

## Lesson A3–15

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# Understanding and Designing Plumbing Systems

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**Unit A.** Mechanical Systems and Technology

**Problem Area 3.** Construction Systems

**Lesson 15.** Understanding and Designing Plumbing Systems

### **New Mexico Content Standard:**

**Pathway Strand:** Power, Structural and Technical Systems

**Standard: VIII:** Plan, implement, manage, and/or provide support services to facility design and construction; equipment design, manufacture, repair, and service; and agricultural technology.

**Benchmark: VIII-B:** Follow architectural and mechanical plans to construct building and facilities.

**Performance Standard: 2.** Install plumbing equipment and fixtures.

**Student Learning Objectives.** Instruction in this lesson should result in students achieving the following objectives:

1. Define the plumbing system and show how it works.
2. Discuss how to design a plumbing supply system.
3. Discuss how to design a plumbing drain-waste-vent system.

**List of Resources.** The following resources may be useful in teaching this lesson:

**Recommended Resources.** One of the following resources should be selected to accompany the lesson:

Black & Decker. *The Complete Guide to Home Plumbing*. Minnetonka, Minnesota: Creative Publishing, 1998.

Burkybile, Carl. *Designing, Installing, Maintaining, and Repairing Plumbing Systems*. University of Illinois: Information Technology & Communication Systems (U3056).

Hogan, Elizabeth L. *Basic Plumbing Illustrated*. Menlo Park, California: Sunset Publishing Corp., 1992.

Hometime Video. *Plumbing*. Sponsored by Chevrolet Trucks.

Phipps, Lloyd J., et al. *Introduction to Agricultural Mechanics*, Second Edition. Upper Saddle River, New Jersey: Prentice Hall Interstate, 2004. (Textbook, Chapter 16)

**Other Resources.** The following resources will be useful to students and teachers:

Burke, Stanley R., and T.J. Wakeman. *Modern Agricultural Mechanics*. Danville, Illinois: Interstate Publishers, Inc., 1992. (Textbook, Chapter 16)

## List of Equipment, Tools, Supplies, and Facilities

Writing surface  
Overhead projector  
Transparencies from attached masters  
Copies of plumbing designs

**Terms.** The following terms are presented in this lesson (shown in bold italics):

Air chamber  
Clean-out plug  
Drain-waste-vent system  
Load factor  
Plumbing fixtures  
Soil stack  
Storm drain system  
Supply system  
Traps  
Venting  
Waste lines  
Water hammer

**Interest Approach.** Use an interest approach that will prepare the students for the lesson. Teachers often develop approaches for their unique class and student situations. A possible approach is included here.

*Plumbing is one of the “easiest to do” of all the various construction skills. There is nothing difficult or hard to understand about plumbing. Yet, to the average person the plumbing system is, somewhat of a mystery. Ask students why they think the previous statement is true. The reason is with the exception of **plumbing fixtures** (sink, tub, toilet, shower, etc.), the plumbing system is usually hidden within the structure of the building. In addition to the lack of visibility, the lack of knowledge regarding the design, installation, operation, maintenance, and repair of the plumbing system is responsible for the “mystery of plumbing”. This lesson and the four that follow will help students to solve the mystery of plumbing.*

## Summary of Content and Teaching Strategies

**Objective I:** Define the plumbing system and show how it works.

**Anticipated Problem:** What is a plumbing system and how does it work?

- I. The plumbing system is really made up of two systems: the **supply system** that brings in fresh water, and the **drain-waste-vent system** that takes out used water and sewage. The drain-waste-vent system, commonly abbreviated DWV, also lets air in and waste gases out. Between these two systems are the fixtures (sinks, tubs, toilets, and so on).
  - A. When designing a plumbing system, first consult the local plumbing codes so that the requirements are met as the design is developed. In some cases, plumbing must be done by a licensed plumber. Other areas allow anyone to do plumbing, but the work must be inspected and approved.
  - B. Every plumbing system design begins with identification of needs. Consider the kind and number of fixtures along with the quantity of both hot and cold water that will likely be used. With these needs in mind, select adequate piping for water supply and DWV for each fixture.
  - C. To increase efficiency and reduce costs, design the plumbing so that fixtures are clustered close together. Well planned buildings have rooms needing plumbing placed back to back or above and below each other. If you do not feel qualified to draw up the plumbing plan, hire an architect or a plumber to develop and draw the plan.
  - D. First place the fixtures in the plan. Then draw in the piping systems. Color code the cold water, hot water, and drain-waste-vent lines to make the plan easier to understand and follow.

*Assign readings in the recommended resources. They will provide students with basic introductory information. Look at plumbing plans from a building and go on a field trip to see the roughed-in plumbing. Use TM: A3–15A to see a basic plumbing plan for a one story house with a basement.*

**Objective 2:** Discuss how to design the plumbing supply system.

**Anticipated Problem:** What is needed for the plumbing supply system?

- II. If your property is in town, the water supply is easily obtained by tapping into the city's water main. City water company employees make the connection to the water main and install a water meter to measure water usage. If you live in the country, your water will likely come from a well. It is advisable to hire a professional well contractor to find a water supply, drill the well, and install a well pump and pressure tank.
  - A. Once hooked into the water source, the supply system carries fresh clean water to all of the various fixtures in the building. The supply system is a closed continuous system where water flows under pressure. Recommended pressure varies from 40–60 pounds per square inch (psi) depending on such things as the number of fixtures, the height of the building, the length of piping, and the size of the piping.
  - B. Water pressure is created by using a water pump to pump water, or by allowing water to flow by gravity from a water tower. Water towers are filled by pumping water into them. They have the advantage of providing a more constant pressure than water pumps. They also provide a reserve of water for peak use periods. Tall buildings may use the water tower principle and store water in a storage tank on the roof of the building.
  - C. To maintain water pressure, design and run supply lines as short and direct as possible using a minimum number of fittings. Use pipe of adequate size, but do not use pipe larger than needed. Oversized supply lines cause a drop in pressure while undersized lines do not deliver sufficient water supply. The correct size supply line is determined by estimating the demand for water at each fixture. The most common size supply line is  $\frac{1}{2}$  inch. Bathtub, dishwasher, kitchen sink, laundry sink, lavatory, shower, washing machine, flush toilet, and water heater all require the  $\frac{1}{2}$  inch size supply line.
  - D. If a supply line branches off to supply more than one fixture, the rule of thumb is a  $\frac{3}{4}$  inch line can supply three  $\frac{1}{2}$  inch lines and a  $\frac{1}{2}$  inch line can supply three  $\frac{3}{8}$  inch lines.
  - E. The types of pipe suitable for supply lines include PVC (polyvinyl-chloride) and CPVC (chlorinated polyvinyl-chloride) plastic, copper tubing, and galvanized iron. Black iron and lead pipe should not be used for supply lines.
  - F. When the supply lines are drawn in the plan, care should be taken to place the hot water line on the left and the cold water on the right. To prevent the heat transfer from hot to cold, water pipes should be at least 6 inches apart. In a good design both hot and cold lines should have a shutoff valve at each fixture.
  - G. Supply lines should be secured to walls, floors, and ceilings. Noise vibration is the result of loose unsupported pipes. **Water hammer**, the other potential supply system problem, is the banging sound sometimes heard when faucets are shut off quickly. To prevent the banging, an **air chamber** made by simply adding a 12 inch vertical extension of the supply line capped on the top is added. The air trapped in the air chamber cushions the moving water to a smooth and orderly stop when the faucet is shut off.

Have students read the suggested references listed in the resource sections. They will provide good introductory information. Look at a plumbing plan. Trace the supply system design from the city water main or the rural well through the building to the various fixtures. Discuss the materials used, the size and placement of piping, location of shutoff valves, arrangement of hot and cold lines, and the prevention of vibration and water hammer. TM: A3–15B provides a good overview of preventing water hammer and vibration.

**Objective 3:** Describe how to design the plumbing drain-waste-vent system.

**Anticipated Problem:** What is needed for the plumbing drain-waste-vent system?

- III. DWV system connections are simpler for city properties. City employees are responsible for making the connections to the municipal sewer system. Rural properties require the installation of a septic tank and filter field. Designing and installing the domestic sewer system which is right for your property is a job best left to a professional sanitary contractor.
  - A. Since the DWV piping is the most expensive piping, after placing the fixtures this piping should be drawn in first. Good design uses the least possible materials and fewest turns. All fitting connections should be smooth and all bends or curves gradual. As previously mentioned, grouping fixtures helps keep the cost down. The DWV system is generally divided into the soil stack, waste lines, vents, and traps.
  - B. The **soil stack** is a vertical pipe that extends from the lowest point in the system to at least 6 inches above the roof. The drain lines from all the fixtures feed into the soil stack. The bottom end of the vertical soil stack changes direction and is connected to the horizontal main sewer or septic line. A **clean-out plug** is a removable plug located where the pipe changes from vertical to horizontal. This junction between the soil stack and sewer line is a likely location of clogging. In older homes the soil stack may be 4 inch cast iron or 3 inch copper pipe, but today 4 inch ABS (acrylonitrile-butadiene-styrene) or PVC (polyvinyl-chloride) plastic pipe is commonly used.
  - C. **Waste lines** are drain lines that connect fixtures to the soil stack. They either fall straight down or run horizontally with  $\frac{1}{8}$  to  $\frac{1}{2}$  inch of drop per foot of run. The ideal slope is  $\frac{1}{4}$  inch per foot of run. If the drain lines are too small they will tend to clog. If drain lines are too large, they are more difficult to install, cost more, and are not efficient in carrying away the waste. Waste solids tend to settle in oversized pipes.
  - D. The amount of liquid that can flow from a fixture is the basis for determining the size of drain-waste piping. The **load factor** is the number of gallons of water that must be discharged per minute from a fixture or group of fixtures. An average bathroom sink can discharge 1 cubic foot (approximately 7  $\frac{1}{2}$  gallons per minute) or a load factor of 1.
  - E. **Venting** is vertical piping that is used to permit air to circulate into the piping resulting in a relatively constant air pressure throughout the system and allows the exhaust of sewer gas buildup above the roof. All vent pipes are either tied into the soil stack or run as a separate stack through the roof.
  - F. **Traps** are installed between the fixture and the waste pipe to form a “water seal” preventing sewer gas and unpleasant odors from entering the building. Traps also help stop

air from entering the waste pipe while liquid is flowing and thus eliminate noise. Traps may be P, S, or drum.

- G. If the plumbing system has a **storm drain system** it is used to carry away only water that comes from guttering, downspouts, driveway drains, sump pumps, floor drains, and foundation drain tiles or perforated pipe.

*Assign students to read the suggested resource texts. After doing so, they will more fully comprehend the specific topics associated with the content of this objective. Use TM: A3–15C to show the DWV system components. Trace the waste water and sewer gas flow from the fixtures to the city sewer or the rural septic tank and filter field. Show the location of the soil stack, waste lines, vents, and traps. Use TM: A3–15D to show load factors and sizing of DWV piping.*

**Review/Summary.** Using an unlabeled plumbing plan, have students identify the parts of a plumbing system. Identify rules or guidelines that are used to place and design the various parts of the plumbing system. Use the last section of the *Plumbing* video to review how the plumbing system works.

**Application.** Using the accompanying transparencies in their unlabeled form, have students identify the items depicted. Or, obtain an unlabeled plumbing plan and have students identify the components.

**Evaluation.** Take the written test, grade the lab sheet, and evaluate the plumbing plan that is designed and drawn by the students.

## Answers to Sample Test:

### Part One: Matching

1 = d, 2 = g, 3 = c, 4 = a, 5 = h, 6 = i, 7 = e, 8 = b, 9 = j, 10 = f

### Part Two: Completion

1. load
2. clean-out plug
3. Water hammer, air
4. loose or unsupported
5. fixtures, DWV, supply
6. well
7. water tower
8. three
9. straight, direct
10. shut off

**Part Three: Short Answer**

1. The mystery is due to the lack of visibility of the plumbing system and the lack of knowledge regarding the design, installation, operation, maintenance, and repair of the plumbing system.
2. Locate fixtures as close as possible to each other. Locate bathrooms above-and-below each other or back-to-back.

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# Test

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## Lesson A3–15: Understanding and Designing Plumbing Systems

### Part One: Matching

*Instructions.* Match the term with the correct response. Write the letter of the term by the definition.

- |                            |                       |
|----------------------------|-----------------------|
| a. cold water line         | f. storm drain system |
| b. drain-waste-vent system | g. supply system      |
| c. hot water line          | h. traps              |
| d. plumbing fixtures       | i. vents              |
| e. soil stack              | j. waste-drain lines  |

- \_\_\_\_\_ 1. Includes sinks, tubs, showers, etc.
- \_\_\_\_\_ 2. Carries fresh clean water to the plumbing fixtures.
- \_\_\_\_\_ 3. Supply line located on the left.
- \_\_\_\_\_ 4. Supply line located on the right.
- \_\_\_\_\_ 5. Used to seal out sewer gases.
- \_\_\_\_\_ 6. Used to let air in and exhaust sewer gases.
- \_\_\_\_\_ 7. Runs from the main sewer line to at least 6 inches above the building roof.
- \_\_\_\_\_ 8. System that carries away waste, lets air in, and exhausts sewer gases.
- \_\_\_\_\_ 9. Carries used water away from tubs, showers, and sinks.
- \_\_\_\_\_ 10. System that carries away water from the roof by using guttering and down-spouts.

### Part Two: Completion

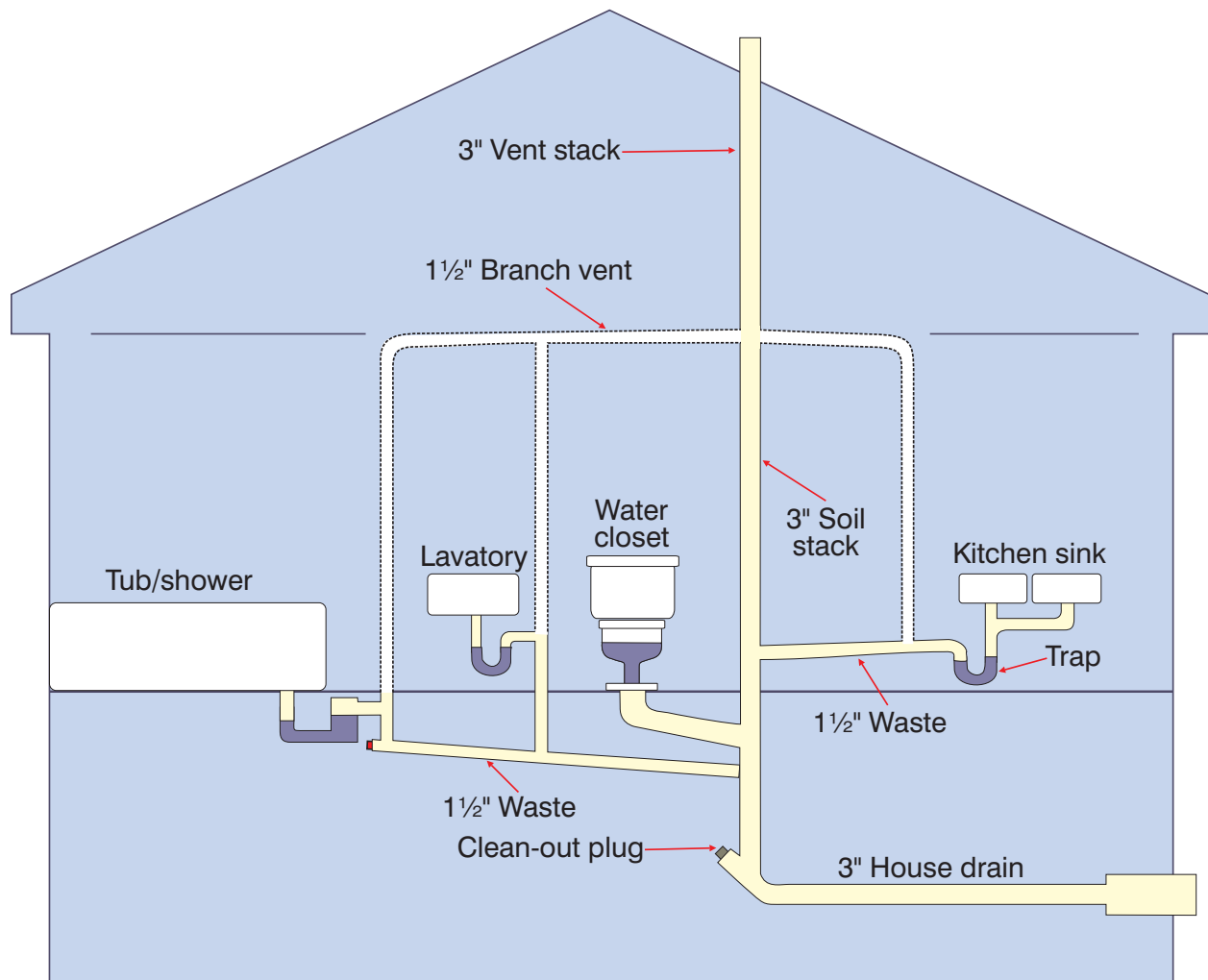
*Instructions.* Provide the word or words to complete the following statements.

1. The \_\_\_\_\_ factor is the number of gallons of water that must be discharged per minute from a fixture or group of fixtures.
2. The \_\_\_\_\_ is located where the vertical soil stack changes to the horizontal main sewer line.
3. \_\_\_\_\_ occurs when faucet water flow is shut off quickly. It can be prevented by adding an \_\_\_\_\_ chamber.





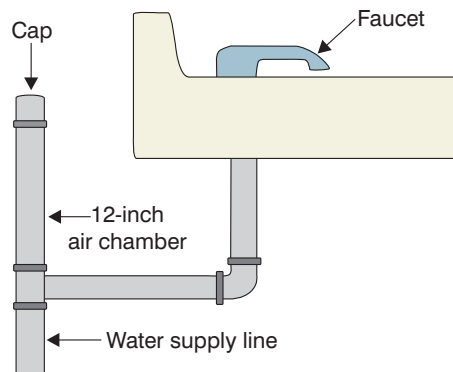
# ONE STORY HOUSE WITH BASEMENT PLUMBING PLAN



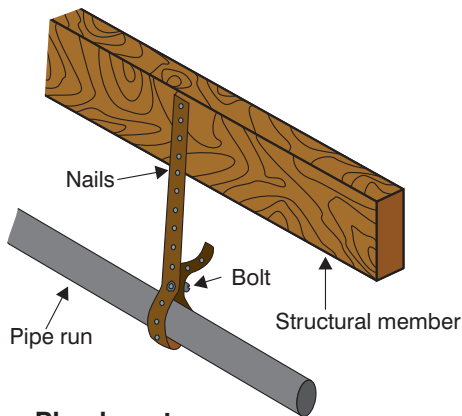
(Courtesy, Interstate Publishers, Inc.)

# TYPICAL FIXTURE HOOKUP

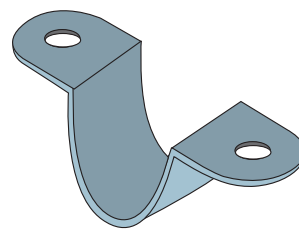
## Preventing Water Hammer



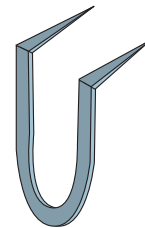
## Preventing Vibration



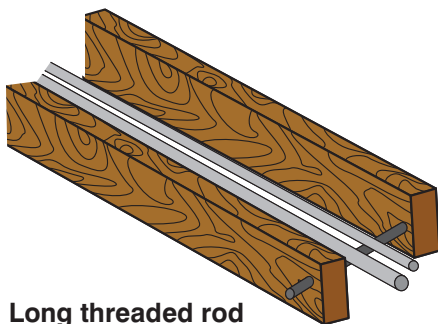
Plumbers tape



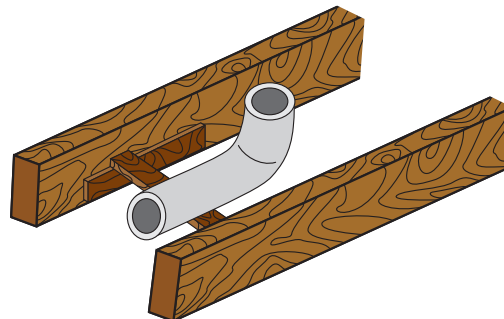
Pipe strap



Reznor hook



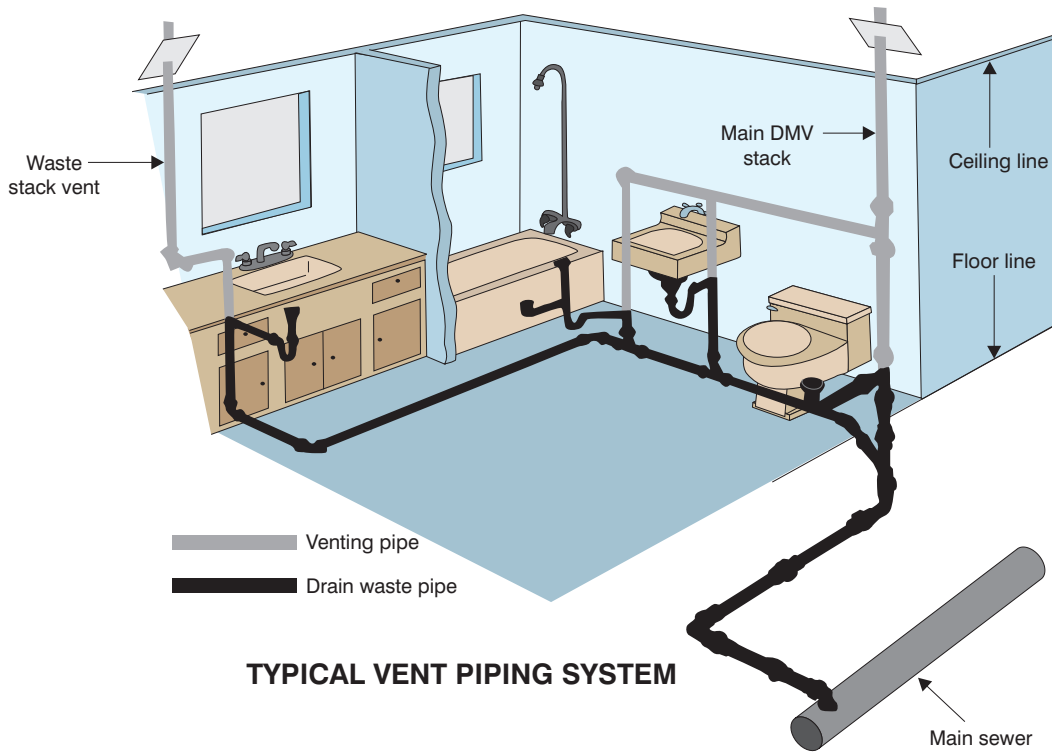
Long threaded rod



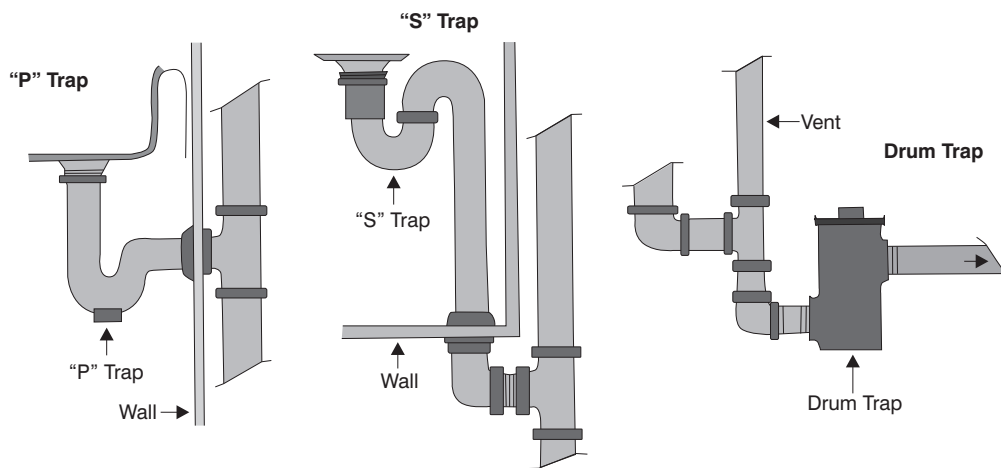
Wooden crosspiece

(Courtesy, Interstate Publishers, Inc.)

# DRAIN-WASTE-VENT SYSTEM COMPONENTS



TYPICAL VENT PIPING SYSTEM



TYPES OF DWV TRAPS

(Courtesy, Interstate Publishers, Inc.)

# LOAD FACTORS AND DRAIN PIPE SIZES

... For Common Plumbing Fixtures

Fixture Type	Load Factor	Minimum Drain Size
Bathtub with no shower	2	1½
Dishwasher	2	1½
Floor drain	1	2
Kitchen sink	2	1½
Kitchen sink with garbage disposal	3	1½
Lavatory—small	1	1½
Lavatory—large	2	1½
Laundry tray (1 or 2 compartments)	2	1½
Shower	2	2
Flush toilet	8	3