14

PLUMBING

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Running water, both hot and cold, which we take for granted in a modern house, is a relatively recent development. It wasn't until the latter part of the 18th century that the flush toilet was invented, and the mass-produced pipes to carry water and waste did not precede the toilet by many years. Only in the past 50 years or so—since copper and plastic have replaced galvanized steel piping—have we been able to install plumbing that can be expected to last for the life of the building.

PLUMBING BASICS

Plumbing consists of two basic systems—a *supply system* of pressurized pipes that carry water into the building and a *waste system* of unpressurized pipes that drain sewage from the building by gravity. Water for the supply system is usually drawn from either a municipal water system or a well. The waste system drains to either a municipal waste facility or an on-site septic system. Residences within urban boundaries are usually connected to public water mains and sewers, whereas a rural property often has a private well and septic system.

The pipes within a house, whether for supply, waste, or vent, are connected to each other with *fittings,* primarily right-angle *elbows* and T-shaped *tees.* These connectors slip over the ends of adjacent pipes. In copper piping, the fittings are made of copper and are soldered to the pipes. In plastic piping, the fittings are glued or clamped to the pipes, depending on the piping system used. Cast iron waste and vent piping is connected with stainless steel clamps that are lined with neoprene gaskets for a tight seal.

The pressurized supply system is equipped with *shutoff valves* so that all or part of it can be deactivated for repair or replacement work. These include a main shutoff valve where the water service enters the house and small shutoff valves at each fixture.

Waste piping and *vent piping* must slope at code-specified angles that range from 1⁄16 to 1⁄4 inch per foot, the exact angle depending on the size of the pipe. These slopes ensure that the waste piping will drain efficiently and that any condensate that accumulates in vent piping will drain into the waste system. Removable cleanout plugs must be provided at strategic locations so that a plumber can gain access to the line by unscrewing one or more of these plugs if a line becomes clogged.

Supply Piping

Water enters the house through a single *supply pipe* (usually 1 or 3⁄4 inch inside diameter) that is buried deeply enough in the ground to prevent it from freezing. When connected to a public water supply, the supply pipe passes through a *water meter* that measures the residence's water usage. The meter is usually at the street in temperate or warm regions and inside the house with an electronic readout on the outside in cold regions. Once within the house, the supply pipe is not reduced in size until it reaches the water heater, after which it may be divided into *branch lines* to supply plumbing fixtures. The water supply to individual fixtures consists of a pair of supply lines—one hot, one cold—usually of 1⁄2 inch diameter, depending on the number of fixtures that are fed by the same pair of pipes (Figure 14.1).

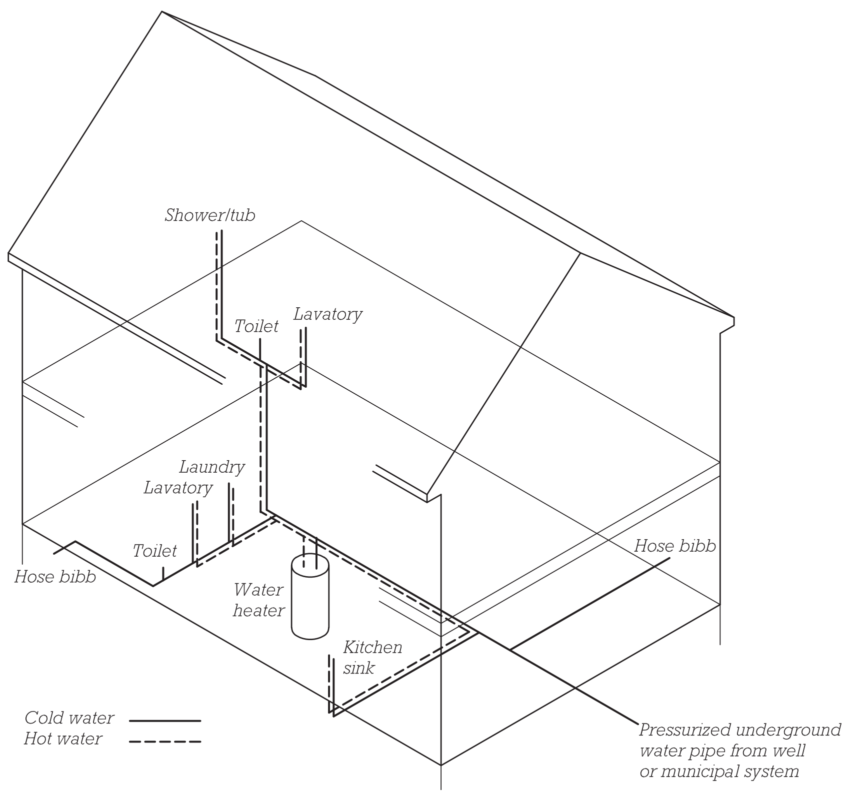

FIGURE 14.1
A typical residential water supply distribution system. Water enters the house through a buried line and branches into two parallel lines. One is for cold water, and the other passes through the water heater and supplies hot water. Most plumbing fixtures require both cold and hot water supplies, but some fixtures such as toilets (water closets) require only cold water.

Supply piping can consist of *copper pipes* with soldered fittings, *polyvinyl chloride (PVC) pipes* with glued fittings, or flexible *cross-linked polyethylene (PEX) tubing* with crimped fittings (Figure 14.2). Copper has been the standard of quality since the 1950s, but PVC, introduced in the 1970s, is seen by some to be an improvement because it is faster and safer to install (no flame to melt solder is required) and it is not corroded by minerals in the water. PEX, the most recent introduction, is even simpler to install than PVC because it can bend like a garden hose, it is quieter with water running through it, and it can withstand expansion when freezing.

The *water heater* is usually a large, insulated storage tank (typically, 40 to 55 gallons) heated by either electricity or gas (Figure 14.3). Electric water heaters are simpler and therefore less expensive to install, whereas gas heaters heat water faster and can therefore be smaller, but their installation is complicated by the requirement to vent combustion products to the outdoors. Hot water may also be supplied by a *demand system*, which passes water through a heating element to heat it instantaneously as it is needed and does not have a storage tank. The advantages of a demand system are that the system is compact and heat is not lost from stored hot water. Demand systems use either electricity or gas as an energy source and are more expensive than conventional water heaters. The most common use of a demand system is for the "instant hot" faucets found at many kitchen sinks.

Figure 14.2
The plumbing department at this home improvement center displays three generations of piping. The machine on the floor cuts and threads galvanized iron pipe. The racks hold a variety of sizes and types of rigid copper and plastic pipe. Out of view is the most recent generation of flexible plastic pipe. *(Photo by Greg Thomson)*

Figure 14.3
A water heater stands next to a forced-air furnace in a garage. This example uses natural gas as a fuel. One of the flexible copper pipes at the top of the heater supplies cold water to the heater, and the other conveys hot water to the house. The large vertical pipe at the top is a vent to exhaust combustion gases to the outdoors. The vertical pipe at the right side is connected to a pressure relief valve at the top of the heater tank and drains to the outside. The gas supply piping can be seen at the lower left of the heater. The heater is strapped to the wall to avert catastrophic damage in the event of an earthquake. The efficiency of the heater can be increased with the addition of an insulating jacket. *(Photo by Rob Thallon)*

Supply piping should be wrapped in thermal insulation. This usually takes the form of either a plastic foam jacketing or slit tubes of closed-cell rubber, which are slipped over the pipes, or a wrapping of glass fiber insulation encased in a vapor-resistant foil or plastic film (Figure 14.4). This insulation has several functions: It helps to keep cold water cold in the pipes and hot water hot. It helps conserve the energy used to heat the water. In humid conditions, it prevents condensation of moisture on cold water pipes.

In locations subject to temperatures that will never drop more than several degrees below the freezing mark, pipe insulation will prevent water from freezing in the pipes. However, no amount of pipe insulation can prevent a pipe from freezing if it is exposed to very low temperatures for a period of hours. This is because a pipe contains only a very small volume of water that does not contain enough heat to overcome heat losses from its large surface area. In cold climates, it is best to design every building so that no supply pipes are located in exterior walls or unheated spaces. If this is not possible and piping must run in crawlspaces, exterior walls, attics, or other unheated locations, it is imperative that the pipes be located on the warm side of the house insulation, next to the interior finish material. The designer should highlight this requirement in the plumbing specification and follow up with careful on-site inspection to be sure that it is implemented. As long as the house itself is heated, a pipe in this location will never freeze. If a pipe falls within the house's insulation or outside it, it is likely that it will freeze, even if it is jacketed with its own insulation. When a pipe freezes, the expansion of the water when it turns to ice will usually split the pipe open. As soon as warm weather returns and the pipe thaws, large quantities of water will flood the house.

FIGURE 14.4
A slotted foam insulation jacket is being installed on this copper supply piping to help conserve energy. When insulation is used on pipes to prevent freezing or condensation, the entire length of pipe must be covered. *(Photo by Greg Thomson)*

Wastewater Piping

Wastewater piping works much like a natural watershed, in which numerous small streams feed into a river that ultimately empties into the sea. In a residential wastewater system, the flow starts at the individual fixtures (toilets, sinks, tubs, etc.). From those fixtures, the waste flows through branch lines to a main drain that passes through the foundation to the building sewer. The building sewer then empties into either a municipal sewer or a septic system.

The pipes in this system have specific names, depending on their use (Figure 14.5). Lines connected to toilets are at least 3 inches in diameter and are called *drain piping* or *soil lines*. Lines free of solids, called *waste piping*, can be smaller—usually 1½ or 2 inches in diameter. The line at the base of the system that is the receptor for all the drain and waste piping is the *building drain*. At a distance of 2 feet beyond the foundation wall, the building drain becomes the *building sewer*.

The wastewater system contains noxious, flammable sewer gases. These gases are kept out of the house by means of a *P-trap* at each fixture that seals the end of the pipe with water (Figure 14.6). When wastewater is released from the fixture, it displaces water held in the trap. A vent on the sewer side of each trap supplies air so that draining water cannot create a suction to pull water out of the trap.

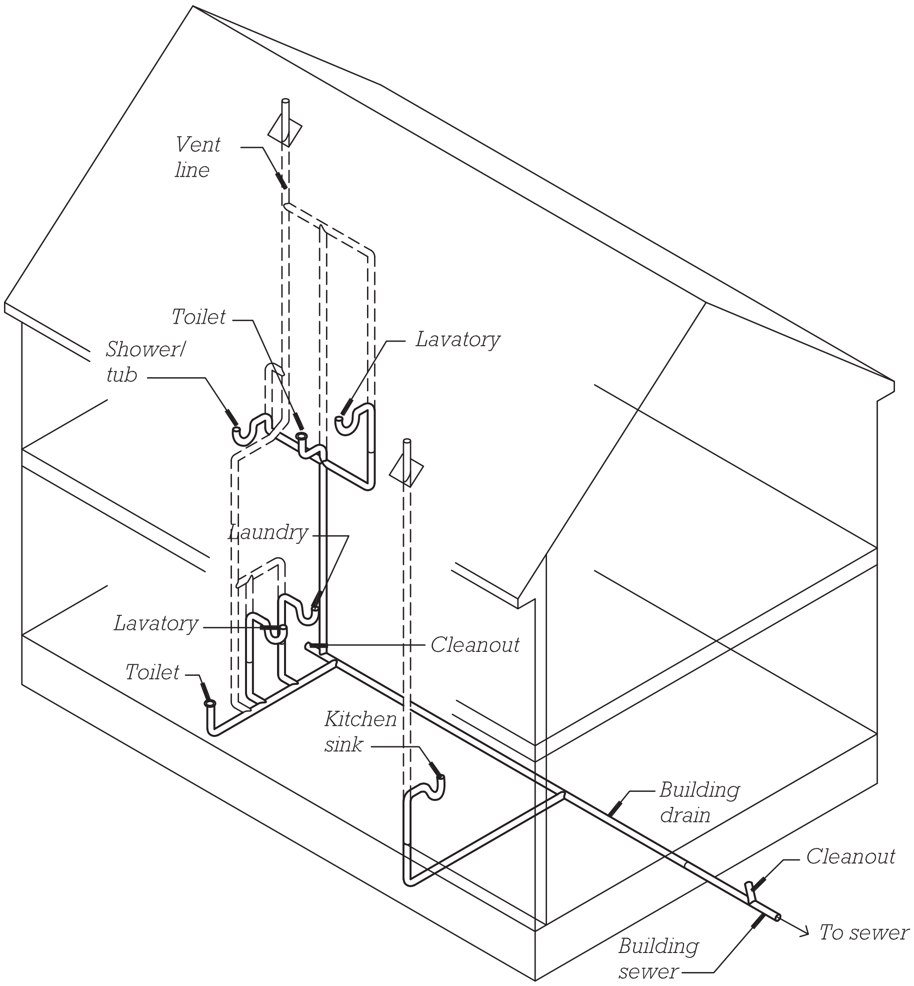

Figure 14.5
A typical residential wastewater system. All fixtures drain to the building drain through sloping or vertical branch lines. At the exterior of the foundation, the building drain becomes the building sewer. All fixtures are vented to the exterior through a network of vent pipes (shown with broken lines).

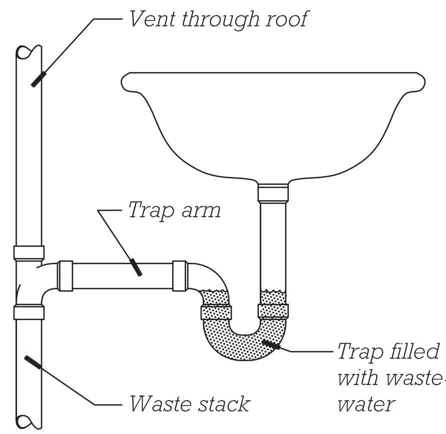

Figure 14.6
A typical plumbing trap prevents noxious waste line gases from escaping into the living space.

Fixture	Drain/Waste Pipe Diameter (in.)
Kitchen sink	2
Bar sink	1½
Washer	2
Laundry tub	2
Lavatory	1½
Shower	2
Tub	2
Toilet	3

Figure 14.7
Typical drain/waste pipe diameters for the plumbing fixtures found in the average house. Actual sizes are determined by the plumber based on building code formulas that assign drainage fixture units (DFU) to various fixtures. A 2½-bathroom house with a dishwasher and laundry facilities usually has fewer than 20 DFU. Thus, all the fixtures in a residence typically discharge into a 3-inch building drain, which can hold 42 DFU when sloping at ¼ inch per foot.

The vent piping extends through the roof of the house. A relatively new device, the *air admittance valve (AAV)*, admits air to the wastewater system without venting through the roof. These valves are installed in the drain-waste-vent system inside the building and admit air whenever negative pressure occurs in the system. The valve remains open until the system returns to zero pressure. The use of AAVs in new construction can substitute for a considerable amount of vent piping. *Cleanouts* are required at strategic points in the system to allow reasonable access for the cleaning of clogged lines.

The entire system, consisting of drain pipes, waste pipes, and vent pipes, is called a *drain-waste-vent (DWV) system*. Materials for residential DWV systems generally consist of black *ABS pipe* (composed of an acrylonitrile-butadiene-styrene copolymer) that is glued at the fittings. This pipe is the least expensive of all approved alternatives, and its only significant drawbacks are that it transmits the sound of draining water and expands and contracts considerably with thermal changes. Other waste pipe materials include *PVC pipe*, used because of its lighter weight, and *cast iron pipe*, used because its mass makes it quieter than plastic. Pipe diameters for residential DWV systems usually include 1½, 2, 3, and sometimes 4 inches (Figure 14.7). All DWV components, including vents, must be sloped to drain. All plastic pipes require special attention to thermal expansion and contraction.

Planning for Pipes

Planning for plumbing begins early in the design phase of a residential project. The location of the water main or the well determines the direction from which the supply pipe will enter the building. The location of the public sewer or the septic system establishes the approximate route for the building drain. Once the basic routes for plumbing to enter and exit the house have been established, sleeves may be designed into the foundation to allow for their passage.

The framing of the building must be planned by the designer to accommodate plumbing. Supply pipes and the smaller diameters of waste and vent pipes will fit within the stud or joist cavities, but special provisions must be made for the large drain pipes. A toilet drain pipe, for example, must be in a particular location, must have a prescribed slope, and can be difficult to route through framing—particularly from upper floors (Figure 14.8). As framing proceeds, the framer can also make the plumber's job more efficient by paying attention to the layout of studs and joists around the plumbing fixtures (Figure 14.9).

Outside the boundaries of the house, all pipes are buried. Usually, the same trench may be used for more than one utility (i.e., water supply, electrical and phone lines), so coordination of plumbing with other utilities is beneficial.

Although the clustering of plumbing fixtures around a plumbing wall (Figure 14.10) does minimize the amount of pipe that must be used and can make the plumber's job easier, it is not usually a high priority except in multiunit projects where savings are multiplied. In custom houses, plumbers generally base their bid on the number of fixtures in any case, ignoring the relative efficiency of the layout. It is always wise to locate the water heater centrally so as to deliver hot water to each fixture as quickly as possible and to specify that vents be tied together in the attic to avoid multiple roof penetrations.

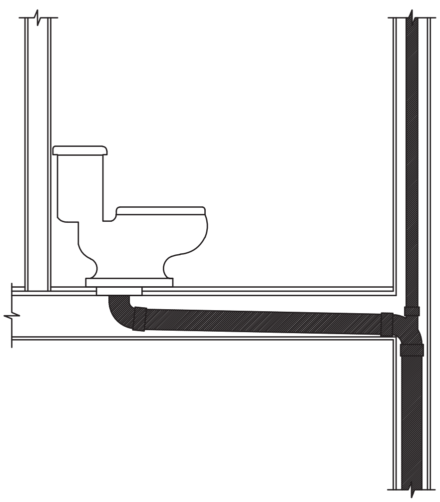

Figure 14.8
A typical water closet flange measures 6 inches (150 mm) from the bottom of the subfloor to the bottom of the bend. The drain line must slope at ¼ inch per foot (1 : 50). The joists in this example must therefore be a minimum of 7 inches deep for the waste line to travel the 4 feet across the bathroom.

Figure 14.9
The framer, knowing that the plumber will need to locate tub and shower valves centered on the tub, has placed studs accordingly. Joists below the tub have been located to allow for the tub trap. The plumber has installed the tub and rough-in supply and waste piping. The framer will now add blocking around the tub edge to provide nailing for finish wall surfaces. *(Photo by Rob Thallon)*

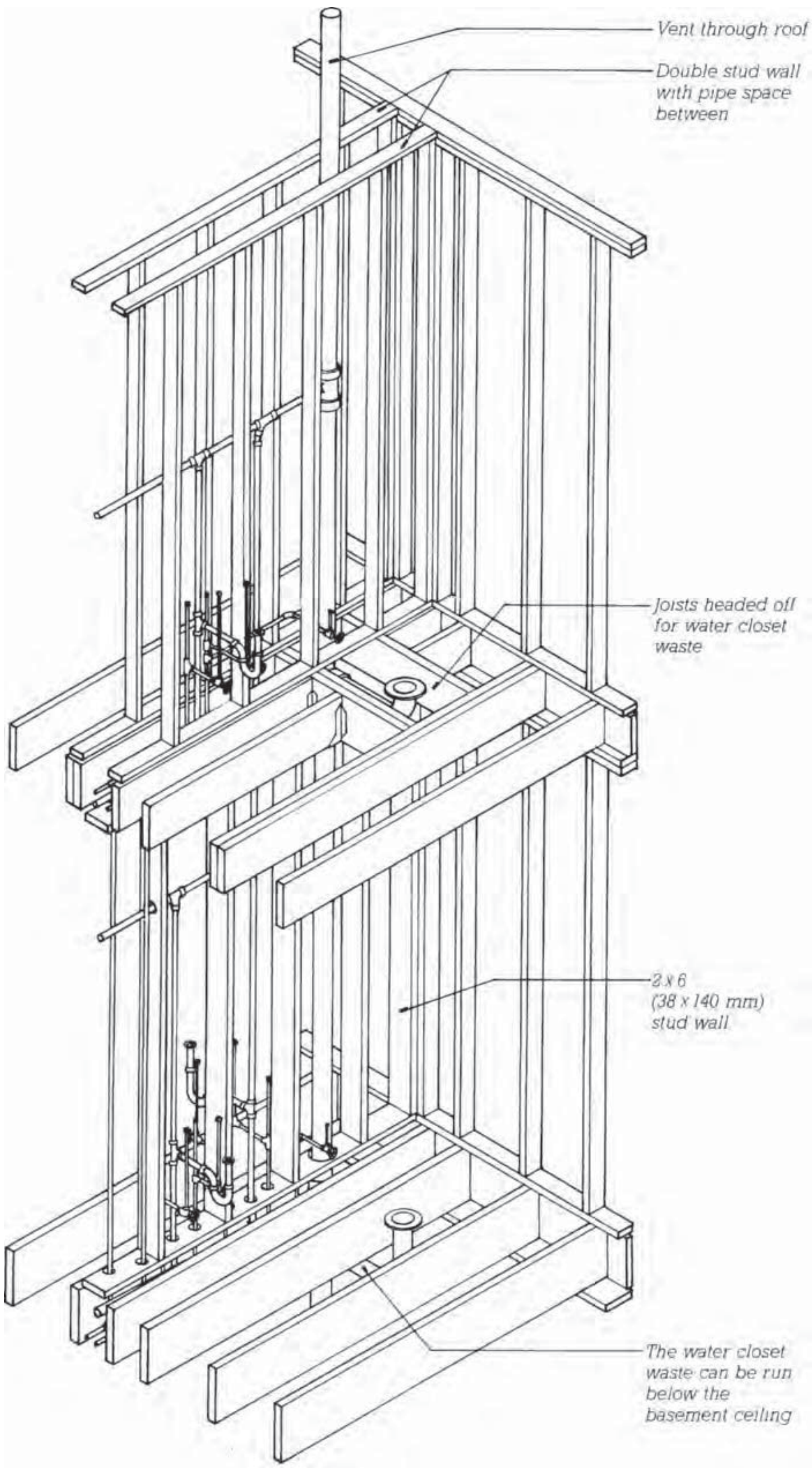

FIGURE 14.10
The plumber's work is easier and less expensive if the building is designed to accommodate the piping. The "stacked" arrangement shown here, in which a second-floor bathroom and a back-to-back kitchen and bath on the first floor share the same vertical runs of pipe, is economical and easy to rough in, compared with plumbing that does not align vertically from one floor to the next. The double wall framing on the second floor allows plenty of space for the waste, vent, and supply pipes. The second-floor joists are located to provide a slot through which the pipes can pass at the base of the double wall, and the joists beneath the water closet (toilet) are headed off to house its waste pipe. The first floor shows an alternative type of wall framing using a single layer of deeper studs, which must be drilled to permit horizontal runs of pipe to pass through.

ROUGH-IN PLUMBING

The scheduling of the plumber varies, depending on the type of construction. With slab-on-grade construction, the plumber arrives on the site with the foundation crew because all subfloor piping must be in place before the slab is poured (see Figure 14.11). In houses with a crawlspace, the plumber should complete work in the crawlspace before the subfloor sheathing has been installed (Figure 14.12). If the house has a basement, the plumber may wait to start work until after the roof has been framed; then the workplace will be protected from the weather and all the rough plumbing can be installed at the same time (Figure 14.13).

Figure 14.11
The plumber has roughed in the drains for this residence to be built on a slab-on-grade foundation. Set at the specified level and sloped to drain, the pipes are supported by the gravel under the future slab. More gravel will be added before the concrete is poured. The batt insulation taped to the vertical sections of pipe will prevent the concrete from making direct contact with the pipes and permit independent movement of plumbing and slab. *(Photo by Rob Thallon)*

Figure 14.12
Both supply and waste piping are typically installed in a crawlspace floor structure before the subflooring is applied. The supply piping is located at the center of the joists, while the waste piping hangs below. Plastic straps and clamps hold the waste piping in place. *(Photo by Rob Thallon)*

This first phase of the plumbing work is called *rough-in plumbing*. It consists of installing virtually all the supply and waste piping within the building. Bathtubs and manufactured showers—because they are very large and will not fit through doors and because they must be connected below the floor—are typically set during the rough-in plumbing phase as well (Figure 14.14). Generally, the waste pipes are installed first because they are the largest and must slope properly to drain. The plumber will drill holes in framing members for these pipes according to guidelines established by the building codes. The pipes are then installed and glued together with *fittings*. The plumber must also install supports for the pipes, which are placed at code-required intervals (Figure 14.15). The supports consist of plastic pipe hangers or a combination of blocking and *plumber's tape*—a flexible galvanized metal strap with holes for fasteners. Sometimes, framing must be modified slightly to accommodate the plumbing. This may be done by either the plumber or the framer.

The supply pipes are installed during the rough-in phase as well. Because they are much smaller than waste pipes and do not rely on gravity, supply pipes can be routed through the framing without much planning.

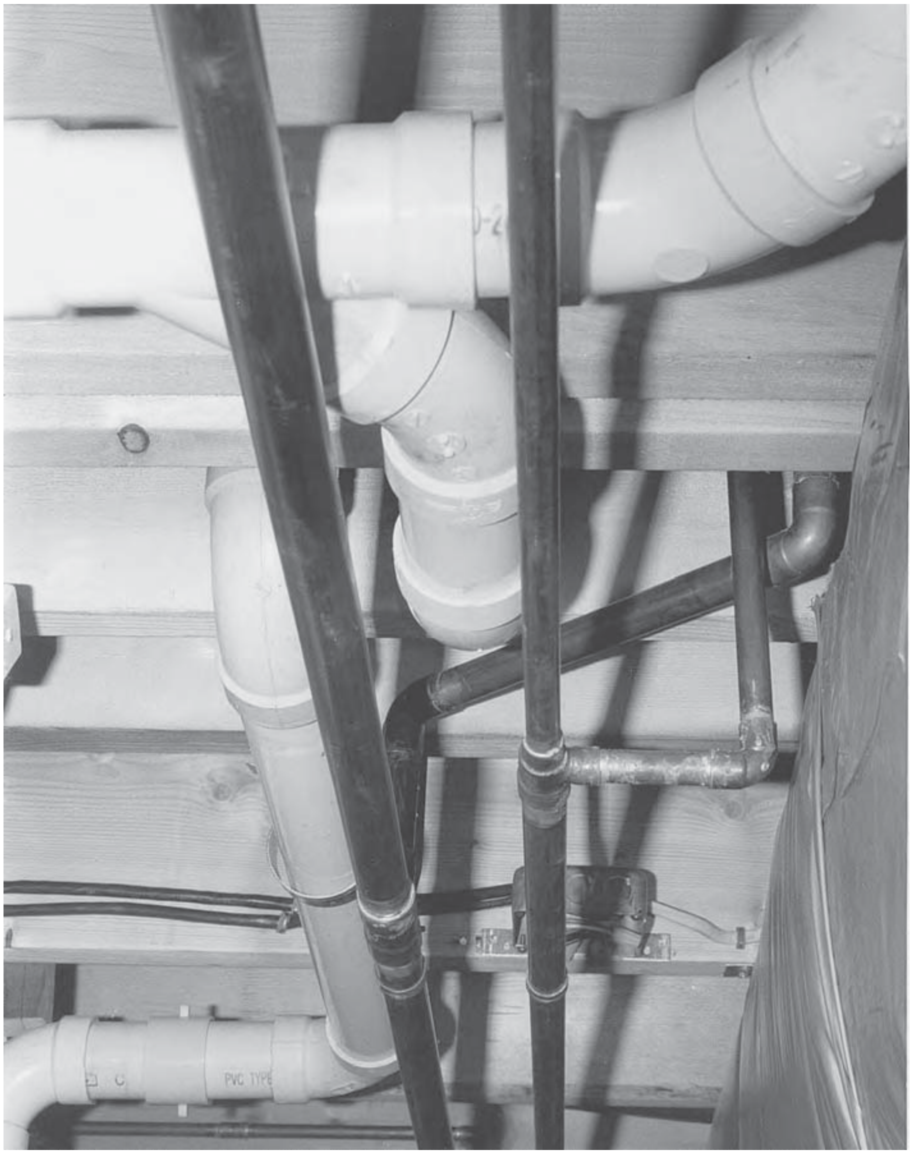

FIGURE 14.13
At the basement ceiling, the plumber installs the plastic waste pipes first to be sure that they are properly sloped to drain. The copper supply pipes for hot and cold water are installed next. *(Photo by Edward Allen)*

FIGURE 14.14
Tubs and preformed shower enclosures are installed during the rough-in plumbing phase because they are often too large to maneuver through a fully framed house and because their trap is connected within the joist space, which will be covered before the finish plumbing phase. *(Photo by Rob Thallon)*

Small holes are drilled for pipes to pass through members, and clamps are used to secure pipes running parallel to framing. A variety of manufactured clips and brackets are used to hold the fixture end of the pipes in place, and the pipes are temporarily capped to keep out dirt and to allow them to be pressure tested. Where pipes must pass close to the surface of the framing, a steel *nailing plate* must be installed on the face of the framing to prevent nails driven during the finish phase of construction from penetrating the pipes.

Once the rough plumbing is installed, it must be tested to detect any leaks, which would be costly to repair once the plumbing is covered with finish materials. The plumber performs the test, and the plumbing inspector verifies it. The supply pipes are tested under pressure with either water or air. The waste system is tested by plugging the lowest part of the drain with an inflatable test plug, capping all branch lines, and filling the system with water until it emerges from a vent on the roof. At the same time, the plumbing inspector confirms that the pipes do not leak; all pipes are checked for proper sizing, for adequate support, and for protection by nailing plates where they are near the surface of the framing.

Finish Plumbing

After the floors are finished, the cabinets installed, and the appliances in place, the plumber returns to the job site to install the *plumbing fixtures* (Figure 14.16). The water heater is installed at this time. Toilet(s) are bolted to the floor, and their cold water supply is connected. Sinks are fastened and sealed to countertops, connected with traps to the waste pipes in the walls, and their faucets installed and connected to the hot and cold water supply. The tub fillers, shower valves, and shower heads are installed and adjusted in the bathroom(s). The dishwasher is supplied with hot water, and its waste line is connected to the kitchen sink drain. When all the fixtures have been installed and tested, the plumber calls the plumbing inspector for a final inspection. The inspector looks to see that code-approved fixtures have been installed, that traps have been installed properly, and that there is adequate vertical distance (an air gap) between spouts and the flood level of the receptacle into which they flow.

Plumbing Codes

The safety and quality of plumbing is governed by the *Uniform Plumbing Code*. This code has been adapted and incorporated into the International Residential Code (IRC). Residential plumbing systems must pass at least two on-site inspections: the rough-in

Figure 14.15
Mounting brackets for piping consolidate functions and allow easy installation at any point in the space between studs. This washer assembly has hot and cold supply valves and a drain for the washer discharge pipe integrated with the mounting bracket. *(Photo by Edward Allen)*

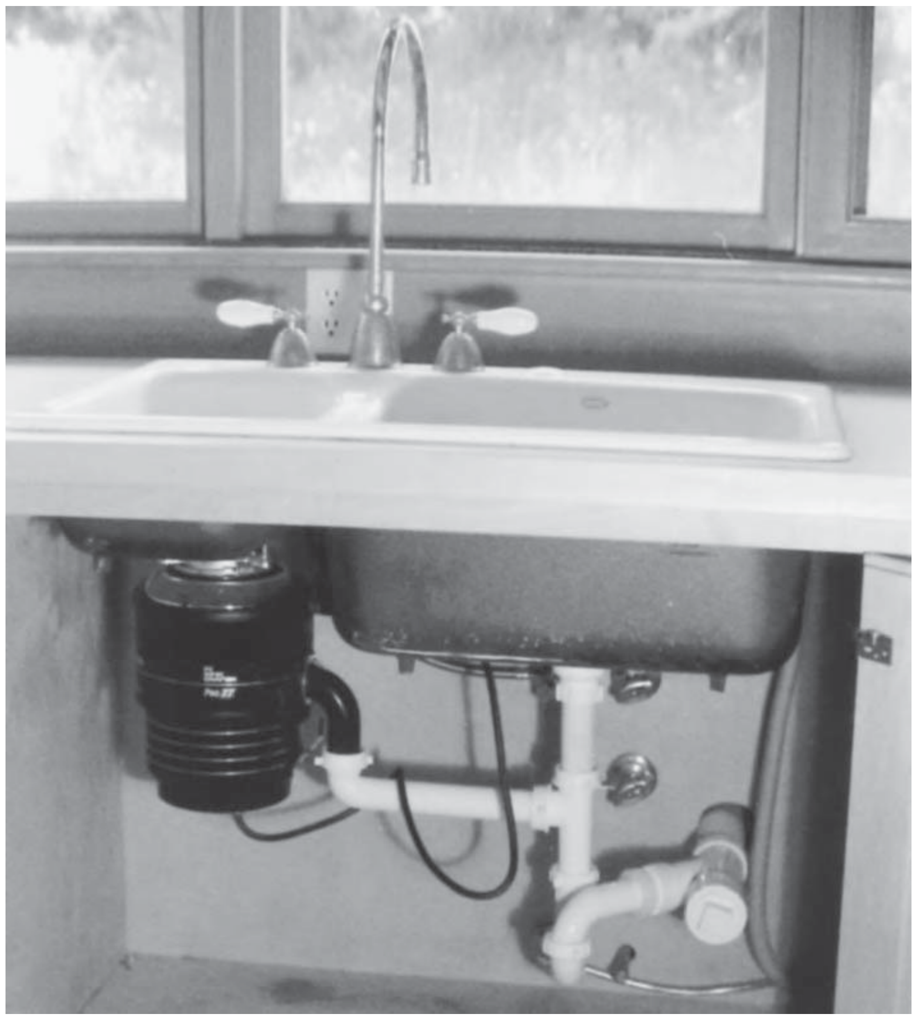

Figure 14.16
During the finish plumbing phase, the plumber installs fixtures and connects them to supply and waste lines in an orderly sequence. In the case of a sink, (1) the strainer(s) and trap are installed on the sink, (2) the sink is fastened to the countertop and sealed, (3) the trap is connected to the waste line, (4) the valves are installed on the sink, (5) the hot and cold water are connected to the valves, and (6) the system is tested for leaks. *(Photo by Rob Thallon)*

inspection and the final inspection, as described previously in the "Rough-in Plumbing" and "Finish Plumbing" sections of this chapter.

Plumbers are intimately aware of the requirements of the code, but architects and builders must also be familiar with specific provisions in the code that will impact the design and construction of the residence. These include the following:

- The minimum number of fixtures in a dwelling
- The materials that can be used for pipes and fittings
- The minimum size of pipes based on how many fixtures are connected to them
- The location and maximum spacing of cleanouts
- The slope of waste drainage piping
- The support of piping
- The minimum distance of vents from operable windows to prevent sewer gas from entering the house

Other Piping Systems

In addition to the supply and waste systems supplied and installed by the plumbing subcontractor, there are a number of other piping systems installed in a residence by the plumber or other subcontractors. The installation of these systems is coordinated with the installation of rough plumbing, wiring, and heating.

The Building Sewer

The plumbing subcontractor is generally responsible for extending the supply and waste pipes only about 2 feet from the house. In the case of the waste system, this is the end of the building drain and the beginning of the building sewer. The installation of the building sewer that connects the building drain to a municipal sewer or septic system is generally performed by either the excavator (sometimes in collaboration with the plumber) or the septic system subcontractor. Both have heavy equipment to excavate ditches, and both have licenses to do this work (Figure 14.17).

Water Supply Line

The water line between the house and the municipal water system or the well may or may not be installed by the plumber. With municipal systems, this line may be installed by the water utility itself. When the supply comes from a well, the well driller will often install the supply line to the house. In either case, the water supply line is often laid in a common trench with other utilities such as electricity, gas, or phone.

Gas Piping

Piping for natural gas or propane is common in residences. This must be

Figure 14.17
A 6-inch building sewer that serves 10 apartments is being installed in this trench. Four-inch lines that carry sewage from five apartments drain to the main sewer from each side. The vertical pipe at the far end of the sewer is a cleanout and will be cut flush with the ground and capped when the finish grade level is established. The sewer is sloped to drain and is supported by a gravel bed. Other utilities will also be installed in the same trench before it is backfilled. *(Photo by Rob Thallon)*

resistant to heat in order to safely contain its combustible contents in the event of a house fire. Until recently, all gas piping was made of *black pipe*—a combination of steel and wrought iron that is resistant to heat and to the corrosive actions of both gas and moisture. However, black pipe has to be threaded at the site wherever it is joined—a very costly operation. A plastic-coated corrugated stainless steel pipe that bends without fittings has now replaced black pipe because its installation costs are much lower. The few connections that are required with this new pipe are made with pressure fittings. Plastic piping may be used for underground gas lines. All gas piping must be installed by a plumber licensed to do so.

Fire Sprinkler System

Residential *sprinkler systems* that automatically extinguish incipient fires have been mandated in multifamily housing since the 1980s and are now required by the 2009 IRC to be in all single-family homes. Although some states are resisting adoption of the provision, it is clear that henceforth it will be problematic to build any residential structure without a fire sprinkler system. Unlike commercial systems where the goal of fire sprinklers is to preserve both life and property, the goal of residential systems is primarily focused on saving lives. So, in contrast to commercial systems that are sized to deliver water to multiple sprinkler heads for 30 minutes or more, residential systems need to supply only one or two heads for 10 minutes. Consequently, residential systems require much less water and use smaller-diameter pipes.

There are two basic types of residential sprinkler systems—*stand-alone* and *multipurpose*—both of which are fed by a supply line connected to the domestic water supply near its source (Figures 14.18 and 14.19). Aside from its connection at the source, a stand-alone system does not otherwise interact with the domestic

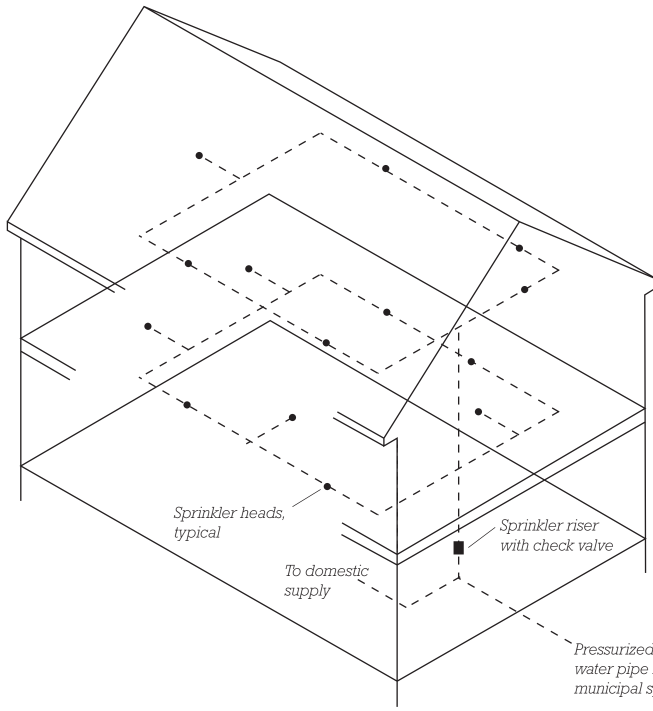

Figure 14.18
Aside from being connected to the same source, a stand-alone residential fire sprinkler system is independent of the water supply.

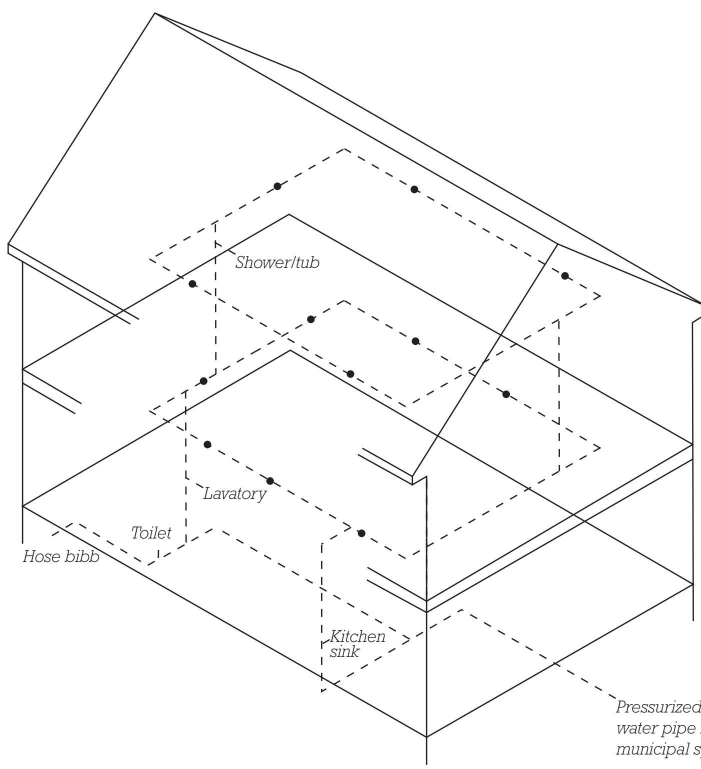

Figure 14.19
An integrated residential fire sprinkler system draws water from branches extended from the domestic supply system. The branches are looped so that water flows past the sprinkler heads whenever water is turned on in the house.

plumbing system. This means that pressurized water stands stagnant in the sprinkler pipes for long periods of time, so a check valve must be installed to prevent backflow of sprinkler water into the domestic supply. A multipurpose system integrates the fire sprinklers with the domestic cold water supply system so that water flows past the sprinkler heads with daily domestic use.

Piping for domestic sprinkler systems is generally made of copper or plastic (chlorinated polyvinyl chloride [CPVC] or PEX). Piping size depends on the size of the system and available water pressure. An average-sized house with average water pressure can usually be made with 1-inch pipe. Metal pipes can be left exposed, but plastic types must be protected from heat with a thermal barrier such as drywall. All types of pipe must be protected from freezing.

As required by code, residential sprinkler heads must be located in all significant rooms, including closets larger than 24 square feet. Large rooms may need more than one head. Residential sprinkler heads are designed to activate after 30 seconds of exposure to temperatures above 155 to 175°F (68 to 79°C). The system can be installed by a plumber or a specially licensed subcontractor and is typically coordinated with and installed at the same time as the plumbing (Figure 14.20).

Figure 14.20
A roughed-in residential fire sprinkler system. A ceiling sprinkler head will be connected to the pipe in the left foreground. At the right, a pipe projects through the wall where an exterior sprinkler head will be installed over a window. *(Photo by Rob Thallon)*

Solar Water Heating

Piping for active *solar heating* applications is usually installed concurrently with the rough plumbing. Piping is typically similar in size and material to the domestic supply system. The system may be installed by a plumber or a licensed subcontractor specializing in solar heating. It is not uncommon to install pipes for future use in a solar system, such as pipes that extend from attic to basement, which could later connect an active solar panel on the roof with a water heater in the basement.

Hydronic Heating System

Hydronic heating systems heat water in a boiler and convey this heat to the rooms of a house through pipes. Some hydronic systems operate at a pressure similar to that of supply piping and are typically installed by a master plumber. Other systems work at lower pressure and may be installed by a separate, specialized subcontractor. In both cases, the piping is similar to residential supply piping and is installed concurrently. These systems are discussed further in Chapter 15.

Central Vacuum System

A *central vacuum system* is powered by a central vacuum/collector unit that is connected by means of 2-inch rigid PVC piping to outlets distributed throughout the house (Figure 14.21). Low-voltage wiring is run with the pipe and is connected to a switch at each outlet that turns on the vacuum when a vacuum hose is inserted.

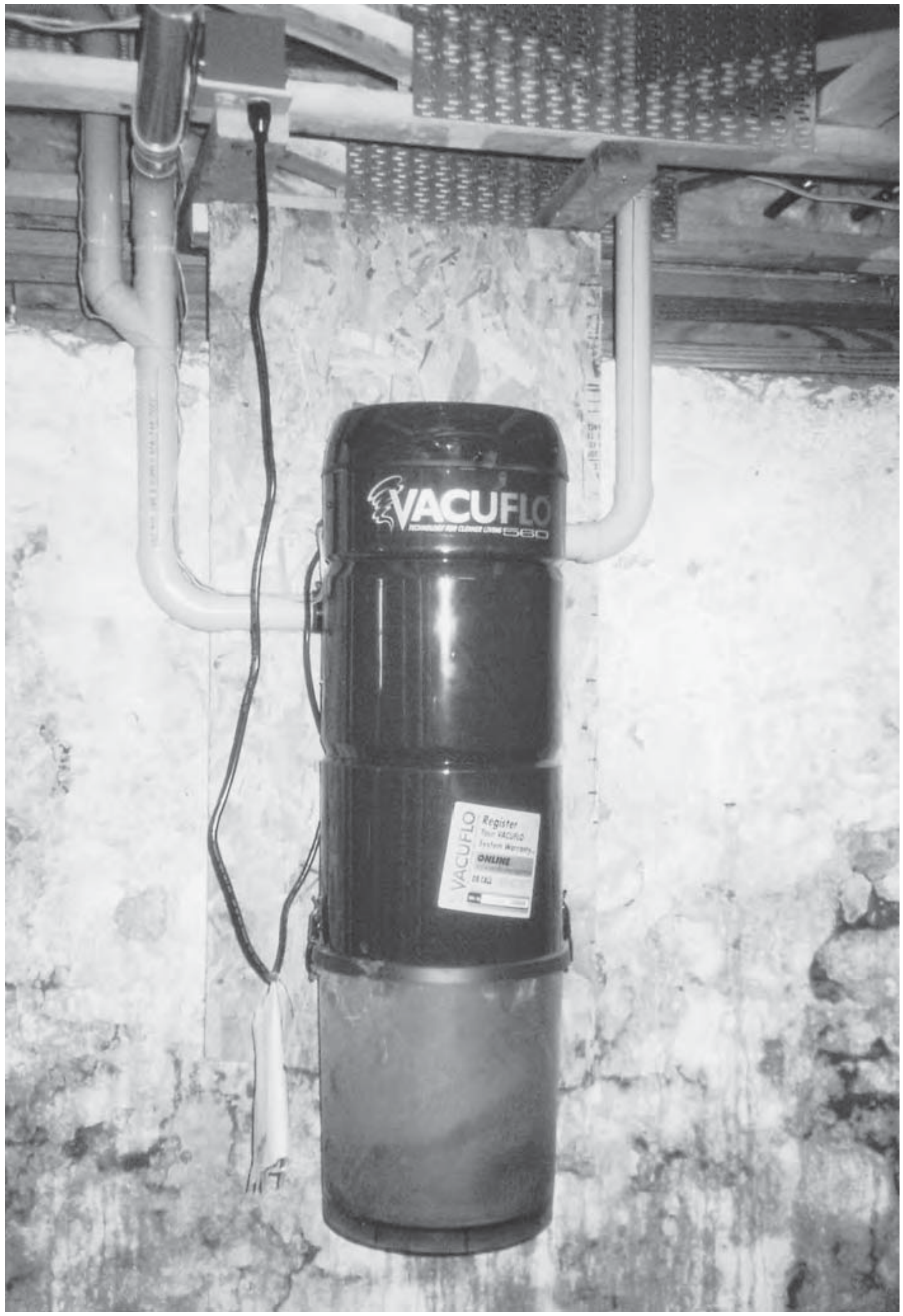

Figure 14.21
A central vacuum system mounted in the basement of a house. Dirt and dust are sucked into the machine through the 2-inch PVC pipes at the left, and air is exhausted to the outside through the pipe at the right. *(Photo by Greg Thomson)*

Building Green with Plumbing Systems

The primary concerns of sustainability with plumbing are reducing water use and reducing the amount of sewage generated. Water use may be reduced by

- Installing composting toilets, which use no water at all. They do, however, occupy a large volume in a building, which requires special planning during the design stage. Not all homeowners (or boards of health) find them acceptable.
- Using 1.6 gallons per flush (6 liters per flush) toilets, which are now the industry standard.
- Using low-flow faucets and shower heads.

Some additional considerations for improving the sustainability of plumbing systems include the following:

• Gas-fired domestic water heaters are more fuel-efficient than electric ones.

• Avoid installation of a garbage disposal and establish a compost pile instead. Garbage disposals use large quantities of water to flush away small quantities of organic material that is better used to fertilize the garden. Furthermore, garbage disposal wastes tend to overload and clog septic systems.

• Plant landscape materials that require little water to grow and minimize the size of lawns.

• Use high-efficiency clothes washers and dishwashers.

• In areas where it is legal, separate gray water (wash water) from sewage and use it to irrigate lawns or gardens.

• Consider using demand water heaters, which heat water just before it emerges from the tap, rather than conventional storage tank heaters, which continually lose considerable amounts of heat.

• The cleaners and adhesives used to install PVC piping, and the solders and fluxes used with copper piping, all generate air pollutants. These dissipate quickly, however, and are seldom a problem in even a newly occupied house.

• PVC piping has the same serious environmental consequences involved with its manufacture and disposal as does vinyl siding. These problems are outlined in the "Building Green" section at the end of Chapter 13.

Figure 14.22
A drain–heat recovery system captures much of the heat that usually escapes in heated water going down a drain. A cold water supply line enters the base of a coil that wraps a drain line, and the heat from draining hot water is transferred to the entering cold water. The system works best with a shower, because supply and drain operate simultaneously, but with a holding tank, it can be effective with other equipment that uses hot water. *(Photo courtesy of Rainbow Valley Design and Construction)*

C.S.I./C.S.C.
MasterFormat Section Numbers for Plumbing

21 13 00	Fire-Suppression Sprinkler Systems
22 00 00	PLUMBING PIPING
22.11 16	Domestic Water Piping
22 13 16	Sanitary Waste and Vent Piping
22 33 00	Electric Domestic Water Heaters
22.34.00	Fuel-Fired Domestic Water Heaters
22 41 00	Residential Plumbing Fixtures
23 21 00	Hydronic Piping and Pumps

Selected References

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

A clearly written and illustrated guide to the design and installation of supply and DWV piping. Sections on tools and materials complete the coverage of rough plumbing.

2. Hemp, Peter. *Installing and Repairing Plumbing Fixtures*. Newtown, CT: Taunton Press, 1994.

The companion to the previous reference. This one describes the materials and process of finish plumbing.

Key Terms and Concepts

supply system
waste system
plumbing fitting
elbow
tee
shutoff valve
waste piping
vent piping
supply pipe
water meter
branch line
copper pipe
polyvinyl chloride (PVC) pipe
cross-linked polyethylene (PEX) tubing
water heater
demand system
drain piping
soil line
building drain
building sewer
P-trap
air admittance valve (AAV)
cleanout
drain-waste-vent (DWV) system
ABS pipe
cast iron pipe
rough-in plumbing
fittings
plumber's tape
nailing plate
plumbing fixture
Uniform Plumbing Code
gas piping
black pipe
fire sprinkler system
stand-alone sprinkler system
multipurpose sprinkler system
solar water heater
hydronic heating system
central vacuum system

Review Questions

1. What are the three most commonly used types of supply piping? What are the advantages and disadvantages of each?

2. What are the reasons for insulating supply piping?

3. What is the difference between a drain line and a waste line?

4. Explain in detail the reason for vent piping.

5. How does a trap prevent sewer gases from entering the house?

6. Why does the plumber usually have to schedule at least three phases for the completion of the plumbing of a new house?

Exercises

1. Design a new bathroom for an existing house. Make a three-dimensional drawing showing all of the supply and waste piping required to serve the fixtures in the new room. If possible, indicate how to connect the new proposed piping to the existing plumbing in the house.

2. Go to a home improvement store and make a list of all the materials required to add a lavatory in your bedroom.

3. Call a local plumbing contractor and ask permission to visit a residential construction project with the plumber. Describe the phase of construction under way and take notes about exactly what the plumber will be doing that day.