gov/fta/3_res.htm.

“Water Heaters and Energy Conservation — Choices, Choices!,” *Home Energy Magazine Online*, May/June 1996, www.homeenergy.org/eehem/96/9605waterheat.html.

PRODUCT INFORMATION

Addison Products Company, P.O. Box 607776, Orlando, FL; 407-292- 4400.

American Water Heater, 500 Princeton Road, P.O. Box 4056, Johnson City, TN; 800-999-9515.

DEC/Therma-Stor, P.O. Box 8050, Madison, WI 53708; 800-533-7533.

Gas-Fired Products Incorporated, Charlotte, NC; www.thermastor.com.

Water Film Energy, Inc., P.O. Box 48, Oakdale, NY 11769; 516-758-6271; www.oikos.com/gfx.

PLUMBING DESIGN & ENGINEERING

ESSENTIAL KNOWLEDGE

Properly sized and performing plumbing systems are vital for the comfort, convenience, health, and safety of home occupants. Rehabilitation reasons can range from obvious failures of a system such as leaks, corrosion, and stoppage; to not-so-obvious failures such as leaks of dangerous gas from sewers or combustion appliances. Plumbing systems can include water supply and distribution; drain, waste, and vent systems; fuel supply and storage; appliance venting and exhausting; fire protection systems; and gray water systems. Plumbing fixtures themselves are covered in another volume, as are septic systems.

There are a few major factors that drive the decision to rehab plumbing systems: how well the system meets the needs of occupants, how the system performs and complies with code requirements, how possible rehabilitation might save resources, and the cost and feasibility to rehab. The scope of rehab work can vary from simple repair, to removal and replacement of systems, to adding new ones. Fire protection systems and fuel systems are examples of added systems.

Materials, designs, and codes have changed and evolved over the years. Code-complying original installations may now be below standard or dangerous. For example, an old plumbing fixture such as a bathtub could be filled with contaminated water that could drain back into potable water supply because the fill spout is below an overflow drain. Older toilets used much more water, and older shower heads used more water and energy than those that now comply with the Energy Policy Act and the National Plumbing Standards of 1992. While “fixture” concerns are not addressed here, they drive decisions to change systems and components. Existing vents might not work with a new, more efficient appliance that produces cooler and high moisture vent products. Materials previously approved may be hazardous to occupant health or prone to failure, such as lead in water systems, which is a well publicized hazard. Certain connectors and pipe in polybutylene water systems are known to fail. Asbestos insulation in many old plumbing installations is a hazard. Recommendations regarding the removal and disposal of asbestos are available from the Environmental Protection Agency (EPA) Asbestos Information Hotline: 800-438-2474.

Designs and installations previously deemed state-of-the-art may not work well, and in some instances could be dangerous. Old drain, waste, and vent systems are examples. Without proper venting, sewer gases can create unhealthy conditions. New materials and designs can alleviate flaws. There are positive system developments as well. Research and, subsequently, codes have permitted water pipe supply sizes to be downsized for branches. The house’s present system, if in good condition, may be able to accommodate more fixtures. There are many new materials and upgrades to old materials and methods. There is a plethora of connectors, valves, reducers, and adaptors to allow change from one material to another.

As design, research, and new materials have evolved, so have codes. One national code, the International Residential Code for one- and two-family dwellings, was first promulgated in draft form and issued in 1998. It is being updated for an April 2000 release. This code covers most residential plumbing systems. The International Association of Plumbing and Mechanical Officials (IAPMO), nevertheless still publishes its “Dwelling Requirements of the Uniform Plumbing Code.”

This guide will review attributes of many systems and materials, along with advantages and disadvantages. These attributes are not necessarily comprehensive and readers are advised to undertake research of individual systems, products, installation recommendations, warranties, and code acceptance for their own locale. This guide cannot foresee the scope of a project or predict costs, but systems components are evaluated as more or less costly than others.

FURTHER READING

Plumbing a House, Peter Hemp, Newtown, CT: The Taunton Press, 1994.

Renovating Old Houses, George Nash, Newtown, CT: The Taunton Press, 1996.

The Old House Journal Guide to Restoration, Patricia Poore, New York: E.P. Dutton Books, 1992.

International Residential Code (Draft), International Code Council, Falls Church, VA 22041, 1998.

The Consumer's Guide to Home Improvement, Renovation & Repairs, The Enterprise Foundation, New York: John Wiley and Sons, 1995.

1996 ASHRAE Handbook - HVAC Systems and Equipment, ASHRAE, Atlanta, GA, 1996.

WATER SUPPLY & DISTRIBUTION SYSTEMS

ESSENTIAL KNOWLEDGE

There are many causes for rehabilitation maladies that affect water supply and distribution systems. Leaks, poor water quality, poor supply of hot or cold water, insufficient pressure, noise, vibration, and presence of hazardous materials can all be driving forces.

Water distribution in today's homes originates from a one-pipe delivery system with pipes and fittings of lead. Ancient Romans had lead water pipes, and in fact the term "plumbing" is derived from the Latin "plumbum," meaning lead. Ancient Egyptian artifacts show use of copper water piping. A variety of pipes and fittings could be present in any rehab project, including brass, copper, iron, and steel. Water piping materials and fittings have changed in popularity and code acceptance. Many types are approved for use, and can be used in combination if electrogalvanic and grounding continuity are properly addressed. Galvanized iron and galvanized steel piping (with some yellow and red brass and copper) was quite popular prior to World War II, but were replaced by copper tubing post-war and by plastics from the 1970s. Iron/steel pipes suffered corrosion and scale build-up in certain water types, especially in hot water lines. Copper tubing was approved by ASTM B88 in 1932 and is the same material used today. Copper has had some problems with aggressive, corrosive water.

There is a variety of plastic materials approved for use. Some plastic flexible water piping materials have had problems with splitting and fitting failure. One material used in the 1970s and '80s, polybutylene fittings, failed in many homes with disastrous results. A new hybrid piping material, KITEC by IPEX, is a composite pipe made of aluminum laminated between interior and exterior plastic layers. It claims national code approval, easy workability, sound dampening, and is corrosion-proof with good flow rates.

Water conservation has become mandated in recent years. Toilets, faucets, and showerheads must now often meet lower water use standards. Consumers are more cognizant of excess water use and energy cost for heating water which is wasted. Energy recovery devices are available and growing in popularity. Insulation, better system design, and solar heating options can also be explored.

Water quality and other health concerns are national and local issues. Filtering water systems are becoming more popular, installed below the kitchen sink/counter. Galvanized iron piping has corrosion problems that are often exacerbated by adverse water conditions and heat. Lead water services for houses were quite common, and lead in water continues to be a problem. Lead solder for copper joining has been banned. Jacksonville, Florida has "aggressive, corrosive water" and has banned the use of copper in domestic water systems. Asbestos was a popular insulation material for piping and must be carefully removed or encapsulated.

TECHNIQUES, MATERIALS, TOOLS

The water system should be thoroughly inspected and tested. Depending on the reason for rehabilitation, the water distribution system can be repaired, modified, or replaced. Some reasons include presence of

lead piping, failed polybutylene joints or pipes, low water pressure, corroded or broken pipes in under-slab or concealed locations, or condensation on cold water piping due to deteriorated or missing insulation. Codes may require renovations to any plumbing system to conform to current code without requiring the entire system to comply. Failed systems can be ripped out and replaced entirely or in part with the same or differing materials. Many adapters and couplings are available for these purposes. Note that water distribution systems have historically been used for grounding electrical systems. Please keep this in mind during rehab work and restore or provide for this important safety requirement.

Design requirements for water distribution systems are water volume, water pressure, number of fixture units, the total water demand, the height of fixtures above the water supply (static head), frictional loss due to distance and piping material, and the developed length of the pipe and fittings. Code requirements may vary from one municipality to another, but water supply fixture limits and minimum branch sizes are mostly the same. These are some code requirements to satisfy proper system performance: minimum (15 psi) at the highest plumbing fixture, and maximum (80 psi) system pressures are required for the water source. Tanks and pumps increase pressure and pressure regulators and relief or vacuum valves decrease pressure. Piping design for single-family houses is usually done by a plumber with approval by the plumbing inspector. Professional engineers typically are never involved with single-family plumbing systems. A good guide to design is by plumber Peter Hemp in *Plumbing a House*.

1. IMPROVE WATER DISTRIBUTION.

Water distribution systems and house sizes have changed over the years from small homes with limited systems to large ones with elaborate systems. Long delays for hot water at remote fixtures created a shift from single-pipe systems and introduced recirculating hot water systems. These loop systems can be expensive and use large amounts of energy in water heating and pumping if not properly designed. The draining of cold water awaiting hot water in the single-pipe system is resource depleting and time consuming. NIBCO has a “Just Right” modified loop product that uses natural convection to circulate hot water. A check valve and passive recirculating line forming the “forgotten” system can be easily installed for a similar passive recirculation system. The electric tracer wire system has a single pipe hot water self-regulating supply system that solves many loop problems. MetLund D’Mand System is suitable for rehabilitation and adaptation to existing plumbing. A remote sink has a pump and control system installed on the fixture angle stops. A push-button calls for hot water and the pump recirculates the water, which saves energy and water (Fig. 1).

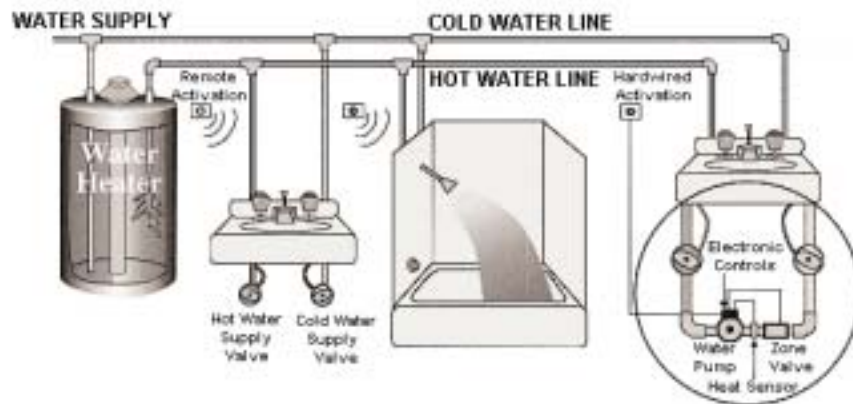


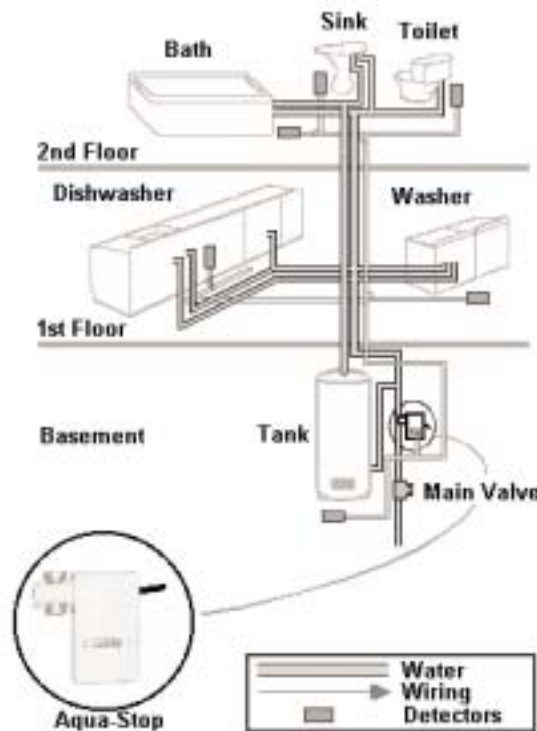
FIGURE 1

METLUND D'MAND RECIRCULATION SYSTEM

Manifold distribution systems are now recognized by major codes. The introduction of flexible plastic tubing like PEX-cross-linked polyethylene allows easy distribution of small-diameter, joint-free branches to individual fixtures. A larger supply line is connected to the manifold. The systems claim faster hot water delivery, balanced flow, easily accessible control valves, and no water hammer. This is an appropriate solution that can be installed around an existing failed system, with phased replacement of fixtures and branches. A classic distribution concern is water leaks and resultant damage. Aqua-Stop offers a water leak detection system (Fig. 2). Sensors are placed on the floor near potential leak sources, such as toilets, tubs, dishwashers, water heaters. The sensors will shut the main supply valve if a leak occurs and sound an alarm. System sensors can be hard-wired or remote.

ADVANTAGES: Improves responsiveness of water distribution throughout the home.

DISADVANTAGES: Some systems can be costly. Consult local codes as to whether such systems are permitted.



AQUA-STOP INSTALLATION



INTEGRAL SOLDERING FITTING

FIGURE 2, 3

2. INSTALL NEW COPPER PIPING.

Copper is a very popular material used since the 1930s. Joint solders previously contained some percentage of lead. Federal law changed to prohibit lead solder in potable water systems. Joints are made by soldering, brazing, and two-component adhesives. Soldering can be done by electric resistance tools and by torches. Tees can now be mechanically pulled from continuous tubing with new tools. A “new” copper fitting has recently been introduced from Europe: patented in 1934, the “integral soldering” fitting has been a standard in England (Fig. 3). IMI Yorkshire now imports American-sized integral soldering fittings, which ensure the proper amount of solder is provided. The solder is in the middle of the fitting, which provides a better joint and saves labor. Copper tubing is inserted into each end of a fitting, applied heat melts the solder ring, and the two tubes are fused together.

ADVANTAGES: Nearly every code approves; long track record; relatively easy installation; limited 50-year warranty; corrosion resistant with some water types; less support needed than plastic pipe; fire resistant; comes in coils and tubes.

DISADVANTAGES: Higher cost; some aggressive water attacks copper; flame normally present in joining; system noise; conducts heat and needs insulation; condensation concerns; tubing can kink.

3. INSTALL CHLORINATED POLYVINYL CHLORIDE (CPVC) PIPING.

Used since the 1950s, CPVC is approved by most codes for both hot and cold water distribution. BF Goodrich, inventor of CPVC, reformulated it in 1992 to be more workable in cold weather—an earlier drawback. CPVC is popular in new construction applications above and below slabs.

ADVANTAGES: Lower cost; easy installation and joining; no corrosion concerns; no water hammer; reduced conductance losses, which saves energy and reduces condensation; comes in coils and tubes.

DISADVANTAGES: More support needed than copper or steel; 24-hour joint cure time recommended; needs expansion capacity for piping by all codes; relatively recent product (first used in 1959). Installation during extremely hot temperatures can result in later joint failure.

4. INSTALL CROSS-LINKED POLYETHYLENE (PEX) PIPING.

Cross-linked polyethylene (PEX) flexible thin wall tubing had its beginnings in Europe in the 1970s and has been in use in the U.S. since the 1980s for radiant heating systems and hot and cold water distribution systems. Most codes approve its use, and some allow 3/8" branches. Long PEX coils are used in the new manifold water distribution systems, and eliminate expensive joints.

ADVANTAGES: Low cost; relatively easy installation. Highly flexible; greater water flow; joints and repairs can be made wet; tubing has memory, returns to old shape; kinks can be removed by heat; eliminates water hammer; improved freeze-resistance with better insulation than metallic piping; easy repair. Seems less vulnerable to nail punctures.

DISADVANTAGES: Not all codes approve; should not be exposed to sunlight; needs room for expansion; more support required than copper or steel.

FURTHER READING

1996 ASHRAE Handbook - HVAC Systems and Equipment, ASHRAE, Atlanta, GA, 1996.

Plumbing a House, Peter Hemp, Newtown, CT: The Taunton Press, 1994.

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The Old House Journal Guide to Restoration, Patricia Poore, New York: E.P. Dutton Books, 1992.

Journal of Light Construction, March 1997.

"The Forgotten Hot Water Recirculating System," *PM Engineer*, May 1998.

PRODUCT INFORMATION

BF Goodrich, Flow Guard Gold (CPVC), Cleveland, OH 44141; 800-864-4851; www.flowguardgold.com.

Copper Development Association, New York, NY; 800-CDA-DATA; www.copper.org.

Yorkshire Fittings, USA, Brentwood, TN 37027; 615-309-8669.

IPEX, Inc. (KITEC), Englewood, CO 80112; 800-473-9808; www.ipexinc.com.

Metlund, Costa Mesa, CA; 800-METLUND; www.metlund.com

NIBCO "Just Right," Elkhart, IN 46516; 800-234-0227; www.nibco.com.

SPARCO Anti-Scald Valve, Warwick, RI 02886; 401-738-4290; www.sparco-inc.com.

US Brass, Brass PEX, Dallas, TX; 800-872-7277; www.usbrass@zurn.com.

13

DRAIN, WASTE, & VENT SYSTEMS

ESSENTIAL KNOWLEDGE

There are a number of indications of the need to rehabilitate the drain, waste, and vent systems: leaks; clogged, slow, or non-working drains; or odors. The nature of these problems can be complex, so thorough investigation is advised. Leaks and slow drainage may reveal corrosion in waste pipes. Previous rehabs might have introduced dissimilar materials that corrode through electrogalvanic action, e.g., brass and iron fittings joined. Drains need to be sloped to remove waste water and solids. Building or pipe settlement can change pipe slope and the system may not work properly or may fail entirely. Odors can be a warning of serious problems. A toxic, explosive blend of gases could be present, caused by something as simple as a dry trap or as serious as a non-existent vent system. Vents protect against back pressure and siphoning and provide system air circulation. Cross connections are also a concern. Waste system design has evolved over time, and older approved methods did not recognize that siphoning could occur between potable and contaminated water. Older tub installations are an example with supply being located below overflow drains (Fig. 1). Local codes should be checked before proceeding with rehabilitation.

Drainage systems are basically gravity designed with venting introduced to assure the system performs properly. System capacities are now better understood, and codes allow smaller pipes. The older, existing system to be rehabed may potentially allow for greater expansion. The National Plumbing Standards was adopted in 1992 to mandate water-saving toilets, shower heads, and faucets. New materials, methods, and devices are now used along with old standards. Cast iron piping in a bell and spigot configuration was a common material, and has been replaced since the 1970s by plastics. Now hubless cast iron is regaining some upscale market share due to its sound-dampening properties.

Depending on the reason for rehabilitation, systems can be repaired, modified, or replaced. Proper analysis of the existing system and its condition is crucial. Various non-destructive diagnostic tools

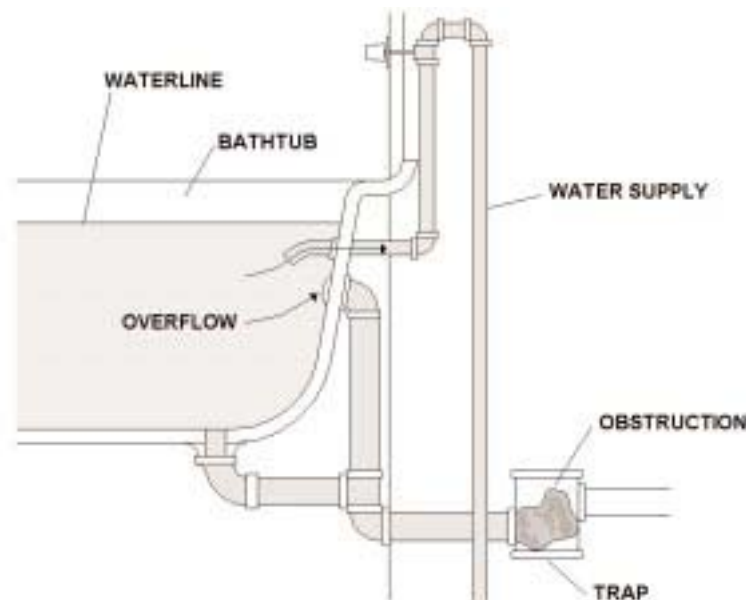


FIGURE 1

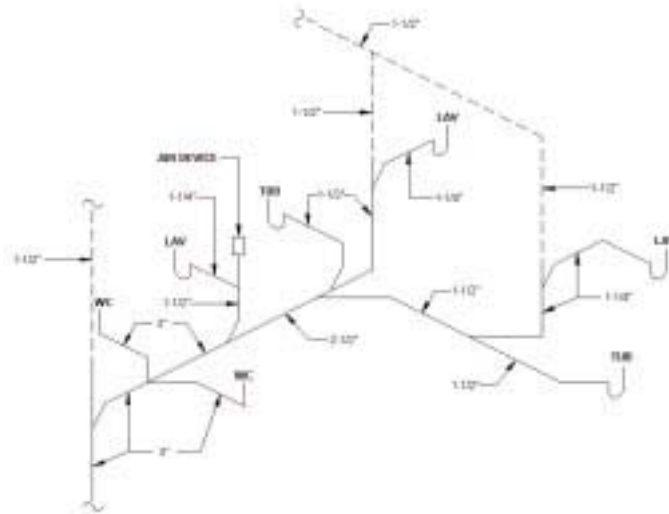
POTABLE WATER CONTAMINATION

and services are available if opening up walls or ceilings or access under slabs for inspection is not an option. Small pipe TV inspection and electronic leak detection systems are examples.

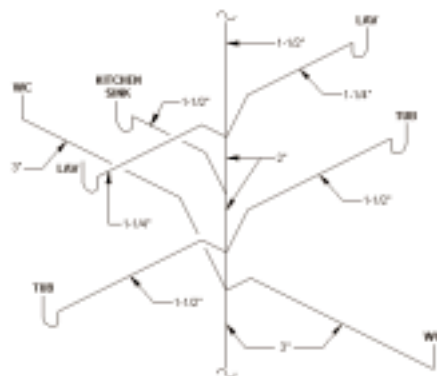
Drainage system materials used in residential construction include cast iron, galvanized and non-galvanized steel, galvanized wrought iron, lead, copper, brass, vitrified clay pipe, and plastics—acrylonitrile butadiene styrene (ABS-DWV) and polyvinyl chloride (PVC-DWV). Rehab projects on houses built after 1970 might involve plastic DWV pipe and fittings. Adapter fittings allow use of a variety of materials if desired. Cast iron is a better sound insulator but more costly, so blended systems are popular. Cast iron is used in sound-sensitive areas and plastic in non-sensitive areas. Existing materials can be combined with new or other materials, provided electrogalvanic or code concerns are addressed.

There are many new code-approved drainage systems and designs that can be considered. If the system is to be modified or replaced, a new design could be in order. New designs might be adapted to solve problems with the existing system. Drainage systems are calculated to handle a certain load, and fixtures are assigned values known as fixture units. These units are added to determine pipe sizes. Code tables state maximum unit capacity and lengths for drains and vents, and minimum pipe sizes. Local codes should be consulted.

Vent strategies have evolved from conventional to common vent, wet venting, waste stack venting, and circuit venting. Various strategies evolved to minimize pipe runs and roof penetrations. A common vent connects two fixtures. The wet vent pipe doubles as a waste pipe and is increased in size. Wet vents may be horizontal (Fig. 2), vertical (Fig. 3), or combined (Fig. 4). Waste stack venting requires all fixture drains to connect separately to it (Fig. 5). Size requirements apply to these alternate methods. Circuit venting can connect a maximum of eight fixtures to a horizontal drain (Fig. 6). Slope and size requirements apply here as well. In cold regions, vents penetrating roofs may experience frost or snow closure; a pipe at least 3" in diameter is required for the last portion of the vent.



TYPICAL HORIZONTAL WET VENTING



VERTICAL WET VENTING

FIGURE 2

FIGURE 3

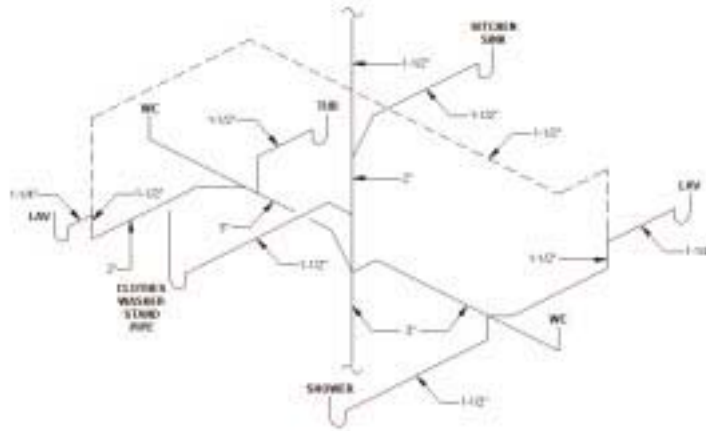


FIGURE 4 COMBINATION VERTICAL AND HORIZONTAL WET VENTING

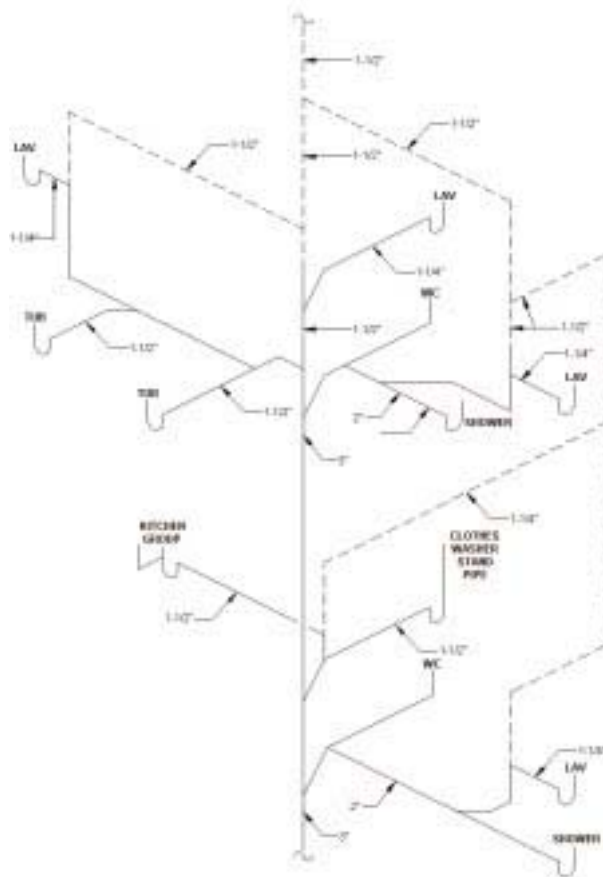


FIGURE 5 TYPICAL SINGLE-STACK SYSTEM FOR A TWO-STORY DWELLING

TECHNIQUES, MATERIALS, TOOLS

1. INSTALL CAST IRON DRAIN, WASTE, AND VENT (DWV) PIPING.

Cast iron was originally used in bell and spigot configurations with lead and oakum joints and upgraded to Tyler or rubber compression joints. Hubless pipe and fittings joined with elastomeric and stainless steel couplings are most popular currently. Cast iron can rust and is coated with an asphaltic compound. It almost disappeared as a residential waste pipe material in the 1970s, but is still used.

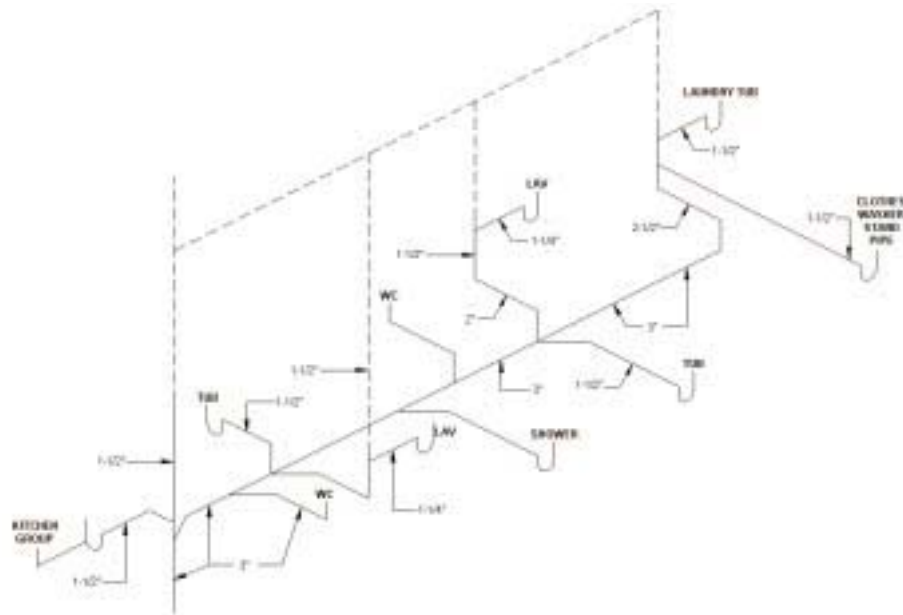


FIGURE 6

CIRCUIT VENT WITH ADDITIONAL NON-CIRCUIT VENTED FIXTURES

ADVANTAGES: All codes accept. Fireproof, good sound insulator; stronger, requires less support; long lasting; can be buried in a trench; needs no protection from nail punctures; 3” pipe fits in standard 2x4 wall without furring; needs no expansion allowance; hubless is easy to disassemble.

DISADVANTAGES: High cost and weight; requires more labor to install; not easy to cut.

2. INSTALL COPPER DWV PIPING.

Copper DWV is found in many older systems. It is also more costly than cast iron. The torch needed for joining copper creates a potential fire hazard, but new joining techniques are available. For example, an electric resistance joint tool can be used; Copperbond, is a UL-approved two-component adhesive that replaces soldering or brazing.

ADVANTAGES: Accepted by all codes; thin wall, lightweight, easy to cut and assemble; 3” pipe/fittings fit in 2x4 wall; fireproof; less labor than cast iron.

DISADVANTAGES: Costs more than cast iron; transmits noise but not as much as plastic does; requires nail protection plates; open flame typically required for joints.

3. INSTALL ACRYLONITRILE BUTADIENE STYRENE (ABS-DWV) AND POLYVINYL CHLORIDE (PVC-DWV) PIPING.

Plastics—ABS-DWV and PVC-DWV—are the predominant materials now used in rehab and new residential construction. In various regions of the country, plumbing professionals seem to have preferences for one material over the other—typically the materials do not share a given market equally. Reduced cost and labor are reasons for popularity. Most codes accept these materials. New York State code will not allow plastic in underground residential use.

ADVANTAGES: Low cost; less labor intensive; easy to cut and assemble; lightweight.

DISADVANTAGES: Fumes present with solvents and primers; material transmits noise; expands slightly; needs more support; care needed with underground installation; protection needed for nail punctures; ABS burns on its own, while PVC burns only with flame present; ABS deteriorates in sunlight.

4. INSTALL PUMPS AND EJECTORS TO DISCHARGE WASTE.

Slow or stopped waste drains may indicate that the drainage connections do not meet gravity requirements in rehab situations. Adding a pump might solve marginal or non-performing lines. Also, new plumbing fixtures might be located so that gravity will not expel waste (ie: basement fixtures). Sewage ejectors,

pumps, or grinder pumps may be required to lift discharge. Specific code requirements exist on pipe sizing, venting, electrical connections, and audiovisual alarms. These devices should only be used when absolutely necessary because of cost, access requirements, pump failure, and power failures. The units must be well sealed and designed for removal and replacement. Check with local authority on placement; exterior locations are typically most desirable.

ADVANTAGES: Allows plumbing fixtures below gravity connection points.

DISADVANTAGES: Costly; power failures stop system; needs a monitoring system and alarm; easy access required for unit replacement.

5. INSTALL GRAY WATER AND HEAT RECOVERY DEVICES.

Rehabilitation requires consideration for resource savings alternatives. Low-flow fixtures and shower heads to save water and energy are now mandated by the Energy Policy Act. Gray water collection systems are a sustainable choice for any rehab project because they recycle water from bath tubs, showers, lavatories, and clothes washing machines. The Uniform Plumbing Code allows gray water to be collected and used for irrigation. As a conservation method or in areas with restricted water use, gray water systems may be appropriate. However, cross-contamination is a concern with gray water. Check your local code for design requirements and approval. Heat recovery devices for waste hot water are new, energy-saving options. One waste water heat recovery device is the GFX. Shower, laundry, bath, dishwasher, and sink waste hot water flows through a copper DWV section wrapped with a copper water pipe feeding the water heater (Fig. 7). The device is installed vertically in the main drain and works best in basement applications, but non-basement applications are available. Most codes approve its use.

ADVANTAGES: Saves resources; gray water allows landscape gardens in arid locations; GFX saves energy.

DISADVANTAGES: Costly; cross-contamination concerns; needs storage containers; GFX needs basement location for best results; may be difficult to obtain.



FIGURE 7

GFX WASTEWATER HEAT RECOVERY SYSTEM

6. INSTALL AN AIR ADMITTANCE VALVE.

An air admittance valve is a relatively new device approved by some codes that can aid plumbing rehab. Some plumbing fixtures are difficult to vent due to location—kitchen island sinks are the classic example. An air admittance valve placed above the trap eliminates all other vent piping (in some circumstances; generally, at least one vent in the system is required to terminate above the roof line). Studor Inc. invented the technology and such vents are popular in Europe. Air admittance valves allow air to enter but prevent gases from escaping (Fig. 8). Valves must be accessible and installed above the fixture served (Fig. 9).

ADVANTAGES: Allows venting in difficult locations; saves venting pipe and materials.

DISADVANTAGES: Less costly, spring-activated devices were used in manufactured homes and spring corrosion caused a high failure rate. Diaphragm designs of Studor and others do not have the corrosion problem. Not all codes allow air admittance valves.

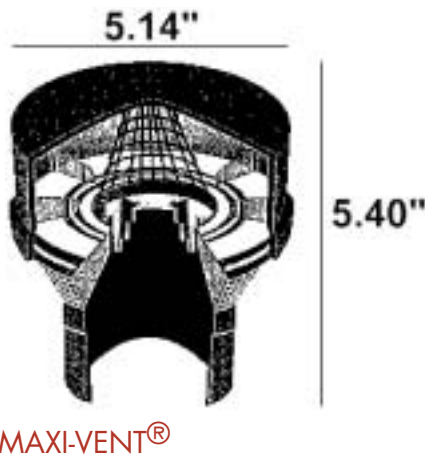


FIGURE 8



FIGURE 9

AIR ADMITTANCE VALVE BEHIND SINK

FURTHER READING

Directory of Water Conserving Plumbing Products, Walnut, CA: IAPMO, updated monthly; 909-595-8449.

1997 Dwelling Requirements of the Uniform Plumbing Code, Walnut, CA: IAPMO; 909-595-8449.

International Residential Code (Draft), International Code Council, Falls Church, VA, 1998.

The Old House Journal Guide to Restoration, Patricia Poore, New York: E.P. Dutton Books, 1992.

Plumbing a House, Peter Hemp, Newtown, CT: The Taunton Press, 1994.

The Consumer's Guide to Home Improvement, Renovation & Repairs, The Enterprise Foundation, New York: John Wiley and Sons, 1995.

PRODUCT INFORMATION

Cast Iron Soil Pipe Institute, Chattanooga, TN 37421; 423-892-0137; www.cispi.org.

Charlotte Pipe & Foundry (cast iron), Charlotte, NC 28235; 800-438-6091; www.charlottepipe.com.

Studor, Inc. Air Admittance Valves, Dunedin, FL 34698; 800-447-4721, www.studor.com.

WaterFilm Energy, Inc., P.O. Box 48, Oakdale, NY 11769; 516-758-6271; www.oikos.com/gfx.

FUEL SUPPLY SYSTEMS

ESSENTIAL KNOWLEDGE

There are three predominant residential fuel systems—natural gas, propane, and fuel oil. Rehabilitation might be necessary in the event of leaks, odors, corrosion, system damage, or appliance change. Gas—manufactured from coal or derived naturally from underground sources—has been used in houses since the mid-1880s. Lighting and cooking were first uses of gas with space and water heating added later. Propane (liquified petroleum gas) became a residential fuel source in the 1920s and has approximately 5 million residential customers currently. Oil became a source in the same period but the 22,000 houses built in Levittown, New York starting in 1947 gave oil a big boost. There were 16 million residential customers pre-oil embargo (1973), 12 million thereafter.

As with any plumbing system, the existing condition and code compliance should be determined. Natural gas system designs depend upon utility supply pressure, heating value of the gas, appliance needs, and distances from supply to appliances. Negotiating a higher service pressure from the utility allows for a smaller internal distribution system. The gas load center concept is a relatively new fuel system innovation. The concept is similar to electrical distribution with a central panel and branch circuits. Gas lines come to a manifold at a panel and valved branch runs connect to gas appliances. Flexible gas tubing with fewer joints allows the concept to work easily. In some homes in Japan portable cooking appliances and ventless portable space heaters are plugged into quick-connect gas outlets. The trend is likely to grow here as well. MB Sturgis makes quick-connect gas outlets for barbecues and other appliances. Another trend concerns seismic safety; Los Angeles now requires seismic activity-triggered shutoff valves for gas systems in new homes. Flexible gas tubing, now available, may be a safe alternative because it is less likely to shear or rupture between joints.

Propane and oil systems usually have a fuel delivery source that provides service as well. System designs are per local and national codes. These two fuels require a storage tank in addition to the delivery source. The propane tank is owned by the service provider and must be outside the residence. Tanks can be below grade, but typically are above. Ten feet from the house exterior is a typical distance for tank location, but they can be closer. Underground connections are typical, with polybutylene frequently used as a new underground material for piping.

Oil storage tanks can be indoors or outdoors. Existing underground tanks should be surveyed for corrosion—a major problem, with potential environmental impacts due to leaks. Indoor tanks require venting and a blocked vent line causes filling problems. Oil systems may have a single supply pipe or a loop.

Carbon monoxide (CO) from fuel combustion is a safety concern and certain manufacturers and associations recommend installing sensors near potential CO sources. Some first-generation carbon monoxide detectors were too sensitive and alarmed at non-dangerous levels. New detectors are available now with appropriate alarm thresholds.

TECHNIQUES, MATERIALS, TOOLS

The following are the most common fuel supply system piping and fittings. Consult your local code agency, utility, or supplier for other materials and methods.

1. INSTALL STEEL PIPE AND FITTINGS.

This is the traditional material for residential fuel systems, along with cast iron pipe. The majority of systems use threaded joints but welded joints are also common in older homes (which may make systems rehab more complicated). It is the most popular natural gas piping material in new construction. The rigid nature of steel pipe might make rehab projects difficult. Flexible tubing, if allowed by your local code, usually is easier for installation in rehab work.

ADVANTAGES: All codes approve; low material cost; requires fewer supports; nail proof.

DISADVANTAGES: Labor-intensive; sophisticated tools required; rigid; difficult to modify; heavy; can corrode; pipe should not be used for support when exposed (clothes racks, etc.) because of pipe damage/breakage.

2. INSTALL COPPER PIPE AND FITTINGS.

This is the traditional material used today in residential propane and fuel oil installations. It is allowed by some utilities and codes for natural gas fuel supply and is painted yellow to distinguish it from water piping. Sulphur found in some gas corrodes copper and internal tinning is required in the tubing. See Section 12 for connection techniques.

ADVANTAGES: Approved by most codes; flexible; faster; easier to install; allows long runs; fewer fittings; lightweight; corrosion-resistant; easy to modify; easy for manifold systems; easy appliance hookup.

DISADVANTAGES: Not allowed by some utilities for natural gas; can be easily confused with water piping; some gas is corrosive to copper; needs nail plates to prevent puncture; needs more pipe supports than steel.

3. INSTALL CORRUGATED STAINLESS-STEEL TUBING (CSST).

Developed initially in Japan, CSST was first manufactured in the U.S. in 1988. It is now approved by most major codes. CSST is used in residential and commercial work with natural gas and propane. It is gaining market acceptance, with five U.S. manufacturers now producing CSST. Features mechanical couplings that vary per manufacturer. Plumbers require training before installations. Widely used in manifold distribution systems.

ADVANTAGES: Wide code approval; flexible; lightweight; faster and easier to install; long runs with fewer fittings; easy to modify; one-person installation; corrosion proof; easy for use with manifold systems; easier appliance hookup.

DISADVANTAGES: New material; still not approved by some codes; higher material cost; requires specialized tools for assembly; needs nail plates to stop punctures; needs more support than steel.

FURTHER READING

1996 ASHRAE Handbook - HVAC Systems and Equipment, ASHRAE, Atlanta, GA, 1996.

Domestic Oil Burners, Charles A. Burkhardt, New York: McGraw-Hill, 1961.

National Fuel Gas Code (NFPA 54), International Approval Services, Cleveland, OH 44131, 1996, www.gasweb.org/gasweb.

PRODUCT INFORMATION

Copper tube, Copper Development Association, New York, NY; 800-CDA-DATA; www.copper.org.

Gas Tite, TiteFlex Corporation (CSST), P.O. Box 90054, Springfield, MA 01139; 800-662-0208; www.tite.flex.

P.G.P., Parker Hannifin Corp., Paraflex Division, Ravenna, OH 44266; 800-4-PARFLEX, www.parker.com/fcg.

TracPipe, OmegaFlex, Exton, PA 19341, 800-671-8622, www.omegaflex.com.

WARDFLEX Ward Manufacturing, Blossburg, PA 16912; 800-248-1027; www.wardmfg.com.

APPLIANCE VENTS & EXHAUSTS

ESSENTIAL KNOWLEDGE

Combustion appliances require venting and certain appliances require exhausting. Rehab work on vents and exhausts may be needed because of failure of equipment, venting, or structure. Venting failures may be deadly or cause health problems, and are difficult to ascertain. Carbon monoxide deaths are often in the news and detectors are becoming more common. Venting failure indicators might include corrosion, smoke (with oil equipment), soot, backdrafting, appliance operation failure, excess moisture, or visual damage.

Combustion appliances can be fueled by natural gas, propane (liquified petroleum gas), or oil. Traditionally, appliances were designed with a draft hood or diverter to vent combustion gases. Vents were sized based on tables indicating maximum capacities for certain vent area, height, lateral (horizontal run), and material. Traditional venting materials are masonry (lined and unlined), cement asbestos pipe, and single- and multi-walled metal pipe.

The 1987 U.S. National Appliance Energy Conservation Act (NAECA) increased minimum efficiency requirements for residential gas and oil-fired appliances, because vents will not perform properly if they are too large or too small. The annual fuel utilization efficiency (AFUE) became at least 78% for gas appliances and 80% for oil. New appliances meeting these and higher AFUE ratings produce fewer and cooler combustion products. Condensation and corrosion can be a problem because moisture can deteriorate chimneys through freeze/thaw action and corrode metal vents. New high-efficiency, self-condensing appliances produce such cool, moist exhaust that they use venting materials similar to drain system materials and need to be sloped to drain the moisture.

In response to higher efficiency appliances, the National Fuel Gas Code (NFPA 54) in 1992 changed venting design requirements with concern for minimum and maximum flue capacities. Certain fan-assisted combustion system appliances were included to overcome venting problems. Oil appliance venting design standards have never been published but are expected in NFPA Standard 31.

Some non-combustion appliances require exhausts. Codes require clothes dryer exhausts, and gas ranges should be exhausted (but are not required to be). Dryer failure indicators may be excess moisture, clothes not drying, high energy bills, smoke, or odors. Lint and grease buildup can create fire hazards, while blocked systems or combustion by-products can create health hazards.

The physical condition of the existing venting and exhaust system should be checked, especially to insure the passageway is properly lined, clear, and free of obstructions. If the vent/chimney was previously used for solid or liquid fuel, it should be cleaned. The failure indicators mentioned above need to be reviewed and system operation verified. Ages of combustion appliances should be matched to the vent system to determine if a new efficient appliance has been installed without an appropriate flue modification. As mentioned above, improper venting and flue damage may result. Existing oil appliances might have had their older burners replaced with the more efficient retention-head oil burner. This could require a flue modification because new levels of water and acid concentration could be present. Typically corrosion-resistant materials and/or heat loss reduction are introduced to ensure proper draft and reduce condensation. Some codes require the existing chimney or vent be brought into code conformance if a new appliance is connected.

A properly designed vent controls draft and removes flue gases. Selection of a replacement vent or checking compliance should consider factors such as appliance draft, configuration, size, heat, and

condition; construction of surroundings; building height; material selection; and code requirements. Charts in codes show selection, clearance from combustible material, and vent termination requirements. Gas appliances are classified in four categories that allow different listed vent products. Category I has non-positive vent static pressure with vent gas temperature that avoids excessive condensation production in the vent. A Type B vent is listed and labeled for this category. Other categories require special vents. Additional requirements exist for multiple appliance vents. Direct-vented appliances have through-wall designs. To ensure intake air and combustion gas outlets are in proper locations, one guide is shown (Fig. 1).

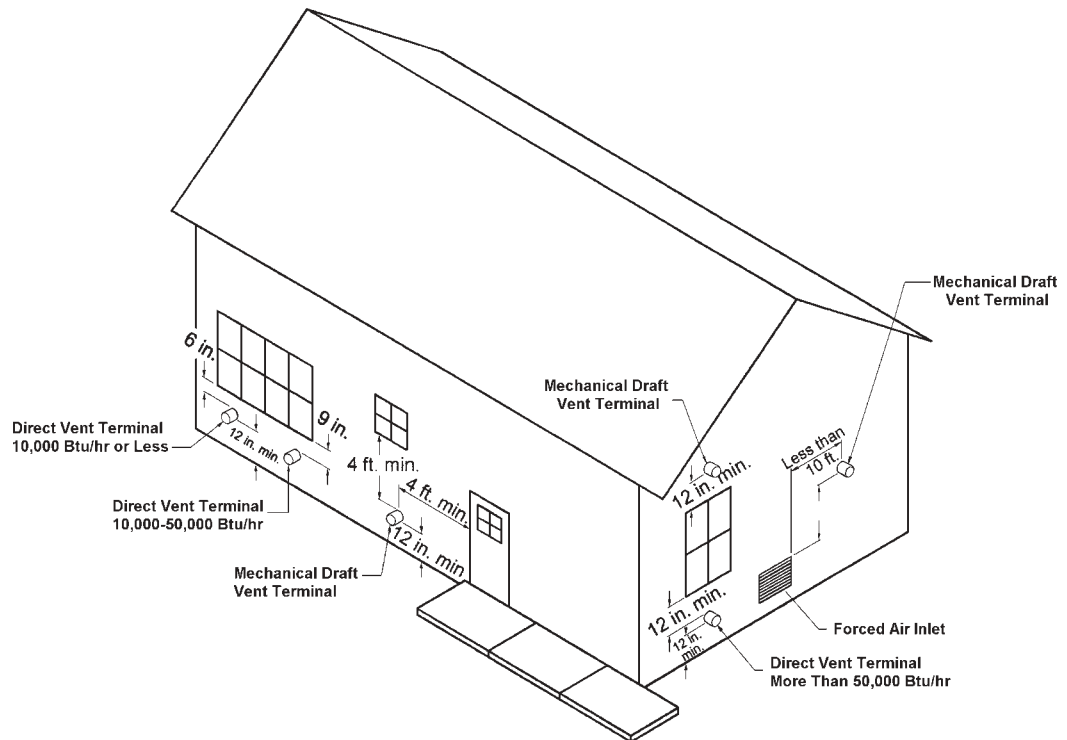


FIGURE 1

THROUGH-WALL VENT LOCATIONS

TECHNIQUES, MATERIALS, TOOLS

1. INSTALL A NEW EXHAUST FOR A CLOTHES DRYER.

Installing a new clothes dryer or modifying an existing dryer installation may be part of the rehab project. These appliances, whether gas or electric, require exhausting to the home's exterior. Lint buildup may lead to fire or health problems, making exhausting imperative. The International Residential Code for One and Two Family Dwellings (IRC) has specific requirements for exhausts regarding duct size, length, and construction standards. A maximum length of 25' has been established based upon a compilation of appliance manufacturers' recommendations. Bends reduce the length allowed but there are exterior mounted powered exhausts available. The local code should be checked for approvals. Most dryers exhaust approximately 150 to 200 cfm of air. The IRC requires makeup air provisions if dryers exhaust more than 200 cfm. With bath exhaust fans commonly exhausting 50 cfm of air, and range hoods 150 cfm, adding a clothes dryer exhaust may cause an assortment of problems, such as backdrafting of combustion appliances or fireplaces. Bath and kitchen exhausts might not exhaust during dryer operation.

ADVANTAGES: Can ensure fire safety with dryer use; improves indoor air quality; reduces lint and moisture inside the home.

DISADVANTAGES: May induce backdrafting of combustion appliances and fireplaces; may inhibit function of other exhausts in the home.

2. INSTALL A NEW EXHAUST FOR A RANGE.

Range exhausts typically are not code required, relying on windows for exhaust or non-venting filters for cleaning air. Range exhausts are recommended for indoor air quality and safety issues, particularly for gas ranges, as emissions of carbon monoxide, nitrous oxide, and others are present. Fouled burners can produce dangerous levels of benzene, indicated by a yellow flame. Moisture is a product of gas combustion as well, with a gallon of moisture released per 100,000 Btu/hr input (1/8 gallon per hour per average burner). Kitchen exhausts can be recirculating or circulating. Recirculating "exhaust" hoods do not exhaust and move approximately 40 cfm of air through a filter then back to the kitchen. Filters are either charcoal or activated carbon coated fiber, and require maintenance. Circulating exhausts vary from 150 cfm average two-speed hoods to downdraft exhausts of 500 cfm or more. Manufacturers provide similar duct openings so equipment can be replaced (typically 3 1/4" x 10" or 7" round). Duct length is critical and manufacturers' recommendation should be followed. Smooth metal duct material is preferred over flexible metal. An equivalent length adjustment must be made for flex.

ADVANTAGES: Better indoor air quality; mitigates fire hazard.

DISADVANTAGES: Recirculating hoods do not address combustion products and are not recommended.

FURTHER READING

1996 ASHRAE Handbook - HVAC Systems and Equipment, ASHRAE, Atlanta, GA, 1996.

Domestic Oil Burners, Charles A. Burkhardt, New York: McGraw-Hill, 1961.

E Source Technology Atlas Series: Residential Appliances, E Source, Inc., Boulder, CO, 80302, 303-440-8500, 1996, www.esource.com.

National Fuel Gas Code (NFPA 54), International Approval Services, Cleveland OH 44131, 1996.

FIRE PROTECTION SYSTEMS

ESSENTIAL KNOWLEDGE

According to the National Fire Protection Association (NFPA), there were 406,500 residential fires and 3,360 deaths in the U.S. in 1997. Domestic fires are low probability but high consequence events. Experts indicate that most fires occur in kitchens, family/living rooms, and bedrooms, with highest loss of life in bedrooms and family/living rooms. Fires reportedly burn hotter and faster than 25 years ago because of newer materials in home furnishings.

This Old House magazine recommends adding sprinkler heads during rehab to water systems—a “some protection is better than none” philosophy. However, fire protection engineers say an added system may not perform adequately because there are no hydraulic calculations to verify that the system will work. No valves or alarms are available to tell when the sprinklers might accidentally fail. A loop is needed with sprinkler heads so that standing water in the pipes will not be a concern—potable water that does not circulate can become contaminated. The Director of Operation Life Safety of the International Association of Fire Chiefs suggests adding fire sprinklers to various areas rehabed, essentially adding a system on an “installment plan” basis. Other professionals take an “all or nothing” approach to sprinkler systems. Adding an automatic fire sprinkler system can add to life safety and property protection. Automatic fire sprinkler systems are required in some rehab construction in certain jurisdictions. The local code should be consulted.

NFPA Section 13D governs residential sprinkler systems for one- and two-family construction. Residential systems are relatively new with NFPA 13D, adopted in 1980. Complex automatic fire protection systems are commonly installed in commercial, institutional, and high-rise construction. Residential systems are designed to be less complex. Life safety is the top priority in residential applications, compared to saving property in commercial systems. Still, requirements are deemed too extreme and costly by many. Opponents feel more effective solutions could be enacted. NFPA 13D requires sprinklers in most rooms with flows to allow occupants 10 minutes escape time. The multipurpose system combining plumbing and fire sprinklers are newly approved by NFPA and could be considered. Insurance companies may provide a 5% to 20% yearly insurance rebate to homeowners with sprinkler systems. Canadian insurers may provide a 35% to 40% rebate.

Automatic fire sprinkler systems are designed to provide minimum water flow from heads for a specified escape time. NFPA 13D requires at least one automatic water supply. For homes not on a public water system, a captured water supply large enough for a 10-minute flow from two heads is required. Pools, tanks (elevated or with electric pumps), or tanks pressurized with nitrogen propellant may be used.

Residential sprinklers are separate “wet” systems, compared to wet or dry standpipe systems found in commercial construction. System supply configurations and connections vary in type and complexity and are usually determined by local code. NFPA 13D requires sprinklers in most rooms, except baths, closets, attics, and garages. Heads in non-habitable spaces provide a system with better coverage, but this is more difficult and costly, particularly in rehab work. Wet systems also need protection for freezing temperatures. A fire sprinkler professional, familiar with the local code requirements, should design the system.

Piping materials include welded and seamless steel, wrought steel, copper, and chlorinated polyvinyl chloride (CPVC) and polybutylene (PB). All are common materials used in residential construction. Copper can be used in any area, but CPVC must be used in concealed areas or adjacent to smooth ceilings. CPVC fire sprinkler pipe is a different product than water supply pipe with different code approvals, and the two cannot be combined in most cases. Both can be used with the same fittings but

have varying wall thicknesses. For example, BF Goodrich BlazeMaster CPVC has pipe wall thickness of SDR 13.5 IPS vs. Flow Guard Gold with SDR 11 CTS.

PEX cross-linked polyethylene, multipurpose tubing system for sprinklers has been submitted for UL approval, (approval appears likely), which would lower the 175 psi pressure requirement to 130. Smaller pipe runs, 1/2" vs. 3/4" or 1" would be featured with multiple service connections to each sprinkler head. The material would be a very cost-effective and easy product to install in rehabs. Check with your local code official.

Sprinkler heads vary in design and type. They can be ceiling or side wall mounted, concealed or exposed, and in metallic or prepainted finishes. Quick-response residential sprinkler heads contain a fusible link, pellet or frangible glass bulb. All must be nationally listed and approved. There are many heads available with widely ranging performance ratings (k factor). Coverage from 144 sf to 400 sf per head is possible depending on available flow rates and system pressure. There is a Consumer Products Safety Commission national action filed along with various suits against Central's Omega sprinkler heads. The heads when tested failed to work at the designated pressure, but most worked at higher pressures. If the rehab project includes these heads the International Association of Fire Chiefs recommends you have Omega heads removed and replaced.

Other system elements include a riser and components that control and monitor for the flow of water to the system. The riser components may vary depending on design and code requirements. Typically, they consist of a check valve that lets water flow in only one direction, a pressure gauge, a pressure relief circuit and drain, a flow switch, and a test valve. The riser is connected to the supply. If the water supply is not public, a tank, pond, or source other than a well will be needed. Self-contained systems are available with electric pumps or pneumatic pressure systems.

If running distribution piping within finished walls is not possible, DecoShield makes a UL listed cover and support system. The product was designed for surface mounting retrofit systems in existing buildings and would be appropriate for most rehabs (Fig. 1).



FIGURE 1

DECOSHIELD SYSTEM

TECHNIQUES, MATERIALS, TOOLS

1. INSTALL A STAND-ALONE RESIDENTIAL SPRINKLER SYSTEM.

The stand-alone system is separate from a house's water distribution system and is the most common. A main control valve from the water source to the domestic and fire systems, pressure gauges, check valves, water flow detectors, and drain and test connections are typical.

ADVANTAGES: System water flow activates an alarm; all codes approve; can be connected to fire station; more control of system (flushing and maintenance).

DISADVANTAGES: Can be deactivated by accident; requires more materials and labor; more difficult for rehab.

2. INSTALL A MULTIPURPOSE RESIDENTIAL SPRINKLER SYSTEM.

NFPA issued a Technical Interim Amendment on October 28, 1998 approving multipurpose or combined systems for Section 13D. This means the fire sprinkler and domestic water distribution system can be combined. Most plumbing codes prohibit such systems, but Highland Springs, California and Dupont, Washington are two of many locales that allow them.

ADVANTAGES: Lower cost than stand-alone systems; cannot be deactivated accidentally; reduced materials and labor; easier to install.

DISADVANTAGES: Does not include an alarm; some plumbing codes do not allow; contaminated water is possible without loops in the system; future additions to the house's water system (i.e., water softeners and backflow prevention) could hurt calculated effectiveness.

3. INSTALL A COPPER PIPED SYSTEM.

Copper has been in use for sprinklers since the 1930s and remains the most popular piping material for stand-alone and multipurpose systems. Approval of alternative materials that cost less and are easier to install might change the use of copper piping. The integral soldering fitting described in Section 12 can speed construction.

ADVANTAGES: Code-approved in any installation; commonly used in other plumbing systems; relatively easy installation; fabricated by soldering or brazing using conventional equipment or electric resistance tools; compact within thin walls; tees can be pulled mechanically.

DISADVANTAGES: Costly; more rigid than plastic; brazing or soldering are potentially dangerous; pipe may be subject to condensation; susceptible to theft.

4. INSTALL A CPVC-PIPED SYSTEM.

CPVC water piping has been used in single-family housing since 1959. A reformulation in the 1990s solved cold weather workability problems. CPVC for fire sprinklers is a different product and was introduced in 1986. Code requires CPVC to be installed behind a thermal barrier in most cases, except with quick response sprinklers in special cases.

ADVANTAGES: Low cost; somewhat flexible; more easily installed with cut and glue/weld fittings; better insulation properties than copper.

DISADVANTAGES: Use limited to specific areas; more support required; transitions needed to other non-PVC sections; chars during fire.

FURTHER READING

Automatic Sprinkler Systems Handbook, Quincy, MA: National Fire Protection Association, 1997.

"The Economics of Fast Response Residential Sprinkler Systems," *Fire Journal*, May 1985.

National Fire Protection Association, Section 13D, "Installation and Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes," Quincy, MA, 1996.

"Sprinkler Codes A'Changing," *Journal of Light Construction*, Dec. 1989.

"Sprinkle, Sprinkle Little Star," *This Old House*, Jan. 1998.

PRODUCT INFORMATION

BF Goodrich BlazeMaster, Cleveland, OH 44141; 800-331-1144; www.bfgoodrich.com.

Creative Systems, Inc., DecoShield, Jamesville, WI 53545; 608-757-0717.

Reliable Automatic Sprinkler Co., Mt. Vernon, NY 10552; 800-431-1588; www.reliablesprinkler.com.

APPENDIX

PROFESSIONAL ASSOCIATIONS AND RESEARCH CENTERS

AIR CONDITIONING CONTRACTORS OF AMERICA (ACCA)
1712 New Hampshire Avenue, NW
Washington, DC 20009
202-483-9370
www.acca.org

AIR CONDITIONING AND REFRIGERATION INSTITUTE (ARI)
4301 North Fairfax Drive, Suite 425
Arlington, VA 22203
www.ari.org

AMERICAN COUNCIL FOR AN ENERGY-EFFICIENT ECONOMY (ACEEE)
1001 Connecticut Ave. NW, #535
Washington, DC 20036
202-429-8873
www.aceee.org

AMERICAN GAS ASSOCIATION
400 N. Capitol Street, N.W.
Washington, DC 20001
202-824-7000
www.aga.org

AMERICAN NATIONAL STANDARDS INSTITUTE
11 West 42nd Street, 13th Floor
New York, NY 10036
212-642-4900
www.ansi.org

AMERICAN SOCIETY OF HEATING, REFRIGERATING, AND AIR-CONDITIONING ENGINEERS (ASHRAE)
1791 Tullie Circle, NE
Atlanta, GA 30329
404-636-8400
www.ashrae.org

AMERICAN SOCIETY OF PLUMBING ENGINEERS (ASPE)
3617 Thousand Oaks Blvd., #210
Westlake, CA 91362-3649
805-495-7120
www.aspe.org

AMERICAN SOCIETY OF SANITARY ENGINEERING (ASSE)
28901 Clemens Road, Suite 100
Westlake, OH 44145
440-835-3040
www.asse-plumbing.org

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)
100 Barr Harbor Drive
West Conshohocken, PA 19428
610-832-9500
www.astm.org

BUILDERS HARDWARE MANUFACTURERS ASSOCIATION
355 Lexington Avenue, 17th Floor
New York, NY 10017
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August 1999
HUD-DU100C000005956

