$67.00

PLUMBER'S HANDBOOK

REVISED

6th EDITION

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Revised and Updated
by
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Craftsman Book Company
6058 Corte del Cedro/ Carlsbad, CA 92011

Acknowledgements

The author expresses his sincere thanks and appreciation to:

- Mr. A. T. Strother, Executive Director of the Plumbing Industry Program of Miami, Florida, for granting permission to use excerpts from his article "A History of Plumbing" which appeared in *The Florida Contractor Magazine*.
- the Florida Energy Committee and the Environmental Information Center of the Florida Conservation Foundation, Inc. for pertinent information necessary to authenticate the thermosiphon and pumped solar water heating system.
- American Standard for providing the plumbing fixture roughing-in measurements (as illustrated in Chapter 21).
- Josam Manufacturing Company for providing the plumbing fixture carriers (as illustrated in Chapter 21).
- the International Association of Plumbing and Mechanical Officials, 4755 E. Philadelphia Street, Ontario, California 91761.
- the International Code Council, 4051 Flossmoor Road, Country Club Hills, IL 60487.
- the National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169.
- Randy Lorge, plumbing instructor, for the drawing on the front cover of this book.
- To Hilda Massey and Tracey Gans for their wonderful support in this endeavor by the authors.

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Book Foreword

Hello, My name is Tom Bigely.

At the time of the publication of The Plumber's Handbook, sixth edition, I serve as chairman of the World Plumbing Council (WPC) and the Plumbing Director for the United Association of Plumbing and Pipefitters. As Chair the WPC, I have given my commitment to work with the highest level of plumbing professionals to achieve a mutual goal of creating the best possible plumbing for the world through the growth and development of the world's plumbing industries. One of the most important industries in the plumbing profession is education. The education of plumbers is very dear to my heart and my career in plumbing includes working as a plumber, an instructor and later, the National Training Director of a training program that annually educates thousands of some of the best plumbers in the USA, Canada and beyond.

I first met co-author, David Gans when we were both serving on the National Board of Directors for the International Association of Plumbing and Mechanical Officials (IAPMO). Since then David has moved up the ranks and is currently serving as President of IAPMO. IAPMO is a premier plumbing code and standards development organization that publishes the *Uniform Plumbing Code* and has over 5000 members which include installers, code officials, engineers, and manufactures of plumbing products.

Since we met, David and I have become close friends and have traveled extensively to plumbing events around the world. On each trip together, David has been a pleasure to collaborate with and clearly values building positive relationships with other plumbing industry professionals and organizations. He believes firmly that our plumbing industry consists of quality people, great ideas, great plumbing codes and quality plumbing products. David has always impressed me with his passion for plumbing, his integrity and his sound decision making. David's passion for and knowledge of plumbing is evident in his endeavor to update this book with the latest code language, materials and methods.

The Plumber's Handbook is unique in that it uses common language to explain the code requirements used by both the *Uniform Plumbing Code* and the *International Plumbing Code*. Together, these two codes are used in all states other than New Jersey which uses the *National Standard Plumbing Code*. Many States use both the *UPC* and *IPC* codes and people in those States will greatly benefit by reading this book. This book is impressive since it covers topics A-Z of plumbing including every part of a typical plumbing system. With test questions at the end of each chapter, The Plumber's Handbook would make an excellent addition to any plumbing school training curriculum or person interested in self-study.

Thank you for your interest in The Plumber's Handbook and your efforts to be an educated plumber!

You are on your way to improving the plumbing of your community, country and the world!

Tom Bigely

World Plumbing Council Chairman 2023

David and Tom at a plumbing trade show, Germany 2022

Contents

1

Plumbing and the Plumber

If you've chosen plumbing as your profession, you should find it one of the most challenging and satisfying of all construction trades. The many variations in design, layout, and installation methods present a challenge to any competent professional plumber, plumbing inspector or plumbing plans examiner. But notice that word *competent*. If you don't have a good knowledge of practical plumbing methods and of the minimum requirements of modern plumbing codes, you're going to be discouraged, frustrated, and confused.

Learning plumbing from a code book is a very difficult task. That's the reason for this manual. It's intended to help you grasp the important design and installation principles recognized as essential to doing professional-quality plumbing work. What you learn here should be applicable nearly anywhere in the U.S., regardless of the model code adopted by your jurisdiction. And if you're just learning the fundamentals of plumbing, you'll find this book much easier than reading and understanding the code.

Remember, however, that this book is not the plumbing code. The two most widespread model code organizations, The International Association of Plumbing and Mechanical Officials (IAPMO) and the International Code Council (ICC) have graciously allowed this book to utilize some of their tables for understanding the basic use of their codes. With that said, all plumbers will have to refer to their local code on a regular basis. I'll emphasize the minor variations in model plumbing codes throughout this book, so you should easily recognize them as you read and compare sections of this book with your local code. *But the basic principles of sanitation and safety remain the same, regardless of the geographical location.*

The History of Plumbing

The art and science of plumbing came into being as mankind struggled against disease. The history of civilization is the history of plumbing. At the dawn of civilization, when two or three families gathered together to make a tribe, people drank from springs and streams. They made no provisions for the disposal of sewage and garbage. We can assume that when their site became fouled with kitchen refuse and human waste, they just moved on. If disease killed members of the tribe because they neglected the laws of sanitation, they didn't understand the cause and effect. They didn't know that lack of cleanliness breeds disease.

Archeologists, while digging in various parts of the world, have confirmed that even ancient civilizations developed plumbing systems for protecting health. At Nippur, in Babylon, archeologists uncovered an aqueduct made of glazed clay brick that dates back to 4,500 B.C. This aqueduct contained three lines of glazed clay pipe. Each section was 8 inches in diameter and 2 feet long, with a flanged mouth. Other excavations have revealed glazed clay pipe in jar patterns, concave and cone shapes and a sewage system complete with manholes.

On the island of Crete, some of the palaces of ancient kings were equipped with extensive water supply and drainage systems. The glazed clay pipe was found to be in perfect condition after 3,500 years. Archeologists even discovered evidence of plumbing fixtures constructed of hard clay.

In ancient Greece, further advances were made in cleanliness. Greek aqueducts took pure water from mountain streams into cities. Sewers, which exist to this day, carried away waste to the surrounding rivers. They understood that bathing was a desirable habit. Greeks portrayed Hygeia, the goddess of health (from whose name we get the word "hygiene"), as supplying pure water to a serpent, the symbol of wisdom.

The ancient Egyptians also realized the value of sanitation. Moses was acquainted with the sanitary science of the Egyptians and used it in framing the code of laws found in the book of Leviticus.

The Romans in the time of Julius Caesar developed the principles of sanitation to a high art. Unlike the ancient Greeks and Egyptians, they were familiar with lead, which they imported from the British Isles. They called it *plumbum*. The word *plumbing* is derived from the Latin word for a worker in lead. The Romans used lead in many of the same ways we use it today.

Two thousand years ago the city of Rome had an adequate water supply and sewage disposal system. Water was piped from hills and mountains 50 miles distant from the city. To bring this water into Rome, great overhead aqueducts and underground tunnels were built of masonry. Branch lines carried water into the homes of the upper class for private bathrooms long before the development of the great public baths. Some baths in Pompeii had floors and walls of marble, with brass, bronze and silver fixtures.

From as far back as 600 B.C. Rome had an elaborate drainage system called the *Cloaca Maxima*. This main was 13 feet in diameter and was joined by many laterals. It was constructed from three concentric rows of enormous stones piled one on the top of another without cement or mortar. It still exists and is used today in the drainage system of *modern* Rome.

When Rome set out to conquer the world, they took their bathing habits with them. In what is now Great Britain, in the city of Bath, archeologists uncovered a Roman bath 110 feet long and 68 feet wide.

In the 12th century, trade guilds were first organized in England. The first apprenticeship laws were passed in 1562 during the reign of Queen Elizabeth. These laws required an apprenticeship of seven years and made apprenticeship in all crafts compulsory. It was not until 1814 that the compulsory clause was removed and apprenticeship was made voluntary. The first known master plumbers' association was organized in England and incorporated in the College of Heralds of London.

With the discovery of the New World, man, like his ancient ancestors, sought to escape the dark and dirty cities of Europe for a fresh campground.

Although America has become a symbol of high standards in plumbing and sanitation, progress in the early development of sanitation and plumbing was very slow. As the population of the early settlements increased, conditions deteriorated. Garbage and sewage dumped onto the ground and seepage from earth-pit privies polluted nearby wells.

Health conditions became so intolerable that eventually public sewers had to be installed underground and extended to each building. Although New York in 1782 installed the first sewer under the streets, Chicago is credited with having the first real city sewage system, constructed in 1855.

Plumbing as we know it today traces its roots back many centuries, but was not really perfected until the twentieth century. Many older Americans, reared without indoor plumbing, still remember the open well, the pitcher pump, the outhouse, and the Saturday night romp in the old wooden tub. The modern bathroom, city water, and the sewers of today are taken for granted. But don't forget that plumbers protect the health of our nation and the world.

2

Designing Drainage Systems

The private sanitary drainage system is the essential part of most plumbers' work. It includes all the pipes installed within the wall line of a building on private property for the purpose of receiving liquid waste or other waste substances (whether in suspension or in solution), and the pipes which convey this waste to a public sewer or a private, approved sewage disposal system.

You have to install the drainage system so it's not a health or safety hazard. Most municipal authorities have adopted codes to protect the public health. And since the majority of requests for clarification and resolution before any Board of Rules & Appeals center on the drainage system, it's vital that you understand this section of your code.

Although sanitary drainage and vent arrangements are the heart of the plumbing system, most experts agree that this is the most complex, misunderstood, and misinterpreted section of the code. Engineers, plumbers and plumbing officials frequently disagree about its intent and interpretation. That's why it's not surprising that most of the questions (and the isometric drawings) in the journeyman's and master's examinations are taken from this section of the code.

Although plumbing installation details may vary, the basic principles of sanitation and safety remain the same, wherever you work. You shouldn't have any trouble recognizing any minor changes from the basic rules I'll describe here as you read and compare this book with the code used where you work.

Isometric Drawings

Before you can understand drainage and vent systems, you must be familiar with isometric drawings. Isometric drawings are the way plumbing professionals communicate with each other. They're used by the plumbing contractor to estimate the cost of new work and to show the job foreman how to rough-in a particular job. Anyone who deals with plumbing work must be able to make and interpret isometric drawings. Although it may look difficult, with a little study you'll soon find that it's easy to read and make isometric illustrations.

You have only three basic angles to illustrate in a plumbing system: the horizontal pipe, the vertical pipe, and the 45-degree angle pipe. The only pieces of equipment necessary are a sharp No. 2 pencil and a 30-60 right triangle. If you follow the directions and practice the exercises in this chapter, you'll be able to produce your own isometric projections and understand those made by others.

Practicing Isometric Drawings

First, draw a circle with a dot in the exact center. Place the letter N at the top of the page to designate the direction of north. See Figure 2-1. In the top half of the drawing, the solid lines indicate the angles you'll need to illustrate the sanitary system. The horizontal broken line is just a constant to make the angles clear.

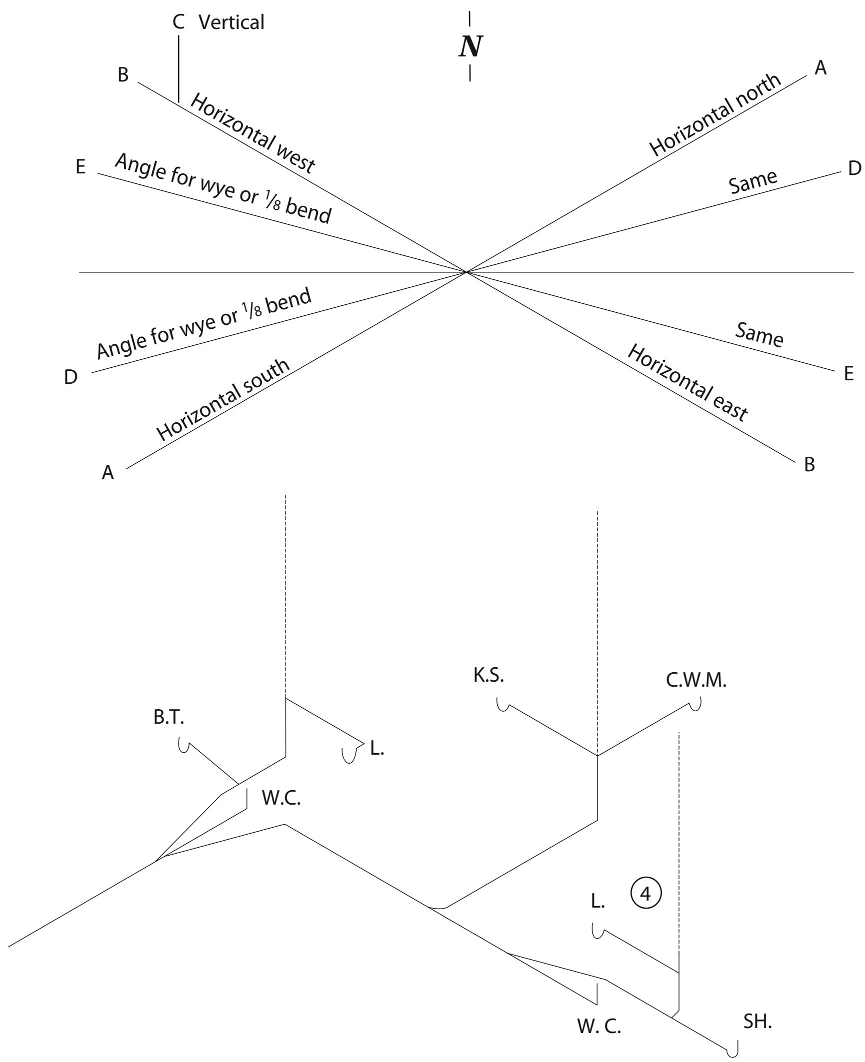

Figure 2-1

Isometric drawing illustrating the various angles

Square the short base of the triangle with the right edge of your paper and draw line A through the center dot. (This represents the north-south horizontal pipe.)

Again using the triangle, square the short base with the left edge of your paper and draw line B through the center dot. (This represents the east-west horizontal pipe.)

To draw line C (the vertical line), square the short base of the triangle with the lower edge of the paper and use the long base as a straightedge. Connect line C with the desired horizontal line. Line C represents the stacks in your isometric. The vertical line is the only line in an isometric that also represents the actual slope of a pipe and *always* represents a completely vertical pipe.

To find where to place line E, divide the area equally between the horizontal line B and the horizontal broken line. Then draw line E east and west through the center dot. (This shows the change in direction at the 45-degree fittings of either a wye or 1/8 bend.) The same procedure will, of course, yield D north and south. The lower portion of Figure 2-1 shows a simple isometric drawing that includes all three basic angles you use to design rough plumbing for any building.

Take time to make sure you understand this process. You can't become proficient in the plumbing trade until you learn how to draw isometric layouts correctly.

Fittings Within an Isometric Drawing

The lines on isometric drawings represent pipe and fittings. Symbols show the location of the fixtures. The symbols you use are the same regardless of the type of pipe used.

Figures 2-2, 2-3, and 2-4 show typical isometric drawings and the no-hub pipe fittings they represent. I've numbered each fitting in these drawings to correspond with the drawing of the same fitting. Look at Figure 2-2. You'll see that the "horizontal twin tap sanitary tee" (also known as an "owl fitting") is fitting number 14 in the isometric drawing. This fitting permits two similar fixtures to connect to the same waste and vent stack at the same level. In this case it connects two lavatories.

Fixture Abbreviations, Definitions and Illustrations

There are several common abbreviations used to identify various types of plumbing fixtures in isometric drawings and floor plans. For example, some writers will use the letter *L* to designate a lavatory. Others

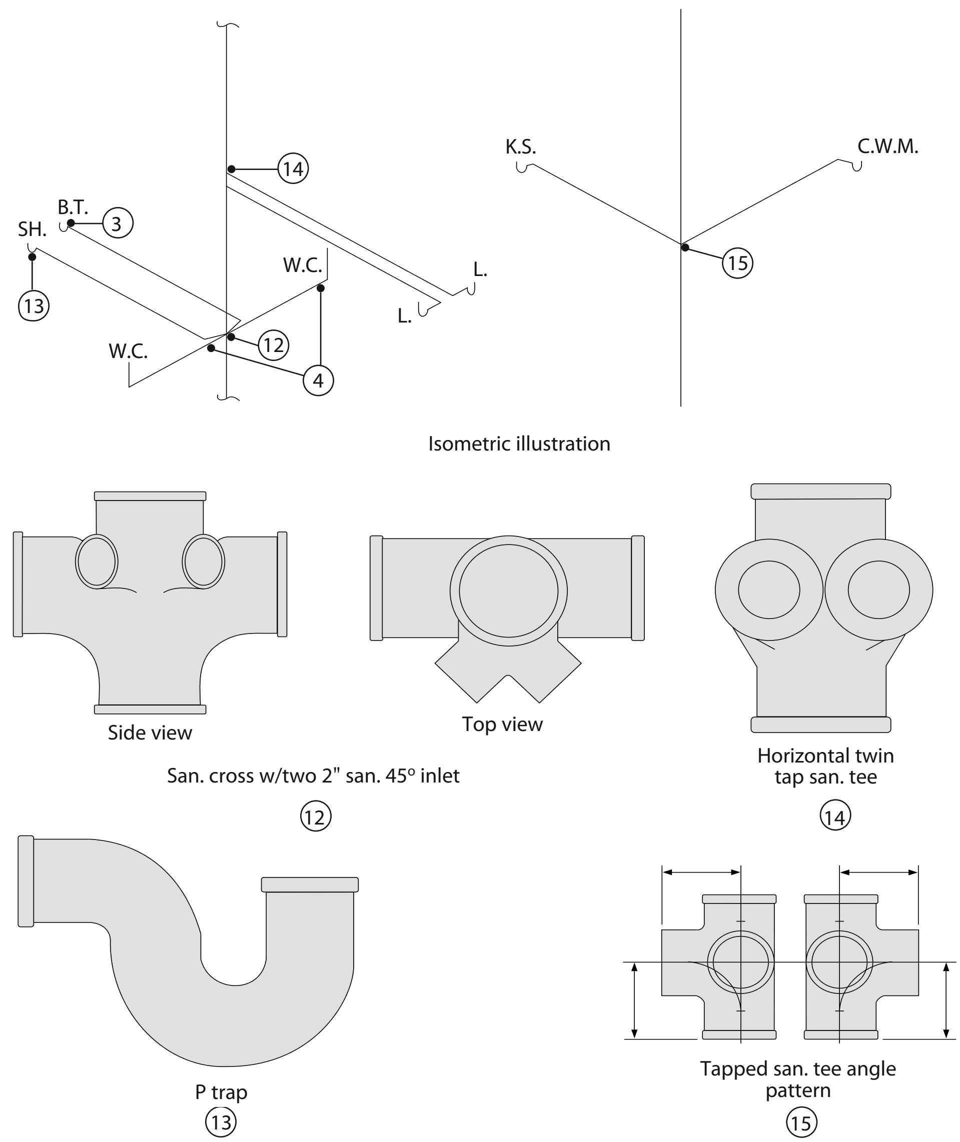

Figure 2-2
Fittings illustrated with isometric drawings

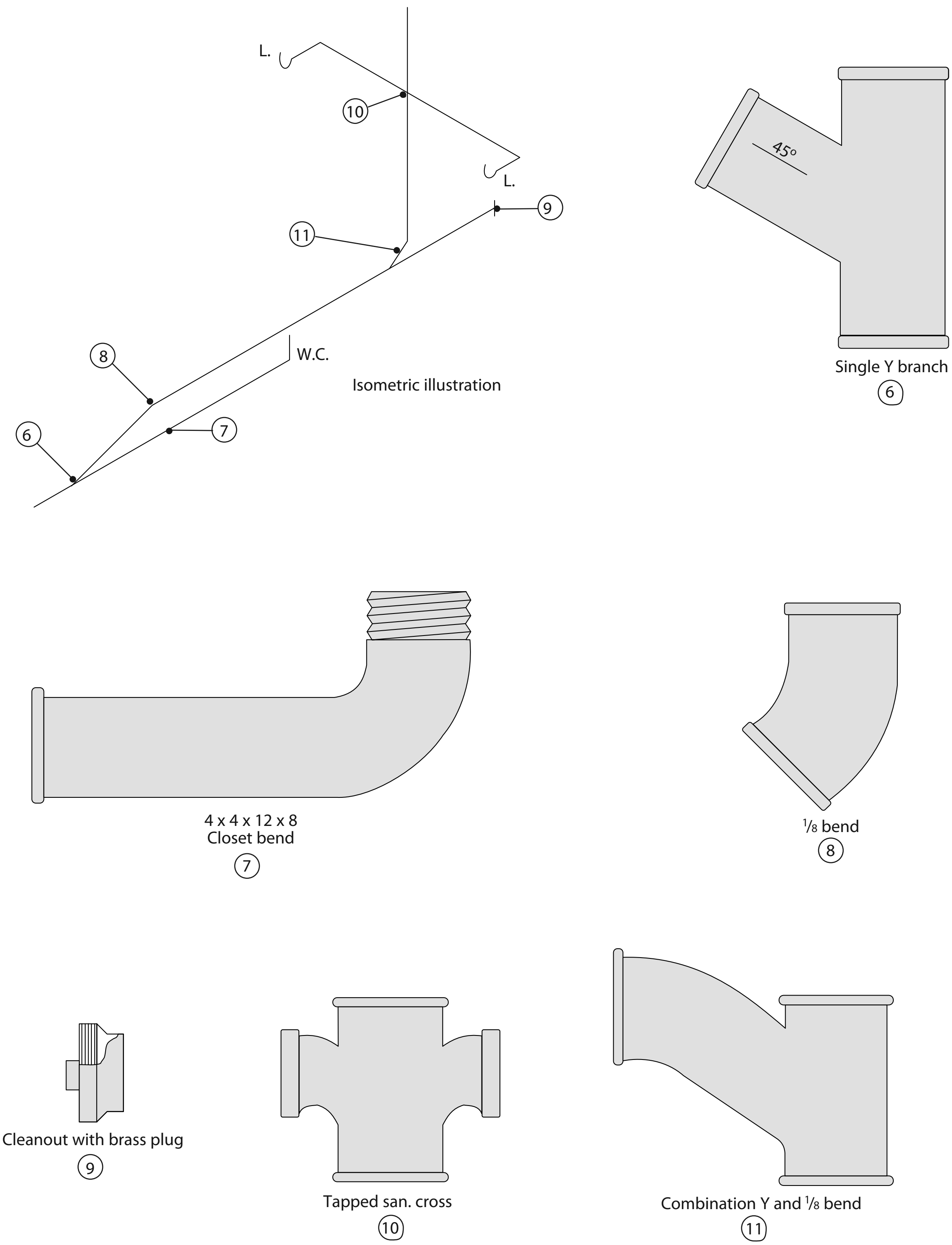

Figure 2-3
An isometric drawing and its fittings

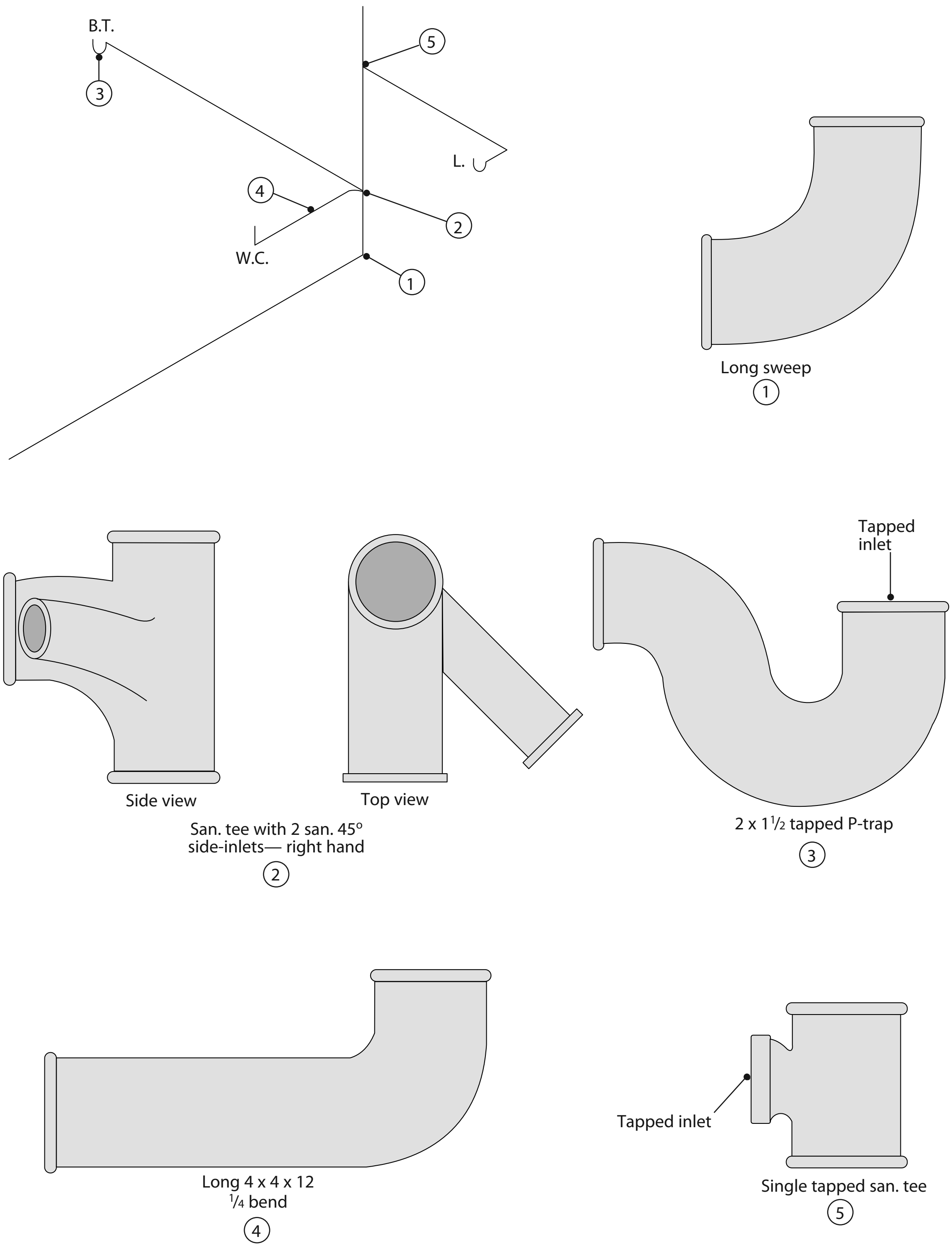

Figure 2-4

Another isometric drawing and its fittings may use *LAV*. I'll use the abbreviations in Figure 2-5 to identify plumbing fixtures in isometric drawings and floor plans in this book.

One of the first steps in becoming a plumber is learning to identify the basic piping arrangements as defined in your local code. Without this knowledge, you won't be able to design, lay out or install pipes and fittings. Figures 2-6, 2-7 and 2-8 show three sanitary isometric drawings which include all the major parts of basic drainage and vent systems. The illustrations identify the parts of the system with symbols, and each includes a legend showing what the symbols mean.

Plumbing fixtures	Abbreviations
Bathtub	B.T.
Cleanout	CO
Clothes washing machine	C.W.M.
Kitchen sink	K.S.
Lavatory	L.
Shower	SH.
Water closet	W.C.
Vent through roof	V.T.R.

Figure 2-5
Typical plumbing fixture abbreviations

Figure 2-6 is a sanitary isometric drawing of a typical two-bath house, including a kitchen and utility room. It shows an installation on the flat connected to a public sewage system. Figure 2-7 is a typical one-bath house with a kitchen and utility room. The installation is on a stack system connected to a private sewage disposal unit (a septic tank). Installation on the flat requires less height than a stacked system. Figure 2-8 shows a typical battery of plumbing fixtures often found in a two-story public building.

I've made every effort to use simple, easily understood language to clear up the complex and seemingly contradictory wording of the code. The code may identify a particular section of pipe by several different terms with various definitions. The definitions we'll use for the parts of a drain, waste and vent system are on page 14. You'll find each of them illustrated in at least one of the isometric drawings.

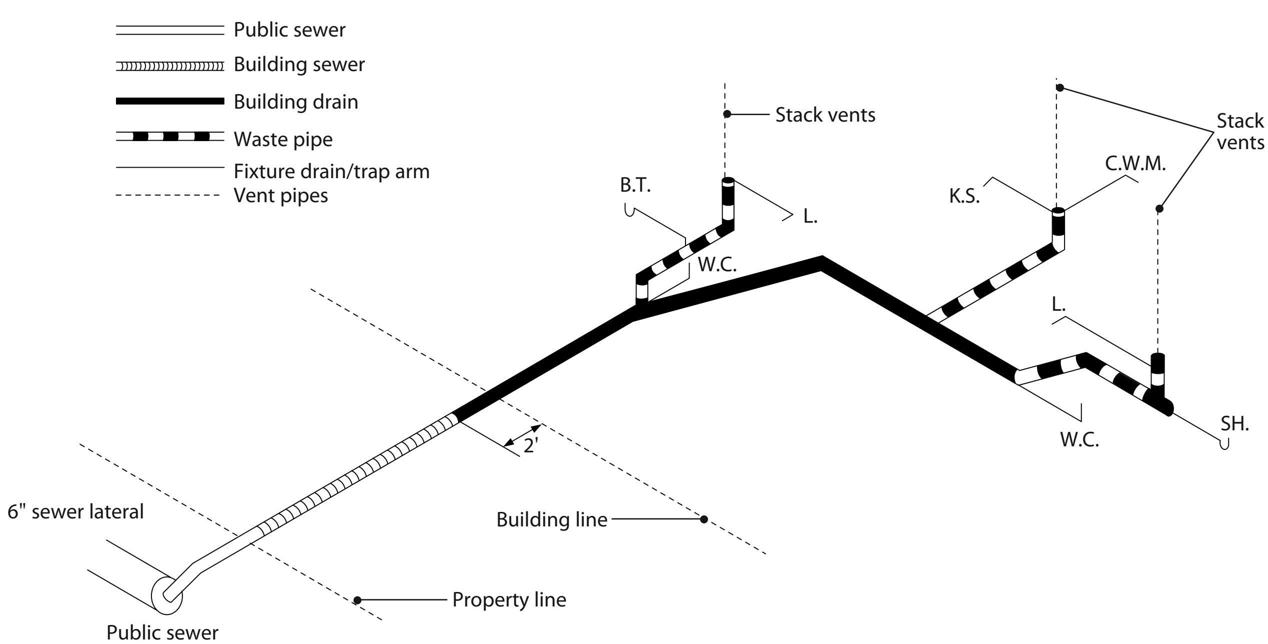

Figure 2-6
Isometric drawing of a two-bath house illustrated in graphic symbols

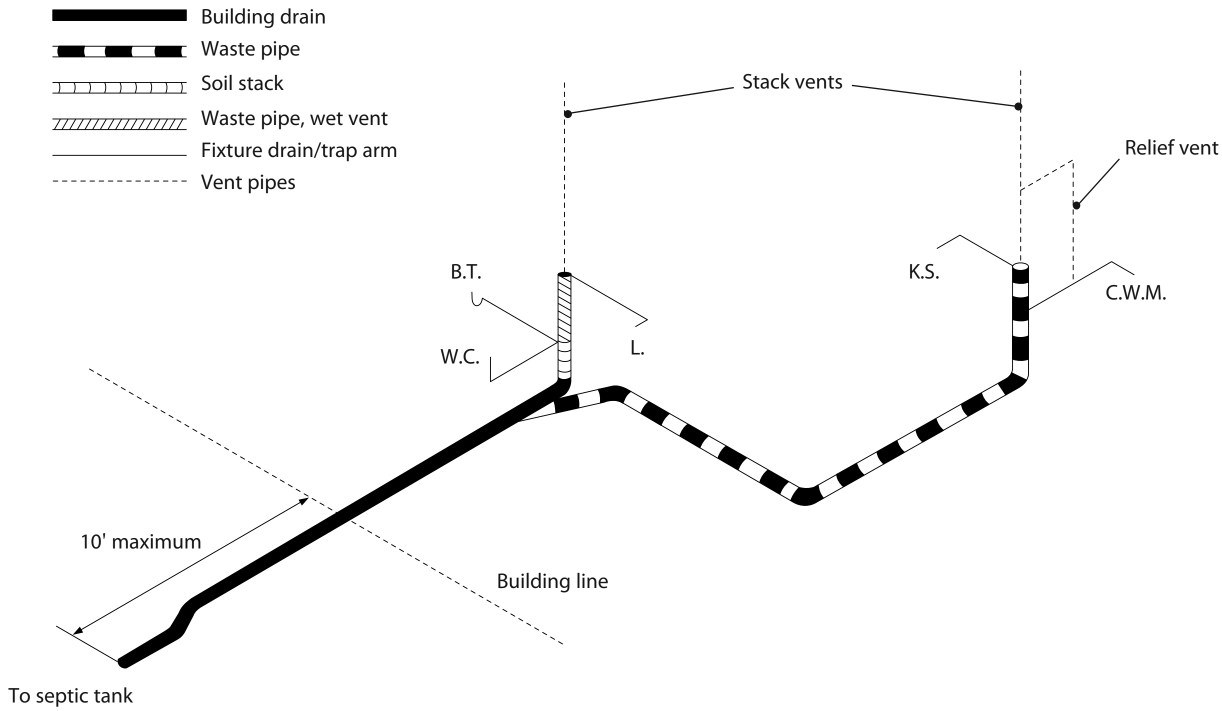

Figure 2-7
Isometric drawing of a one-bath house

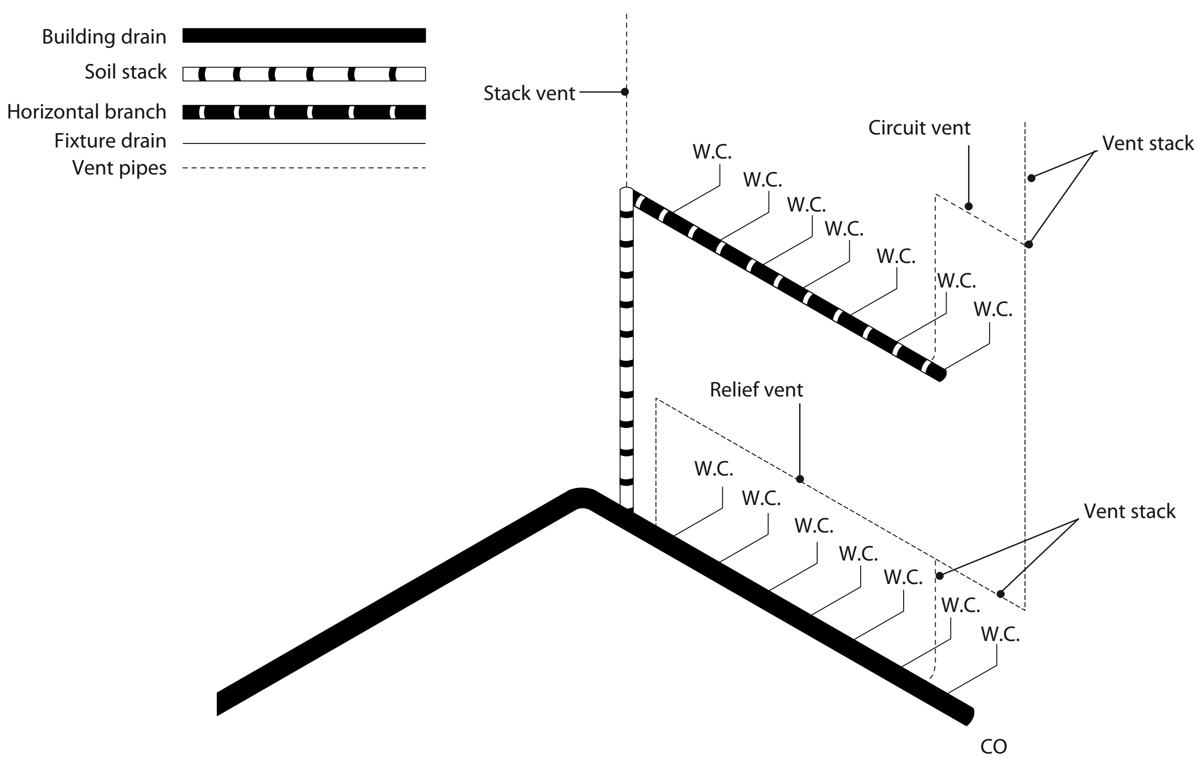

Figure 2-8
Isometric drawing of a two-story public building

Public Sewer

A public sewer may also be called a *municipal sewer*. This sewage collection system is located in a street, alley or a dedicated easement adjacent to each parcel of privately owned property. Public sewers are common pipes installed, maintained and controlled by the local authorities, paid for through some form of taxation.

Most public sewers include a 6-inch sewer lateral from the main several inches past the property line of each lot. This makes it easy for individual property owners to connect to the system. When a homeowner or plumbing contractor pulls a permit for a sewer connection, they can check with the local municipal engineering department for the depth and location of the lateral.

Building Sewer

A building sewer is the part of the main horizontal drainage system that conveys sewage or other liquid waste from the building drain to the public sewer lateral. The building sewer begins at its connection to the 6-inch lateral a few inches within the property line. It terminates at its connection to the building drain 2 feet (more in some codes) from the outside building wall or line.

It's also known as a *private sewer*, since it's not controlled directly by the public authority. It's installed and maintained by the individual property owner.

Another name for the building sewer is a *sanitary sewer*, because it carries sewage that doesn't contain storm, surface, or ground water.

Building Drain

The building drain is the main horizontal collection system, exclusive of the waste and vent stacks and fixture drains. It's located within the wall line of a building. It carries all sewage and other liquid wastes to the building sewer, which begins 2 feet (more in some codes) outside the building wall or line.

It's also considered a *main*, since it acts as the principal artery to which other drainage branches of the sanitary system may be connected.

Fixture Drain

The fixture drain is the part of the drainage system that includes the pipe from the fixture trap to the vent serving that fixture. It may connect directly to a vertical vent stack above the floor or, in the case of a shower or bathtub, to the horizontal wet vent section beneath the floor. It's often referred to by plumbers as the *trap arm*.

Waste Pipe

The waste pipe is the drainage pipe that carries liquid waste (but no fecal matter) from a fixture drain to the junction of any other drainpipe. In the code it's also called *liquid waste*, because it doesn't carry waste from water closets or bed pan washers.

Soil Stack

A soil stack is the vertical section of pipe that receives the discharge of water closets, with or without the discharge from other fixtures. Then it conveys this waste, usually to the building drain.

The *branch interval* performs the same function as the soil stack and becomes an integral part of the soil stack. The only difference is in its vertical height. It usually corresponds to a story height but it can never be less than 8 feet in length. Stacks also include any vertical pipe, including the waste and vent piping of a plumbing system.

Horizontal Branch

A horizontal branch is the part of a drainpipe that extends laterally from a soil or waste stack and receives the discharge from one or more fixture drains.

A more detailed and complete section on abbreviations and definitions is included in the Appendix at the end of the book.

How to Size the Drainage System

When you size individual pipes (vertical or horizontal) in a drainage system, there's one major determining factor: the maximum fixture unit load. But you also have to consider the types of fixtures used, the slope of the drainpipe, and the vertical length of drainpipes.

Your code book contains tables which list the various fixture load values. Use them to compute the total fixture load for any kind of plumbing system. In this book, I'll provide typical tables that we'll use in sizing the examples in this chapter. The first one is Figure 2-9, which gives the fixture units per fixture for both the *UPC* and the *IPC*. It includes the most common residential fixtures.

The residential or commercial fixture units may vary between codes, but in most cases that doesn't affect the pipe sizes. Let's consider just one variation. With a 2 inch trap, the *UPC* counts 3 fixture units for a domestic clothes washer while the *IPC* counts 2 fixture units for this particular fixture.

Now look at Figure 2-10. Use Figure 2-9 to tabulate the total fixture unit load for each pipe size in the drawing, using both the *UPC* and the *IPC*. Of course, Figure 2-9 is just a sample. Your code book includes a complete table of fixture unit values and trap sizes for residential and commercial fixtures. Figure 2-11 shows my tabulation for the plan in Figure 2-10.

Special Fixtures

Figure 2-12, *Special fixtures* (identified in some codes as *Fixture unit equivalents* or *Fixtures not listed*), is for fixtures that aren't included in Figure 2-9. These are fixtures, equipment or appliances with an intermittent flow and an indirect connection to the drainage system, usually found in commercial buildings. Some of these special fixtures are drinking fountains, bottle coolers, milk or soft drink dispensers, ice making machines and coffee urns.

Figure 2-12 is based on maximum drain or trap size up to 3 inches and the fixture unit values in the *UPC* and *IPC*. Let's use it to size a special fixture to illustrate. A coffee urn comes from the manufacturer equipped with a 1/2- or 3/4-inch drain from the drip

Fixture	International Plumbing Code		Uniform Plumbing Code	
	F.U. value as load factor	Minimum trap size (in)	F.U. value as load factor	Minimum trap size (in)
Bathtub (with or without overhead shower)	2	1 1/2	2	1 1/2
Shower stall, residential	2	1 1/2	2	2
Lavatory, residential	1	1 1/4	1	1 1/4
Water closet, private (1.6 gpf)	3	Integral	3	Integral
Kitchen sink, residential	2	1 1/2	2	1 1/2
Clothes washing machine, residential	2	2	3	2

Data from the *IPC*® with permission of the *ICC* ©2021, and from the *UPC*™ with permission of the *IAPMO* ©2021

Note: Fixture units and trap sizes may vary from those listed above. Check local code requirements.

Figure 2-9
Fixture units per fixture

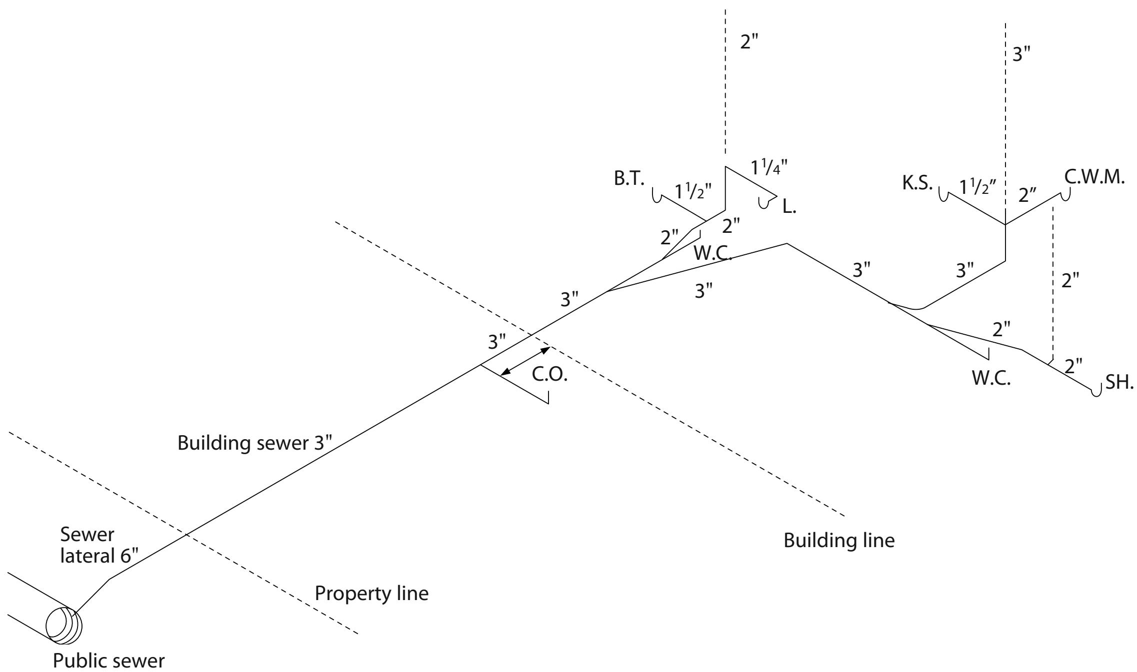

Figure 2-10

Plumbing drainage system illustrated and sized on the "flat"

Fixture type and number	International Plumbing Code	Uniform Plumbing Code
	Total F.U.	Total F.U.
1 bathtub (with or without overhead shower)	2	2
1 shower	2	2
2 lavatories	2	2
2 water closets, private 1.6 gpf	6	6
1 kitchen sink, domestic	2	2
1 clothes washer, residential	2	3
Total	**16**	**17**

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Note: Fixture units and trap sizes may vary from those listed above. Check local code requirements.

Figure 2-11

Cumulative fixture unit load for Figure 2-10

International Plumbing Code		Uniform Plumbing Code	
Fixture drain or trap size (in)	Fixture unit value	Fixture drain or trap size (in)	Fixture unit value
1¼ and smaller	1	1¼	1
1½	2	1½	3
2	3	2	4
3	5	3	6
Note Fixture units vary considerably between codes using the same size traps as listed above. Check local code requirements.			

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Note: Fixture units and trap sizes may vary from those listed above. Check local code requirements.

Figure 2-12

Special fixtures

pan. It has a waste drain smaller than 1¼ inches. You can see in Figure 2-12 that it's rated as 1 fixture unit. You'll need the table from your local code when sizing any building drainage system.

Continuous and Intermittent Flow Devices

Some devices (pumps, sump ejectors, air conditioning equipment and similar devices) discharge into a drainage system with a continuous flow. The code allows 2 fixture units for each gallon per minute of flow. The manufacturer usually provides the flow rate information.

Figure 2-13 shows intermittent flow rates up to 50 gallons per minute (based on the *UPC*). You'll have to check with your local building code for flow rates exceeding 50 gallons per minute. Some codes don't address intermittent flow rates.

If you list the number and types of fixtures and refer to these three tables, you'll be able to calculate the maximum fixture unit load for any building. Your code also has additional tables, footnotes and subsections for sizing vertical drainage, horizontal drainage and vent pipes, based on fixture units and other conditions. Model codes vary greatly in the way they assign fixture units. You'll see what I mean when you compare the *IPC* in Figures 2-14 and 2-15 with the *UPC* in Figure 2-16.

Uniform Plumbing Code	
GPM	**Fixture unit value**
Up to 7½	1 F.U.
8 to 15	2 F.U.
16 to 30	4 F.U.
31 to 50	6 F.U.
Discharge capacity for over 50 gallons per minute shall be determined by the Authority Having Jurisdiction.	

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Figure 2-13

Discharge capacity in GPM for intermittent flow only

International Plumbing Code			
Maximum number of drainage fixture units connected to any portion of the building drain or the building sewer, including branches of the building drain[a]			
Diameter of pipe (inches)	**Slope per foot**		
	⅛"	**¼"**	**½"**
2	—	21	26
2½	—	24	31
3	36	42	50
4	180	216	250

[a] The minimum size of any building drain serving a water closet shall be 3 inches.

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Note: Pipe size, slope per foot and fixture units may very between codes. Check local code requirements.

Figure 2-14

Building drains, horizontal branches and sewers

International Plumbing Code				
Maximum number of drainage fixture units (dfu)[a]				
		Stacks[b]		
Diameter of pipe (inches)	**Total for horizontal branch[a]**	**Total discharge into one branch interval**	**Total for stack of three branch intervals or less**	**Total for stack greater than three branch intervals**
1½	3	2	4	8
2	6	6	10	24
2½	12	9	20	42
3	20	20	48	72
4	160	90	240	500

[a] Does not include branches of the building drain. Refer to *IPC* Table 710.1(1).

[b] Stacks shall be sized based on the total accumulated connected load at each story or branch internal. As the total accumulated connected load decreases, stacks are permitted to be reduced in size. Stack diameters shall not be reduced to less than one-half of the diameter of the largest stack size required.

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Note: A branch or stack can't be smaller than 3" when serving a water closet.

Figure 2-15

Horizontal fixture branches and stacks

Uniform Plumbing Code					
Size of pipe (in)	**1¼**	**1½**	**2**	**3**	**4**
Maximum units drainage piping[1]					
Vertical	1	2[2], 7	16[3]	48[4]	256
Horizontal	1	1, 7	8[3]	35[4]	216[3]
Maximum length drainage piping					
Vertical (ft)	45	65	85	212	300
Horizontal (unlimited)	—	—	—	—	—
Vent piping, (see note) horizontal and vertical, maximum units	1	8[3]	24	84	256
Maximum lengths (ft)	45	60	120	212	300

Notes:

[1]Excluding trap arm.

[2]Except sinks, urinals and dishwashers — exceeding 1 fixture unit.

[3]Except six-unit traps or water closets.

[4]Not to exceed five water closets or five six-unit traps.

[5]Based on ¼ inch per foot slope. For ⅛ of an inch per foot slope, multiply horizontal fixture units by a factor 0.8.

[6]The diameter of an individual vent shall not be less than 1¼ inches nor less than one-half diameter of the drain to which it is connected.
Fixture unit load values for drainage and vent piping shall be computed from Table 702.1 and Table 702.2(2). Not to exceed one-third of the total permitted length of a vent shall be permitted to be installed in a horizontal position. Where vents are increased one pipe size for their entire length, the maximum length limitations specified in this table do not apply. This table is in accordance with the requirements of Section 901.3

[7]Up to 8 public lavatories are permitted to be installed on a vertical branch or horizontal 1½ branch sloped at ¼ inch per foot.

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Figure 2-16

Maximum fixture unit loading and maximum length of drainage and vent piping

Figure 2-14 (*Building drains, horizontal branches and sewers*) lists the pipe size, fall (slope) per foot and maximum fixture units for each horizontal pipe. The most generally accepted fall per foot for horizontal pipe is ¼ inch, though ⅛ inch is also usually acceptable. Sometimes you can use falls of 1/16 or ½ inch per foot for difficult installations involving special conditions, but you should get prior approval from your administrative authority. (The *UPC* has a separate sewer table.)

You'll need Figure 2-15 to compute the fixture units, pipe size and permitted length of soil and waste stacks for multistory buildings.

Figure 2-16 is all-inclusive. It lists the pipe size, ¼ inch fall per foot (⅛ inch is also acceptable, see footnote 5), and maximum fixture units for horizontal and vertical drainage pipe for single or multistory buildings.

Use Figures 2-14 through 2-16 *only* for the examples in this book — not on your jobs. They include only the pipe sizes illustrated in Figure 2-12. Your code book will include larger sizes.

Figures 2-17 and 2-18 are identical layouts for a five-story building. Figure 2-17 follows the *IPC* while Figure 2-18 follows the *UPC*. As we size them, you can compare the maximum fixture units under the two codes.

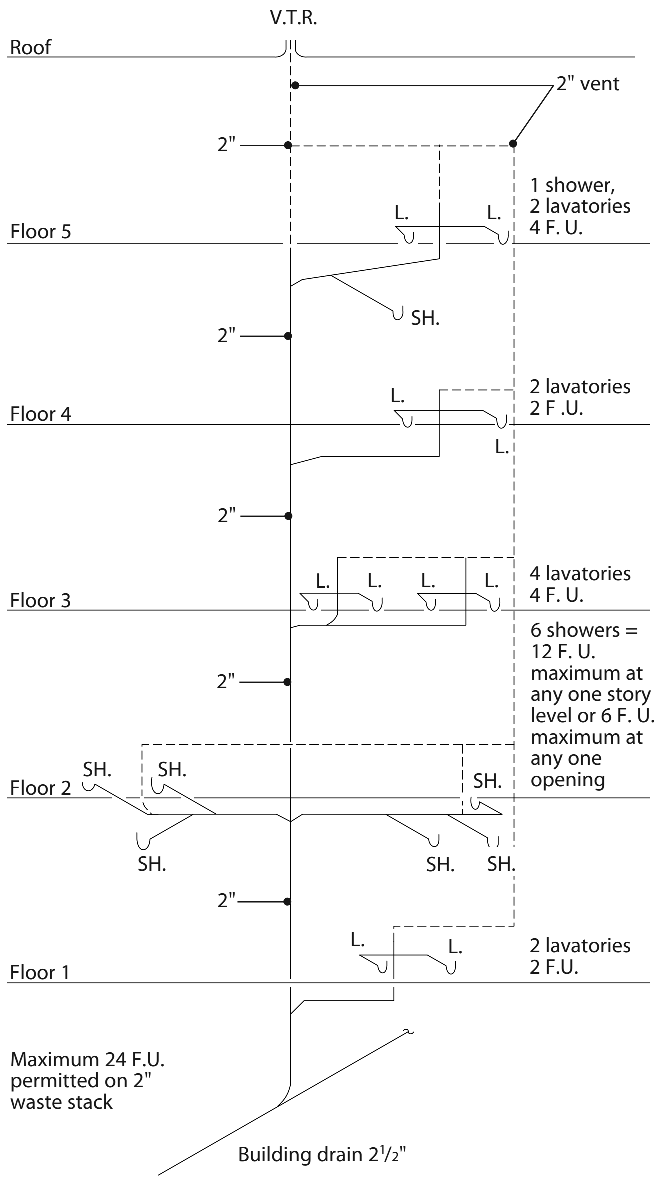


Figure 2-17
Plans showing maximum 24 F. U. on 2″ waste stack (IPC)

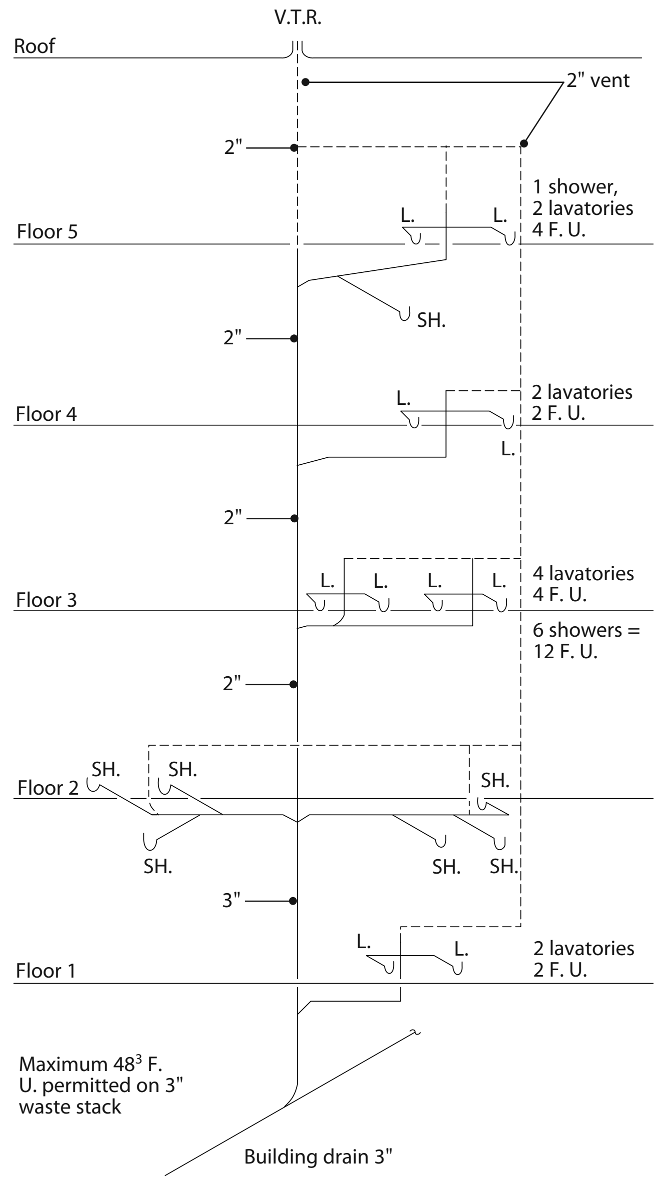


Figure 2-18
Plans showing the stack adjusting in size as load increases to 24 F.U.(UPC)

International Plumbing Code

Use Figure 2-15 for this example. Look at line 2, a 2-inch waste pipe. The maximum number of fixture units for a 2-inch stack is 24 (column 5). Column 3 shows that total fixture units at any one floor opening carrying waste into this 2-inch stack can't exceed 6. Remember, this is a *waste stack*, not a *soil stack*. This means, according to our definition, that this waste pipe, because of its size, conveys *only liquid waste not containing fecal matter.*

Now turn back to Figure 2-9 (*IPC* side) and note the fixture units given for each type of plumbing fixture. Figure 2-15, line 2, shows that you can install 12 showers (total 24 F.U.) on this 2-inch stack at *different* floor levels. Or you can install, at any *one* story level, three showers (total 6 F.U.) on a branch drain connected to this 2-inch stack. You can install 24 residential lavatories (total 24 F.U.) on this 2-inch stack at *different* floor levels, or six lavatories (total 6 F.U.) on a branch drain connected to this 2-inch stack at any *one* story level.

Now size the building drain on the basis of a $^1/_4$-inch fall per foot. In Figure 2-14, first column, find your 2-inch pipe diameter. Line one shows it can carry up to 21 fixture units. Since you need 24 fixture units, a 2-inch horizontal waste pipe won't be large enough. However, line two shows that the next larger size, $2^1/_2$ inches, will accommodate the 24 fixture units for this building.

The showers and lavatories have the same fixture unit values in both codes. You may wonder why there's this difference in pipe sizes since the layout and fixture unit values are identical. The major difference between codes is in *how* the fixture units and other restrictions are applied to a plumbing system.

Uniform Plumbing Code

Now let's size the waste stack and building drain in Figure 2-18 under the *UPC*. Using Figure 2-16, look at the *Vertical* line in column 3. We have a 2-inch vertical drainage pipe (waste stack). Its maximum load is 16 fixture units with some restrictions (see the footnotes). Notice the 2-inch pipe is large enough for the combined waste fixture count at floor level 2, yet needs to be increased to a minimum of 3 inches at floor level 1.

To size the building drain in Figure 2-18, look again at Figure 2-16. The fixture units and pipe sizes for horizontal pipe are based on a slope of $^1/_4$ inch per foot (see footnote 5). You see that the *Horizontal* line shows the number of fixture units you can use with the various pipe sizes listed at the top of each column. To accommodate 24 fixture units you must use a 3-inch building drain, as shown in column 5.

The layouts shown in Figure 2-17 (*IPC*) and Figure 2-18 (*UPC*) illustrate that different pipe sizes may be required when you install 24 fixture units in a five-story building. (Incidentally, this isometric layout is acceptable to most codes.)

More Comparisons of the Plumbing Codes

Now let's find the cumulative fixture unit load for the two-bath house illustrated in Figure 2-10. In the table in Figure 2-11, you see that the total fixture units in the *IPC* is 19. In the *UPC* for this same building, it's 18. To compare and size the drainage pipes included in Figures 2-14, 2-15 and 2-16, you'll also note that the fixture unit difference between these two codes has *no effect on the pipe sizing in Figure 2-10.*

Figure 2-10 shows the building sewer is sized at 3 inches, even though the calculation table for Figure 2-10 shows *16* fixture units for the *IPC* and *17* fixture units for the *UPC*. This may seem confusing to many plumbers, as some local codes require a minimum 4-inch size building sewer. Let's take a closer look at how the two major codes respond.

The *IPC* states, "The maximum number of drainage fixture units connected to a given size of building sewer, shall be determined using Table 710.1(1)." In Figure 2-14 in this book, you can see that according to *IPC*'s Table 710.1(1), a 2-inch pipe would be adequate at a $^1/_4$-inch slope per foot. It can handle 21 fixture units. Nevertheless, the size of this particular building sewer is controlled by footnote, which clearly requires a minimum 3-inch building sewer.

Now let's check the other code. In the *UPC*, the building sewer size is controlled by a subsection called *Size of Building Drain*. It says: "The minimum size of any building sewer shall be determined on the basis of the total number of fixture units drained by such sewer. No building sewer shall be smaller than the building drain."

As you look at Figure 2-16 you see that at $^1/_4$-inch fall per foot, a 3-inch horizontal pipe is large enough to carry up to 35 fixture units! Since we have only 17 fixture units, the sewer by this code can be 3 inches.

It seems that our tabulation is complete. But there may be certain restrictions, limitations and exceptions imposed on a drainage system. *Any such exceptions will always supersede the established pipe sizes and fixture units in any code drainage table.* Before you size the drainage pipes for any building, be sure you're familiar with the footnotes (usually located at the bottom of each table). Also check any other relevant subsections scattered throughout the code book.

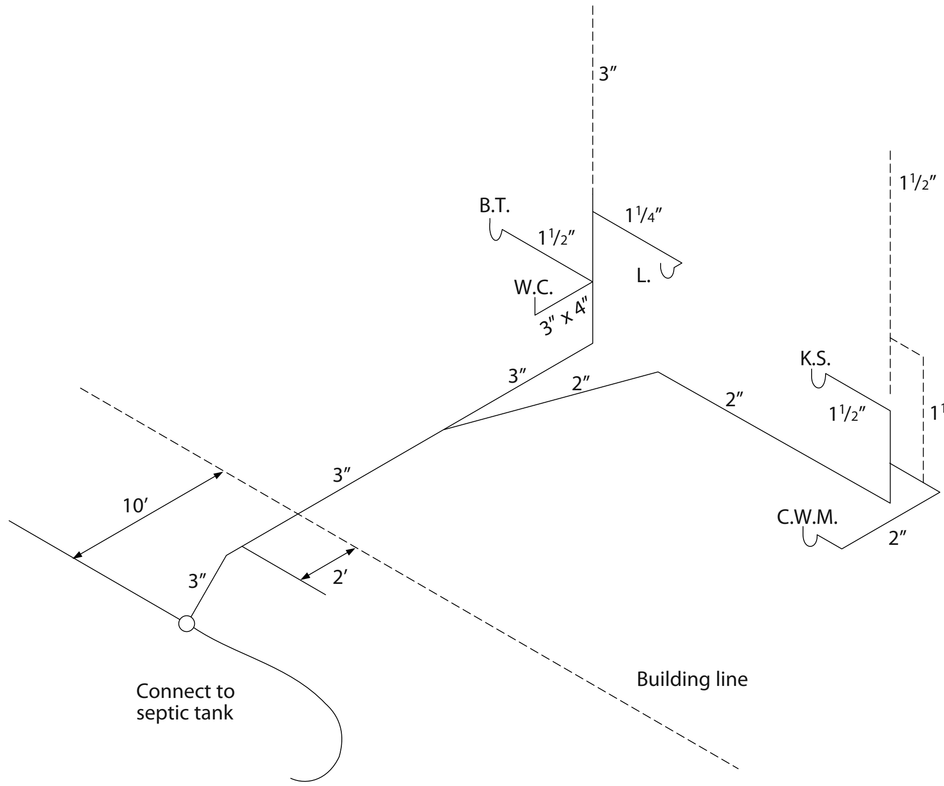


Figure 2-19
Plumbing drainage system illustrated and sized on the "stack"

Some Unique Code Agreements and Disagreements

Now let's check code comparisons for other common areas of the drainage system. More often than not they'll agree. One code may address a subject, while the other may not address it at all, or will do so in a different way. It may take your best effort to understand the drainage system and the vent system (Chapter 3 in this book). Considered the most complex sections of the code, they're often misunderstood and misinterpreted.

- Codes generally agree that the following are *prohibited:* (1) fixtures with waste openings larger than the waste pipe to which they connect and (2) fixtures that convey greasy waste on a 2-inch *waste stack* that vents lower fixtures.
- A *waste stack* is referred to as a *soil stack* when water closets or similar fixtures are installed. In such instances, the size is increased to 3 inches and is governed by footnotes below Figures 2-15 and 2-16.
- The *IPC* permits using side inlet fittings under certain conditions. The *UPC* calls it a prohibited fitting.
- The *UPC* states that no waste connection can be made to a closet bend or stub of a water closet or similar fixture. The *IPC* doesn't address this.
- The building sewer shown in Figure 2-19 is connected to a septic tank. Though this is a building sewer, it's not classified as such by some codes because its developed length doesn't exceed 10 feet. Therefore, the part of the sewer pipe exceeding the 2-foot limit (more, in some codes) beyond a building exterior wall may be considered part of the building drain and sized at 3 inches.
- Take a look at Figure 2-20, an addition with a bathroom at the rear of an existing building. (Figure 2-20 can also illustrate similar requirements for an accessory building on the same lot.) The plot plan shows the sewer from the

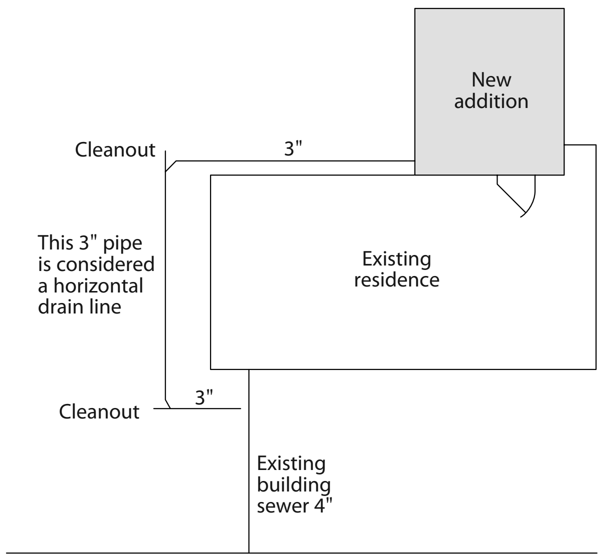


Figure 2-20
Sewer installation for addition

new addition running around the outside of the existing building and connecting to the existing sewer in the front yard. The new sewer pipe is sized at 3 inches, when some codes would normally require 4 inches. Why? The code that usually requires a 4-inch pipe has made an exception in this case. It's considered to be a horizontal drain so you can size it according to Figure 2-14 (*IPC*) or Figure 2-16 (*UPC*).

Codes permit the same exception for accessory residential buildings located on the same lot with an existing building that share a single building sewer. (For similar commercial buildings you usually have to get special approval from your administrative authority.)

- The building drain in Figure 2-10 is sized at 3 inches. For all buildings with one or two water closets, the minimum-size building drain is 3 inches. If this building had a third bathroom, some codes require increasing the building drain to 4 inches at the junction of flow from all three water closets. The *UPC* permits up to three water closets on a 3-inch building drain. See Figure 2-16, footnote 4.

Again referring to Figure 2-10, the waste pipe (also called a *wet vent* in this design) is sized at 2 inches. Why? The code states that the minimum-size vent (wet or dry) to serve a water closet is 2 inches.

Also in Figure 2-10, consider the pipe leading to the kitchen sink and clothes washing machine. Figures 2-14 and 2-16, at $^1/_4$-inch slope per foot, show that a 2-inch pipe is large enough to convey the waste (measured in fixture units) of these two fixtures. Why the 3-inch pipe? Again, footnotes and subsections in the code modify the plumbing possibilities.

- The *IPC* requires at least one minimum-size vent stack of not less than 3 or 4 inches extending through the roof. The *UPC* allows the cross-sectional area of multiple vents to be added together to equal the area of the required sewer.

Each bathroom has a 2-inch wet vent. The *IPC* requires a 3-inch pipe up through the sanitary tap cross. You can satisfy the code requirements most economically by making this vent stack the main vent for this building.

Sizing Drainage Pipes, Multistory Building

To illustrate how to size the drainage in a multistory building, we'll use the drainage figures in this book. Of course, larger pipe sizes are listed in your code. We'll calculate pipe sizes from Figures 2-14 and 2-16. Again, we'll compare the *International* and *Uniform Plumbing Codes'* sizing methods. The load is accumulated at the base of each stack. The sizes shown in Figure 2-21 are based on a fall of $^1/_4$ inch per foot.

The difference in the two codes for sizing the building drain is noted in Stacks B, C and D. At $^1/_4$-inch slope per foot, the *IPC* allows up to 21 fixture units for Stack C on a 2-inch drain, while the *UPC* allows only 8. To accommodate the 18 fixture units illustrated in Figure 2-21, the *UPC* requires a 3-inch pipe. Always check your local code.

To size the vertical drainage pipes in a multistory building, start with the top drainage fixture units and work down to the building drain. Accumulate the total

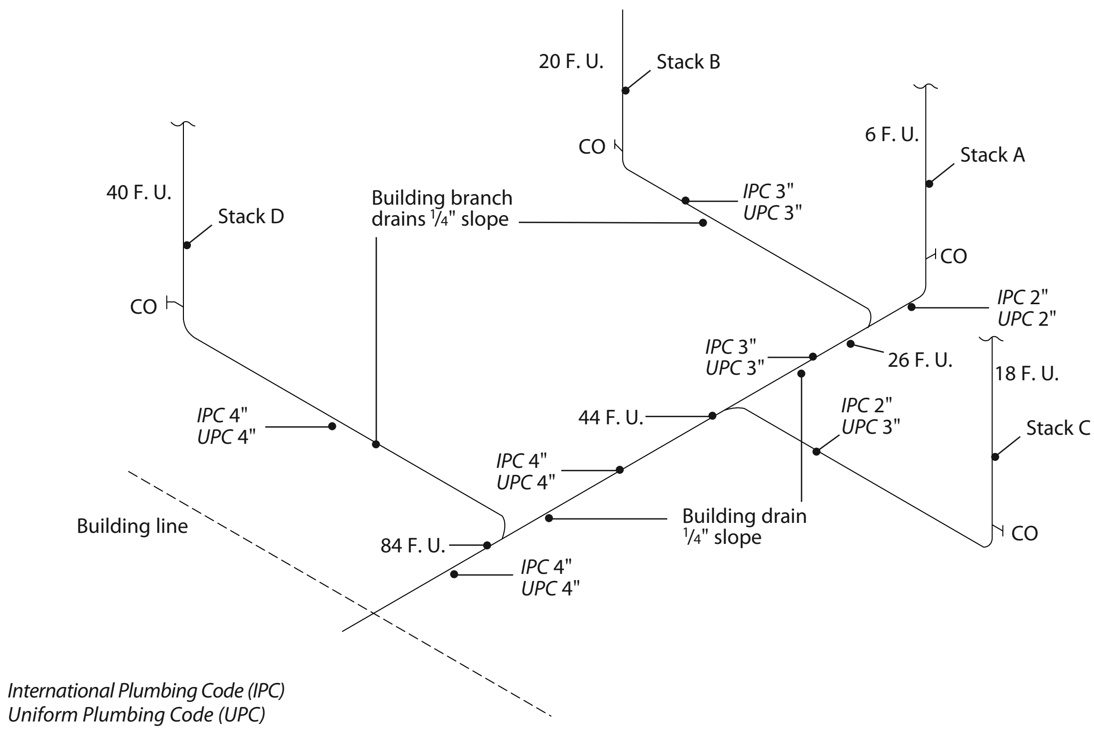


Figure 2-21
Sizing the building drain and branch drains

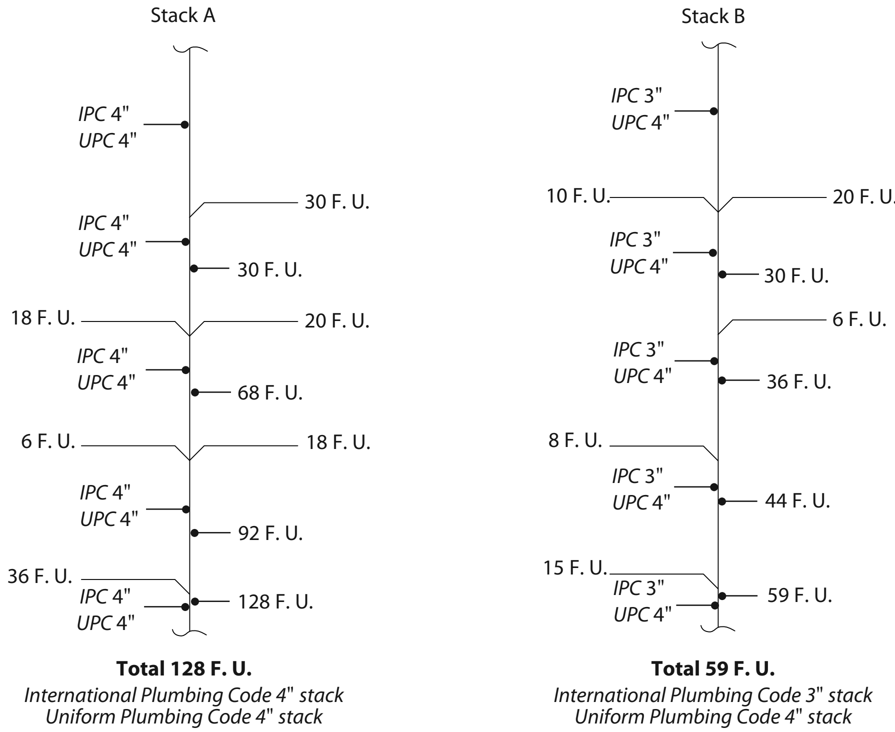
fixture loads at the base of the stack. That total determines the size and length of the entire vertical stack. The vertical waste or soil stack must be the same size throughout its length. Keep in mind that a larger horizontal branch drain can't empty into a smaller vertical waste or soil stack.

The fixture load for sizing the stacks in Figure 2-22 is limited to those listed in the drainage portion of Figures 2-15 and 2-16. Again, we'll compare the sizing requirements from the *International* and *Uniform Plumbing Codes*. Look at Figure 2-22. For Stack A, with 128 fixture units, both codes require a 4-inch stack. For Stack B, with 59 fixture units, you see that the *IPC* requires only a 3-inch stack while the *UPC* requires a 4-inch stack.

Figure 2-23 may need some clarification. Note that stacks A and B extend to the upper floors in this multistory building, and that Section C reflects a horizontal fixture branch drain connecting several fixtures to the building drain. We'll use Figures 2-14 and 2-16 to size the building branch drain and building drain, using the cumulative fixture unit values at the base of each stack.

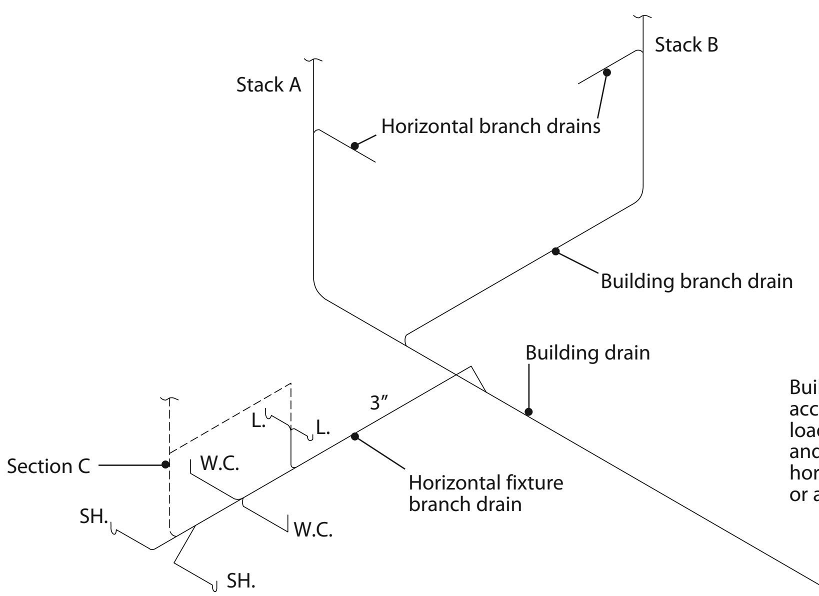
Stacks A and B connect to the building drain or building branch drain. Since several fixtures connect to the drainpipe, Section C is *not* a building drain. Using the *IPC* (Figure 2-14), it must be sized as a 3-inch horizontal fixture branch. But if you're using the *UPC* (Figure 2-16), this pipe isn't considered special. You'd size it at 3 inches as a horizontal drainage pipe subject to the total fixture units and types of fixtures.

Look now at Figure 2-24. A soil or waste stack can't be smaller than the largest horizontal branch pipe connected to it. There's one exception: “A 3" × 4" water closet bend shall not be considered a reduction in pipe size.”



The difference in the two codes is the number of drainage fixture units allowed on a vertical drainage stack. For example: The *International Plumbing Code* permits up to 72 F. U. on a 3" stack and up to 500 F. U. on a 4" stack. The *Uniform Plumbing Code* permits up to 48 F. U. on a 3" stack and up to 256 F. U. on a 4" stack.

Figure 2-22
Sizing vertical stacks



Building drain and branch drains are sized according to the cumulative fixture unit load values at base of stack (Figures 2-14 and 2-16 this book). Section C is sized as a horizontal fixture branch drain, Figure 2-15, or a horizontal drainage pipe, Figure 2-16.

Figure 2-23
Sizing a horizontal branch drain

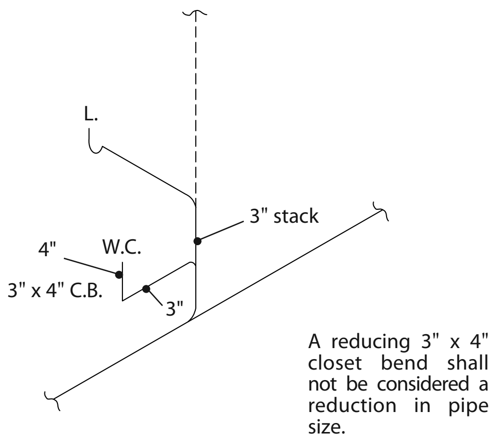


Figure 2-24
Reducing closet bend illustrated

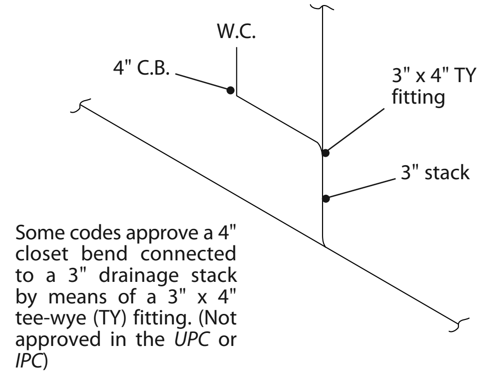


Figure 2-25
4" closet bend connecting into 3" stack illustrated

Some codes allow a 4-inch horizontal fixture branch drain to connect to a 3-inch stack or horizontal building drain under certain conditions. Let's look at a couple of these, as illustrated in Figures 2-25 and 2-26.

Future Fixtures

Provisions may be required in some buildings for the installation of future fixtures. When this occurs, consider the number and types of fixtures when sizing drain and vent pipes. Properly-sized pipes must then terminate with properly-plugged pipe or pipes. See Figure 2-27.

Vertical Offset in Drainage Pipes

You can consider as straight any vertical stack with an offset of 45 degrees or less. Size it as a straight vertical stack. However, a relief vent is required (1) in buildings having 10 or more branch intervals (10 or more stories high), or (2) if a horizontal branch drain connects to the stack within 2 feet above or below the offset (*IPC)*. See Figure 2-28.

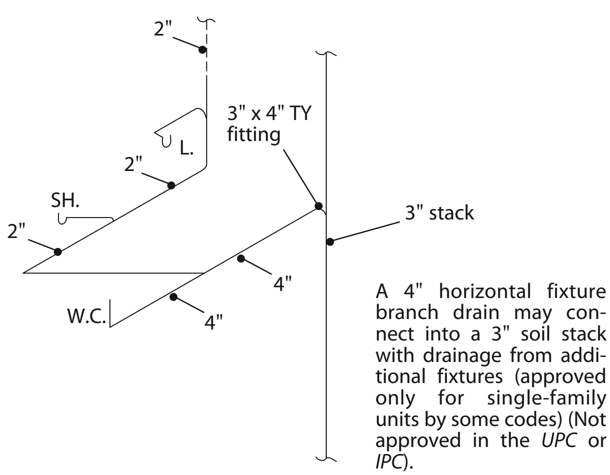


Figure 2-26
4" drain connecting into 3" stack illustrated

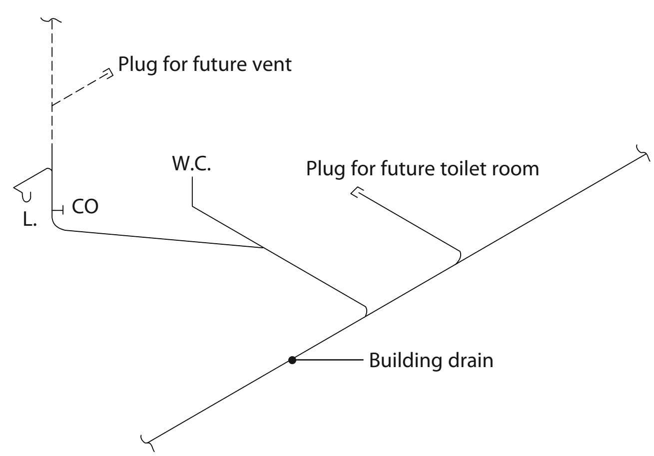


Figure 2-27
Drainage and vent pipe plugged for future installation

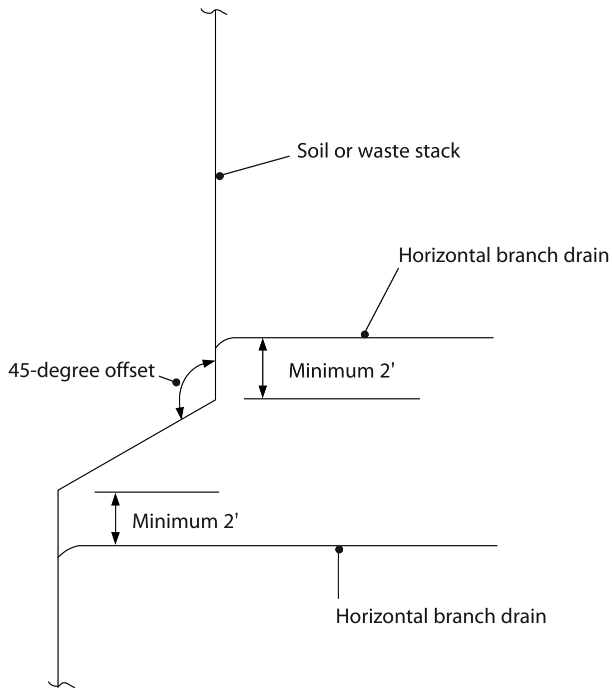


Figure 2-28
Example of 45-degree offset in vertical stack

Horizontal Offset in Vertical Drainage Stack

Here's how to size vertical stacks having an offset of more than 45 degrees (see Figure 2-29). The vertical portion above the offset may be sized as a regular stack. Compare Figures 2-15 and 2-16 for sizing guidelines. Size the horizontal portion as a building drain using Figures 2-14 and 2-16. The vertical portion below the offset can't be smaller than the horizontal pipe. Horizontal branch drains shouldn't be connected to the vertical stack within 2 feet below or above the offset unless they're properly vented (*IPC*). See Chapter 3 for venting details.

Horizontal Branch Drains

Most codes require that horizontal branch drains in multistory buildings have a minimum separation of 8 feet. Figure 2-30 illustrates this.

Suds Pressure Zones

Following the close of World War II, soap and chemical industries began to develop and market many new products. Synthetic detergents provide plentiful

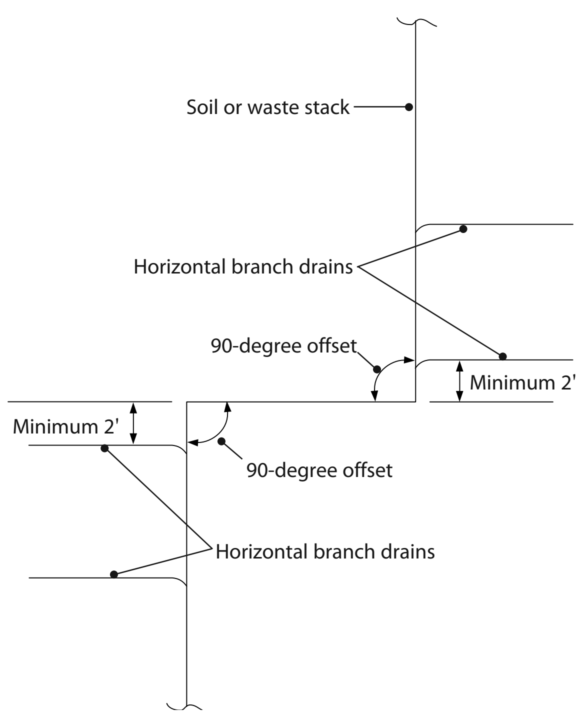


Figure 2-29
Example of horizontal offset in vertical stack

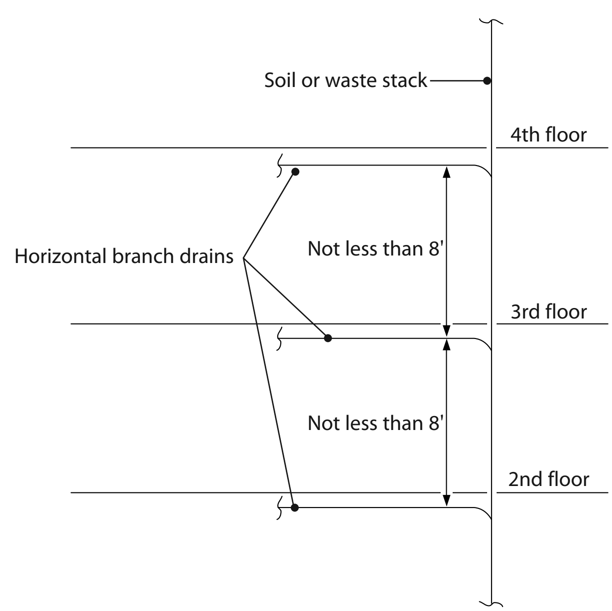


Figure 2-30
Example of minimum 8' separation of horizontal branch drains

quantities of long-lasting suds in both hard and soft water. The down side is that the increased use of these products has increased the volume of suds in household wastes — and their attendant problems.

Multistory residential buildings always get the worst of it. When upper floor fixtures and appliances discharge wastes containing detergents, they mix with the suds-producing ingredients as they rush down the inner wall of the stack. These suds settle into the lower sections of the drainage pipes. The air that accompanies wastes is forced down into the suds in the lower sections. This mixture compresses and forces the suds to move through any available path of relief. Improperly designed drainage and vent piping may serve as relief paths, perhaps causing suds to bubble up into lower floor fixtures.

Different codes address this particular problem with varying degrees of concern, or perhaps not at all. Where these conditions exist, check with local authorities for any special design that may be required.

Some codes consider bathtubs, laundries, clothes washing machines, kitchen sinks and dishwashers as suds-producing fixtures and appliances. Figure 2-31 shows the likely location of suds pressure zones when large numbers of these fixtures are used.

Fixtures which produce sudsy detergents will normally discharge at an upper level into a soil or waste stack. In tall residential buildings which serve fixtures at lower levels, avoid connecting the drainage and vent piping for the lower fixtures to any suds pressure zone. Figure 2-32 illustrates one way to install waste pipe from suds-producing fixtures so it's acceptable to most codes.

The *UPC* doesn't require special drainage designs for single-family residences and buildings that don't exceed three stories. But it outlines certain restrictions in residential buildings more than three stories high. It prohibits suds-producing piping from connecting into a drainage pipe within 8 feet of any vertical-to-horizontal change of direction. Check local code requirements.

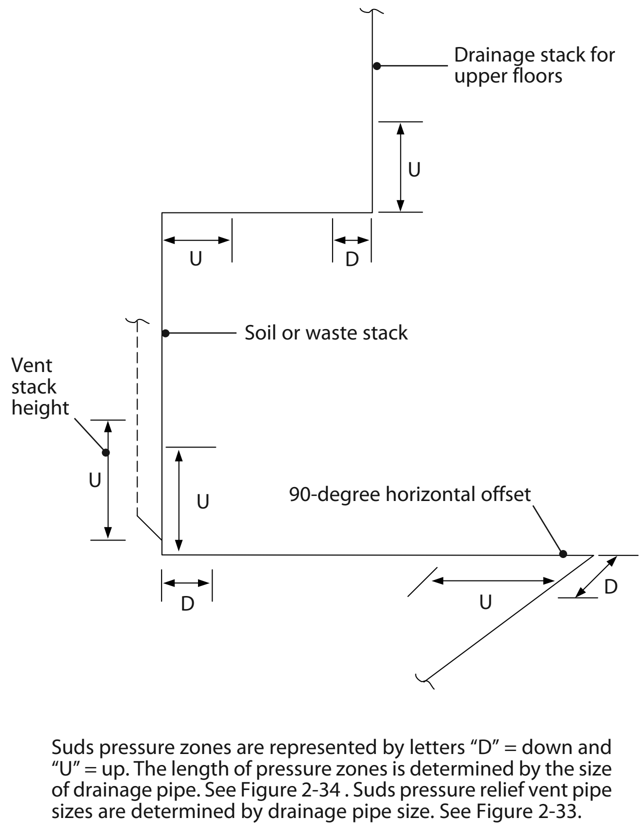


Figure 2-31
Suds pressure zones

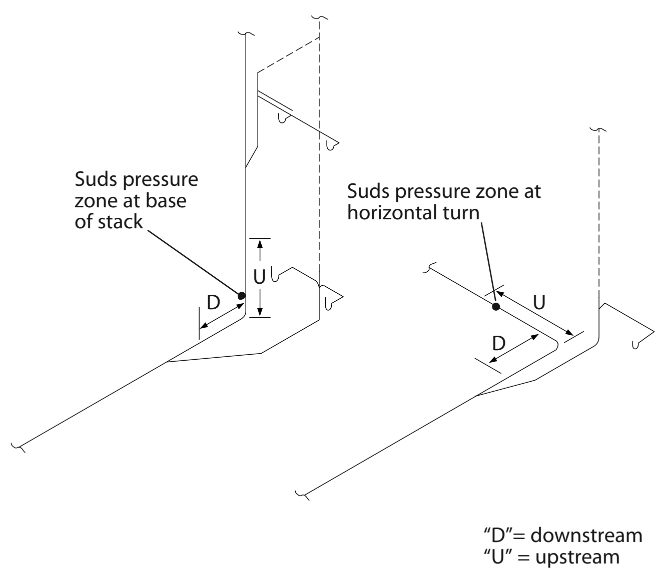


Figure 2-32
Suds producing zones

In designing a drainage system with suds-producing zones, there are two ways to determine the distance for pipe connections to horizontal and vertical lines. See Figures 2-33 and 2-34.

The *UPC* has a flat 8-foot separation regardless of the pipe size used. Other codes accept separation connections in pipe diameters for upstream and downstream suds-producing zones. For example: 40 pipe diameters *upstream* and 10 pipe diameters *downstream*. It works like this: A 4-inch vertical stack *upstream* would equal 160 inches, or 13.3 feet (4" × 40 ÷ 12 = 13.3 feet). A 4-inch vertical pipe downstream would equal 3.3 feet (4" × 10 ÷ 12 = 3.33 feet).

Figures 2-33 and 2-34 should help you avoid the necessity of individual pipe size calculations when designing drainage systems affected by suds. Though most codes accept these calculations, it's always wise to check. You can see that Figure 2-33 shows relief venting, while Figure 2-34 shows drainage pipes upstream and downstream.

Drainage Systems Below Sewer Level

Where a drainage system or a part of a drainage system can't discharge to the building sewer or public sewer by gravity flow, you're required to discharge the wastes into an approved sump. Automatic pumping equipment then will lift the contents and discharge it into the building gravity drainage system. Be sure the sump and pumping equipment are of adequate capacity for the volume and types of liquids to be conveyed.

Remember, only waste that requires lifting can discharge into a sump. Size, install and vent the drainage system for this waste like a standard gravity system. Other drains must discharge by gravity into the building gravity drainage system.

Sewage Ejectors

Sumps and receiving tanks must be in accessible locations for inspection, repairs and cleaning. Constructed of concrete, metal or other approved materials, they must also be tightly covered and vented. Be sure the concrete sump walls and bottom are reinforced and designed to acceptable standards. Metal sumps or tanks must be thick enough to serve their intended purpose and be protected from external corrosion.

For public use, most codes require a duplex pumping system. This permits the pumps to discharge waste alternately. Also, in case of repair, one pump can remain in service.

You must install a check valve and gate valve in the discharge line between the pump and the building gravity system. In the case of a horizontal building

Drainage pipe size	Relief vent size
1½"	2"
2"	2"
3"	2"
4"	3"
Note: A suds relief vent, relieving the nonpressure zone, shall be provided at each suds pressure zone where such connections are installed.	

Figure 2-33
Suds pressure relief vents

Drainage pipe size	"U" upstream	"D" downstream
1½"	5'0"	1'6"
2"	7'0"	1'6"
3"	10'0"	2'6"
4"	13'0"	3'6"

Figure 2-34
Suds pressure zones for various size drainage pipes, upstream and downstream

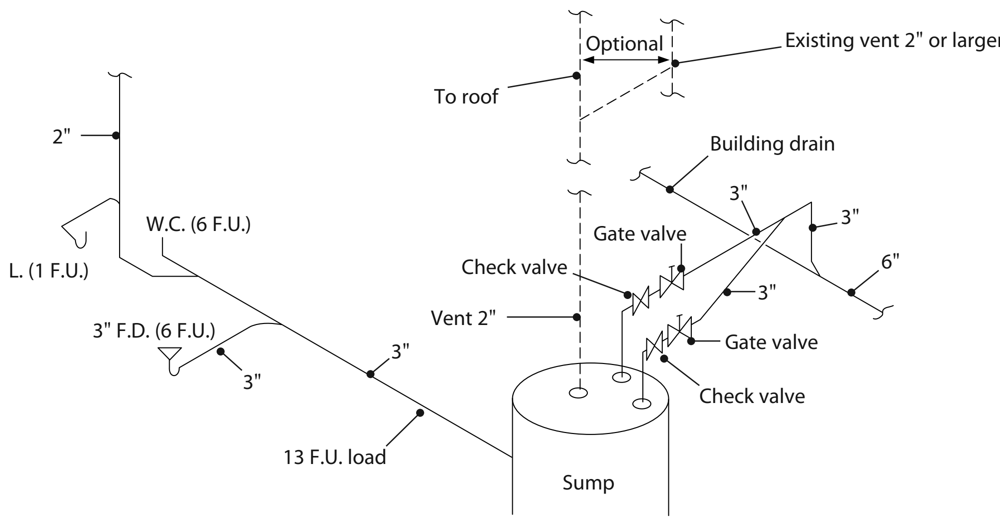


Figure 2-35
Sewage ejector "public use" sump

gravity drain, the sump discharge line must connect from the top through a wye branch fitting. The connection has to be at least 10 feet from the base of any soil or waste stack.

Always install the gate valve on the discharge side of the check valve. It must be the full-way type with corrosion-resistant working parts. It's important not to overload the building drainage system. The *Uniform Plumbing Code* allows two fixture units for each gallon per minute of flow. The discharge piping must be at least 3 inches in diameter in commercial and public installations. See Figure 2-35 for piping details.

Sumps receiving clear water waste from floor drains, air conditioning condensate drains and the like need not have a cover or be vented.

Review Questions for Chapter 2 (answers are on page 275)

1. What are the two parts of a private sanitary drainage system?
2. What is the aim of municipal codes in relation to drainage systems?
3. On which section of the code do the Boards of Rules and Appeals have the most requests for clarification and resolution?
4. From what section of the code are most of the questions and isometric drawings on the journeyman and master's examinations taken?
5. What purpose do isometric drawings serve?
6. List two reasons why it's important for a plumbing contractor to know how to make and interpret isometric drawings.
7. What are the three basic pipe angles you need to illustrate in an isometric drawing for a plumbing system?
8. What do the lines on an isometric drawing represent?
9. What is the purpose of a horizontal twin tap sanitary tee?
10. How are plumbing fixtures identified in isometric drawings and floor plans?
11. What is another term for a public sewer?
12. What are the two other terms used for a building sewer?
13. Why is a building drain also known as a main?
14. Plumbers often refer to a fixture drain by what other terms?
15. What kind of waste is carried by a waste pipe?
16. What is a soil stack?
17. What function does a branch interval serve?
18. What is a horizontal branch?
19. What's the main factor you use to determine pipe size within a drainage system?
20. Besides maximum fixture unit value, what three additional factors must you take into consideration when sizing drainage piping?
21. For what purpose would you use the tables in your code book that list the various fixture load values?
22. How are special fixtures connected to the drainage system?
23. Name two devices that are considered special fixtures.
24. Name two continuous and intermittent flow devices that you can connect to a drainage system.
25. How many fixture units does the *Uniform Plumbing Code* allow for each gallon per minute of flow from continuous flow devices such as sump ejectors?
26. Name one major area of difference between the model codes when it comes to designing drainage systems.
27. What is the generally accepted fall per foot for horizontal pipe?
28. What will restrictions, limitations and exceptions always supersede in any code book?
29. How do most codes regard fixtures with waste openings larger than the waste pipe to which they need to connect?
30. What does the code call a stack that receives the discharge from a water closet?
31. What's the minimum size vent required by the *UPC* to serve a water closet?
32. What's the code-accepted minimum size for a main vent stack in a building?
33. When sizing drainage piping in a multistory building, at what point do you accumulate the fixture unit load?
34. What procedure must you follow in sizing vertical drainage pipes in a multistory building?
35. How does the size of a vertical waste/soil stack vary from one end to the other?
36. What's the one exception to the rule that a soil or waste stack can't be smaller than the largest horizontal branch pipe to which it connects?
37. What are the main considerations when sizing drain and vent pipes for future fixtures?

38. How do you define a vertical stack with an offset of 45 degrees or less when you're sizing it?
39. How do you size the horizontal portion of a vertical stack that has an offset greater than 45 degrees?
40. In a vertical stack, what's the minimum distance for an offset above or below the horizontal branch?
41. What's the minimum required separation of horizontal branch drains in a multistory building?
42. Since World War II, how have synthetic detergents affected the characteristics of household waste?
43. Name two suds-producing fixtures or appliances.
44. What problems can occur when suds-producing fixtures and appliances discharge into an improperly designed drainage and vent system?
45. When it's impossible for waste to drain by gravity into the building drainage system, where must it be discharged?
46. Why should sumps and receiving tanks be accessibly located?
47. Why do most codes require that sumps for public use be equipped with a duplex pumping system?
48. What two devices are required in the discharge line between the pump and the gravity system?
49. According to most codes, what's the minimum acceptable size for a sump discharge pipe in a commercial or public installation?
50. What is not required on a sump receiving clear water waste from floor drains or air conditioning condensate drains?

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3

Designing Vent Systems

Vent pipes are vital to the successful functioning of plumbing fixtures and the sanitary drainage system. Although the English inventor Joseph Braman first developed the water closet in 1778, water closets couldn't be installed for common use in buildings until a way was found to protect the fixture trap seals. Siphoning and back pressure in building drainage systems destroyed the trap seal and allowed objectionable odors and sewer gases to escape into the building.

A theory about protecting the traps of plumbing fixtures by installing vents was proposed and tested in the late 1800s. Further field testing helped to determine the distances from traps and the sizes of vent pipes needed to serve various plumbing fixtures. Finally, in 1875, it was found that by extending all vent pipes to the atmosphere above the building's roof, any odor from the system would escape from the building.

This breakthrough in the development and design of the sanitary drainage system eliminated resistance to indoor plumbing systems. Plumbing installations in buildings soon became routine design features. By the late 1800s, many cities began establishing separate plumbing codes to protect the health of people in densely populated areas. Plumbing practices varied considerably from municipality to municipality, and the early code requirements in each area reflected these variations.

Eventually, the U.S. Department of Commerce launched a comprehensive effort to standardize the plumbing code. Scientific experiments conducted by the National Bureau of Standards formed the basis for many of the new plumbing requirements.

States authorized the establishment of examining boards made up of qualified plumbers who, along with other agencies, were requested to write plumbing regulations and amend these regulations when necessary to keep abreast of new materials and installation methods. Although plumbing practices still vary from area to area, the variations today are usually minor.

Types of Vents

A *vent system* consists of all the vent pipes of a building. It may include one or more pipes installed to provide a free flow of air to and from a drainage system. This is to prevent back pressure or siphonage from breaking the water trap seals serving the fixtures.

Here are the types of vents most plumbers will need to be familiar with to install drain, waste and vent systems:

Battery Venting — *Battery venting* uses a branch or circuit vent to vent a group of two or more similar adjacent fixtures that discharge into a common horizontal waste or soil branch. Some of these fixtures may be the above-floor type shown in Figure 3-1, and others may be the floor-outlet type shown in Figure 3-2.

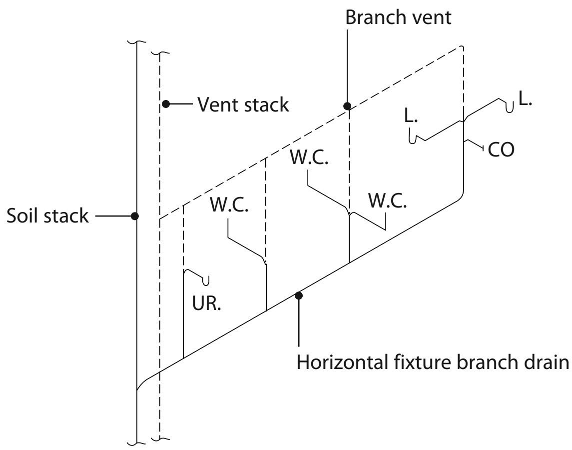


Figure 3-1
Branch vent

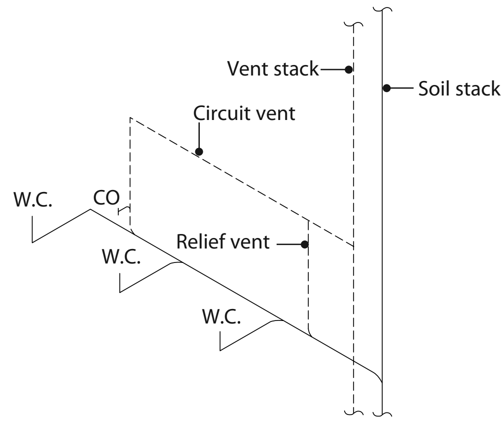


Figure 3-2
Circuit vent

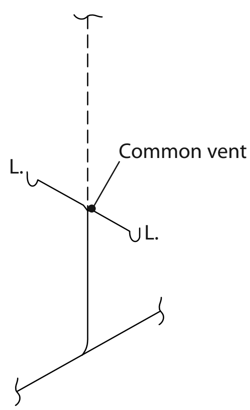


Figure 3-3
Common vent

Branch Vent **—** A *branch vent* connects one or more individual vents to a vent stack (Figure 3-1).

Circuit Vent **—** A *circuit vent* functions much like a *branch vent*. Circuit vents serve two or more fixtures and rise vertically from between the last two fixture traps located on a horizontal branch drain. They are connected to the vent stack as shown in Figure 3-2.

Common Vent **—** A *common vent* is a vertical vent that serves two fixture branches installed at the same level. In Figure 3-3 these are two lavatories.

Continuous Vent **—** A *continuous vent* is the vertical portion that's a continuation of the drain it's connected to (see Figure 3-4). It's also called a *stack vent.*

Dry Vent **—** A *dry vent* is that portion of a vent system that receives no waste discharge (Figure 3-5).

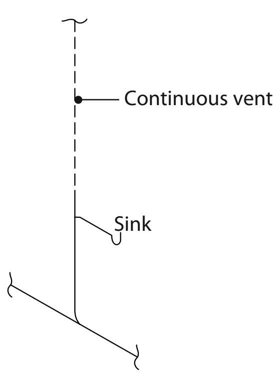


Figure 3-4
Continuous vent

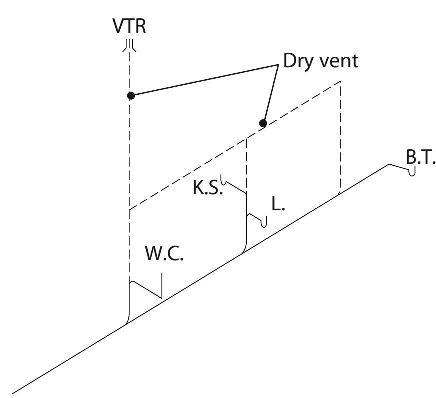


Figure 3-5
Dry vent

Individual Vent — An *individual vent* (Figure 3-6) is a pipe installed to vent a single fixture trap. It may connect to the existing vent system above the fixture served or terminate through the building roof into the open air.

Main Vent — The *main vent* is the principal pipe of a venting system to which vent branches may be connected. The main vent may connect at the base of a soil or waste stack below the lowest horizontal branch to the building drain (see Figure 3-7).

Relief Vent — Relief vents provide additional air circulation in taller buildings and in circuit vented drains serving four or more toilets. Relief vents are shown in Figures 3-2 and 3-8.

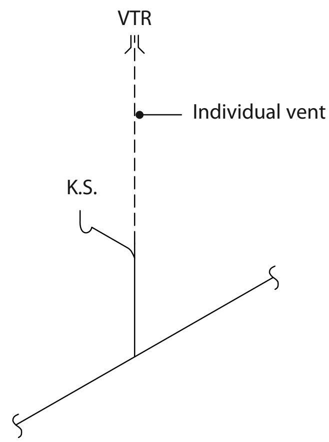
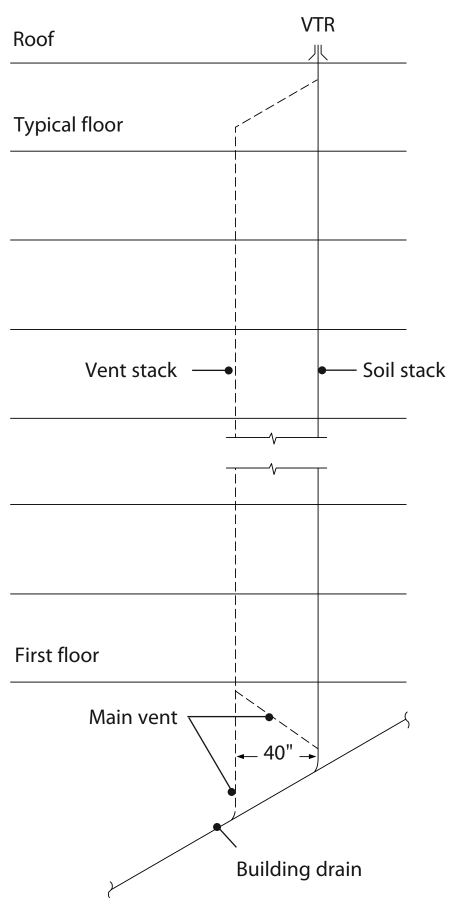
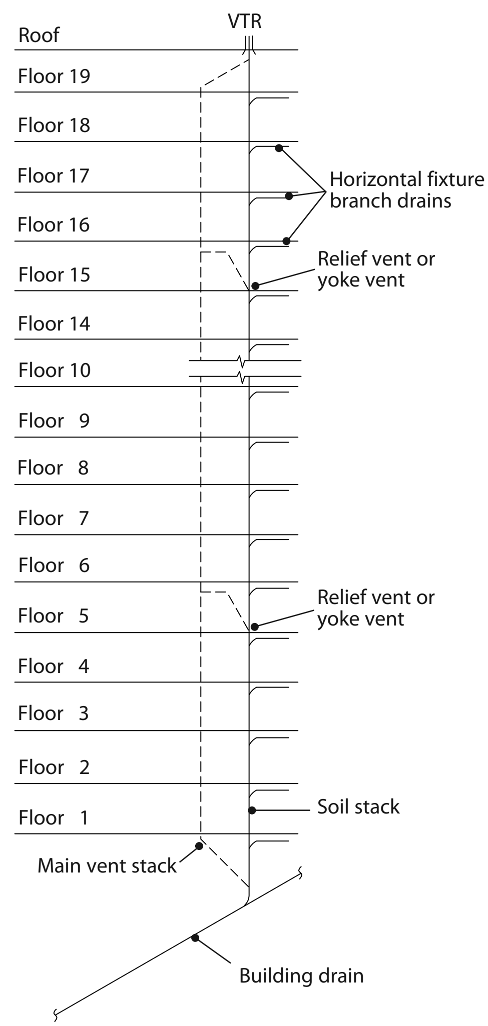


Figure 3-6
Individual vent



Note Main vent to connect at base of soil or waste stack. *International Plumbing Code* will accept main vent to connect to building drain, but requires a maximum 40" separation between the two stacks.

Figure 3-7
Main vent



Note The diameter of relief vents must not be smaller than the diameter of the main vent they connect to.

Figure 3-8
Relief vents

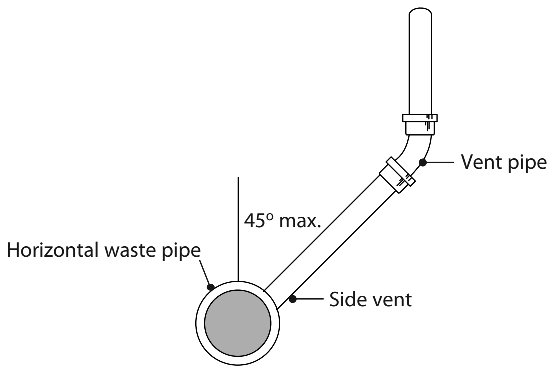


Figure 3-9
Side vent

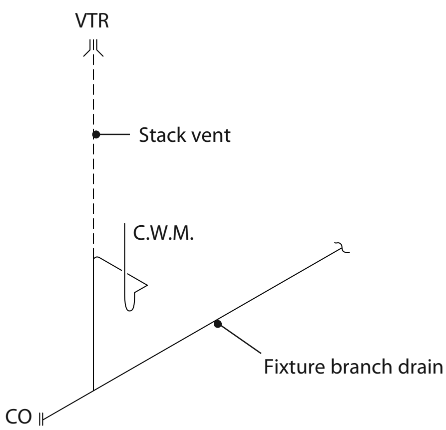


Figure 3-10
Stack vent

Side Vent — A *side vent* is a vent that connects to a horizontal drain pipe through a fitting at an angle no greater than 45 degrees to the vertical (see Figure 3-9).

Stack Vent — A *stack vent* is nothing more than the extension of a soil or waste stack (dry section) up and through the roof of a building (Figure 3-10).

Stack Venting — *Stack venting*, as shown in Figure 3-11, is a method of venting fixtures through the soil or waste stack.

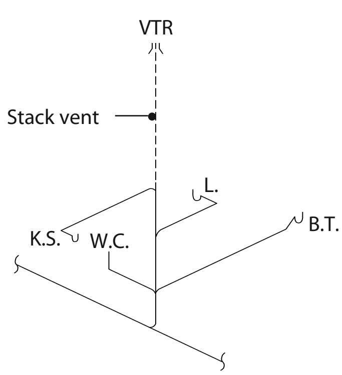
Vent Header — A *vent header* is a single pipe that receives the connection of two or more vent pipes and then connects to the main vent stack or extends to the atmosphere separately at one point (Figure 3-12).

Vent Stack — A *vent stack* is the vertical portion of a vent pipe. Its primary purpose is to provide circulation of air to and from all parts of a drainage system. Vent stacks are shown in Figures 3-1, 3-2, and 3-12.

Wet Vent — A *wet vent* is a waste pipe that vents and conveys waste from fixtures other than water closets. Figures 3-13 through 3-18 show various *wet vent* systems.

Yoke Vent — A *yoke vent* is a pipe connecting upward from a soil or waste stack to a vent stack for the purpose of preventing pressure changes in the stack. A yoke vent is shown in Figures 3-8 and 3-19.

Venting procedures that are not listed here or defined specifically in most codes will be discussed and illustrated later in this chapter.



Note Stack vents are vents that are equal in size to the waste stack

Figure 3-11
Stack venting (IPC)

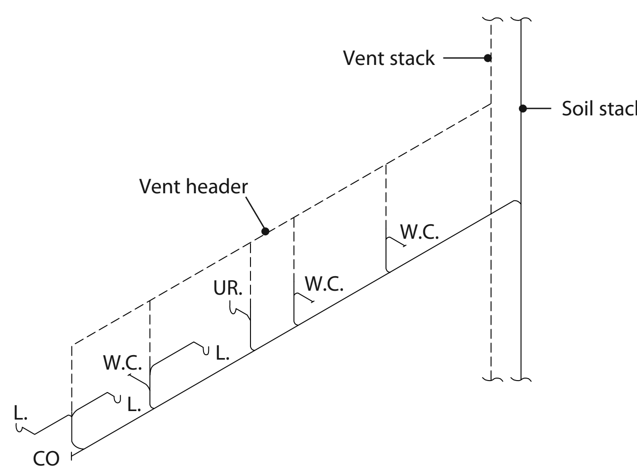


Figure 3-12
Vent header

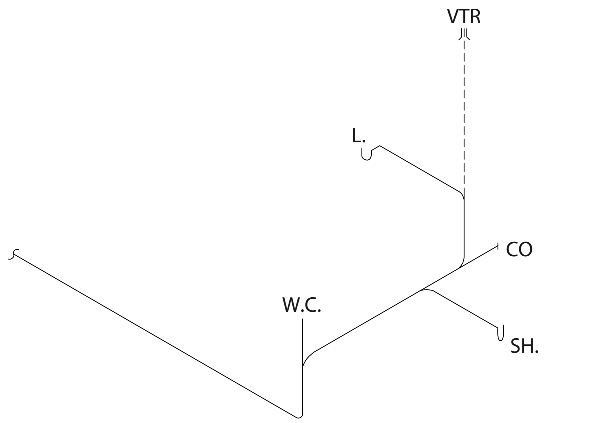


Figure 3-13
Wet vented system

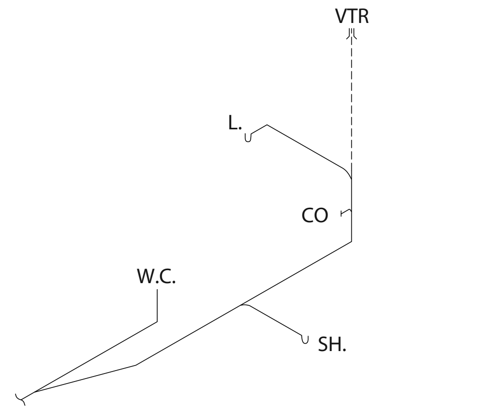


Figure 3-14
Horizontal wet vented system

Problems Created by Inadequate Venting

In rural areas where inspections aren't required, or in municipalities where inspections are lax, inadequate sizing and arrangements of vent pipes can cause problems. Following are some of the problems related to poor venting:

- Plumbing fixtures may drain slowly, as if a partial stoppage exists.
- Water closets may need several flushes to remove the contents from the bowl.
- Back pressure (known as *positive* pressure) within the drainage pipes may force sewer gases up and through the liquid seals and into the building.
- Plumbing fixtures located a greater distance from a vent pipe than is permitted by code may, when the contents are released, siphon the liquid trap seal. This siphoning action is known as *negative* pressure.
- In very cold climates, as the warm moist air flows up and out of the vent pipes and makes contact with the cold atmosphere, there's a danger of frost forming on the inside of the pipes. This can restrict the free flow of air within the drainage system.

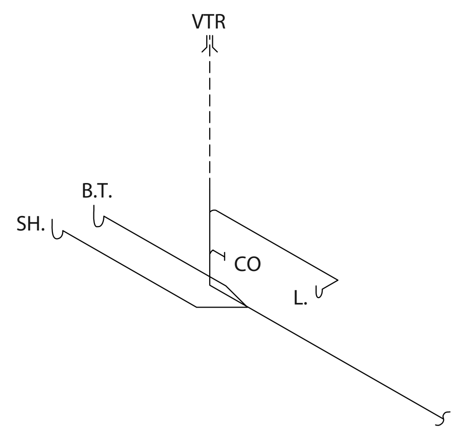


Figure 3-15
Horizontal wet vented shower and bathtub

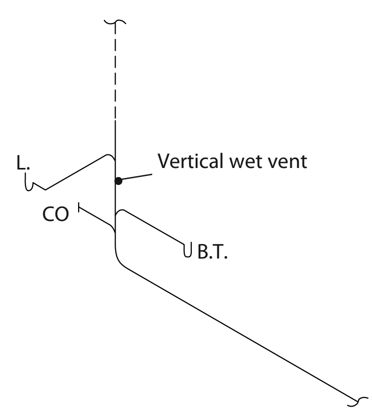


Figure 3-16
Vertical wet venting

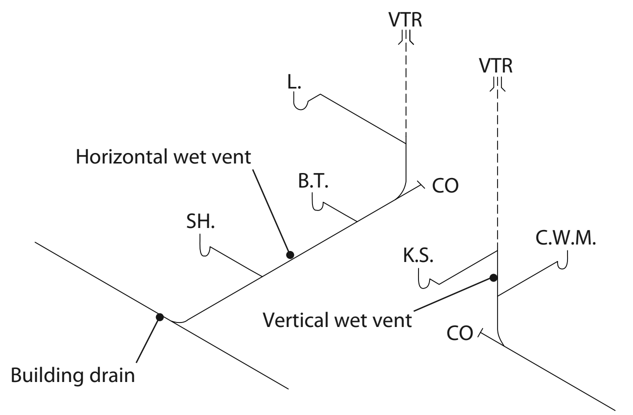


Figure 3-17
Horizontal and vertical wet venting

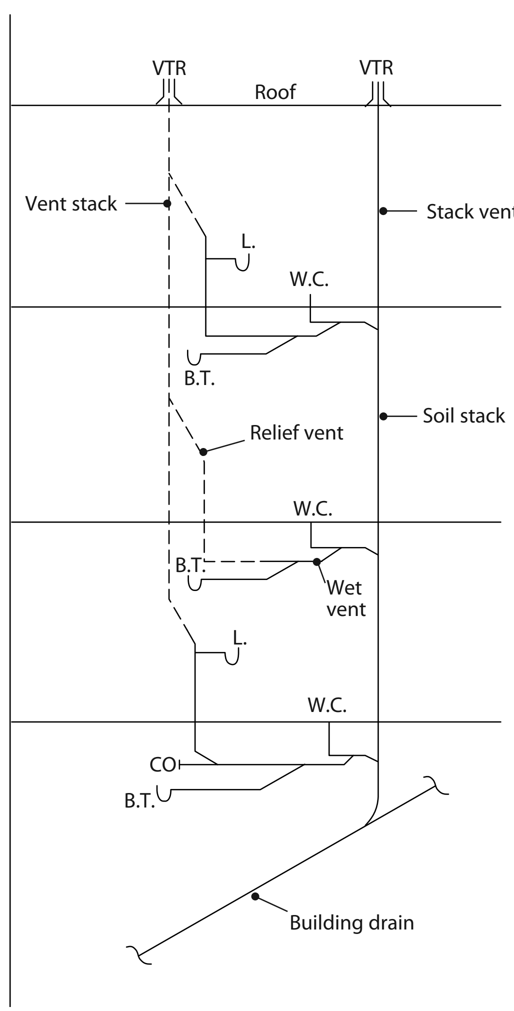


Figure 3-18
Alternate method of wet venting single bathrooms in multistory buildings

The plumbing codes have regulations for preventing these problems. For example, in regions where there's a danger of frost forming inside a vent pipe, the codes have the following regulations:

The *International Plumbing Code* requires that a vent extension through a roof be at least 3 inches in diameter. When it's necessary to increase the vent size, the change in diameter must be made at least 12 inches inside the building.

The *Uniform Plumbing Code* mandates that vent terminals be at least 2 inches in diameter but never smaller than the required vent pipe. The diameter increase has to be made at least 12 inches *inside* the building, below the roof, and must terminate at least 10 inches above the roof. See Figure 3-20.

Correctly sizing and arranging the vents as well as understanding how the parts work together is fundamental to installing an adequate vent system.

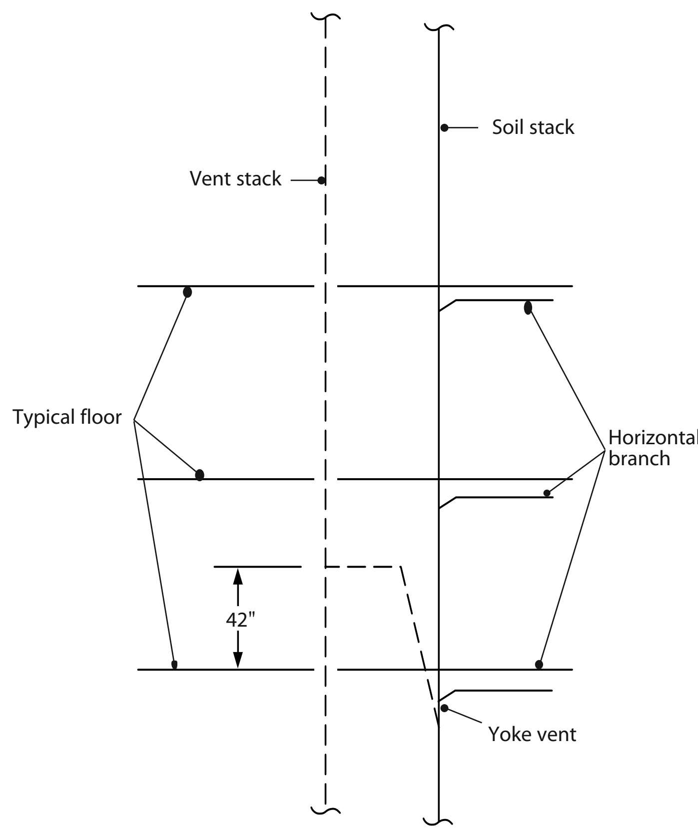


Figure 3-19
Yoke vent

How to Size the Vent System

You size and arrange vent pipes to relieve pressure that builds up as plumbing fixtures discharge water into the sanitary drainage system. This free flow of air within the system keeps the back pressure or siphoning action from destroying fixture trap seals.

The sizing of a vent pipe, like sizing its cousin, the soil and waste pipe, depends on the maximum fixture unit load, its developed length, the type of plumbing fixtures, and the diameter of the soil or waste stack it serves. You can use Figure 3-21 to compute the size and permitted length of vent stacks for multistory buildings. We've included it for you to use to follow along with our examples. However, it's just a partial table. For larger sizes and lengths, you'll have to consult the code.

How do you interpret Figure 3-21? Look at lines 4 and 5, both involving a 2-inch waste stack. In line 4, the 2-inch waste stack serves 12 fixture units. If the height of the building doesn't exceed 30 feet, a 1¹/₄-inch vent stack *may* be used. If the building exceeds 30 feet, but is less than 75 feet, you can use a 1¹/₂-inch vent.

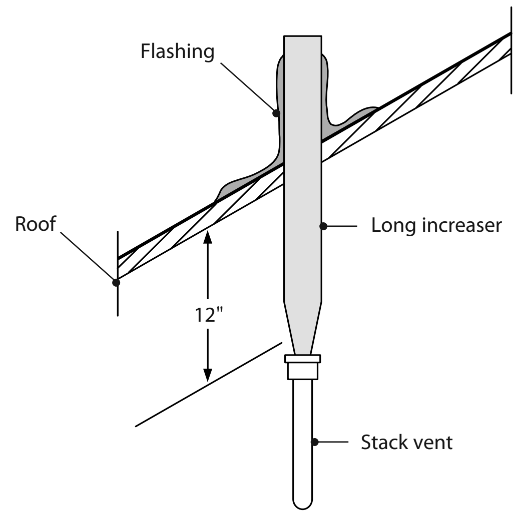


Figure 3-20
Cold-climate vent terminals

Finally, for a building height of more than 75 feet but less than 200 feet, you *must* use a 2-inch vent stack. These are the minimum sizes permitted by the code. It's OK to upgrade a plumbing system by using larger vent pipes — as long as the vent pipe doesn't exceed the diameter of the soil or waste stack it serves.

Diameter of soil or waste stack (in)	Total fixture units being vented	Maximum developed length of vent (ft)[a] Diameter of vent (in)				
		1¹/₄"	1¹/₂"	2"	2¹/₂"	3"
1¹/₄	2	30	—	—	—	—
1¹/₂	8	50	150	—	—	—
1¹/₂	10	30	100	—	—	—
2	12	30	75	200	—	—
2	20	26	50	150	—	—
2¹/₂	42	—	30	100	300	—
3	10	—	42	150	360	1,040
3	21	—	32	110	270	810
3	53	—	27	94	230	680

a. The developed length shall be measured from the vent connection to the open air

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Figure 3-21
Size and length of vent pipes (IPC)

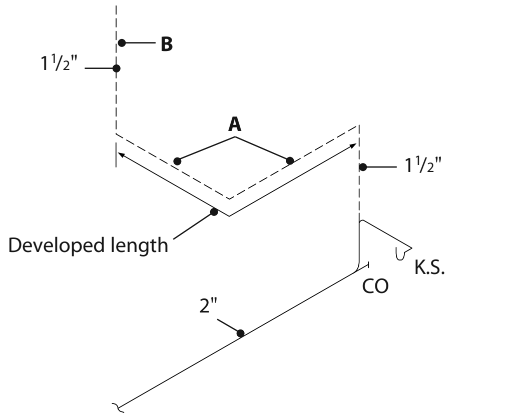

Figure 3-22
Maximum horizontal length of vent pipe

Here's something you'll want to take notice of in Figure 3-21, which gives maximums allowed by the *IPC*. Even though the 2-inch waste pipe on line 5 is the same as the one on line 4, the height of the vent pipe must decrease as the maximum fixture unit load increases. A larger load requires more air flow, and air is restricted more and more as a pipe grows longer.

Always check your code for any footnotes or subsections that place restrictions or limitations on a vent pipe or vent system. These footnotes or subsections always supersede the established tables in the code.

Basic Sizing Principles

Here are the basic principles for sizing venting, as summarized in most codes:

- For each building with a single building sewer receiving the discharge of a water closet, there must be at least a stack or stacks combining to equal not less than 3 or 4 inches, extending through and above the building roof.
- If there's an accessory building or buildings located on the same lot, with one common building sewer, use the size tables in the code (Figure 3-21) to find the minimum size vent stack or stacks to serve each accessory building. There's one exception to this basic rule: Should a water closet be located in the accessory building, the vent stack must be no smaller than 2 inches.
- No vent, wet or dry, for a water closet can be less than 2 inches in diameter.
- The diameter of the vent stack can't exceed the diameter of the soil or waste stack to which it connects.
- The diameter of an individual vent can't be less than $1^1/4$ inches nor less than one-half the diameter of the drain to which it's connected. In other words, if a drain is 3 inches, the minimum size vent is $1^1/2$ inches. If a drain is 4 inches, the minimum size vent is 2 inches.
- The following rules illustrate the relationship of the horizontal and vertical vent pipe to the total permitted pipe length:

  1) The maximum length of any vent pipe is determined by the diameter of the vent pipe.

  2) When the vent diameter is increased one pipe size for its entire length, the maximum length limitation does not apply (*Uniform Plumbing Code*).

  3) The horizontal section of a vent pipe (see A in Figure 3-22) must not exceed one-third of the total permitted length of vent pipe as illustrated by the vertical section B.

  4) Some codes will allow the horizontal section (A) to be installed up to 20 feet in length.
- A vent pipe must rise vertically to a point at least 6 inches above the flood level rim of the fixture it serves before it can be offset horizontally and connect to any other vent. See Figure 3-23.
- Vent stacks may sometimes have a dual role. In some installations they both supply and remove the air from a drainage system, and serve as cleanouts for inserting a cleaning cable. An installation must meet these requirements in order to qualify for this dual role:

  1) It's a one-story building with not more than one 90-degree change in direction in the drainage system.

2) The vent stack is vertical throughout (without any offsets) and extends up through the roof.

3) The vent stack or combination of vent stacks are equal in area to the required sewer for the building.

Special Venting Systems

The following installations require special venting systems.

Venting Island Sinks

Island sinks, and other fixtures located away from walls and partitions, are becoming more and more common in construction. As you might guess, you have to use special venting arrangements for them.

Example

Figure 3-24 shows an arrangement that's clearly acceptable under the regulations of the *Uniform Plumbing Code*, and probably most other codes as well. To vent this island sink according to code requirements, follow the guidelines shown in this example:

1) The island sink and similar equipment traps must be roughed-in above the floor. The vent is extended at least as high as the underside of the drainboard, and then turned downward to connect to the horizontal sink waste pipe immediately downstream from the vertical sink waste pipe.

2) You connect the return vent to the horizontal waste pipe through a wye-branch fitting. Provide a foot vent at the base of the vertical fixture vent by using a wye-branch fitting roughed-in below the floor that extends to the nearest partition. This vent should then extend separately through the roof or connect to another vent if one is available.

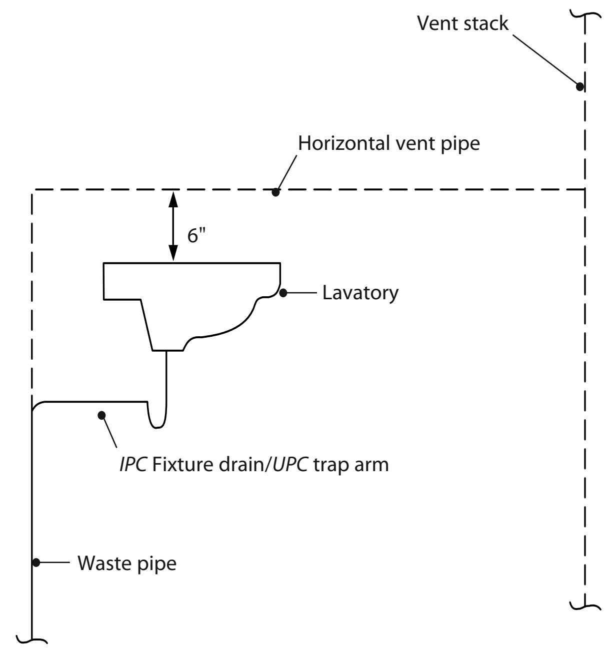

Figure 3-23
Minimum height of vent pipe above floor-level rim of fixture

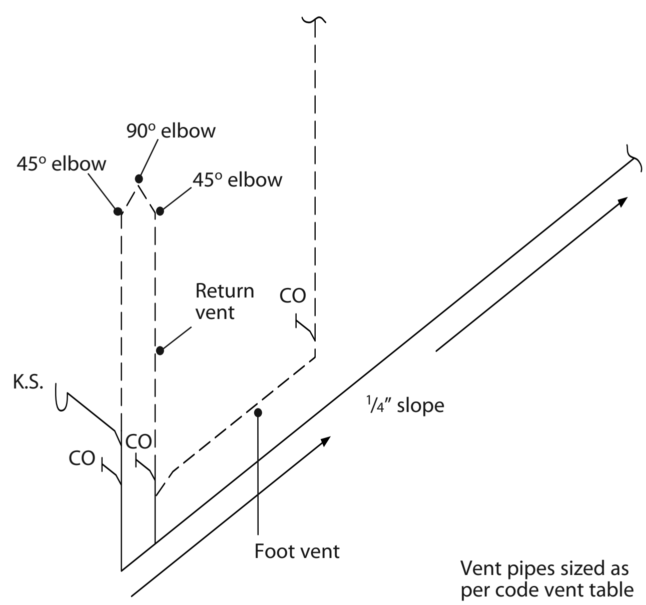

Figure 3-24
Venting an island sink

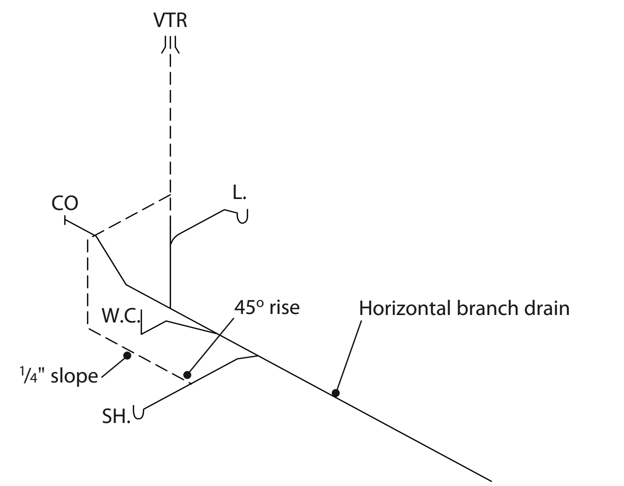

Figure 3-25
Re-venting a minor fixture located downstream from a water closet

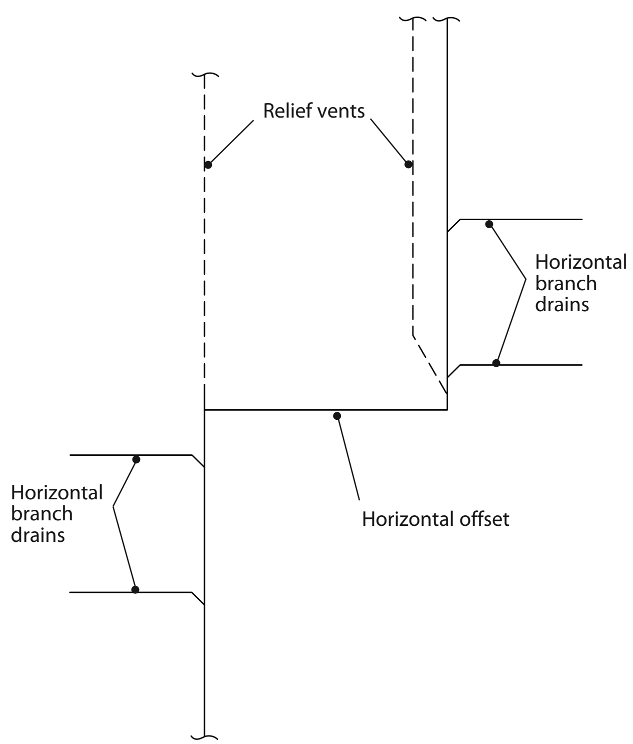

Figure 3-26
IPC Venting horizontal offset in a vertical stack

3) Make sure the fittings below the floor are the drainage type and that the vent has a minimum slope of $^1/_4$ inch per foot back toward the drain pipe. The return bend under the drainboard must be a one-piece fitting or it should be assembled using a 45-degree, a 90-degree and then another 45-degree elbow (in that order).

4) You can use the code vent table in your code book to size the pipes.

5) The island sink waste pipe upstream from the return vent can't be used for any other fixture. You'll also need to install an accessible cleanout in the vertical portion of the foot vent.

Venting Required Downstream of a Toilet

When a fixture, such as a shower or bathtub, is located downstream from a major fixture, such as a water closet, you must vent the fixture. This is necessary to prevent siphonage of the fixture trap. Figure 3-25 illustrates the correct venting procedure.

Venting a Horizontal Offset in a Vertical Stack

Figure 3-26 illustrates how to vent a horizontal offset in a vertical stack. You must provide a relief vent at the top of the lower section and a vent at the base of the upper section, above the offset. Use the vent tables in your code book to size the pipes.

Wet Vents

Most codes permit this special method of venting in all types of occupancies. It provides adequate protection for fixture trap seals located along the vent (see Figure 3-27). Since it's a single piping system, it's economical and can serve to vent several adjoining plumbing fixtures located on the same floor level.

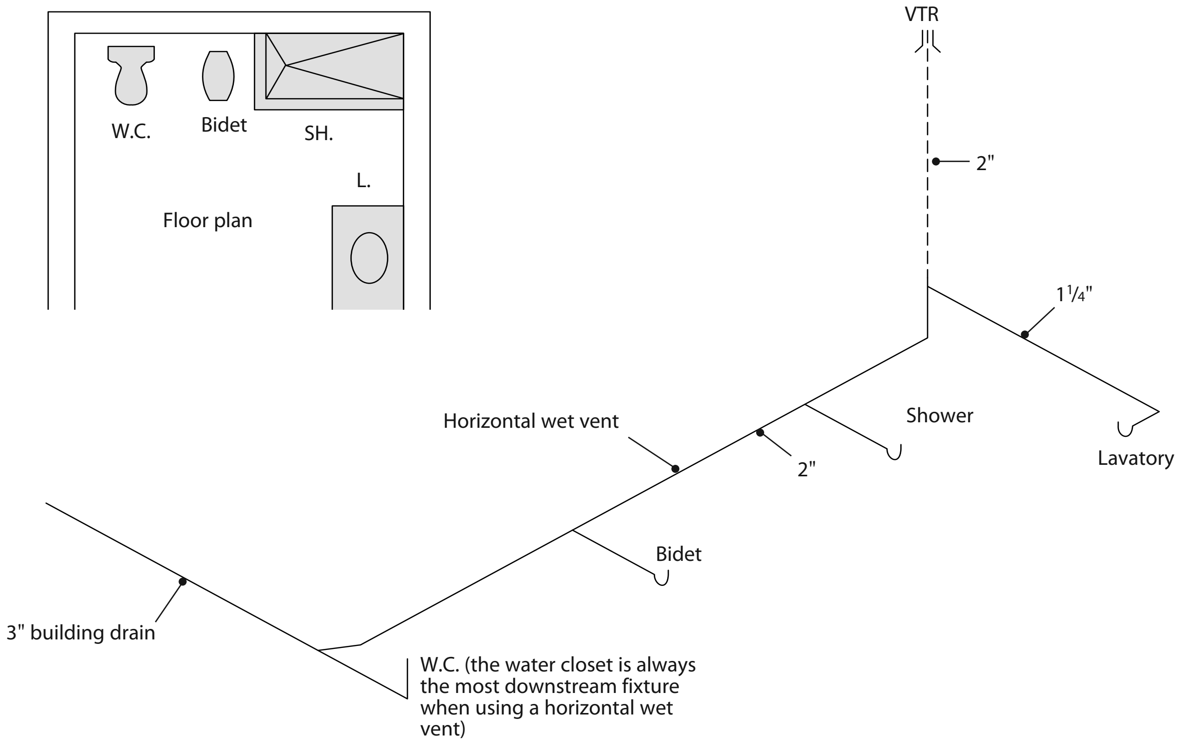

Figure 3-27
Horizontal wet vent (UPC and IPC)

A wet vent may be vertical or horizontal (refer back to Figure 3-17). As a wet vent, it can convey waste only from fixtures with low unit ratings. This excludes water closets and similar fixtures. Because a wet vent serves a dual purpose, the plumbing code has placed a number of restrictions on its use. The restrictions, pipe sizes and maximum capacities for wet vents are as follows:

- A horizontal wet vent may be used for up to two bathroom groups located on the same floor level.
- A $1^1/_2$-inch horizontal wet vent can convey one fixture unit (*IPC*).
- A 2-inch horizontal wet vent can convey up to four fixture units. Water closets and fixtures requiring a waste opening greater than 2 inches can't use a wet vent.
- A $2^1/_2$-inch horizontal wet vent can convey up to 6 fixture units (*IPC*). Water closets or other fixtures requiring a waste opening greater than 3 inches aren't permitted.
- A 3-inch horizontal wet vent can convey up to 12 fixture units (*IPC*). The *UPC* allows five or more. Water closets or other fixtures requiring a waste opening greater than 4 inches aren't permitted.
- The water closet must always be the most downstream fixture in a horizontal wet vent system.

Remember to always check local codes for their specific requirements regarding wet vent installations.

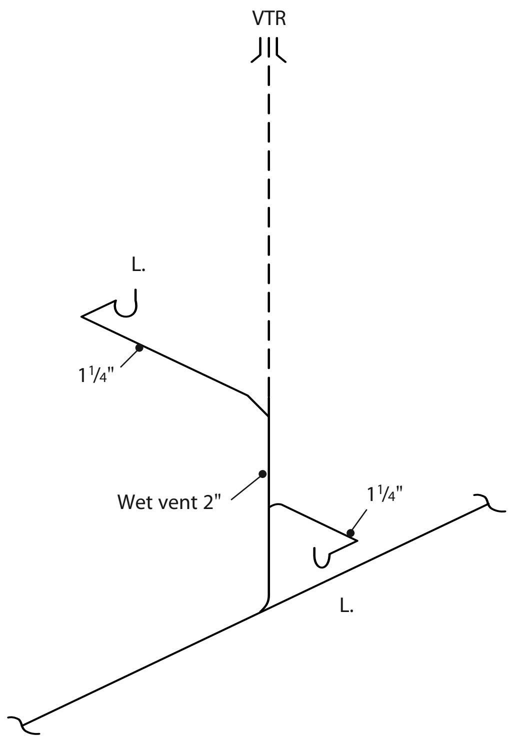

Figure 3-28
Wet venting fixtures at different levels

Venting Fixtures at Different Levels

You can use a common vent when two fixtures are connected to a stack at different levels. The vertical drain (wet vent) must be one pipe diameter larger than the highest fixture drain, but never smaller than the lower fixture drain. Figure 3-28 shows an example of a vertical wet vent.

Sump Vents

When there's a sub-building drain in a basement that conveys body waste to a sump or retaining tank, you must install a local vent for the tank. A sump or retaining tank must have a gas- and air-tight cover. A local vent will permit the air within the tank to escape as the sewage enters. When the sewage is ejected, the vent will permit air to re-enter the tank. This keeps the sub-building drainage system from becoming air-locked and useless.

The following venting procedures are accepted by most plumbing codes:

- The sump vent may extend independently up and through the building roof.
- The sump vent may be connected to an existing vent system of the same size or to a larger size vent pipe.

Sumps receiving clear water waste from buildings, subsoil drains, floor drains, air conditioning condensate drains, etc., don't need a cover or a vent.

Waste Stack Venting

The terms *vertical combination waste and vent stack* may be more familiar than *waste stack* venting, as used here and in the code. Waste stack venting is a vertical pipe that receives the discharge from fixtures other than high-fixture-unit-rated ones like water closets and urinals. The code prohibits offsets in the vertical portion of the drainage pipe. Each fixture drain must connect separately to the waste stack, which must be the same size throughout its length.

This type of installation is used most often in a high-rise building for receiving the waste, and for venting specific-type plumbing fixtures. You can use it to your advantage in any multistory building where plumbing fixtures are located directly over each other on different floor levels. It's both economical and practical because it's an installation that uses a single vertical pipe riser.

The *IPC* requires a *stack vent* extending through the roof be provided for the waste stack, and it must not be smaller than the waste stack. For example: If the waste stack is 3 inches, then the stack vent must also be 3 inches. The stack vent may have offsets if necessary. Any offset must be at least 6 inches above the flood level rim of the highest fixture. Look back to Figure 3-23. The vent pipe must be graded to drain back to the drainage pipe by gravity.

Use *IPC* Table 913.4 (Figure 3-29) to size waste stack vents according to the number of drainage fixture units. These tables don't mention the length for the stacks. Check with your inspector for the approved length in your work area before installing this type of system. Figure 3-30 illustrates two ways a waste stack vent may be used. The fixtures are kitchen sinks, though the *Uniform Plumbing Code* doesn't accept the type of vertical combination waste and vent system shown.

To conform to the *Uniform Plumbing Code*, you must meet the following additional provisions:

- Vertical wet venting is limited to vertical waste piping receiving wastes from fixtures with low unit ratings.

Table 913.4 Waste Stack Vent Size		
	Maximum Number of Drainage Fixture Units (dfu)	
Stack Size (inches)	Total discharge into one branch interval	Total discharge for stack
$1^1/_2$	1	2
2	2	4
$2^1/_2$	No limit	8
3	No limit	24
4	No limit	50
5	No limit	75
6	No limit	100

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Figure 3-29
Vertical combination waste and vent (IPC)

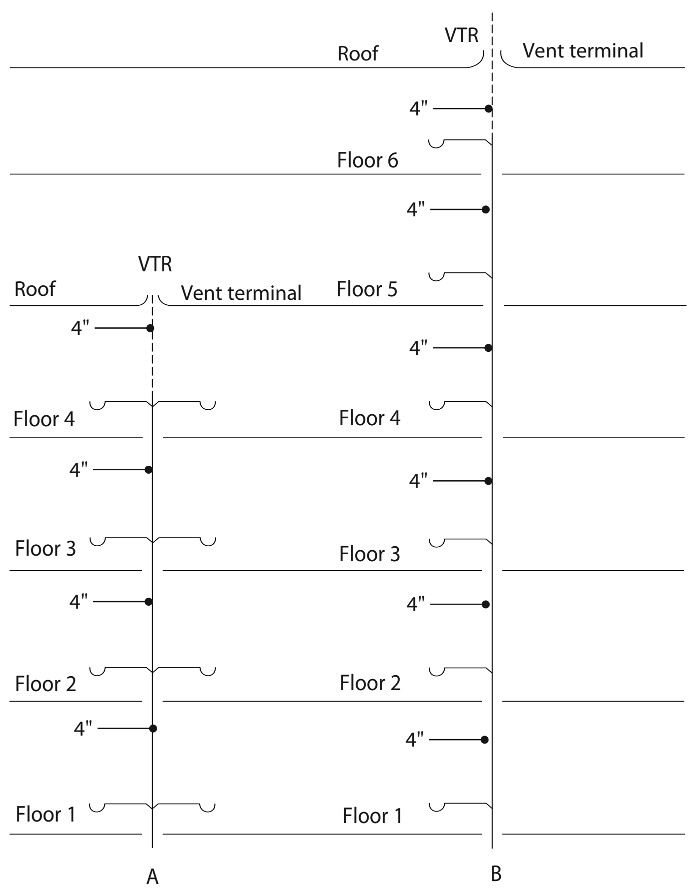
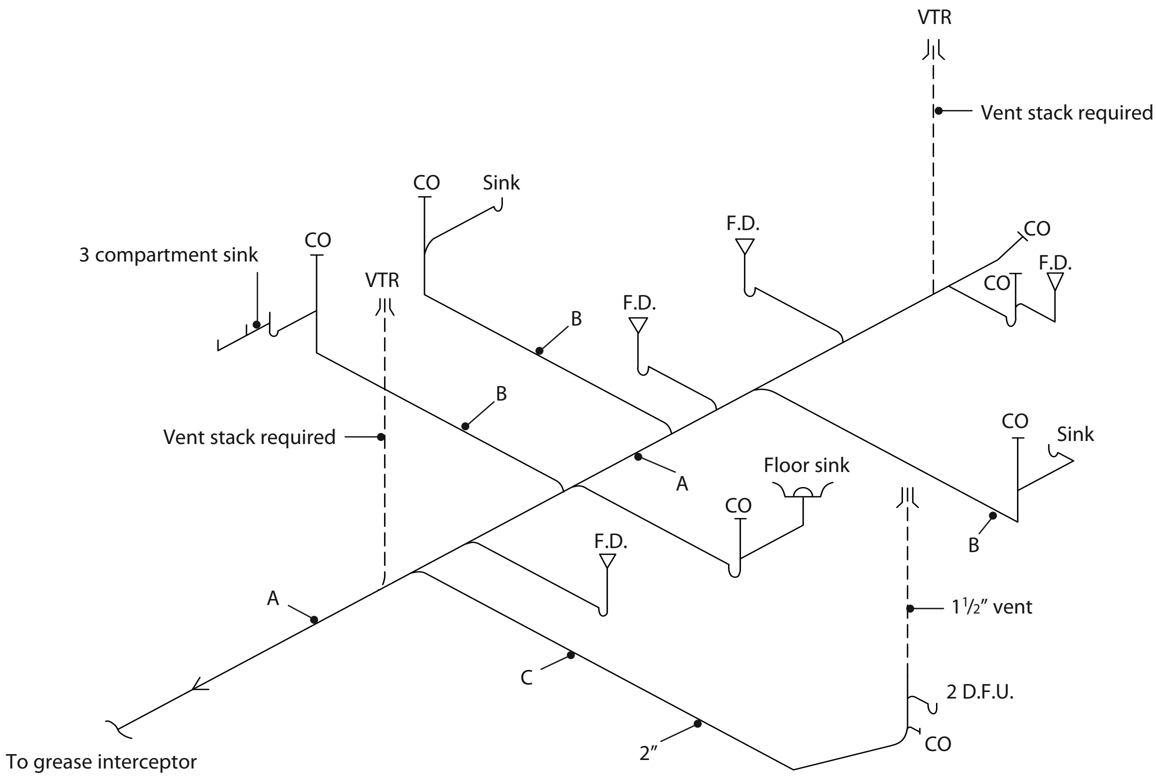


Figure 3-30
Vertical combination waste and vent (IPC)



Notes

A Minimum size of main waste pipe (A) is 6", for a total of 96 F.U. For systems that exceed 96 F.U. the main waste pipe must be two pipe sizes larger than the required sizes as listed in Figures 2-15 and 2-16 for building drains and horizontal branch drains.

B Branch drains (B) for horizontal combination waste and vent system, as illustrated, must be two pipe sizes larger than the required sizes as listed in Figures 2-15 and 2-16 for building drains and horizontal drains.

C Plumbing fixtures with up to three D.F.U. may connect to drainage system by conventional method. Size according to Figures 2-15 and 2-16.

Figure 3-31

Horizontal combination waste and vent system

- The ratings of each fixture can be no more than two fixture units.
- Only four such fixtures can be used.
- The maximum number of fixture units on this vertical wet vent system is eight.
- All wet vented fixtures must be within the same story.
- No vertical wet vent can exceed 6 feet in developed length.

When in doubt about which provisions apply in your area, check with your local code. Some codes may not accept this type of installation at all.

Horizontal Combination Waste and Vent System

Certain plumbing fixtures (usually found in commercial establishments, such as supermarkets or large warehouses with floor drainage) are permitted to use this special system for receiving waste and for venting. It's a one-pipe method you can use where special plumbing fixtures and regular plumbing fixtures aren't adjacent to walls or partitions.

The system is limited to sinks, floor sinks, indirect waste receptors, floor drains or similar applications. The trap of the fixture isn't always individually vented for this type installation. See Figure 3-31.

There's usually code agreement on the basic principles of this type of installation. However, don't install a horizontal combination waste and vent system until you've had your plans and specifications approved by your local administrative authority.

Special Requirements for Horizontal Combination Waste and Vent Systems

The plumbing code has placed a number of restrictions on the use of this type of system. They are:

- Because of possible venting problems, appurtenances (certain types of equipment) delivering large quantities of waste shouldn't discharge into a horizontal combination waste and vent system.
- The horizontal waste pipe and each fixture trap must be at least two pipe sizes larger than the code requires for regular systems.
- The vertical waste pipe must be two pipe sizes larger than the fixture outlet.
- There must be a cleanout installed in the top of the connecting waste tee.
- You must size the floor sink and waste pipe from the floor sink to the trap for the total fixture units.
- Be sure to provide a vent at the upstream end of the waste pipe as well as downstream from all fixtures in the system.
- Design the system to assure that the vertical distance from fixture or drain outlet to the trap (weir) doesn't exceed 24 inches.
- In large installations where you can't avoid long runs, install relief vents at intervals of not more than 100 feet.
- Some codes require that you have a separate vent, installed in an approved manner, for a branch drain exceeding 15 feet.
- You should size vents in accordance with code requirements, but be sure you extend the same size pipe as the waste pipe to a point 6 inches above the flood level rim of the highest fixture before you make any reduction in size.

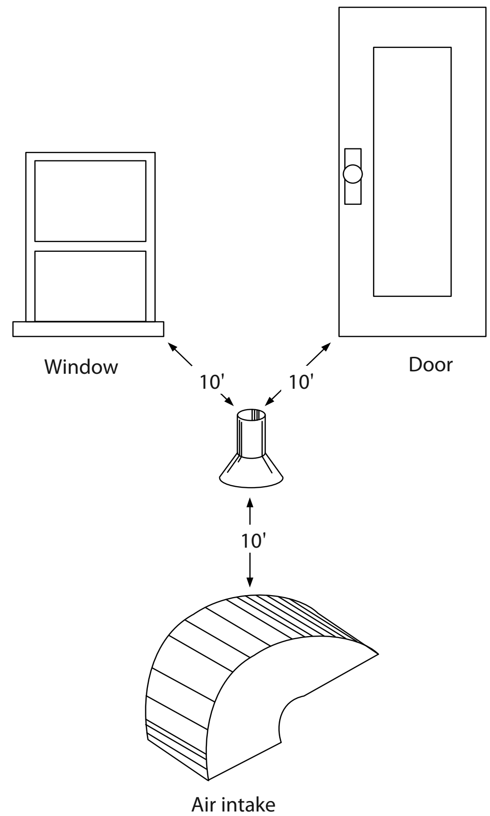


Figure 3-32
Code requirements for vent terminals

Vent Terminals

The following requirements apply to the termination of vent pipes:

Roof termination:

- Terminate vent pipe extensions at least 6 inches above the roof. This ensures that gases and odors in all parts of the drainage system will discharge well above the roof surface. The *IPC* allows for as little as two inches when the vent is protected from another roof or solar panel.
- Where vent pipes penetrate the building roof, you must install approved flashing to make the joint watertight.
- You may not install a vent terminal for a sanitary system within 10 feet of any door, window that opens, or ventilating opening, unless it extends at least 3 feet above (or 2 feet in some codes) the top of that opening. See Figure 3-32.

Nominal pipe size (in)	Cross-sectional area (sq. in.)
$1\frac{1}{2}$"	(1.5 x 1.5 x .7854) = 1.7671
2"	(2 x 2 x .7854) = 3.1416
$2\frac{1}{2}$"	(2.5 x 2.5 x .7854) = 4.9087
3"	(3 x 3 x .7854) = 7.0686
$3\frac{1}{2}$"	(3.5 x 3.5 x .7854) = 9.6212
4"	(4 x 4 x .7854) = 12.5664

Figure 3-33
Aggregate cross-sectional area of pipes

- The *UPC* requires a vent pipe terminal must be at least 3 feet in any direction from any lot line, alley or street, and the *IPC* requires 10 feet.
- Where danger of frost closure exists, any vent extension through a roof must be a minimum of 3 inches in diameter (or 2 inches in some codes). If it's necessary to increase the size of the vent terminal, you must make the change in diameter inside the building, at least 12 inches below the roof, and terminate the vent pipe at least 10 inches (6 inches in some codes) above the roof. (Refer back to Figure 3-20.)
- Do not allow vent terminals to be used to support flags, TV aerials, clotheslines or other similar items.

Sidewall vent termination:

- The *IPC* allows for sidewall vent termination as long as it is 10 feet above grade, 10 feet from a property line and effectively screened to prevent birds or rodents from blocking the vent.
- If a roof is used as a sun deck, solarium or similar function, the vent must extend a minimum of 7 feet above the roof deck.
- A vent pipe installed outdoors must be at least 10 feet above the surrounding ground, located at least 3 feet (10 feet in some codes) from any lot line, and be securely supported.

  This type of installation is generally used in venting a sewage system located in a trailer park. (For more information regarding trailer park installations, see Chapter 10.)
- Some codes put limits on the height at which you can use certain materials for vent extensions These include cast iron, copper or screw pipe, or plastic piping. When conditions call for an extension, always check your code for approved materials.

Aggregate Cross-sectional Area of Pipe

The code is careful to insist that you vent a building drainage system by means of one or more pipes. The rule of thumb is that the aggregate cross-sectional area can't be less than that of the largest required building sewer.

How does that play out for the plumber? Figure 3-33 shows the cross-sectional areas of various pipe sizes up to 4 inches. But for pipe sizes other than those shown, to find the cross-sectional area of a building sewer, use the following formula. You'll probably find the formula is familiar.

The square of the diameter of a circle multiplied by .7854 equals the area of the circle.

Let's test out the formula by calculating a pipe size shown in the table so we'll know if we have it right:

If a building sewer is 4 inches, the cross-sectional area of the sewer equals $4 \times 4 \times .7854 = 12.5664$ square inches. So, the total cross-sectional area of the vent pipes can't be smaller than the cross-sectional area of the sewer, or 12.5664 square inches. That's what the table shows.

To find the total aggregate cross-sectional area of pipe, you calculate the total cross-sectional area of all the vent pipes and then add them together. For instance, if you have a vent system consisting of two 2-inch vent pipes and one 3-inch vent pipe, your calculations would look like this:

Vent # 1	*2 × 2 × .7854*	=	*3.1416 sq. inches*
Vent # 2	*2 × 2 × .7854*	=	*3.1416 sq. inches*
Vent # 3	*3 × 3 × .7854*	=	*+ 7.0686 sq. inches*
			13.3518 sq. inches

As you can see, the total cross-sectional area of these three vents (13.3518 square inches) is not less than the building sewer (12.5664 square inches), so they're adequate for this particular example.

Review Questions for Chapter 3 (answers are on page 277)

1. What are the two causes of fixture trap seal loss that vent systems protect against in normal fixture use?
2. What is battery venting?
3. What is the function of a branch vent?
4. How is a common vent used in a plumbing system?
5. What is a continuous vent?
6. What other term is used to describe a continuous vent?
7. What is the term used to describe a vent that does not receive any sewage discharge?
8. How many fixture traps can an individual vent serve?
9. How is a main vent defined in the code?
10. What is the primary function of a relief vent?
11. What is the definition of a side vent?
12. What is the definition of a stack vent?
13. What is the function of a vent header?
14. What is the primary purpose of a vent stack?
15. What two purposes does a wet vent serve?
16. What purpose does a yoke vent serve?
17. What is another term used to describe back pressure?
18. What can occur if you have negative pressure in a fixture drain?
19. According to the *International Plumbing Code*, what's the minimum diameter required for a vent extension through the roof in a frost-prone climate?
20. According to the *Uniform Plumbing Code*, how far above the roof must a roof vent in a cold climate terminate?
21. What does the free flow of air within the sanitary drainage system prevent?
22. How must the height of a vent pipe change as the maximum fixture unit load increases?
23. What is the vent stack requirement for a building with a single building sewer?
24. When a water closet is located in an accessory building, what is the minimum size vent accepted by code?
25. What is the minimum size "dry" vent allowed by code when venting a water closet?
26. What is the smallest individual vent size permitted by code?
27. What is the minimum size vent that can be used for a 3-inch drain pipe?
28. What factor determines the maximum length of any vent pipe?
29. What distance separation is required between a horizontal vent pipe and the flood level rim of the fixture served?
30. What is the term used to describe a kitchen sink that's located away from walls or partitions?
31. How many vents must you use to vent a horizontal offset in a vertical stack and what are they?
32. From what type of fixtures can a wet vent be used to convey waste?
33. How many fixture units will some codes allow on a 3-inch horizontal wet vent?
34. What do you call the vertical drain between two fixtures connected to a stack at different levels?
35. What kind of vent is required by code for a sump that receives body waste?
36. Why is a local vent needed on a sump?
37. What are the venting requirements for sumps receiving clear water waste?
38. In what type building do some codes permit the use of vertical combination waste and wet vent piping?
39. What fixtures are prohibited from discharging into a combination waste and vent stack?
40. In what type of establishments are horizontal combination waste and vent systems usually installed?

41. Name three fixtures that may connect to a horizontal combination waste and vent system.

42. What is an important requirement before you can install a horizontal combination waste and vent system?

43. Why do codes prohibit the connection of appurtenances delivering large quantities of water to a horizontal combination waste and vent system?

44. What is the minimum distance from a door that you may install a terminal for a sanitary vent system?

45. How high above the roof must a vent terminal extend?

46. What does the code require to be installed on a sidewall vent that extends through a wall?

47. Under what area should you never terminate a vent pipe?

48. What is the minimum height above ground level that a vent pipe must terminate when it's installed outdoors?

49. What's the "rule of thumb" for determining the minimum aggregate cross-sectional area required for the vents used in venting a building drainage system?

50. What is the formula you use to find the cross-sectional area of a pipe?

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4

Fixture Traps

By the mid 1850s, plumbing fixtures had been installed in a number of homes in New York City. For these early installations, the plumbers installed a handmade trap in the drain of individual fixtures. Of course, the intent was to prevent the entrance of odors and sewer gases. In those days, fixture traps often lost their water seals due to siphonage and back pressure. That led to two public health problems. First, rats could travel freely from building to building. And second, offensive odors from decomposing sewage in drainage systems permeated the buildings.

All efforts to use check valves and other specially-designed traps to prevent fixture trap seal loss proved ineffective. The principle of venting fixture drains was simply not known at that time. But the design and regulation of plumbing systems progressed rapidly after about 1900.

Building Traps

Health officials required building traps installed on each sanitary or combined building sewer. These proved to be generally effective. See Figure 4-1. They also provided a *secondary* safeguard to keep rats, vermin, sewer gases and odors out of a building. (The individual fixture traps provided the *primary* safeguard.)

That requirement for building traps was a big advance at the time. But since the development of modern collection, drainage and venting systems, most model codes don't require (and in fact actually *prohibit*) building traps.

In areas where sewer gases are extremely corrosive, there may even be a risk of explosions in the public sewer system, especially in larger cities. Occasionally you'll hear news reports of manhole covers blowing off, causing considerable damage. In those areas, local authorities may still require a building trap installed in the building drain line.

So building traps haven't entirely vanished. In the rare situations where they're required, install them as shown in Figure 4-1. It's important to install the cleanouts correctly. Because the building trap is a collection point, it invites stoppages. As always, refer to your local code before you plan the installation of a building trap.

Fixture Traps

The code requires that plumbing fixtures connect directly to the sanitary drainage system and include a water seal trap. Each fixture must be separately trapped, unless they have integral traps built into the fixture body (like a water closet). Integral traps have to meet appropriate manufacturing standards.

Traps are designed and constructed to provide a liquid seal. And they have to provide this protection without materially affecting the flow of sewage or other waste liquids.

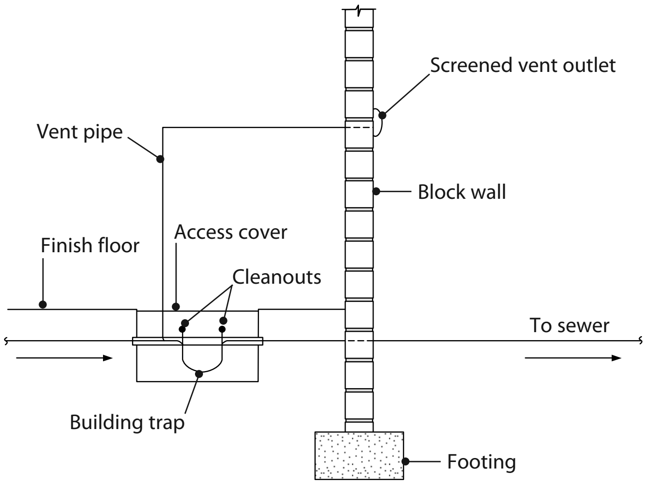

Figure 4-1
Building trap detail — isometric (not always code-approved)

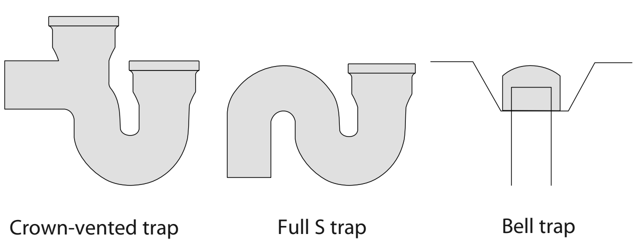

Figure 4-2
*These traps are **prohibited** by code*

Because of the trap's unique importance in protecting public health, the code places many restrictions and limitations on its use. Some of these are listed below. We'll discuss other requirements separately in more detail later.

Here are some of the special trap requirements:

- Fixture traps must be self-cleaning, with the exception of interceptor traps.
- No trap outlet may be larger than the fixture drain to which it's connected. For example, you can't connect a $1^1/_2$-inch trap to a $1^1/_4$-inch drain by using a reducer.
- You can't use any trap which depends on the action of movable parts to retain its seal.
- You can't use any trap with a single barrier or partition.
- Both the *IPC* and *UPC* prohibit bell traps, crown-vented traps, pot traps, running traps, $^3/_4$ S traps, full S traps, drum traps, and traps with more than one slip-joint nut and washer on the discharge side of the trap above the water seal. See Figure 4-2.
- Each fixture trap must have a water seal that's between 2 and 4 inches deep. See Figure 4-3. The only exception is for interceptor traps, which all require deeper seals.
- Fixture traps installed below concrete floors on fill (or otherwise concealed) can't have trap cleanouts.
- All traps must be installed level in relation to their water seals. This prevents negative action and self-siphonage. A pipe that's not level also creates a bad joint for the fixture tailpiece. See Figure 4-4.

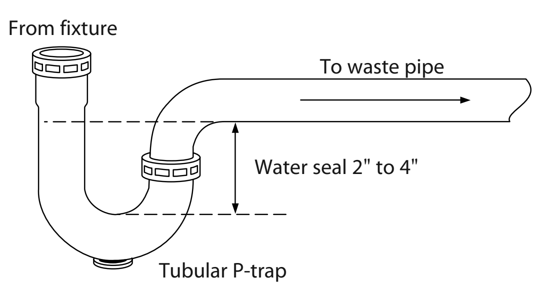

Figure 4-3
Minimum and maximum trap water seal

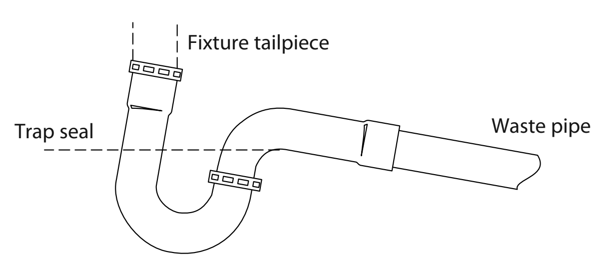

Figure 4-4
Improperly installed trap

- Each plumbing fixture must be separately trapped by a water seal trap with the following exceptions: water closets, urinals or similar fixtures that have integral traps. No fixture can be double trapped. See Figure 4-5.
- Two or three compartment sinks or laundry tubs of equal depth may connect to a single trap with a continuous waste. See Figure 4-6.
- Two or three lavatories adjacent to each other may connect to a single trap if (a) the waste outlets don't exceed 30 inches, center to center, and (b) the trap is centrally located between the three lavatories. See Figure 4-7.
- Restaurant, commercial and industrial sinks served by a single trap can't receive the discharge from a food waste disposal unit. Each food waste disposal unit must be separately trapped. See Figure 4-8.
- A residential food waste disposal unit may be trapped separately from any other fixture or fixture compartment.
- A residential food waste disposal unit may discharge through the continuous waste of a sink. When that's allowed, you must use a directional tee or other approved method served by a single trap. See Figure 4-9.
- Some codes permit a domestic clothes washer to use the same trap serving a laundry tray, if it's adjacent to the laundry tray. See Figure 4-10.
- Codes prohibit the connection of clothes washers or laundry trays to a trap serving a kitchen sink.

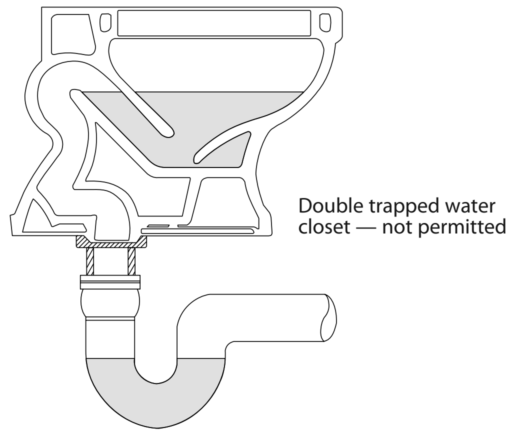

Figure 4-5
No fixture can be double trapped

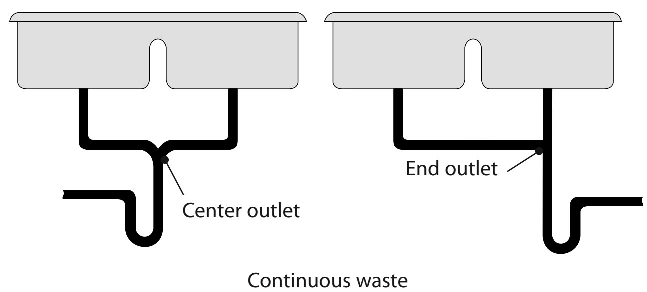

Figure 4-6
Two-compartment sink with one trap, approved

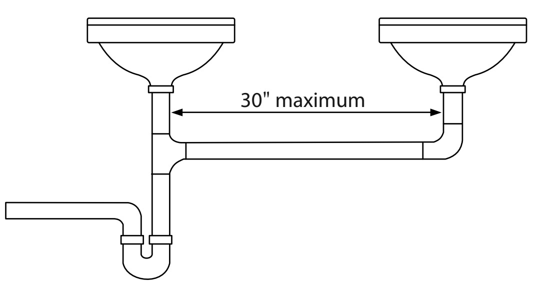

Figure 4-7
Two lavatories with one trap, approved

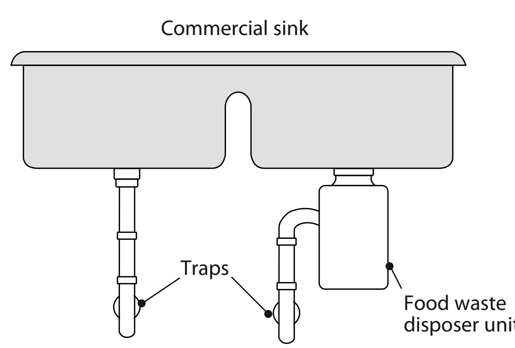

Figure 4-8
Commercial food waste disposer unit must be separately trapped

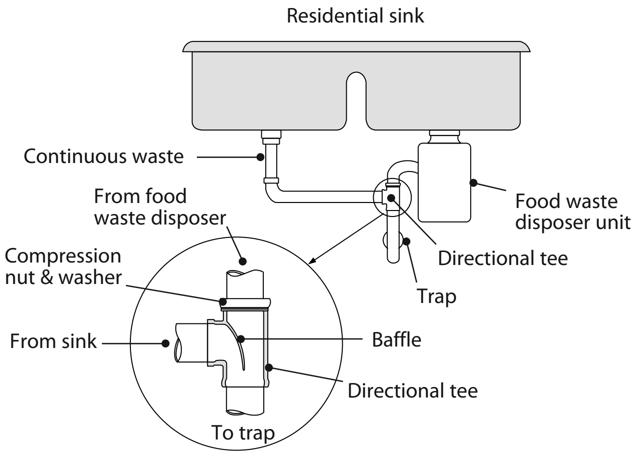

Figure 4-9
Typical residential food waste disposer installation using directional tee

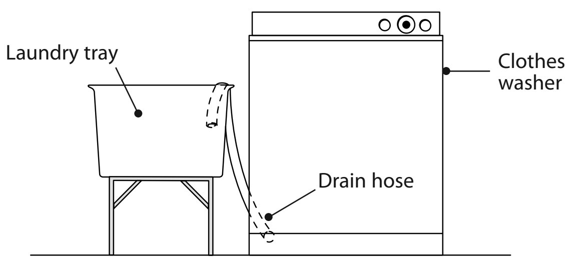

Figure 4-10
Clothes washer and laundry tray using same trap

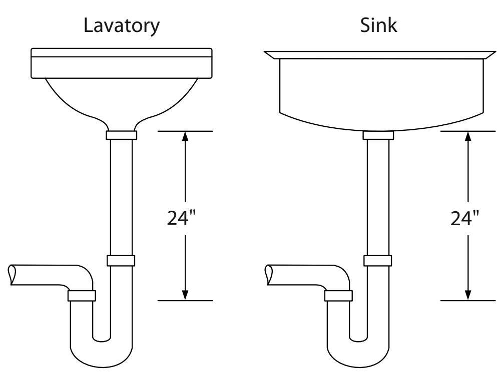

Figure 4-11
Maximum vertical drop from fixture waste outlet to the trap water seal

- Materials for concealed fixture traps (bathtubs, showers, floor drains and similar fixtures) must be cast brass, cast iron, lead, ABS plastic, PVC plastic, or other approved materials. Cleanouts are not allowed on concealed fixture traps.
- Except for fixtures with integral traps, exposed or accessible traps must be of cast iron, cast brass, lead, 17 gauge tubular brass, or copper. Some codes will accept 20 gauge tubular traps. In a plastic system, you must use ABS or PVC traps. Exposed fixture traps may be equipped with cleanouts.
- Traps for chemical, acid or corrosive wastes must be constructed of borosilicate glass, high silicon cast iron, lead pipe with walls at least $^1/_8$ inch thick, or other approved materials.
- There's a maximum vertical drop from a fixture waste outlet to the trap water seal. For kitchen sinks, lavatories, showers, bathtubs, and laundry tray fixtures, the allowable vertical drop is 24 inches. This further prevents self-siphonage of the fixture trap water seal. The shorter the distance between these two points, the more efficient the fixture trap will be. See Figure 4-11.
- The vertical length of a washing machine standpipe can't exceed 42 inches. The vertical standpipe inlet can't be less than 18 inches above the finished floor.
- The vertical drop of the pipe serving floor-connected fixtures with integral traps (water closets, floor mounted urinals and similar fixtures) can't exceed 24 inches. See Figure 4-12.
- Floor drains are considered fixtures, so they're governed by the same 24-inch tailpiece (pipe) limit shown in Figure 4-11. Since it's often difficult to meet code limits, the *IPC* makes an exception for fixtures that are self-siphoning, such as water closets. The *IPC* allows a fixture drain (trap arm) of unlimited length; the *UPC* allows one up to 6 feet in length. See Figure 4-13.

Fixture Trap Sizes

One of the main reasons for code-established fixture trap sizes is to ensure they'll drain the fixture rapidly. Never use sizes smaller than those listed in Figure 4-14. You'll find a more complete listing of trap sizes in your code book.

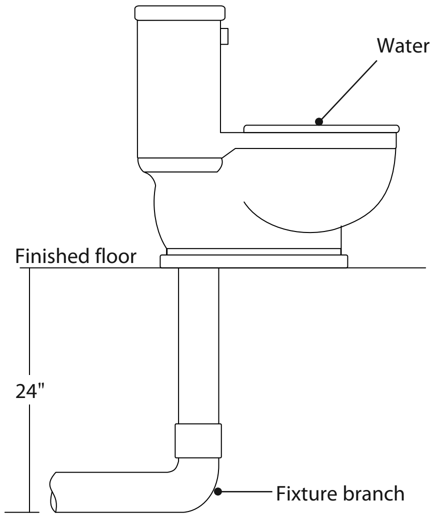

Figure 4-12
Maximum vertical drop from floor-mounted fixtures with integral trap

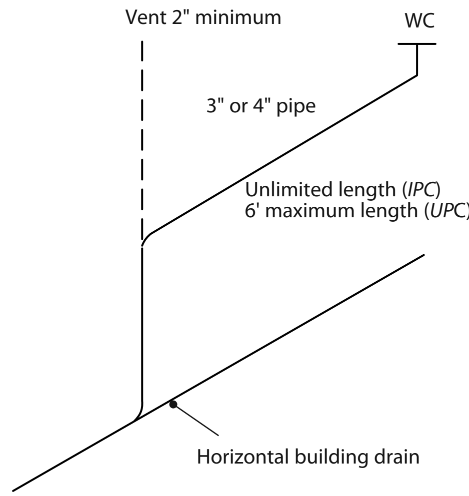

Figure 4-13
Special floor drain installation illustrating maximum water closet trap arm lengths

Horizontal Distance of Fixture Trap from the Vent

In the 1920s, the U.S. Department of Commerce made a substantial effort to establish standards for many plumbing requirements. Most codes now reflect those standards. But unfortunately, model codes differ greatly in several requirements, including the distance of traps from vents and fixture drain sizes. Refer to the table adopted by your local authority for this particular section of the code.

Figure 4-15 shows the discrepancies. The first table shows the requirements in the *International Plumbing Code*. The second table is from the *Uniform Plumbing Code*. Both codes require the fixture drain slope to be $^1/_4$ inch per foot. But each has a different distance for the developed length of the fixture drain to the vent.

Let's look at one example. For a $1^1/_4$-inch trap, the *International Plumbing Code* sets a limit from trap to vent of 5 feet. The *Uniform Plumbing Code* sets a limit from trap to vent of $2^1/_2$ feet. The *IPC* allows the fixture drain (called a *trap arm* in the *UPC*) to be installed in a vertical direction. Differences in the codes exist because of the varied experiences and

Drainage fixture unit values (DFU)	Min. Size Trap and Trap Arm[3] (in)
Bathtub (or combination bath/shower)	$1^1/_2$
Bidet	$1^1/_4$
Clothes washer, domestic, standpipe[2]	2
Dental unit, cuspidor	$1^1/_4$
Dishwasher, domestic, with independent drain	$1^1/_2$ [1]
Drinking fountain or watercooler (per head)	$1^1/_4$
Food waste grinder, commercial	2
Food waste disposer, domestic	$1^1/_2$
Kitchen sink, domestic (with or without food-waste grinder and /or dishawasher)	$1^1/_2$ [1]
Lavatory, single	$1^1/_4$
Lavatory, in sets of two or three	$1^1/_2$
Laundry (with or without dishcharge from a clothes washer)	$1^1/_2$
Shower, single-head trap	2
Sink, commercial with food waste	$1^1/_2$ [1]

[1]Provide a 2" minimum drain.
[2]Buildings having a clothes-washing area with clothes washers in a battery of 3 or more clothes washers shall be rated at 6 fixture units each for purposes of sizing common horizontal and vertical drainage piping.
[3]Trap sizes shall not be increased to the point where the fixture disharge may be inadequate to maintain their self-scouring properties.

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Figure 4-14
Minimum size of nonintegral traps

International Plumbing Code		
Size of fixture drain (in)	Size of trap (in)	Distance from trap
1¼	1¼	5'0"
1½	1½	6'0"
2	2	8'0"
3	3	12'0"
4	4	16'0"

Uniform Plumbing Code		
Size of trap arm (in)	Size of trap (in)	Distance from trap
1¼	1¼	2'6"
1½	1½	3'6"
2	2	5'0"
3	3	6'0"
4 and larger	4	10'0"

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Figure 4-15
Horizontal distance of fixture trap from vent at slope of ¼" per foot

concerns of code development committee members within the two different code bodies. In this example, long trap arms are easier to install, but they're more difficult to maintain.

Here are the general principles for a horizontal run between fixture trap and vent (accepted by most codes):

- The closer the trap to the vent on a minimum slope, the better.
- Every fixture trap must be protected against siphonage and back pressure and have a vent piping system that permits the free flow of air under normal usage.
- Measure the developed length of a fixture drain from the crown weir of a fixture trap to the vent pipe. The measurement, including offsets and turns, must be within the prescribed limits set forth in your code book. See Figure 4-16.
- In some cases, because of the fixture location in a bathroom, kitchen or utility room, you have no option but to exceed the allowable length of the fixture drain. For such situations, both the *IPC* and the *UPC* allow you to increase the pipe size, thus allowing an increase in trap-arm length. However, the *UPC* only lets you increase it one pipe size, so if you increase the required 1½-inch trap size to 2 inches, you can increase the length of the trap arm from its maximum of 3½ feet to 5 feet. See Figure 4-17.
- The traps of floor drains, depending on drain pipe size, are limited by their distance from an individual vent or a vented drainage line. See Figure 4-18.

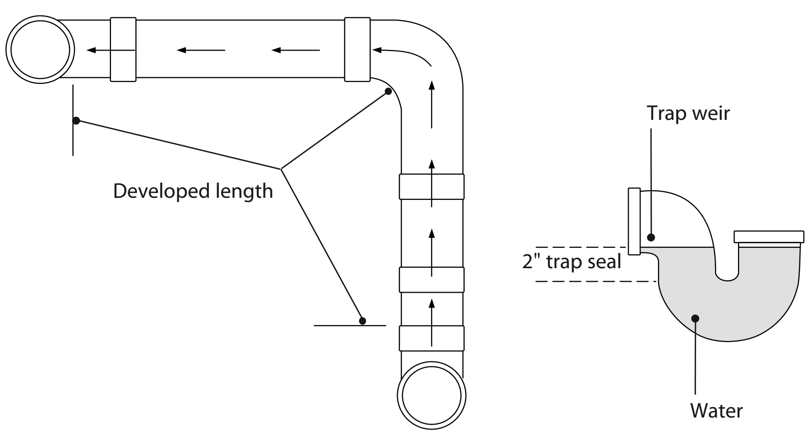

Figure 4-16
Developed length of fixture drain

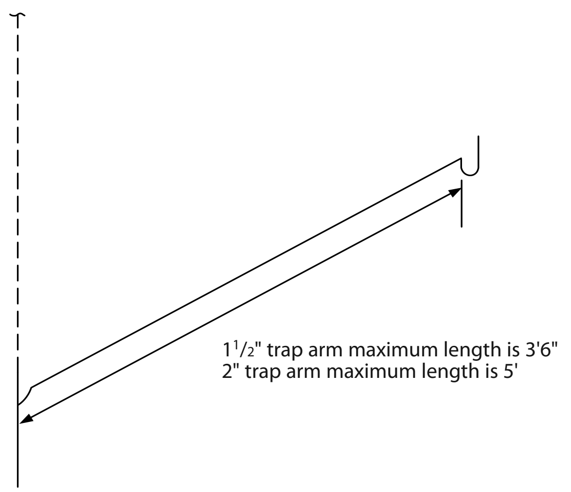

Figure 4-17
Increase of trap and trap arm size for a residential kitchen sink (UPC)

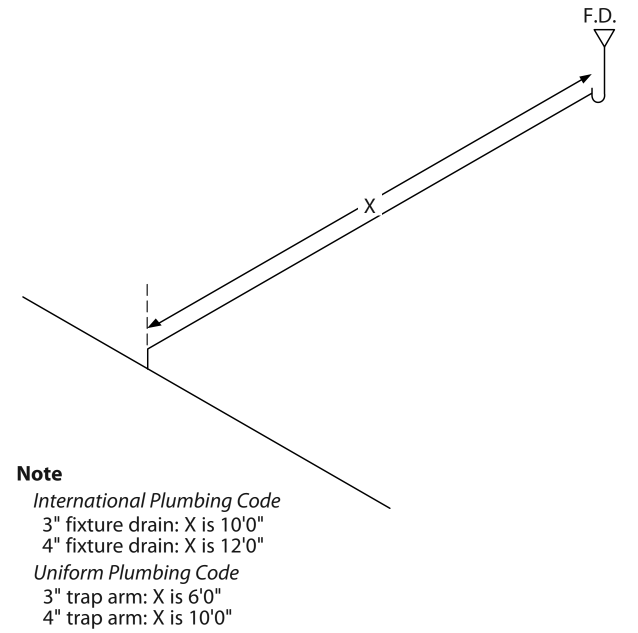

Figure 4-18
Maximum distance of floor drain from building drain

Unvented Lavatories

When a fixture drain/trap arm exceeds the code-accepted length, some codes permit the installation of up to three lavatories or one kitchen sink without re-venting, if:

1) The fixture drain/trap arm is at least 2 inches in diameter throughout its length.
2) The fixture waste outlets connect into the side (not top) of the fixture drain/trap arm.
3) The fixture drain/trap arm slopes no more than 1/4 inch per foot.

Before making this type installation, check your local code. See Figure 4-19.

Broken Trap Seals

There are five ways most likely to break the trap seals: trap siphonage, back pressure, wind effect, evaporation and capillary attraction. Improperly installed plumbing systems can cause trap seal loss by siphonage and back pressure. The other problems aren't related to the installation, and they're far less likely to occur.

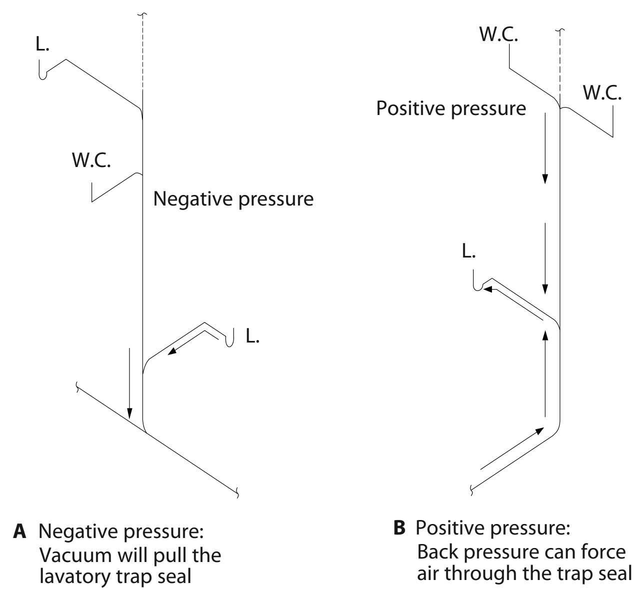

Figure 4-19
Major fixtures (water closets) can't be installed above minor fixtures (lavatories)

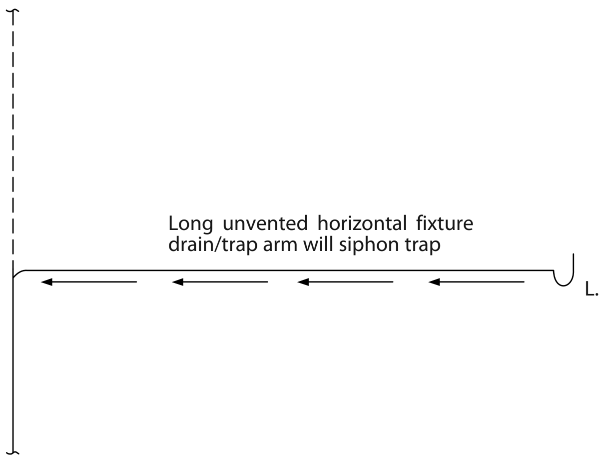

Figure 4-20
This type of installation is not permitted by code

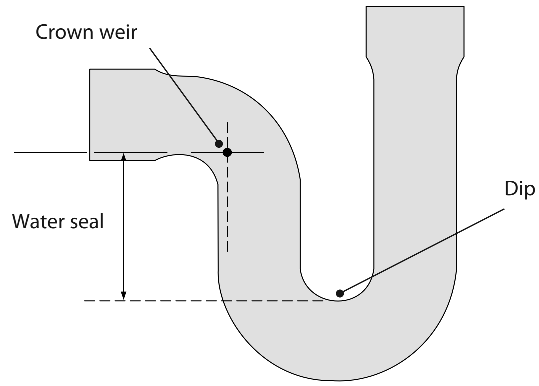

Figure 4-21
One-piece trap

Figure 4-19 shows two examples of trap siphonage due to improper design. Figure 4-20 shows a broken trap seal as a result of improper installation.

Parts of a Fixture Trap

You're probably already familiar with the parts of the two most commonly used traps in the plumbing trade. If not, Figure 4-21 should help you with the parts of a one-piece trap. Figure 4-22 will help you with the parts of a two-piece tubular trap. These simple things could be important on a plumbing examination.

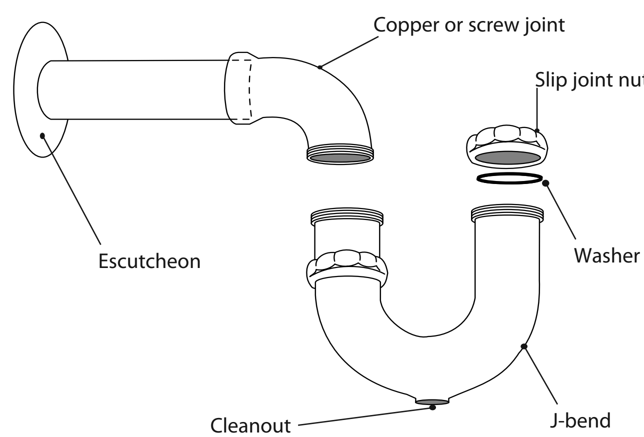

Figure 4-22
Two-piece tubular trap

Review Questions for Chapter 4 (answers are on page 280)

1. What is the purpose of a fixture trap?
2. Under what rare instances are building traps still required today?
3. When plumbing fixtures are connected directly to the drainage system, what must they be equipped with?
4. What must not be affected in the protection of a liquid seal?
5. What is the only kind of trap that doesn't have to be self-cleaning?
6. What rule governs the size of a trap outlet compared to its connecting fixture drain?
7. When can you use a trap that depends on the action of movable parts to retain its seal?
8. Name two traps prohibited by most model codes.
9. What is the minimum depth of fixture trap seals?
10. What is the maximum depth of fixture trap seals?
11. What kind of trap is exempted from the normally required depth of a trap water seal?
12. Where should you locate the cleanouts when you install fixture traps below a concrete floor on fill?
13. When installing a fixture trap, what do you consider when determining its correct level?
14. Why may a water closet not have a separate trap?
15. When can two or three lavatories adjacent to each other use a single trap?
16. Where must a single trap be located when three lavatories are connected to it?
17. According to code, when may a fixture be double trapped?
18. When may a food waste disposal unit in a restaurant discharge through a pot sink trap?
19. When, according to some codes, may a food waste disposal unit discharge through a continuous waste of a sink served by a single trap?
20. Under what circumstances can a domestic clothes washer use the same trap that serves a laundry tray?
21. Name two materials that the code approves for concealed fixture traps.
22. What does the code prohibit concealed fixture traps from having?
23. When a tubular trap is used, what minimum gauge must it be?
24. Name two acceptable materials commonly used for accessible fixture traps.
25. What code-approved materials may be used for chemical, acid or corrosive wastes?
26. If lead pipe is used to convey chemical, acid or corrosive wastes, what is the required wall thickness?
27. What is the maximum vertical drop from a shower outlet to the trap water seal?
28. What is the minimum height of a vertical standpipe inlet from the finished floor??
29. What is the maximum vertical drop of floor drains to the trap water seal?
30. What is one of the main reasons that fixture trap sizes were established by code?
31. Using the *UPC* table in Figure 4-15, what is the maximum length of a 3" trap arm?
32. What must every fixture trap be protected against?
33. When figuring the developed length of a fixture drain, what measurement, as well as the distance from the crown weir to the vent pipe, must be included?
34. In some instances, because of the fixture location, the fixture drain may exceed the limits set by code. When this occurs, what must be installed?
35. What are two adverse reactions to a fixture trap when a plumbing system is improperly installed?

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5

Cleanouts

Years ago, cleanouts weren't required on drainage piping. If you had an obstruction, you'd have to cut a hole in the blocked drainage pipe and insert a cleaning cable to remove it. Then you'd patch the hole with a cement mixture or other impervious material. Sooner or later your patch job would likely deteriorate and allow raw sewage to seep out. Then you have a health hazard for anybody in the area.

The major plumbing maintenance problem is, in fact, clogged drains. The most common cause of clogged drains is a foreign object or some substance that's not intended for a drainage pipe. Here are the most common causes of stoppages:

1) Foreign objects lodged in the drainage pipe: These can be pencils, toys, baby diapers, paper tissues, toothbrushes, sanitary napkins, overrim bowl deodorants, or anything else you can imagine. I've even found apples!

2) Accumulation of hair or other matter: There's no avoiding the problem of normal body hair accumulation. But there's no reason to make it worse. Pets should never be bathed in bathtubs or sinks of any kind. Avoid the use of bath oils. And don't use a clothes washer without a built-in lint catcher.

3) Deposits of grease or other substances: Grease, cooking oils, butter, gravy and coffee grounds can clog any kitchen drain. These materials should go out with the household garbage, not dumped into the kitchen drain, even if you have a garbage disposer.

All drainage piping is subject to stoppages, no matter how well designed the system. Accessible cleanouts will save you valuable time and the owner unnecessary expense. We're fortunate that cleanouts are now an absolute requirement for the drainage system. Today's model codes specify locations, distance between cleanouts, size, and other requirements.

The Importance of Accessible Cleanouts

Consider the relevant code when you design and install cleanouts for the building drain. It's essential that you provide complete access to all parts of the drainage system. Let's explore code requirements for this.

Location of Cleanouts

1) Many local authorities require a cleanout or test tee where a building sewer connects to the public sewer lateral at the property line. The *IPC* allows a test tee at this location serves a dual purpose. It serves as a cleanout and access for a test plug to perform a water test on a building sewer. See Figure 5-1. Some authorities require that a cleanout be extended up to the finished grade (Figure 5-2), while others don't. If you extend the cleanout to grade in an area with foot traffic, you'll have to countersink the cleanout head (Figure 5-3) to protect people from tripping and the cleanout from damage.

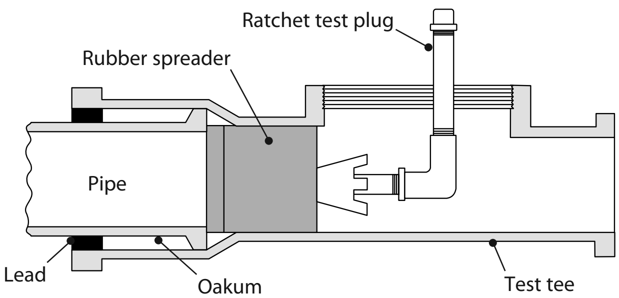


Figure 5-1
Test tee used for water testing building sewer and as a cleanout

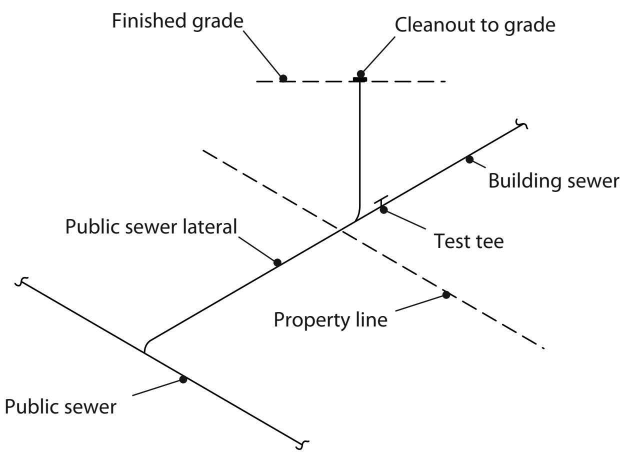


Figure 5-2
Cleanout extended up to finished grade

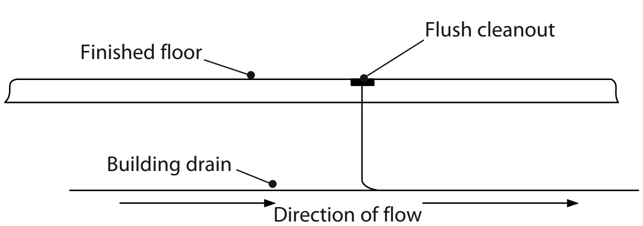


Figure 5-3
Countersunk cleanout

2) In most cases you'll have to locate a full-size cleanout outside the building at the junction of the building drain and the building sewer, usually within 2 feet (more in some codes) of the building line.

Some administrative authorities don't require this cleanout if there are other cleanouts upstream accessible to a 75-foot sewer cable. If you put a cleanout at this location, it must be a two-way fitting that permits upstream as well as downstream rodding. See Figure 5-4. This fitting may or may not have to be brought to grade, depending on local code requirements. And again, in an area that carries foot traffic, you'll have to countersink it (Figure 5-3).

3) Cleanouts are required on all building sewers at intervals not to exceed 100 feet in straight runs. See Figure 5-5.

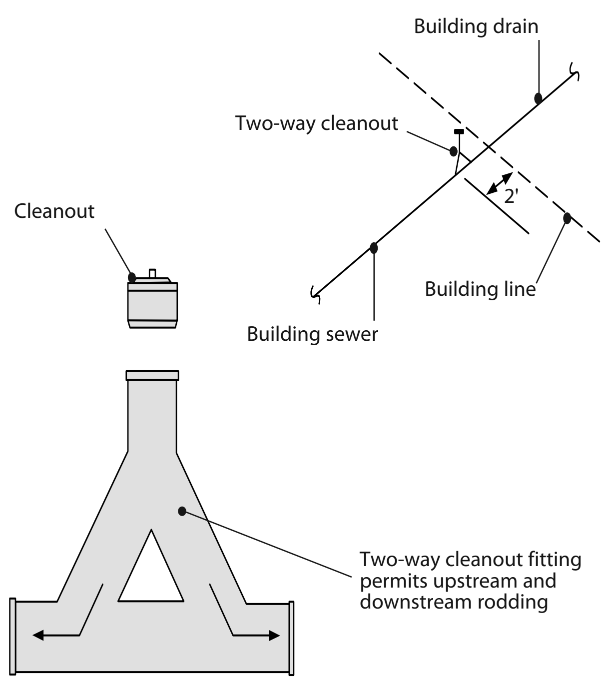
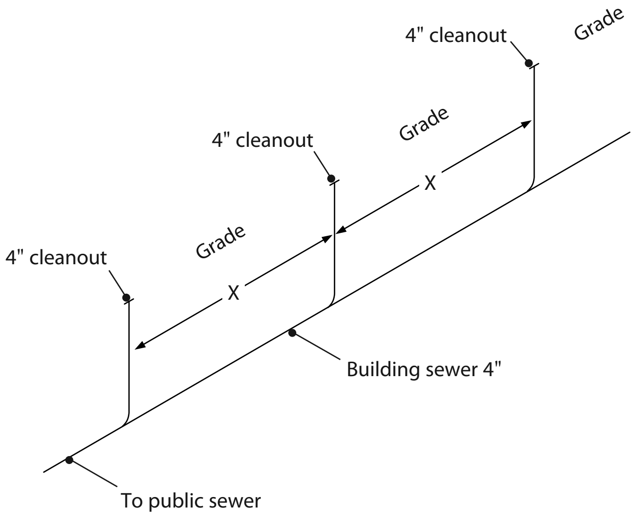


Figure 5-4
Two-way cleanout (shown isometrically)



Note Separation distances "X" vary according to code used. See text.

Figure 5-5
Cleanouts required

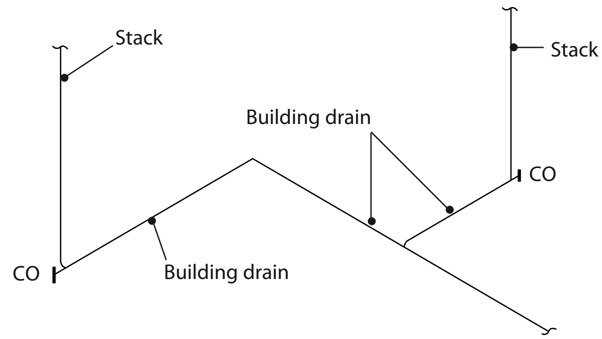


Figure 5-6
A cleanout must be provided at change of direction greater than 45 degrees (IPC)

4) Accessible cleanouts are required on all grade level horizontal drainage piping. Check your local code for the separation distances. For each change of direction greater than 45 degrees *(IPC)* or 135 degrees *(UPC)* you must provide a cleanout. Figure 5-6 shows required cleanout locations for compliance with the *IPC*.

5) You can put cleanouts in horizontal drainage lines beneath concrete flooring if they're accessible and flush with the finished floor. Cleanouts in walkways, hallways, and rooms must have countersunk plugs to prevent tripping or accidental injury. See Figure 5-3.

6) You can install a cleanout in the base of an exposed or concealed vertical stack not more than 4 feet above the finished floor, as shown in Figure 5-7. If you can't extend the cleanout to an accessible outside location, use a cleanout tee in the vertical stack. The cleanout plug must be accessible. If it's concealed, the cleanout must have a removable cover plate or access door to permit rodding. The raised head on the cleanout plug may be tapped to accept the long screw that holds it in place (Figure 5-8).

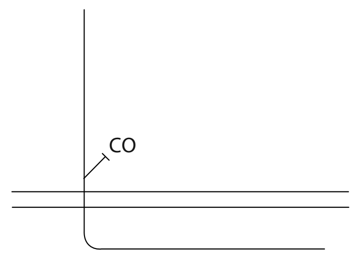


Figure 5-7
Provide a cleanout at the base of all required stacks

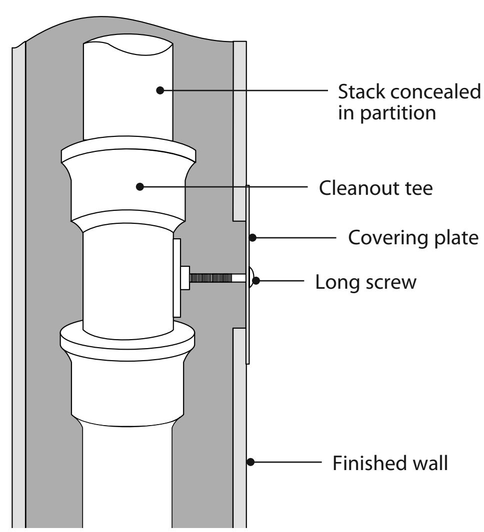


Figure 5-8
Cleanout on vertical stack

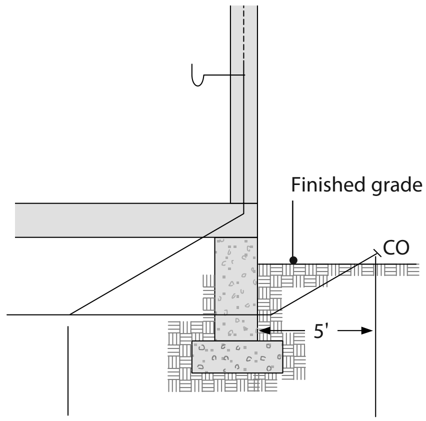


Figure 5-9
Dead end created with cleanout extension

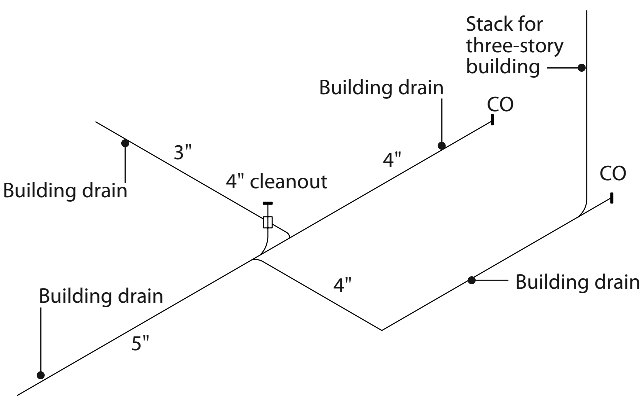


Figure 5-10
Where cleanouts are required

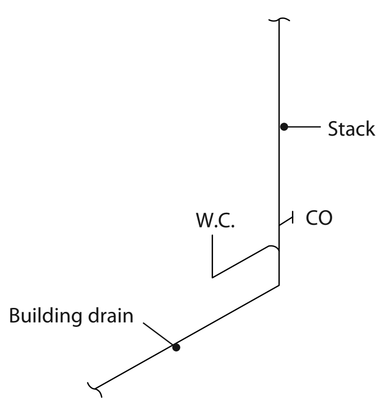


Figure 5-11
Water closet outlet is not considered an equivalent cleanout

7) When you extend a cleanout from the base of a stack to the outside of a building, it creates a dead end. You can't locate the cleanout more than 5 feet from the building wall. See Figure 5-9.

8) Every code requires a cleanout at the upstream end of the pipe for each horizontal drainage line. Of course, there are some exceptions.

9) For additional cleanout requirements and cleanout locations, see Figure 5-10. The stack needs a cleanout at its base because the change of direction is greater than 45 degrees and it's higher than one story. Where building drain pipes join together, requiring the drain size to increase in size, use a cleanout of the same size, brought to grade or finished floor level.

Cleanout Exceptions

1) A water closet is no longer considered a substitute for a regular cleanout. The water closet fixture drain (trap arm) need not have a cleanout. See Figure 5-11.

2) An exposed P trap connected to the drainage pipe with a slip joint or ground joint connections still has to have a cleanout at the base of the stack.

3) P traps that accept the discharge from residential clothes washers, floor drains, shower drains or tub drains with removable strainers don't require cleanouts.

4) Where there's a two-way cleanout in the building drain that permits rodding upstream to the base of a stack, such as for stack A in Figure 5-12, you don't need a cleanout at the base of the stack itself. But this only applies on main drains, not on branch lines, as a rodding machine can't make the turn into a branch. Thus, as shown in the diagram, both stacks B and C, since they're on branch lines, *will* require a cleanout at their base.

5) Rain leaders require a cleanout (Figure 5-13).

Cleanout Clearances

The *UPC* mandates there must be no less than 18 inches clearance or workspace for piping 2 inches and smaller. Piping larger than 2 inches must have 24 inches clearance. See Figure 5-14.

Direction of Flow

The cleanouts you install must allow someone to insert a sewer cable in the direction of flow to clear blockages. Use two-way cleanouts to permit upstream and downstream rodding whenever practical. Look back at Figures 5-3 and 5-4.

Prohibited Uses for Cleanouts

Never use cleanout openings to install another fixture or a floor drain unless you get written permission from your local authority. And if you do change the use of a cleanout, you must provide another cleanout of equal access and capacity.

Cleanout Material and Design

The required thickness for cleanout ferrule bodies is the same as that required for pipe and fittings of like material. The cleanout plug must extend at least $^{1}/_{4}$ inch above the hub. Any cleanout plug for new installations must be made of heavy brass or plastic at least $^{1}/_{8}$ inch thick, with a raised nut or a recessed socket for removal. The ferrule and cleanout plug must have ANSI standard tapered pipe threads. See Figure 5-15. Cleanouts are required to be listed to the appropriate standards.

Cleanout Sizes

Cleanouts must be the same nominal size as the pipe in which they're installed, up to 4 inches. See Figure 5-16. You can also use a 4-inch cleanout for building drains 4 inches and larger. For building sewers 8 inches and larger, most codes require manholes.

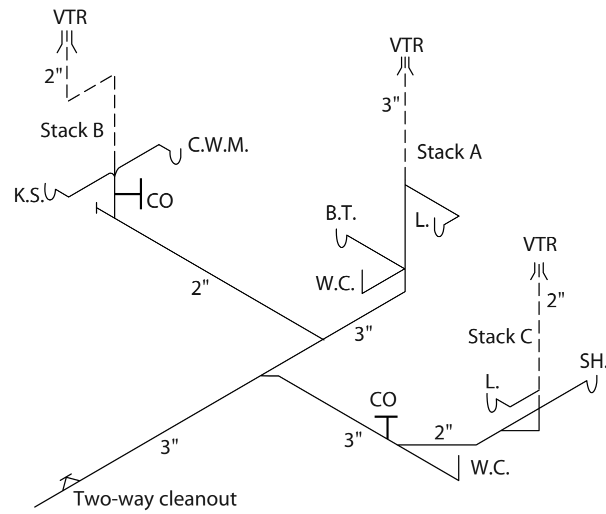


Figure 5-12
Additional cleanout locations

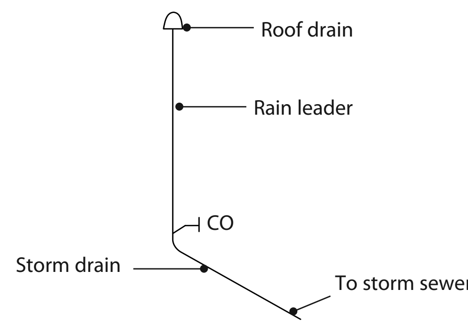


Figure 5-13
Cleanout required for rain leader

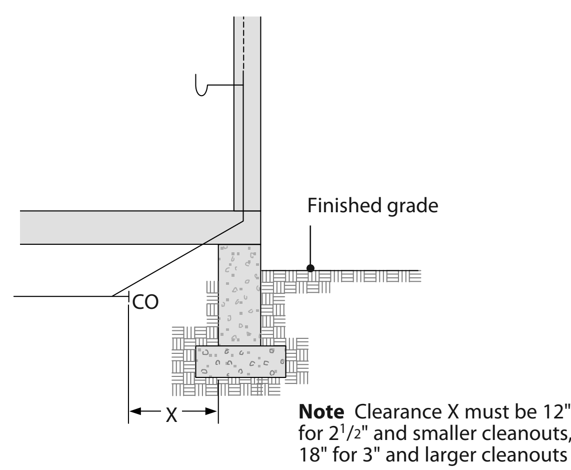


Figure 5-14
Cleanout clearances

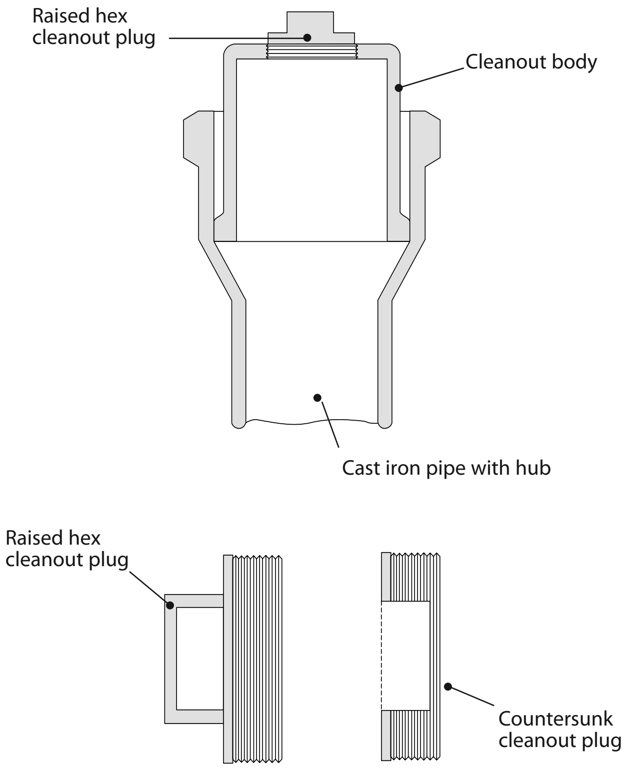


Figure 5-15
Cleanout design

International Plumbing Code		Uniform Plumbing Code	
Nominal pipe size (in)	**Nominal cleanout size (in)**	**Nominal pipe size (in)**	**Nominal cleanout size (in)**
$1\frac{1}{4}$	$1\frac{1}{4}$	$1\frac{1}{4}$	$1\frac{1}{4}$
$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$
2	2	2	$1\frac{1}{2}$
3	3	3	$2\frac{1}{2}$
4 and larger	4	4 and larger	$3\frac{1}{2}$

Note The *IPC* requires a 6" cleanout for an 8" and larger building drain.

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Figure 5-16
Cleanout sizes

You must locate a manhole with an approved cover at every change in direction, pipe size, alignment, grade or elevation. Straight runs must have manholes no more than 400 feet apart (*International Plumbing Code*) or 300 feet apart (*Uniform Plumbing Code*). Approved manhole covers must be used. See Figure 5-17.

Exterior Cleanouts

When you install drainage lines under blacktop or other paved surfaces (in commercial locations, for example), you may have to terminate a standard type cleanout in an area that carries vehicular traffic. If you do, install an approved cleanout box. That will protect the drainage pipe and cleanout from surface loads. A cleanout box is generally made of concrete or metal, fitted with an extra heavy removable cover for rodding. See Figure 5-18.

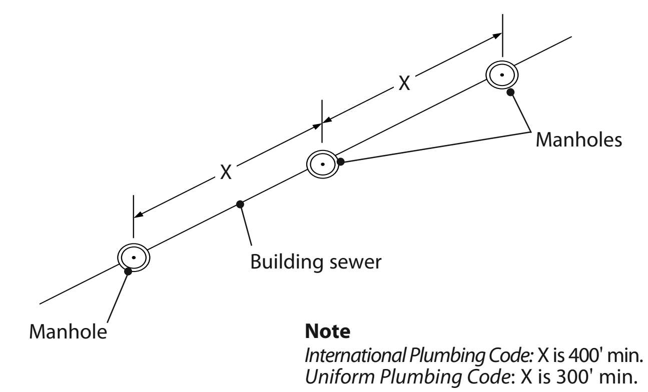

Figure 5-17
Manhole spacing

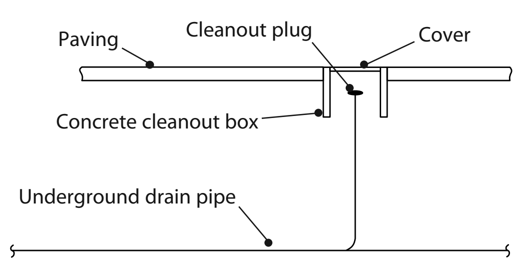

Figure 5-18
Cleanout and piping installed under paved area

Review Questions for Chapter 5 (answers are on page 281)

1. What procedures did plumbers use to clear stoppages before cleanouts became an essential part of the drainage system?
2. Name three important requirements for cleanouts regulated in today's model codes.
3. What is the most common plumbing maintenance problem?
4. What is the most common cause of clogged drains?
5. Name two things commonly found in the kitchen that are likely culprits in causing a clogged drain.
6. What dual purpose does a cleanout (or a cleanout tee) provide when installed where a building sewer connects to the public sewer lateral?
7. What is the name of the fitting that permits upstream as well as downstream rodding?
8. When a cleanout is extended to grade in an area subject to frequent traffic, what type cleanout head should be used?
9. According to the *Uniform Plumbing Code*, what is the maximum separation distance between 4-inch cleanouts?
10. What must be installed near the base of each vertical waste or soil stack?
11. If it's not possible to extend a cleanout to an accessible outside location, what alternative do the codes allow?
12. When a dead end is created by a cleanout, what is the maximum distance it can extend outside the building wall?
13. What plumbing fixture was sometimes considered a substitute for a cleanout, but is no longer allowed?
14. What is not needed in a P trap into which floor drains with removable strainers discharge?
15. When is the only time a roof stack terminal in a one-story building may be used as a cleanout?
16. What does the code require rain leaders be equipped with when they connect to a horizontal storm drain?
17. What clearance is required by code for a 2-inch cleanout?
18. In what direction should cleanouts be installed?
19. What are two prohibitions for the use of cleanout openings?
20. What must cleanout plugs be equipped with?
21. When may a building sewer be installed without manholes?
22. What does the *International Plumbing Code* give as the minimum size for a cleanout installed in a 4-inch pipe at the junction of a building drain and a building sewer?
23. What is the smallest-size cleanout acceptable for a 6-inch building drain, according to the *Uniform Plumbing Code*?
24. According to the *International Plumbing Code*, what is the maximum distance between manholes on a sewer installed on a straight run?
25. What does the code require when a standard-type cleanout terminates in an area where there's vehicular traffic?

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6

Interceptors, Special Traps and Neutralizing Tanks

Grease, oil, flammable waste, sand, plaster, lint, hair, glass and acids are objectionable — even harmful — to building drainage systems, public sewers, sewage treatment plants or septic tanks. That's why the code requires these materials to be intercepted, separated or neutralized before they enter any private or public drainage system.

Commercial buildings primarily use *interceptors* or separator traps to accumulate and recover objectionable substances in liquid waste before they can enter the drainage system. When you install interceptor traps, be sure to locate them where they're readily accessible. They don't do any good unless there's a way to maintain the interceptors and remove the accumulated matter.

Interceptors, separators and *neutralizing tanks* are available in many types and sizes to fit their particular functions. Make sure you have approved detailed drawings, specifications and locations clearly shown on your working blueprints before you begin installation. And keep in mind that waste that doesn't require intercepting, separation or neutralizing can't discharge through them.

Grease Interceptors

Grease interceptors are required in these commercial buildings:

- restaurants
- hotel kitchens
- cafeterias
- bars
- clubs
- supermarkets
- meat processing plants

Grease interceptors aren't generally required in single-family residences, private living quarters, apartment buildings or establishments that sell only packaged food. There are two types of grease interceptor installations, called simply *inside* and *outside* installations.

Inside Installations

Depending on code approval, architects will probably choose an inside interceptor for small restaurants or other businesses generating small amounts of grease. Grease interceptors installed indoors are of the hydro-mechanical type and have a sealed lid to minimize odors. Grease interceptors must have a grease retention capacity of 2 pounds for each GPM of flow. Figure 6-1 gives you the most common code sizing criteria for small establishments. Grease interceptors for small restaurants require at least 1.5 hours retention time.

Figure 6-2 shows a typical factory-built cast iron unit. This kind of interceptor is available in sizes ranging from 40 pounds to the maximum 100 pounds permitted by code. Figure 6-3 shows typical installations for three common inside interceptors — two floor-mounted and one below the floor.

Required rate of flow per minutes (gal)	Grease retention capacity (lb)
20	40
25	50
35	70
50	100

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Figure 6-1
IPC criteria for inside hydromechanical grease interceptor

Small grease interceptors like these always need an approved flow control fitting located where it's visible and accessible. The flow can't exceed the rated capacity of the interceptor. Flow control fittings with adjustable or removable parts are prohibited. You can see the flow control fitting in all three installations in Figure 6-3.

Each fixture discharging into a grease interceptor (Figure 6-3 A) must be individually trapped and vented in an approved manner. But notice there isn't a trap in Figure 6-3 B. The *IPC* allows you to omit a fixture trap for a single fixture if it meets the following conditions:

- The horizontal distance between the fixture outlet and the grease interceptor is no more than 5 feet.
- The vertical fixture tailpiece or drain isn't more than 30 inches.

Locating an Inside Grease Interceptor

- The interceptor must be easily accessible for inspection, cleaning and removal of grease at all times.
- Service personnel must have access without using ladders or moving heavy objects.
- Never install the interceptor in a part of the building where food is handled.
- Locate the interceptor as close as possible to the fixture it serves.

In some parts of the country you can buy water-cooled interceptors which speed up the coagulation of the grease. While this improves the efficiency of the interceptor, it's not always the safest system. The jacket contains a circulating potable water supply for cooling purposes. If it fractures or corrodes, there's the potential for a potable water cross-connection. Codes almost always prohibit the use of such interceptors. Don't waste time installing a water-cooled

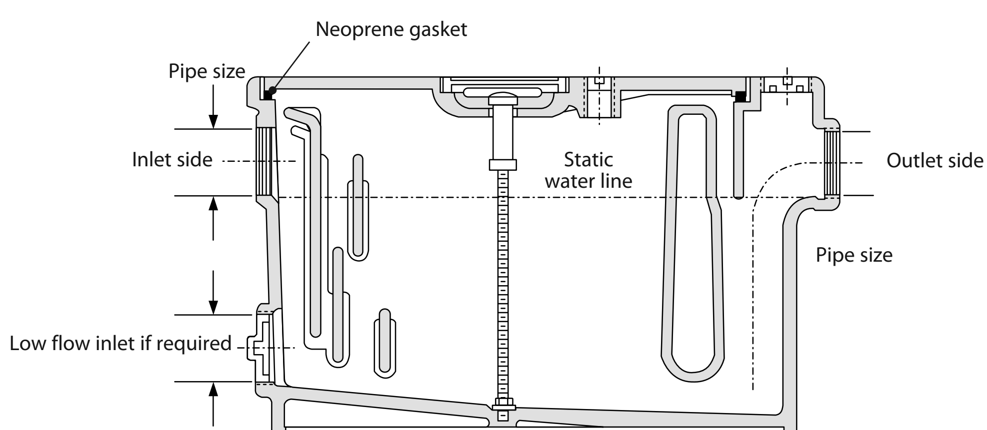


Figure 6-2
Typical inside grease interceptor

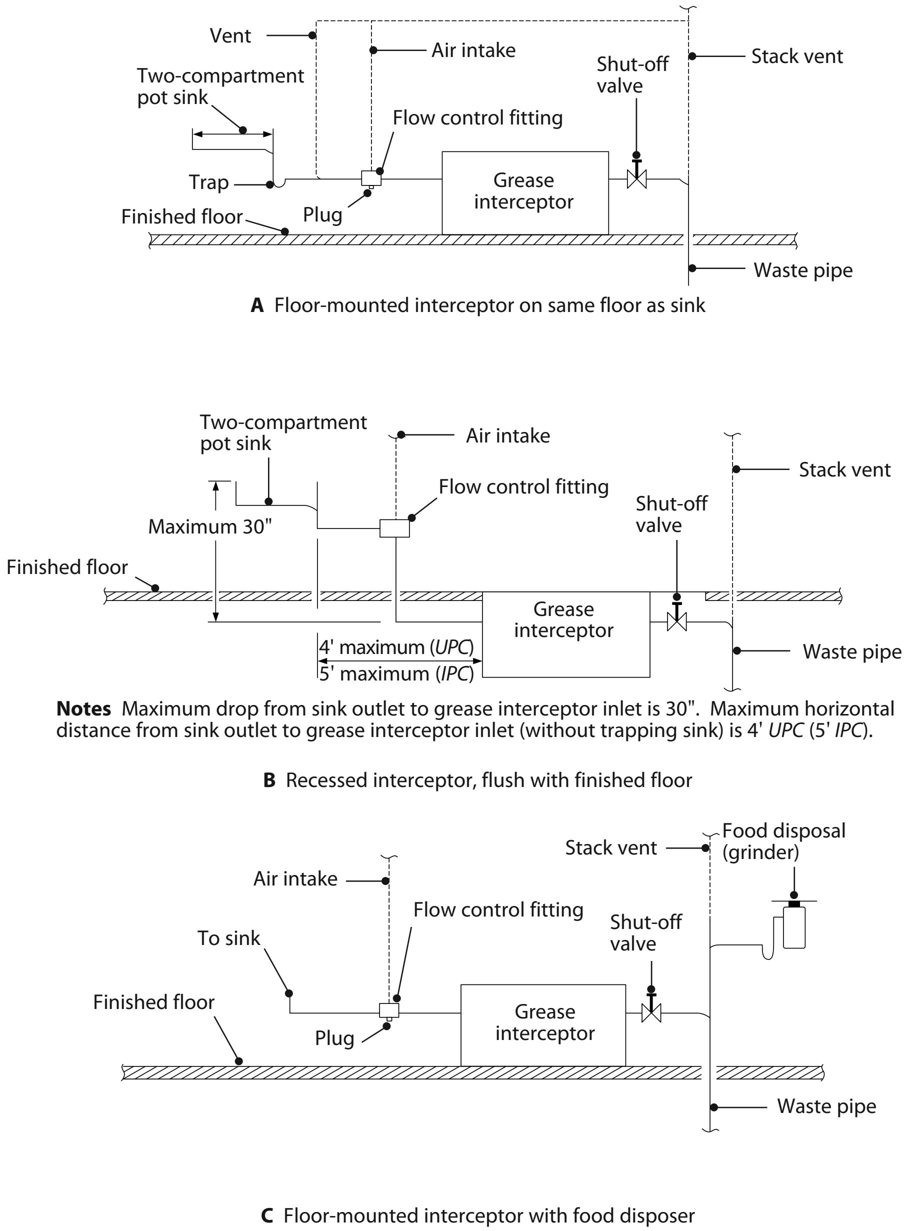


Figure 6-3
Typical installations of inside grease interceptors

unit unless you're certain that it has local plumbing official approval.

Codes generally prohibit food waste disposals (grinders) and commercial dishwashers from discharging through a grease interceptor. See Figure 6-3 C. Local plumbing officials may make an exception for dishwashers if they're satisfied that the temperature of the waste water and/or the action of detergents won't affect the operation of the interceptor.

Outside Installations

Most codes require sizing grease interceptors for fully-equipped commercial restaurants according to seating capacity (meals served) and hours of operation (i.e., 8, 16 or 24 hours). The formula should also provide for a retention period for cooling and separation of grease. For example, a fully-equipped restaurant open for business 8 to 24 hours requires a retention time of 2.5 hours. A single-service kitchen

Liquid capacities of grease interceptors for eat and/or drink establishments (gal)			
Up to 50 persons	51 to 100 persons	101 to 150 persons	151 to 200* persons
750	1,500	2,250	3,000
*For restaurants with more than 200 fixed seats, multiply the additional seats by 15 gallons.			

Figure 6-4
Liquid capacities of grease interceptors for restaurants

open for the same period requires a retention time of only 1.5 hours.

Most codes don't provide established sizing methods for commercial grease interceptors but leave it to the discretion of the health department or the local plumbing official. They usually require sizing commercial grease interceptors by the number of fixed seats or meals served at peak hours. However, each code has a different formula. Identical restaurants in different geographical locations often require interceptors of different sizes.

We'll look at two model codes — a typical local code and the *Uniform Plumbing Code*. The local code has a sizing table for restaurants with seating capacities up to 200 persons (Figure 6-4 in this book). As a rule-of-thumb guide for restaurants with seating capacities larger than 200, multiply the additional seats by a waste flow rate of 15 gallons. Neither the hours open nor the type of equipment used is a factor.

The *Uniform Plumbing Code,* has a very simple method for sizing gravity interceptors. Simply count the number of fixtures, then look at *UPC* Table 1014.3.6 (summarized here in Figure 6-5) for the size interceptor required.

As a plumber you probably won't be asked to install outside grease interceptors. You'll only connect the piping to the inlet and outlet openings provided. But you still need to know how to size, design and locate grease interceptors. Many questions on the plumbing exams come from this section of your code.

Grease Interceptor Design (Outside)

Your local code governs the materials that can be used for outside grease interceptors. The most commonly accepted material is concrete, either precast or poured-in-place. In some areas, the code may also approve steel, fiberglass-reinforced polyester or polyethylene. The structural design criteria for outside grease interceptors are fairly uniform across the country. Figure 6-6 shows the principal requirements.

- The inlet invert must discharge at least $2^1/_2$ inches above the liquid level line.
- The outlet tee must extend to within 8 inches of the bottom of the tank.
- For maintenance, provide two minimum 20-inch diameter cleanout manholes (one over

TABLE 1014.3.6
GRAVITY GREASE INTERCEPTOR SIZING

DFUs[1,3]	INTERCEPTOR VOLUME[2] (gallons)
8	500
21	750
35	1000
90	1250
172	1500
216	2000
307	2500
342	3000
428	4000
576	5000
720	7500
2112	10 000
2640	15 000

For SI units: 1 gallon = 3.785 L

Notes:
[1] The maximum allowable DFUs plumbed to the kitchen drain lines that will be connected to the grease interceptor.
[2] This size is based on: DFUs, the pipe size from this code; Table 703.2; Useful Tables for flow in half-full pipes (ref: *Mohinder Nayyar Piping Handbook*, 3rd Edition, 1992). Based on 30-minute retention time (ref; George Tchobanoglous and Metcalf & Eddy, *Wastewater Engineering Treatment, Disposal and Reuse*, 3rd Ed. 1991 & Ronald Crites and George Tchobanoglous. *Small and Decentralized Wastewater Management Systems*, 1998). Rounded up to nominal interceptor volume.
[3] When the flow rate of directly connected fixture(s) or appliance(s) have no assigned DFU values, the additional grease interceptor volume shall be based on the known flow rate (gpm) multiplied by 30 minutes.

Data from the *UPC*™ with permission of the *IAPMO* ©2021

Figure 6-5
Sizing criteria for outside grease interceptor from the Uniform Plumbing Code

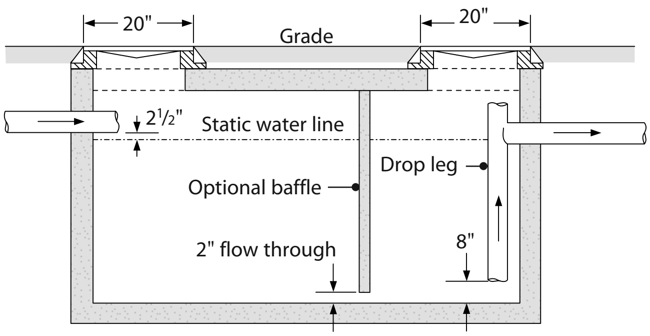


Figure 6-6
Outside gravity grease interceptor detail

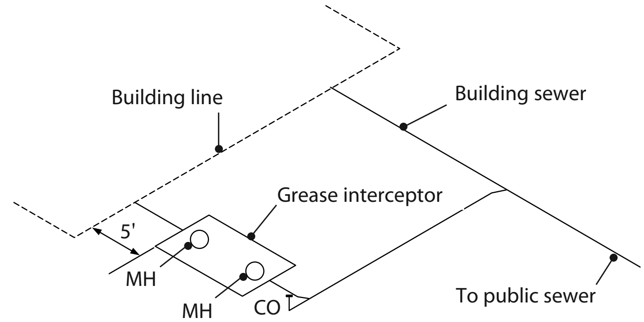


Figure 6-7
Outside gravity grease interceptor location

the inlet and one over the outlet tee) brought to grade. Manhole covers must be gas-tight.

- For cleaning purposes, very large grease interceptors require a minimum of one manhole per 10 feet of length. (Example: a grease interceptor 21 feet long would require three manholes, one over the inlet tee, one over the outlet tee, and one in the middle.)

- Grease interceptors must be designed and installed so that they won't become air bound. The two model codes take different approaches to this issue. The *UPC* requires a vent downstream of a gravity interceptor; the *IPC*'s position is that adequate air can pass through the vents that they serve, so a vent isn't necessary.

  Even if you work where the *IPC* is adopted, be sure your local jurisdiction hasn't adopted the *UPC*'s stricter requirement.

- Most codes require grease interceptors to have at least two compartments with fittings designed for grease retention. See Figure 6-6.

- In areas subject to vehicular traffic, grease interceptors must have adequate reinforcement and cover.

- Waste discharge piping from an interceptor may be connected to the existing building sewer. See Figure 6-7.

Grease Interceptor Location (Outside)

Observe the following code restrictions when installing an outside grease interceptor on a building site.

- Locate the grease interceptor where there's easy access for inspection, cleaning and removal of intercepted grease.

- An interceptor may serve only one establishment. There's one exception, however. Some local authorities having jurisdiction will accept one or more centrally located grease interceptors in large shopping centers. It may serve several grease-generating businesses, provided the shopping center management assumes, in writing, full maintenance responsibility.

Greasy Waste Systems

Greasy waste lines are designed and installed as a separate drainage system. Waste discharge from fixtures and equipment in establishments that generate grease may connect to the building sewer after passing through a grease interceptor. This includes scullery sinks, pot and pan sinks, dishwashing machines, soup kettles, garbage can washers, and floor drains that may receive kitchen spills. Floor drains and floor sinks that receive waste from certain fixtures and appliances in or near the kitchen (except commercial food disposers) must also connect to the greasy waste system.

Toilets, urinals and other similar fixtures must never waste through a grease interceptor.

There are two types of code-approved greasy waste systems. These are the *conventional greasy waste system* and the *combination waste and vent system.* The two are quite different, so we'll take a closer look at each. Jurisdictions that have adopted the *UPC* will likely reject a proposal to use a combination waste and vent system for greasy waste.

Conventional Greasy Waste System

As the term implies, the conventional system is the most common and the one you'll most often work with. Both small and large restaurants require similar design and installation methods.

The layout and installation of a greasy waste system is no different from that of a building sanitary drainage system. To size the pipes and locate the vents, floor drains and fixtures, just follow the requirements outlined for DWV systems in your local code. An acceptable conventional greasy waste system for a small restaurant with an outside interceptor is shown in Figure 6-8.

Combination Waste and Vent System

The combination waste and vent system is much less common. Codes permit its use only where structural conditions prevent the installation of a conventional system. The combination system provides the horizontal wet venting of a series of traps with a common waste and vent pipe. At best, it's a custom-designed system for locations where you can't provide venting in the usual manner.

Some codes will approve the use of a combination system where conventional venting isn't practical:

- Extensive floor drainage
- Group shower drains
- Floor sinks in supermarkets
- Demonstration or work tables in school buildings
- Similar applications where fixtures aren't located adjacent to walls or partitions

Some codes recommend that you don't connect grease-producing restaurant kitchen equipment to a combination waste and vent system because it's not self-scouring. Other codes don't object to this usage. Check your local code for specific requirements.

All codes require oversized combination system piping. Drainage pipe sizes are at least two pipe sizes larger than those required for a conventional system. This balances the system because the flow line is low enough in the waste pipe to allow adequate air movement in the upper portion. This prevents the loss of trap seals or the possibility of an air-lock condition.

To retain the grease for proper disposal, some codes require installation of an inside grease interceptor as close as possible to any grease-generating fixture or equipment. Figure 6-9 shows a combination system with an inside grease interceptor. Figure 6-10 details how to install three of the fixtures from Figure 6-9.

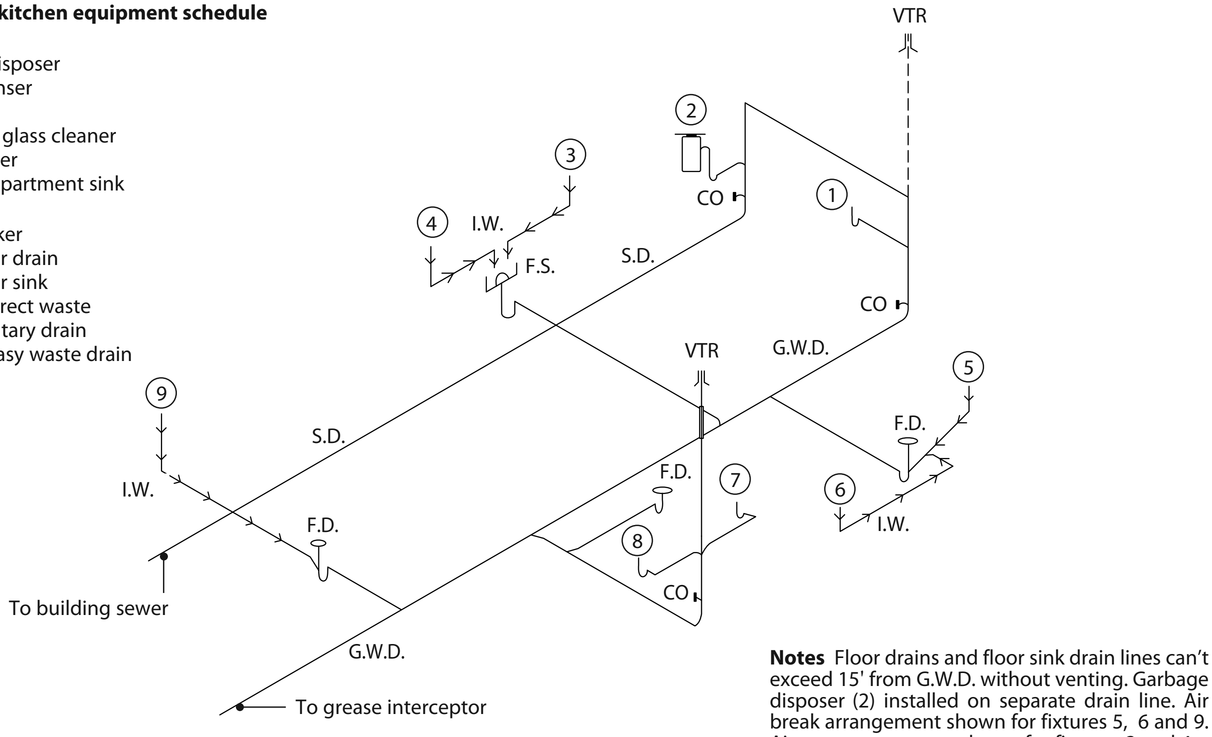
While codes accept the following requirements for a greasy combination waste and vent system, there are a number of local authorities that won't. Check on this beforehand.

- Each waste pipe must be sized in accordance with the adopted code. The *UPC* and *IPC* both utilize the same concept of requiring over sized horizontal pipes that provide some air space above the water traveling down the drain. These systems also have a connection to a vent that is sized for the total drainage fixture unit load for all the fixtures in the system.
- Some codes will accept fixture traps and drains in the normal code size if they're installed above the floor.
- The *UPC* requires the trap to be a pipe size larger than the tailpiece of the fixture it serves.
- The fixture tailpiece should be as short as possible, but should never exceed 2 feet.
- Dishwashers and grease-producing sinks must drain through a grease interceptor.
- To ensure adequate venting, appurtenances that deliver large quantities of water (such as pumps) should not discharge through a combination system.

Commercial kitchen equipment schedule

1. Hand sink
2. Garbage disposer
3. Milk dispenser
4. Ice maker
5. Automatic glass cleaner
6. Bottle cooler
7. Three-compartment sink
8. Pot sink
9. Coffee maker

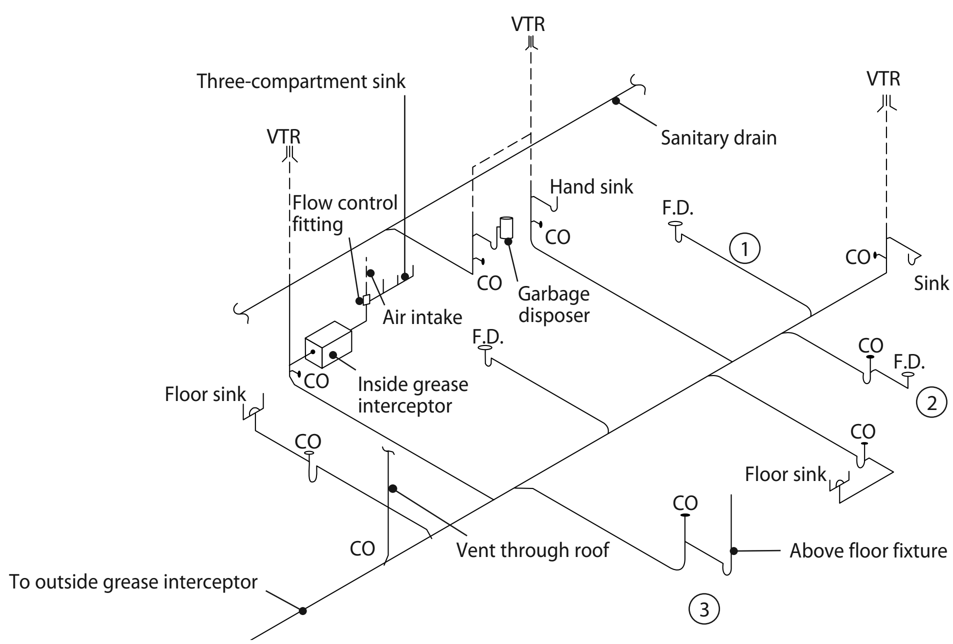
F.D. = floor drain
F.S. = floor sink
I.W. = indirect waste
S.D. = sanitary drain
G.W.D. = greasy waste drain



Notes Floor drains and floor sink drain lines can't exceed 15' from G.W.D. without venting. Garbage disposer (2) installed on separate drain line. Air break arrangement shown for fixtures 5, 6 and 9. Air gap arrangement shown for fixtures 3 and 4.

Figure 6-8

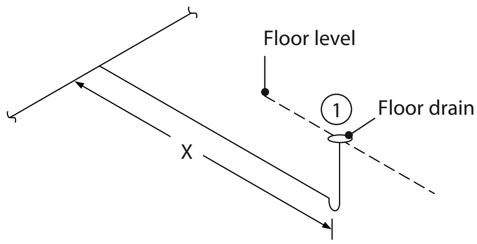
Conventional greasy waste collection system



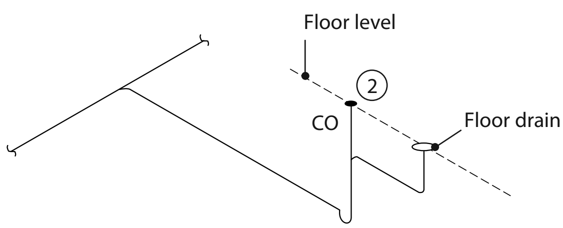
Notes Garbage disposer connects to the building sanitary drain. Inside grease interceptors *optional* for this illustration, as an outside grease interceptor is provided. Figure 6-10 illustrates an enlarged design for fixtures 1, 2 and 3 of the above drawing.

Figure 6-9

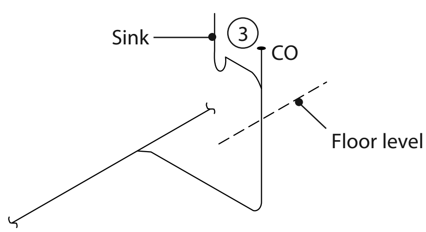
Greasy combination waste and vent system



Distance X shall not exceed 15' without venting.



Floor drain used as indirect waste receptor with cleanout at floor level.



Normal roughing for above-floor fixture in a combination waste and vent system.

Figure 6-10
Examples of how to install fixtures 1, 2 and 3 as illustrated in Figure 6-9

- This type of system works best with one vent upstream and one vent downstream from all fixtures in the system.
- The minimum area of any vent must be at least one-half the size of the waste pipe served. If a waste pipe is 4 inches, the vent pipe must be at least 2 inches.
- Each vent stack must have an accessible cleanout.
- Long mains must have additional relief vents installed at a minimum of 100 feet apart.
- Cleanouts aren't usually required on any wet-vented branch serving a single trap when the fixture tailpiece is 2 inches and provides ready access for cleaning through the trap.
- Fixtures producing $7^1/_2$ gallons of waste per minute must be considered as one fixture unit of load value.
- In the *IPC* and *UPC*, the total length of a combination waste and vent system is unlimited to accommodate long piping installations such as those necessary for supermarkets.

Laundry Interceptors

Lint interceptors aren't required in single-family houses or apartment buildings if there's a washer in each unit. Apartment complexes with a central laundry room are considered commercial and do require lint interceptors.

Commercial and self-service laundries discharge solids (such as lint, string and buttons) along with the liquid waste. They must have lint interceptors to prevent these solids from entering the drainage system. Install a removable screen or a $^1/_2$-inch mesh screen metal basket to collect the solids. The screen construction must allow for easy cleaning. See Figure 6-11.

Some codes label the horizontal drainage pipes which serve self-service clothes washing machines as indirect waste pipes (Figure 6-12). This unique method of piping is economical and practical for this particular application.

The indirect waste system doesn't have to be trapped or vented, like most other plumbing fixtures. The washing machine standpipes are open-ended, 3- or 4-inch diameter pipes extending to about 26 inches above the finished floor. These drain pipes receive the discharge from washers through flexible hoses. A 3-inch standpipe can accommodate two machines; a 4-inch standpipe will serve four machines. Horizontal drain pipes collect waste from the standpipes and convey that waste to a lint interceptor. You don't have to vent this system because the standpipes permit free circulation of air.

Other codes require each washing machine to discharge into individual traps, be vented and connect separately to the horizontal drain pipe. See Figure 6-13. Check with local authorities for the system that's acceptable in the area where you work.

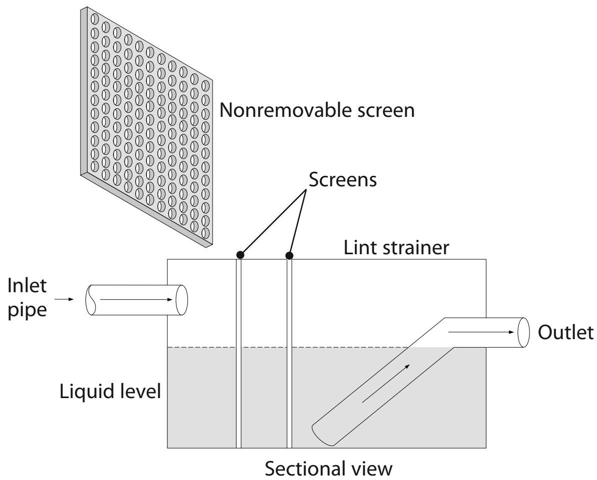


Figure 6-11
Lint interceptor detail

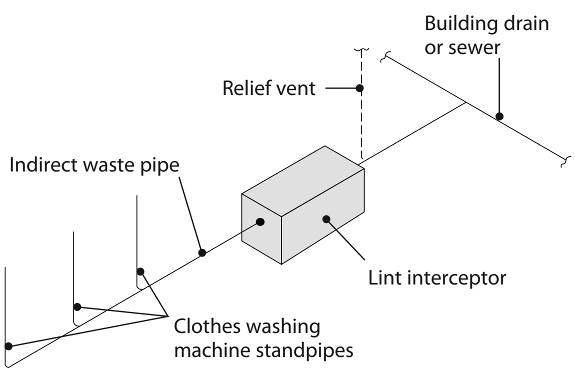


Figure 6-12
Lint interceptor installed in drainage pipe from laundry

The outlet pipe from the lint interceptor is connected to the regular sanitary drainage system serving other fixtures within the building. The code requires that a vent be installed on the horizontal discharge (outlet) pipe as close as possible to the lint interceptor. The vent pipe serves the drainage pipe between the lint interceptor and the building drainage system or building sewer. It supplies and removes air as needed. This ensures a free flow of waste water by preventing the lint interceptor from becoming air locked. See Figures 6-12 and 6-13.

Sizing Lint Interceptors

It's usually the responsibility of the architect to size lint interceptors. But you may have to calculate the lint interceptor size when an architect's seal isn't required — when a self-service laundry locates in an existing building, for example. Unfortunately most codes don't provide established sizing methods. They just recommend design criteria, or leave it to the discretion of local plumbing officials. Commercial laundries rely on the manufacturer's specifications.

Lint interceptors for self-service laundries are sized according to the number of washing machines installed and other factors like the number of cycles, waste flow rate, retention time and storage factor (Figure 6-14). Some codes require a retention period of at least 2.0 hours. Other codes don't require a retention period but depend solely on the screen to collect the solids. Let's see how two codes compare in the sizing of a lint interceptor for a self-service laundry.

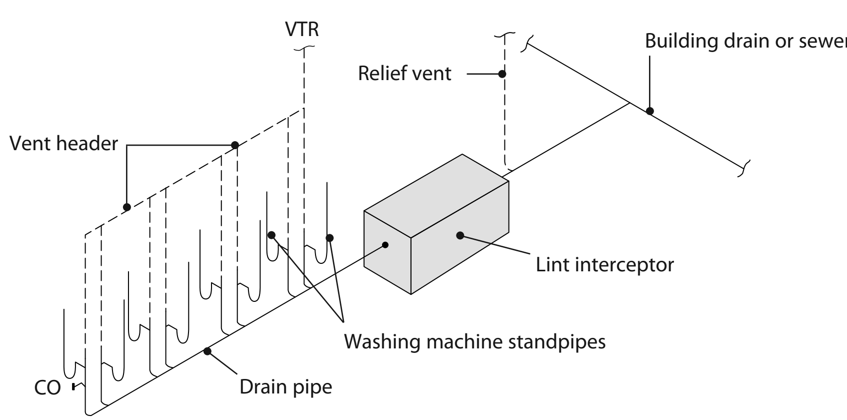


Figure 6-13
Clothes washing machines individually trapped and vented (required by some codes)

A local code provides a fairly small interceptor unit, located either inside or outside a building. Under that code, the minimum-size lint interceptor approved for a self-service laundry with up to 10 washing machines has a liquid capacity of 450 gallons. This is the formula the local code uses:

10 washers × 2 cycles per hour × 3 fixture units per washer × 7.5 gallons flow per fixture unit = 450 gallons storage capacity

This flow-through interceptor has very little retention time. It counts on the built-in screens to collect the solids as the water rushes by. Because of its small capacity, it requires regular maintenance to clear the intercepting compartment and screens. See Figure 6-11.

For self-service laundries that have either more or fewer than 10 machines, you'd multiply each machine by 45 gallons:

1 machine × 2 cycles × 3 fixture units per washer × 7.5 gallons per fixture unit = 45 gallons

Most codes leave the sizing of lint interceptors for commercial laundries to the manufacturer's specifications. It's very different from the sizing of self-service laundries.

Lint Interceptor Construction

Lint interceptors may be made of precast concrete or poured-in-place concrete, steel or other approved materials. No matter what the material, a lint interceptor must have nonremovable baskets or screens to trap materials that would harm the building drain pipe. Larger units require a special basket to trap the solids from waste water entering the lint interceptor. But some codes allow removable screens, usually on small units. Where they're allowed, the screens or basket must be easy to clean.

In most cases, you'll install the inlet pipe one pipe size above the liquid level. The outlet or discharge pipe generally extends downward on a 45-degree angle to within approximately 2 inches of the bottom of the lint interceptor. This achieves two purposes:

1) It prevents lighter objects that pass through the screen and float on the water from sinking into the outlet pipe and then getting into the sanitary drainage system.
2) It creates a liquid seal that serves as a trap, preventing sewer gases from entering the building through the washer standpipes.

Gasoline, Oil and Sand Interceptors

Interceptors are absolutely essential in some settings to prevent gasoline, grease, oil or sand from getting into the drainage system. In the following places they're *always* required:

- Repair garages where motor vehicles are serviced and repaired, and where floor drainage is provided
- Commercial motor vehicle washing facilities
- Gasoline stations with grease racks, grease pits or wash racks
- Factories which have oily and/or flammable wastes as a result of manufacturing, storage, maintenance, repair or testing
- Public storage garages with floor drainage
- Anyplace where sand, oil, gasoline or other volatile liquids can enter the drainage system

Although the codes agree that certain kinds of businesses need interceptors or separators, they don't provide much direction about the size or type of interceptor to install. The code wording usually goes something like this: *The size, type and location of each interceptor or separator shall be approved by the local administrative authority, in accordance with its standards.*

The amount of volatile liquids in a system determines the sizing and design methods for interceptors handling them. Some systems have only small concentrations, while others have larger amounts. We'll look at the guidelines for both types.

Small Concentration of Volatile Liquids

Commercial garages that service or store fewer than 10 vehicles generate small amounts of volatile liquids and sand. Service stations and repair shops that service but don't store vehicles are also included here.

Figure 6-14 shows a typical poured-in-place or precast interceptor. This oil interceptor with a bucket-type floor drain may be approved for small installations without a separate sand interceptor.

Here are some typical criteria that meet the requirements of most codes:

- The interceptor should have a minimum liquid capacity of 18 cubic feet per 20 gallons of design flow.
- Bucket floor drains are generally required. The floor drain outlet should be a minimum of 4 inches (3 inches, in some codes). The bucket, made of the same material as the floor drain, is removable for cleaning. The bottom portion of the bucket is solid to retain sand or other debris. Drainage holes near the top of the bucket let liquid waste pass out of the bucket and into the pipe or pipes leading to the interceptor.
- The inlet drain pipe should enter the interceptor above the liquid level line. Some codes may require the pipe to be vented. Others consider that the evaporation space provides adequate venting.
- There must be a minimum 3-inch (2-inch, in some codes) vapor vent in the evaporation space of the interceptor, venting into the open air. It must terminate in an approved location (most often the outside of a building) at least 12 feet above grade.

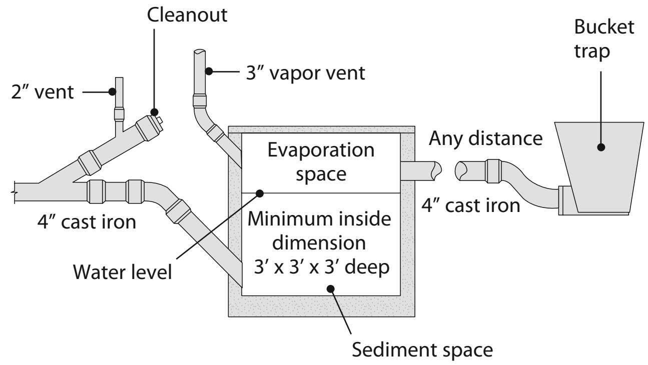


Figure 6-14
Sand and oil "combined" interceptor for small businesses generating small amounts of volatile liquids

- The discharge pipe should enter the interceptor on a 45-degree angle and terminate near the bottom of the interceptor. The liquid depth should be at least 2 feet below the invert of the discharge pipe.
- The discharge pipe should never be smaller than the inlet pipe. It should have a full-size cleanout brought to grade. The vent must be at least 2 inches in diameter.
- Some codes don't require the discharge pipe to be vented *if* it discharges into a catch basin or into a vented building sewer or building drain and the discharge pipe doesn't exceed a 15-foot developed length.
- The interceptor must be located outside the building.
- Each interceptor must be installed so it's readily accessible for removal of the cover, servicing and maintenance.

Large Concentration of Volatile Liquid

Businesses that generate large amounts of volatile liquids must have a waste oil storage tank. This receives and stores excess oil from the interceptor through a gravity overflow line. See Figure 6-15.

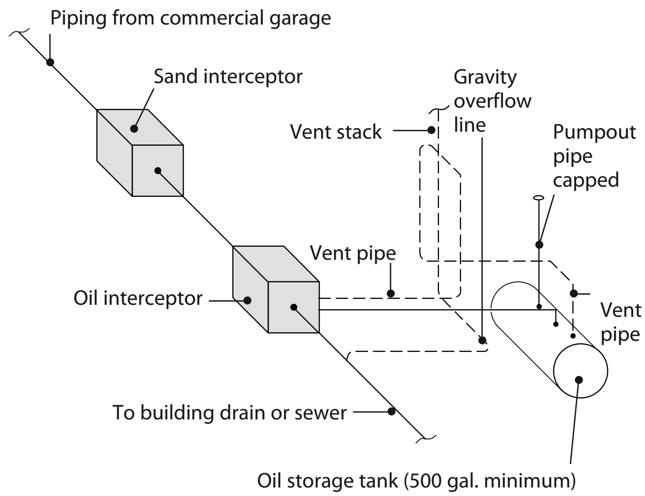


Figure 6-15
Sand interceptor, oil interceptor and oil storage tank for businesses generating large amounts of volatile liquids

As a rule, codes require locating the waste oil storage tank outside the building. The designer will determine its size, capacity and location, with local official approval. Some codes require a minimum 500-gallon capacity. The tank must be approved by a nationally recognized testing laboratory such as UL Solutions. You'll have to provide at least a $1^1/_2$-inch vent ending in the open air 12 feet above grade or through the building roof. You must also install a 2-inch minimum pumpout pipe to grade for removing the oil.

Install a gravity overflow line from the oil interceptor (separator) and connect it to the oil storage tank. Then use a 2-inch vent to remove any accumulation of explosive vapors.

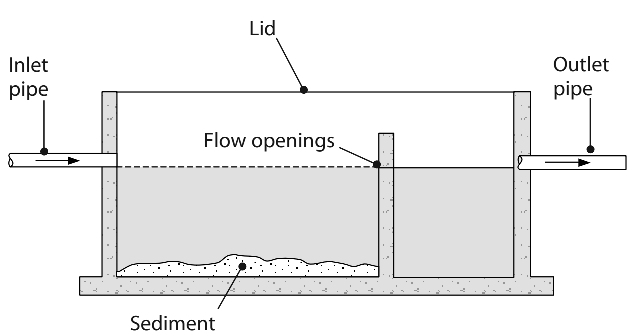


Figure 6-16
Sectional view of sand interceptor (trap)

Sand Interceptors

Most codes require floor drainage systems for all commercial garage buildings. Large numbers of automobiles produce a lot of sand, grit, grease and oil drippings that are regularly washed down the drain. It's essential that you install a sand interceptor that the waste will pass through before it discharges through the oil interceptor. See Figure 6-16.

There are a few other places where sand interceptors are required. These include stairwells, planter drains, beach cabana showers, public pool showers, public pool deck drains and play areas.

The sand interceptor holds sand and grit in the sediment section, as shown in Figure 6-16. The waste water, once free of sand and other debris, may then be discharged into the building sanitary or storm drainage system.

Bottling Plants

Bottling plants must discharge their processed wastes into an interceptor that separates out broken glass or other solids before the liquid waste discharges into the building drainage system. A properly-sized sand interceptor would do the job.

Other Types of Interceptors or Separators

There are many businesses that require special interceptors or separators before their waste waters can be discharged into the building sanitary or storm drainage systems.

Hair Interceptors

The code may require a hair interceptor for barber shop sinks, beauty salon sinks and commercial fixtures used for bathing animals. Any such interceptor must have a removable, easy-to-clean screen basket to intercept hair. See Figure 6-17.

Slaughterhouses

The code requires interceptors (separators) for all drains in slaughtering rooms and meat dressing rooms. They must exclude feathers, scales, entrails and other unacceptable materials from the building drainage system. Interceptors must be approved by local authorities. The architect will provide the type, size and locations on the approved blueprints.

Animal Boarding Businesses

Where animals are confined (animal kennels and zoos), most codes require the special handling of waste before it's discharged to a legal point of disposal (private or public).

The wash-down for such a system has a perforated or slotted grate but no sediment basket. The floor drain isn't usually trapped. The drainage pipe empties into an interceptor tank, which is usually similar in design to a septic tank.

This tank separates the solids, retains them and allows the liquid waste to pass on to a legal point of disposal. The bacterial process that's so effective in digesting human waste isn't very effective with animal waste. Since these animal solids have to be removed frequently, you'll have to install separator tanks that have adequate manholes. Be sure you bring the manholes to grade. See Figure 6-18. As always, your local authority can give you the criteria for an acceptable system.

Transformer Oil Spill Holding Tank

The code requires floor drainage for transformer vault rooms located inside a building. The usual installation is a 3-inch floor drain, at floor level, without a sediment basket or trap. You must install a drain pipe that connects to an oil spill holding tank. This serves as an indirect waste pipe and doesn't require a vent. You'll also need a pumpout pipe (installed to grade) for removing oil spills.

Your local power company is the authority on sizing the tank, which must be large enough to hold the amount of oil contained in the transformer in case of a rupture. Figure 6-19 shows a detailed drawing for a typical transformer oil spill holding tank.

Plaster Work Sinks

The code requires an interceptor trap in drain lines leading from dental and orthopedic sinks (Figure 6-20). Objectionable substances like wax and plaster can't discharge into the drainage system.

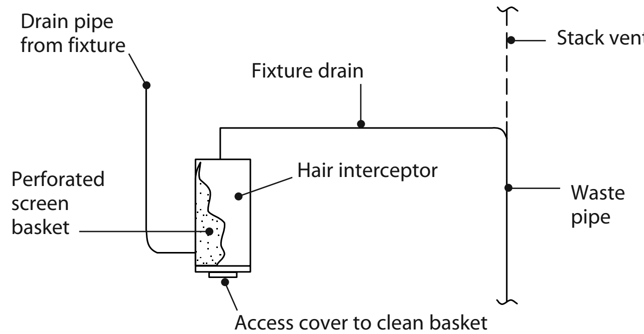


Figure 6-17
Hair interceptor installed in fixture drain pipe

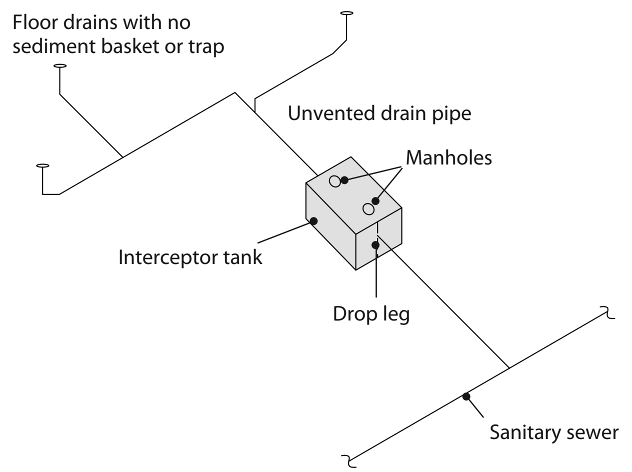


Figure 6-18
Interceptor tank and drainage piping for animal boarding establishments

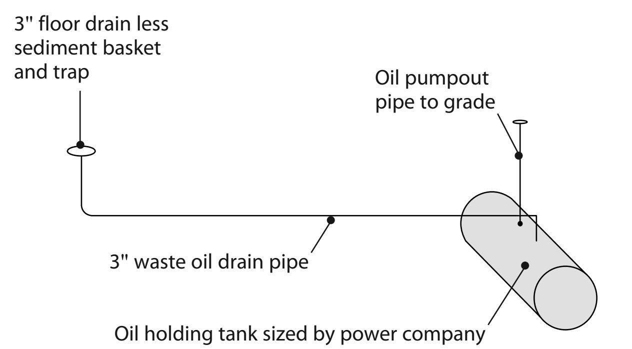


Figure 6-19
Transformer oil spill holding tank and piping detail

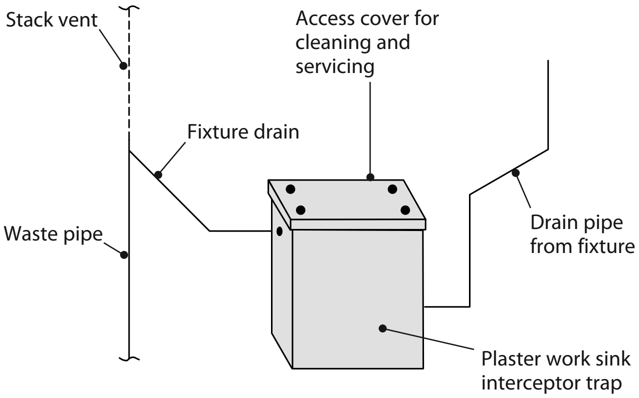


Figure 6-20
Plaster work sink interceptor trap and piping detail

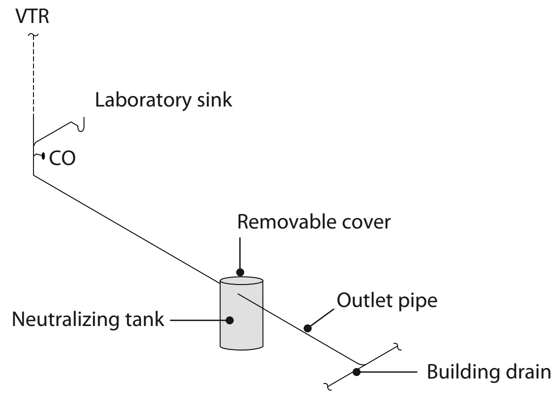


Figure 6-21
Typical acid waste system with neutralizing tank

Neutralizing Tanks

Corrosive liquids, spent acids and other chemicals present a distinct danger. They could damage or destroy a drainage, waste and vent system or create noxious or toxic fumes. To prevent such a possibility, these substances must be neutralized by dilution or other approved treatment before discharging into a building drainage system. Figure 6-21 shows the installation of a typical separate and independent system. Your local authority will want to know the type and amount of corrosive waste generated. It's up to them to approve the size and type of neutralizing tank you use.

Review Questions for Chapter 6 (answers are on page 282)

1. Name at least three types of waste that the code considers objectionable and harmful to the building drainage system.
2. What are the three options for dealing with objectionable and harmful waste before it can enter the drainage system?
3. What is the primary purpose of an interceptor or separator trap?
4. When an interceptor is used, what must your working blueprints show?
5. What type of waste must not go through an interceptor?
6. Name three types of commercial buildings that require the installation of a grease interceptor.
7. Name two types of buildings where grease interceptors are *not* generally required.
8. What are the two types of grease interceptor installations that are usually approved by code?
9. What kind of restaurant will generally use an inside grease interceptor?
10. What is the mandated grease retention capacity of a grease interceptor?
11. What is the maximum grease capacity permitted for an inside grease interceptor?
12. What are the two typical installation methods for inside grease interceptors?
13. Why must an approved flow control fitting be installed on a small inside grease interceptor?
14. If you omit the fixture trap for a pot sink, what distance requirement must be met?
15. In the *IPC*, what is the maximum vertical fixture tailpiece drop for a fixture connected to an inside grease interceptor?
16. Why must grease interceptors be easily accessible?
17. In what part of a building is the installation of an inside grease interceptor prohibited?
18. Why do most codes prohibit the installation of a water-cooled grease interceptor?
19. Most codes prohibit a food waste disposal from discharging through what device?
20. What is the grease interceptor retention time required for a fully-equipped commercial restaurant?
21. What is the minimum retention time required for a grease interceptor in a small single-service kitchen?
22. What are the two major considerations when sizing a grease interceptor for a fully-equipped commercial restaurant?
23. Most codes don't spell out the sizing methods for commercial grease interceptors. Who do they defer to for the sizing methods?
24. Why might identical restaurants in different geographical areas require grease interceptors of different sizes?
25. How does the *Uniform Plumbing Code* size gravity grease interceptors?
26. What is the most commonly accepted construction material for outside grease interceptors?
27. Most codes require the inlet invert in an outside grease interceptor to discharge a minimum of how many inches above the liquid level line?
28. What is the minimum size cleanout manhole for an outside grease interceptor?
29. Outside grease interceptors must be designed and installed to avoid what potential problem?
30. Most codes require that outside grease interceptors have how many compartments?
31. How many manholes are required for an outside grease interceptor 21 feet long?
32. The greasy waste line system is designed and installed for what purpose?
33. When is a greasy waste line allowed to connect to the building sewer?
34. What are the two code-approved greasy waste systems?
35. On which greasy waste system will you most often be working?
36. What are the guidelines for sizing pipes for a conventional greasy waste system?

37. What is the difference between a conventional greasy waste system and a combination waste and vent system?

38. Name three areas where some codes might permit the use of a combination waste and vent system.

39. Why do some codes *not* recommend connecting grease-producing restaurant kitchen equipment to a combination waste and vent system?

40. Why are pipes in a greasy combination waste and vent system sized larger than a conventional greasy waste system?

41. A fixture tailpiece should be as short as possible, never exceeding what length?

42. Why can't large quantities of water (from pumps, for example) discharge into a combination waste and vent system?

43. What is the maximum total length of a branch line of a combination waste and vent system?

44. In a greasy combination waste and vent system, how does the minimum area of a vent compare to the size of the waste pipe it serves?

45. What does the code require that each vent stack in a greasy combination waste and vent system have?

46. Where are lint interceptors *not* required by code?

47. What businesses require lint interceptors in their drainage system?

48. What type of strainer is usually required on a commercial or self-service lint interceptor?

49. What do some codes call the horizontal drainage pipes serving commercial or self-service clothes washing machines?

50. What is the advantage of an indirect waste system for a commercial or self-service laundry?

51. How many clothes washers can a 3-inch standpipe accommodate in a self-service laundry?

52. When a commercial or self-service lint interceptor connects to a building drainage system, where on the horizontal discharge pipe would you *correctl*y locate the vent?

53. Most codes don't provide established sizing methods for self-service laundries. Who does?

54. Who sets the design criteria for commercial laundries?

55. What determines the size of the lint interceptor in a self-service laundry?

56. What is the usual code-required retention period for a lint interceptor?

57. Using the local code formula in our example, what size lint interceptor would be required for a self-service laundry with eight clothes washing machines?

58. What is the general definition of areas where gasoline, oil and sand interceptors are required by the code?

59. Name three types of establishments where the code would require a gasoline, oil and sand interceptor.

60. What governs the sizing and design of gasoline and oil interceptors that handle volatile liquids?

61. Give an example of an establishment that, according to the code, generates small amounts of volatile liquids and sand.

62. What type of floor drain is usually required for an automobile repair shop?

63. What is the minimum liquid capacity for an oil interceptor in the floor drainage system of a service station?

64. In a commercial garage that services or stores fewer than 10 vehicles, where should the inlet drain pipe enter the oil interceptor?

65. If the inlet pipe to an oil interceptor is 4 inches, what is the minimum size required for the discharge pipe?

66. Under what circumstances can you omit the vent for the discharge pipe in an oil interceptor?

67. Where must you locate an oil interceptor for a service station?

68. In addition to an oil interceptor, what is required for businesses that generate large amounts of volatile liquids?

69. According to most codes, what is the minimum size vent required for a waste oil storage tank for a business that generates large amounts of volatile liquids?

70. Codes require that waste oil storage tanks be listed by a nationally recognized listing agency such as UL. What does the abbreviation UL stand for?

71. What's the minimum height above grade permitted for a vent serving a waste oil storage tank?

72. Before it enters an oil interceptor, floor drainage for a commercial garage building must first discharge through what device?

73. Before the liquid wastes can discharge into the building drainage system, bottling plants must discharge their processed wastes into what device?

74. What special device must be installed in the drainage line of commercial fixtures used for bathing animals?

75. The code requires interceptors or separators for all drain lines in slaughtering rooms and meat dressing rooms. Who must approve the blueprints that indicate the type, size and location of these interceptors or separators?

76. Before discharging to a legal point of disposal, most codes require that drainage pipe wastes from animal boarding businesses pass through what device?

77. Where must the waste from transformer vault room floor drainage discharge?

78. Who has the authority to size a transformer oil spill holding tank?

79. Why must dental and orthopedic sinks be equipped with an interceptor trap?

80. What is the purpose of a neutralizing tank?

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7

Indirect Waste Piping, Receptors and Special Wastes

Any fixture, appliance or device that's not classified as a plumbing fixture may be drained by indirect means if it has a drip or drainage outlet. The indirect drainage prevents sewage from backing up into a special fixture and contaminating its contents in case there's a stoppage in the sanitary drainage system.

Special fixtures or appliances include refrigerators, ice boxes, bar sinks, hand sinks, cooling or refrigerating coils, extractors, steam tables, egg boilers, coffee urns, stills, sterilizers, commercial dishwashers, water stations, water lifts, expansion tanks, cooling jackets, drip or overflow pans, air conditioning condensate drains, drains from overflows, relief vents from the water supply system, and similar applications.

Overflow and relief pipes on a water supply system and relief pipes on expansion tanks, sprinkler systems and cooling jackets must always connect *indirectly* to the sanitary drainage system. See Figure 7-1. This prevents any possibility of contaminating the potable water supply through cross connection. To avoid contamination, there must also be a positive separation by indirect means between the waste outlet and the drainage inlet of hospital equipment, and food storage and preparation establishments. This unique method of piping is very practical for fixtures with low discharge rates.

Certain restrictions apply as to *maximum length of indirect waste piping* in hand sinks, bar sinks and similar fixtures. Figure 7-2 shows a water tank overflow drain pipe that illustrates the restrictions. If the length of the indirect waste pipe (X) exceeds 5 feet but is less than 15 feet, the *UPC* requires it be directly trapped. The *IPC* requires it be directly trapped if the pipe is more than 2 but less than 4 feet. You don't have to vent these traps.

All indirect waste receptors must have adequate capacity and a design that prevents splashing or flooding. And any required vent in indirect waste piping must extend separately to the outside air. *Never connect it to a vent which serves a sanitary system.*

Piping Material and Sizes

Indirect waste piping materials must meet local code requirements. Acid and chemical waste pipes must be made of materials that aren't affected by these wastes. We'll cover the materials in detail in Chapter 8.

The sizing of indirect waste piping is fairly simple. It should never be smaller than the drain outlet or tailpiece of the fixture, appliance or equipment served, and in any case, never smaller than $^1/_2$ inch.

Types of Indirect Waste Piping

The code will direct you on which termination method to use given the circumstances. There are two methods of terminating indirect waste piping — *air break* and *air gap*.

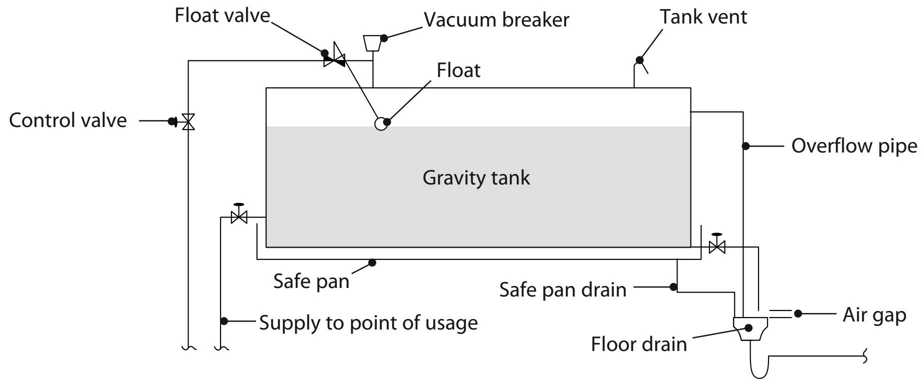


Figure 7-1
Typical water gravity tank showing required air gap

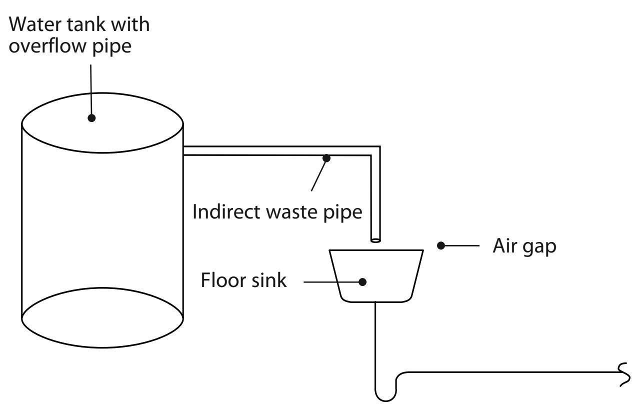


Figure 7-2
Water tank with overflow pipe

Air break is a piping arrangement in which a drain pipe from a fixture, appliance or device discharges indirectly into a fixture or receptor at a point below the flood level rim of the receptor. This method is generally acceptable for low risk hazards into a trapped receptor. There are two indirect *air break* waste methods illustrated in Figure 7-3. Some local authorities will allow an *air break* installation to terminate below the floor or rim of the floor sink or receptor.

In an *air gap* arrangement, there must be an unobstructed vertical distance through the free atmosphere between the drain pipe outlet from a fixture, appliance or device and the flood level rim of the receptor into which it discharges. There must be a minimum separation of 1 inch (*UPC*) or twice the drain pipe size (*IPC*) between the plumbing fixture, appliance, or appurtenance outlet and the rim of the floor sink or receptor. See Figure 7-4.

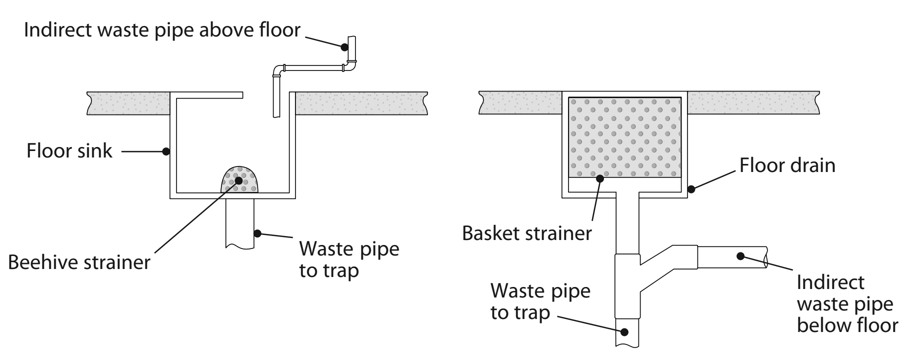


Figure 7-3
Two indirect (air break) waste methods

Receptors

All receptors must always be accessible for inspection and cleaning. We'll look at the three types of receptors you may be installing.

Floor Sink

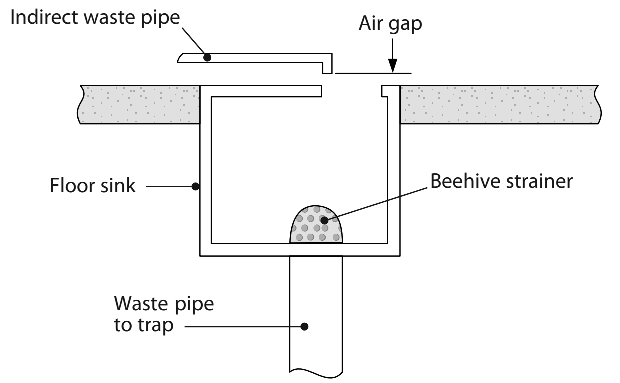
The first receptor type, the *floor sink*, is used with an air gap indirect waste pipe, mostly in restaurants. The top of the receptor, which may be rectangular or round, is open to receive the indirect waste pipe. The type of floor sink you'll install depends on whether or not the area carries pedestrian traffic. One type has a grate that makes it safe for pedestrian traffic. The second type of floor sink, used in areas with no pedestrian traffic, doesn't require a covering grate. It's used in hidden areas where appearance isn't important. Figure 7-5 shows both types.

The code requires that the indirect waste receptor for a floor sink be certified to ASME A112.6.7. Floor receptors receiving waste from fixtures that produce some solids should have a beehive strainer installed to catch debris before entering the drainage system. Indirect waste pipes that convey only clear water waste don't need a beehive strainer. And all indirect waste receptors must have adequate capacity and a design that prevents splashing or flooding.

Floor Drain and Clothes Washer Standpipe

A floor drain is commonly used with *air break* indirect waste pipe. It may also serve as a receptor to receive floor drainage. Look back at Figure 7-3.

Most codes categorize an *automatic clothes washer standpipe* as an indirect waste receptor. It must be no smaller than 2 inches in diameter and be installed above floor level. The *UPC* says the standpipe can never extend more than 30 inches nor less than 18 inches above the trap. The *IPC* says the standpipe can't extend more than 42 inches nor be less than 18 inches above the trap. Rough it in at least 6 inches (but not over 18 inches) above the floor. Make sure the standpipe receptor is properly trapped and vented (Figure 7-6).



Note The air gap must be a minimum of 1".

Figure 7-4
Typical air gap indirect drainage method

A Floor sink receives indirect wastes under equipment while grate provides safety for pedestrian traffic

B Floor sink receives indirect wastes in nontraffic areas

Figure 7-5
Floor sinks

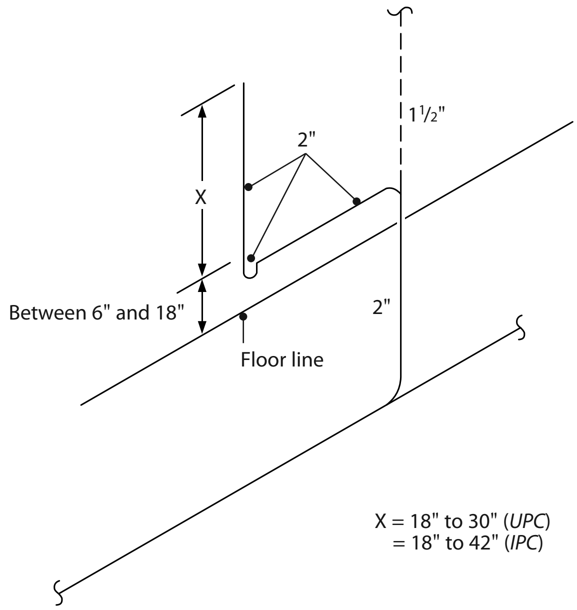


Figure 7-6
Automatic clothes washer standpipe detail

The code prohibits installation of indirect waste receptors in any toilet room, closet, cupboard or storeroom — with this exception. You may install the standpipe for an automatic clothes washer in toilet and bathroom areas if the clothes washing machine is installed in the same room.

Sumps

When the location of a fixture, appliance or equipment prevents drainage by gravity, you'll have to use a sump. The sump pump can empty clear water waste from a basement floor, subsoil drain, air conditioning condensate drain, and similar applications. The pump will lift the liquid and convey it to an approved place of disposal. See Figure 7-7.

Special Wastes

Certain clear water wastes (water lifts, expansion tanks, stills, sterilizers, cooling jackets, sprinkler systems, drip or overflow pans, or similar devices) contain insignificant amounts of impurities. But according to the *UPC*, they still have to discharge through an indirect waste pipe with an *air gap* before they can empty into the building drainage system.

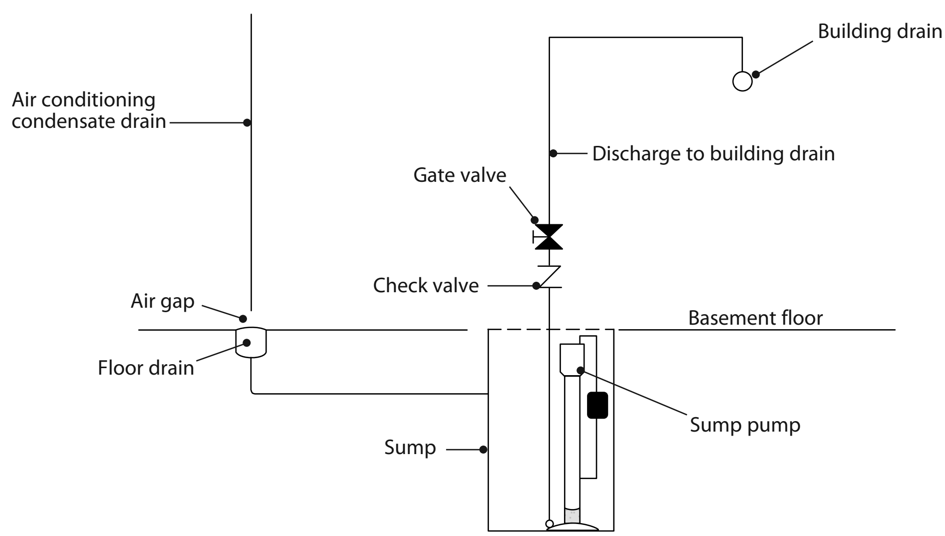


Figure 7-7
Clear water waste sump and piping detail

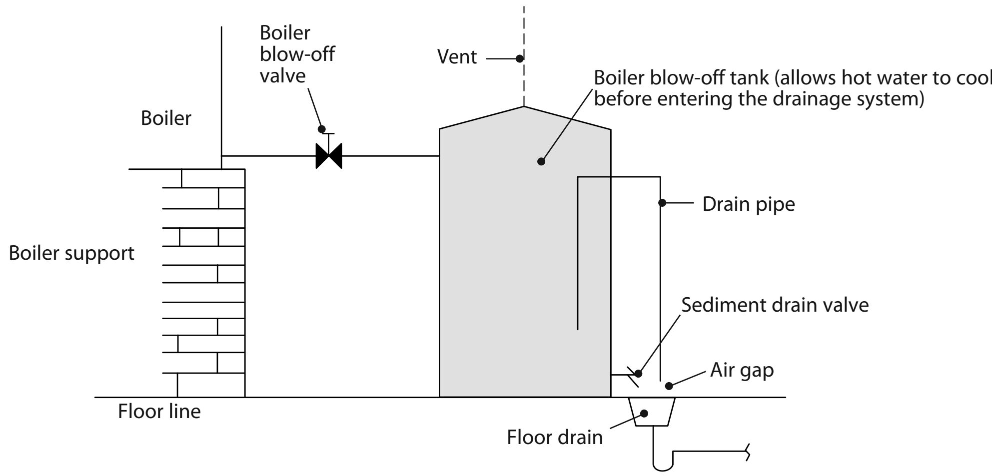


Figure 7-8
Typical boiler blow-off and blow-off tank installation

Air Conditioning Condensate Drains

Pipe carrying the special waste from air conditioning units usually connects to the building sanitary or storm system. In such cases, you must install it as indirect waste. The pipe must discharge through an *air gap* or *air break* type connection. Look back at Figures 7-2 and 7-3.

Local authorities will generally approve one of the following:

- An approved receptor or other suitable fixture
- A sump
- A building storm or sanitary drain
- A building's inside rain leader
- A waste and overflow or lavatory tailpiece. (Note: Not all codes accept this particular method for disposing of air conditioning waste.)
- A properly engineered exterior ground well/pit

In Chapter 8, we'll cover materials, installation specifics, and other disposal methods for air conditioning waste.

High Temperature Waste Water

No steam pipe or water with a temperature above 140 degrees F should discharge directly into any part of a drainage system. The pipe must first discharge into an approved intercepting sump or boiler blow-off tank. See Figure 7-8. It must connect to drainage systems by the *air gap* method. Closed tanks must be vented from the top. The vent must extend separately, full size, above the roof.

Swimming Pool Wastes

Commercial Pools

Swimming pools, wading pools and spas have special objectionable wastes. Ordinary public sewer systems and treatment plants simply can't handle huge amounts of waste suddenly discharged into the system. The health department is concerned about the potential for health hazards when the combined wastes are treated at the treatment plant. That's why piping carrying waste from swimming pools, wading pools and spas that's connected to building sanitary or storm systems has to be installed as an indirect waste. You'll always have to get advance approval from your authority. Additionally, in general, waste authorities will require the pool be treated to remove any chlorine before allowing the pool water to enter into the drainage system.

This also includes other types of pool drainage such as backwash from filters, water from scum gutter drains and deck drains. If the pool's indirect waste line is below the sewer grade, you may be required to install a circulation pump to remove the contents.

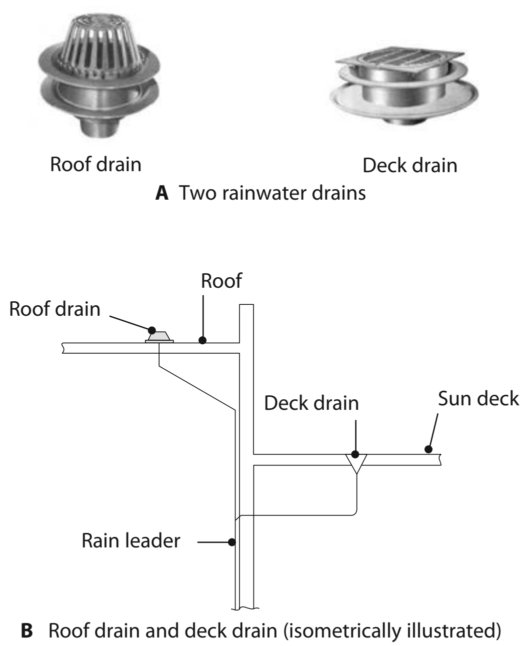


Figure 7-9
Roof and deck drains

Private Pools

If you obtain advance approval from the local authority, there are several approved methods to dispose of backwash water and to empty private pools. Because the quantity is less, you seldom have to connect this waste to a sanitary or storm drainage system.

And remember this: *Pool wastes should never discharge into a sanitary drainage system connected to a septic tank.* It can harm the septic tank and/or the subsoil leach field (drainfield). Sudden large amounts of pool water can create a reverse flow in a drainage system, causing the plumbing fixtures inside to overflow. Also, the chlorine in pool water can destroy the bacterial process that makes the septic tank and leach field function. See Chapter 17 for more detailed information on waste water disposal.

Storm Water Drainage Systems

Rainwater is one of the major *special wastes* that's generated on commercial properties. Take care that the piping you install receives and conveys rainwater to a point where discharge can legally occur — not always a simple task.

Storm drainage includes roof drains, area drains, catch basins, gutters, leaders, building storm drains, building storm sewers, footing drains and ground surface storm sewers.

Rainwater that's not properly collected and disposed of becomes a nuisance and a health hazard. Parking lots and large residential and commercial buildings can collect stagnant pools of storm water. Stagnant pools, besides producing offensive odors, are ideal breeding grounds for mosquitoes.

The code recognizes the importance of collecting and disposing of storm water from commercial properties. Though it's rare nowadays, you might find that some older cities near lakes, rivers or the ocean use a combined sewer system to carry both storm water and partially-treated (or untreated) sewage. These archaic systems end in outfall lines that dump waste into the water at a considerable distance from the shoreline or city. These practices are increasingly unacceptable to informed citizens and politicians. Cities are establishing stricter controls in an effort to correct such environmental assaults.

You'll need advance approval to connect any new construction into an old dual system. Most local codes now require two separate systems: one for sewage and one for storm water collection.

Roof Drains and Special Drains

You must equip *roof drains* with strainers, with the strainer cover extending at least 4 inches above the roof surface. It must have a minimum inlet area of $1^{1}/_{2}$ times the area of the pipe to which it connects.

Unlike most drains, *deck drains* on sun decks, parking decks and similar public areas must have an approved flat-surface strainer. This reduces the chance that pedestrians will trip, become injured and possibly file a lawsuit. Also unusual, the strainer must have an inlet area at least two times the area of the pipe to which it connects. Figure 7-9 shows both types of drains.

Install *area drains* at the foot of a stairwell or similar area where rainwater may accumulate. The pipe's diameter must be at least 2 inches, and it can't drain an area that exceeds 100 square feet. If the area is greater, use regularly spaced floor drains to drain the entire area.

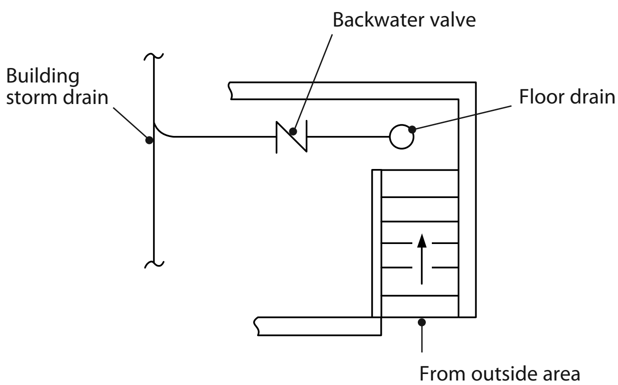


Figure 7-10
Area drain connection to storm drain

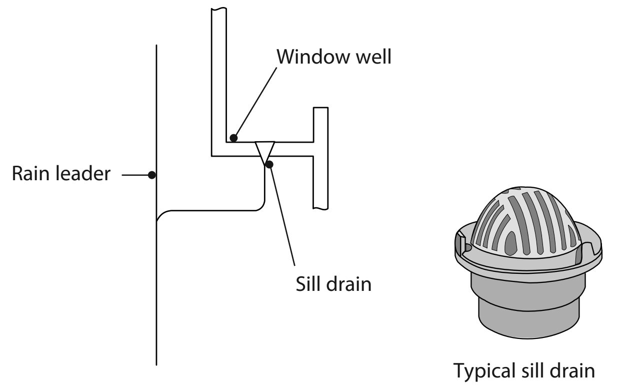


Figure 7-11
Sill drain connection to rain leader

When you connect an area drain to a building storm drain, you'll have to install a backwater valve that's accessible for inspection and maintenance. Floor drains are generally used for this purpose, although flat-surface type strainers like those used on deck drains are also permitted. See Figure 7-10.

Sill drains are drains located where there's a flat surface between a window and an outside wall. You can usually connect the wastes from these drains to an inside rain leader or to the storm water drain (Figure 7-11).

Planter drains may be required for commercial buildings with an indoor planter area. Your local authority may require that the excess waste water pass through a sand interceptor before it's discharged to a legal point of disposal. See Figure 7-12.

Subsoil drains (sometimes called *footing drains*) intercept surface water before it reaches the building's foundation wall or footings. Most codes require subsoil drains for building construction in low or depressed areas where surface water accumulation from rainstorms can present a serious problem. Some codes require subsoil drains for buildings with basements, rooms, cellars or crawl spaces below grade. You can install them inside or outside of the footings. See Figure 7-13. Most subsoil drains have to pass through a sand interceptor before being pumped to an approved legal point of disposal. See Chapter 8 for more detail on special drains.

Figure 7-12
Typical planter drain approved by code

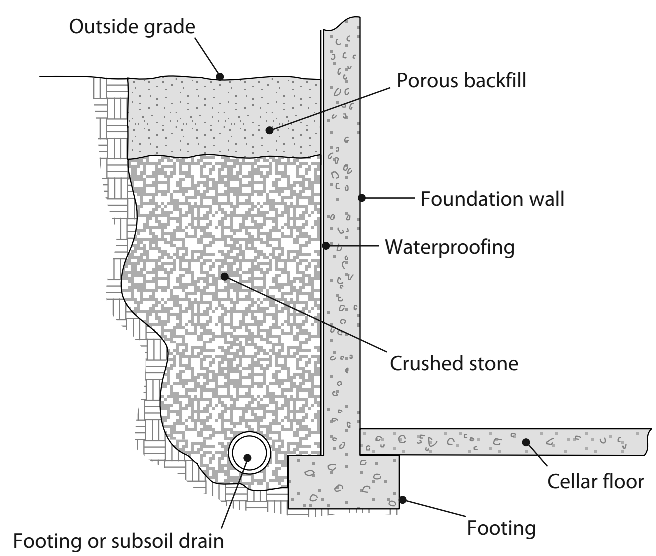


Figure 7-13
Detail of footing drain installation

Sizing Storm Water Drainage Systems

Mechanical engineers are usually responsible for figuring out sizing and disposal methods for storm water drainage pipes. Calculations are based on two factors:

1) The square footage of impervious areas (roofs, parking lots and similar surfaces)
2) The maximum anticipated inches of rainfall in any one hour

If engineers do most calculations, why should you concern yourself with the principles of sizing commercial storm drainage and disposal systems? There are a couple of good reasons. First, it's plumbers, not engineers, who actually install this kind of work. If you install a system that isn't right, engineer's fault or not, you're still going to look bad. Second, you'll have to interpret storm drainage tables and understand regulations if you expect to pass the journeyman and master plumber's examination.

You'll find that there are wide differences between codes when it comes to sizing storm drains. They use different formulas, and there are great variations in maximum anticipated rainfall in any one hour. Rainfall in this country can vary from less than 2 inches to more than 8 inches. Naturally, the less rainfall, the smaller the pipe required. The greater the rainfall, the larger the pipe required.

You need to provide good spacing of the roof drains to eliminate puddling on roof surfaces. If you don't have proper spacing, you won't pass inspection. Of course, the more roof drains you use, the fewer puddles you'll have. Remember, too, that installing smaller roof drains and leader pipes, even though you'll need more of them, is less expensive than installing a smaller number of large drains and leader pipes.

When you know the maximum anticipated rainfall and the square feet of roof surface, you can begin your calculations. Use your local code book tables to determine the size of your leaders and horizontal drain pipes. The examples in this book are based on the *Uniform Plumbing Code*.

The *UPC* and *IPC* have rainfall tables that indicate the diameter of vertical leaders and horizontal piping based on the square footage of the roof area. Figure 7-14 shows the tables for vertical leaders from the *UPC*. Figure 7-15 is the horizontal table from the *UPC*.

Uniform Plumbing Code
Maximum allowable horizontal projected roof areas

Size of drain leader, or pipe (in)	Square feet at various rainfall rates					
	1 in./h	2 in./h	3 in./h	4 in./h	5 in./h	6 in./h
2	2,880	1,400	960	720	575	480
3	8,800	4,400	2,930	2,200	1,760	1,470
4	18,400	9,200	6,130	4,600	3,680	3,070
5	34,600	17,300	11,530	8,650	6,920	5,765
6	54,000	27,000	17,995	13,500	10,800	9,000
8	116,000	58,000	38,660	29,000	23,200	19,315

Sizes indicated in the above table are the diameter of circular piping. Square or rectangular piping may be used, provided the cross-sectional area fully encloses a circle of the pipe diameter indicated in this table.

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Figure 7-14
*Sizing roof drains, leaders, and **vertical** rainwater piping*

Size of pipe in inches	**Maximum rainfall in inches per year**					
1/8"/ft. slope	**1**	**2**	**3**	**4**	**5**	**6**
3	3,288	1,644	1,096	822	657	548
4	7,520	3,760	2,506	1,880	1,504	1,253
5	13,360	6,680	4,453	3,340	2,672	2,227
6	21,400	10,700	7,133	5,350	4,280	3,566
8	46,000	23,000	15,330	11,500	9,200	7,670
10	82,800	41,400	27,600	20,700	16,580	13,800
12	133,200	66,600	44,400	33,300	26,650	22,200
15	238,000	119,000	79,333	59,500	47,600	39,650
1/4"/ft. slope	**1**	**2**	**3**	**4**	**5**	**6**
3	4,640	2,320	1,546	1,160	928	773
4	10,600	5,300	3,533	2,650	2,120	1,766
5	18,880	9,440	6,293	4,720	3,776	3,146
6	30,200	15,100	10,066	7,550	6,040	5,033
8	65,200	32,600	21,733	16,300	13,040	10,866
10	116,800	58,400	38,950	29,200	23,350	19,450
12	188,000	94,000	62,600	47,000	37,600	31,350
15	336,000	168,000	112,000	84,000	67,250	56,000
1/2"/ft. slope	**1**	**2**	**3**	**4**	**5**	**6**
3	6,576	3,288	2,192	1,644	1,310	1,096
4	15,040	7,520	5,010	3,760	3,010	2,500
5	26,720	13,360	8,900	6,680	5,320	4,450
6	42,800	21,400	14,267	10,700	8,580	7,140
8	92,000	46,000	30,650	23,000	18,400	15,320
10	165,600	82,800	55,200	41,400	33,150	27,600
12	266,400	133,200	88,800	66,600	53,200	44,400
15	476,000	238,000	158,700	119,000	95,200	79,300

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Figure 7-15

*Sizing **horizontal** rainwater piping*

First, you need to find the total square feet to be drained. Then check to see if there are any vertical walls that permit storm water to drain onto the roof area. Be sure to review the vertical wall section of your code carefully. Depending on the code you use, you'll add from about 30 to 50 percent of the vertical wall area to the roof area. When you add vertical wall areas to the flat surfaces, it can dramatically increase the size of leaders and horizontal pipes.

Figure 7-16 suggests one way to arrange roof drains and size the storm water pipes for a typical roof with a vertical wall. You can follow this example for draining any type or size roof. In this case, the main roof is 5,000 square feet (100' × 50' = 5,000 SF) with an attached 900-square-foot vertical wall (100' × 9' = 900 SF).

Assume the code in this area calls for adding half of the vertical wall surface. So we'll add 450 square feet to the 5,000-square-foot roof area, for a total of 5,450 square feet to be drained. You can see that two roof drains (each one with a drain capacity of 2,725 SF) will be adequate to avoid puddling on this roof.

Use the *UPC* table in Figure 7-14 to size the rain leaders. The first column shows the leader pipe size in inches. Columns 3 through 14 show the maximum number of square feet that each pipe size can drain. The number at the top of each column is the rainfall rate.

Let's do a sample roof in Montgomery, Alabama. According to the maximum rainfall rates in Figure 7-17, it has a maximum anticipated rainfall of 3.8 inches. Look at the 4-inch column in Figure 7-14. As you move

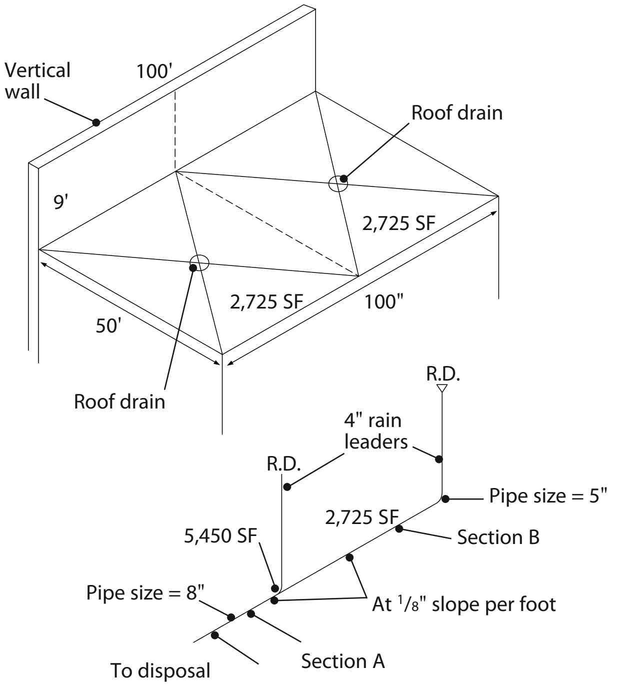

Figure 7-16
Storm water drainage system

down the column, you see 720and 2,200. Neither of these is large enough to drain the 2,725 square foot area. You'll have to move to the next line and use a leader large enough to drain 4,600 square feet. That's a 4-inch vertical leader pipe.

You'll need Figure 7-15 for the horizontal rainwater pipes. It's divided into three sections for slopes of $^1/_8$ inch, $^1/_4$ inch and $^1/_2$ inch. The greater the slope, the larger the area that each pipe size can drain. The left column shows the slope and the pipe size in inches. The other columns show the maximum area that can be drained by that size pipe during a rainfall of 1 to 6 inches per hour.

The slope shown in Figure 7-16 is $^1/_8$ inch per foot, so you'll use the top section of Figure 7-15. Note that the horizontal pipe in the drawing is divided into two sections, A and B. Section A carries the flow for both leaders, or 5,450 square feet. At 4 inches of maximum rainfall, you'll install an 8-inch pipe for Section A and a 5-inch pipe for Section B.

Again, the greater the slope, the larger the area that each pipe size can drain. This also means that each pipe size can be smaller.

Now, from the drawing in Figure 7-16, let's size Sections A and B, using the other two slopes listed in Figure 7-15 and the same rainfall rate (4 inches per hour). At $^1/_4$ inch slope per foot, you can still use a 5-inch pipe for Section B (an area of 2,725 square feet). Section A (an area of 5,450 square feet) needs a 6-inch pipe, which can handle up to 7,550 square feet.

You'll see that at $^1/_2$ inch slope per foot, a 4-inch pipe will work for Section B and a 5-inch pipe for Section A. A smaller pipe can accommodate both Sections A and B.

Generally speaking, you'll find that the tables in code books for sizing storm water drains and leaders are already calculated for the particular geographic area involved. But what if there's more rainfall or less rainfall than Figure 7-15 shows?

The *Uniform Plumbing Code* lets you adjust the figures in Figure 7-15 for varying amounts of rainfall. Here's how it works. In the 1-inch rainfall column, adjust the figures by dividing the square feet in the 1 inch/hour column by the desired rainfall rate in inches/hour. Let's work out an example. Using each of the three acceptable horizontal pipe slopes, we'll figure the number of square feet a 4-inch pipe will carry in a geographic area with a maximum 8 inches/hour rainfall rate.

$^1/_8$ inch slope: In Figure 7-15, the 1-inch rainfall column opposite the 4-inch pipe shows 7,520 square feet.

$$\frac{7{,}520 \text{ SF}}{8''/\text{hour}} = 940 \text{ SF}$$

$^1/_4$ inch slope: In Figure 7-15, the 1-inch rainfall column opposite the 4-inch pipe shows 10,600 square feet.

$$\frac{10{,}600 \text{ SF}}{8''/\text{hour}} = 1{,}325 \text{ SF}$$

$^1/_2$ inch slope: In Figure 7-15, the 1-inch rainfall column opposite the 4-inch pipe shows 15,040 square feet.

$$\frac{15{,}040 \text{ SF}}{8''/\text{hour}} = 1{,}880 \text{ SF}$$

You can repeat this formula with differing pipe sizes and maximum rates of rainfall that aren't listed in Figure 7-15.

Alabama:
- Birmingham 3.7
- Mobile 4.5
- Montgomery 3.8

Alaska:
- Fairbanks 1.0
- Juneau 0.6

Arizona:
- Phoenix 2.2

Arkansas:
- Ft. Smith 3.9
- Little Rock 3.7

California:
- Eureka 1.5
- Lake Tahoe 1.3
- Los Angeles 2.0
- Lucerne Valley 2.5
- San Diego 1.5
- San Francisco 1.5
- San Luis Obispo 1.5

Colorado:
- Denver 2.2
- Durango 1.8
- Stratton 3.0

Connecticut:
- Hartford 2.8
- New Haven 3.0

District of Columbia:
- Washington 4.0

Florida:
- Daytona Beach 4.0
- Jacksonville 4.3
- Melbourne 4.0
- Miami 4.5
- Tampa 4.2

Georgia:
- Atlanta 3.5
- Brunswick 4.0
- Macon 3.7
- Savannah 4.0
- Thomasville 4.0

Hawaii:
- Honolulu Consult local data

Idaho:
- Boise 1.0
- Lewiston 1.0
- Twin Falls 1.1

Illinois:
- Chicago 2.7
- Peoria 2.9
- Springfield 3.0

Indiana:
- Evansville 3.0
- Indianapolis 2.8
- South Bend 2.7

Iowa:
- Davenport 3.0
- Des Moines 3.4
- Sioux City 3.6

Kansas:
- Topeka 3.8
- Wichita 3.9

Kentucky:
- Lexington 2.9
- Lousville 2.8

Louisiana:
- New Orleans 4.5
- Shreveport 4.0

Maine:
- Eastport 2.0
- Portland 2.4

Maryland:
- Baltimore 3.6

Massachusetts:
- Boston 2.7
- Nantucket 2.7

Michigan:
- Detroit 2.5
- Grand Rapids 2.6
- Port Huron 2.7

Minnesota:
- Duluth 2.6
- Minneapolis 3.0

Mississippi:
- Meridian 4.2
- Vicksburg 4.5

Missouri:
- Kansas City 3.9
- St. Louis 3.2
- Springfield 3.7

Montana:
- Havre 2.0
- Kalispell 1.5
- Missoula 1.3

Nebraska:
- Lincoln 2.7
- North Platte 3.5
- Omaha 3.7

Nevada:
- Reno 1.2
- Tonopah 1.3
- Winnemucca 1.0

New Hampshire:
- Concord 2.5

New Jersey:
- Atlantic City 3.4
- Trenton 3.2

New Mexico:
- Albuquerque 2.0
- Roswell 2.6
- Santa Fe 2.1

New York:
- Binghamton 2.4
- Buffalo 2.3
- New York 3.1
- Syracuse 2.4

North Carolina:
- Asheville 3.2
- Charlotte 3.4
- Raleigh 4.0
- Wilmington 4.4

North Dakota:
- Bismarck 2.7
- Devils Lake 2.8
- Williston 2.5

Ohio:
- Cincinnati 2.8
- Cleveland 2.4
- Columbus 2.7
- Toledo 2.4

Oklahoma:
- Oklahoma City 4.1

Oregon:
- Baker 1.5
- Portland 1.3

Pennsylvania:
- Erie 2.4
- Harrisburg 2.9
- Philadelphia 3.2
- Pittsburgh 2.5
- Scranton 2.8

Puerto Rico:
- San Juan 5.7

Rhode Island:
- Block Island 3.0
- Providence 2.9

South Carolina:
- Charleston 4.1
- Columbia 3.5
- Greenville 3.3

South Dakota:
- Huron 2.5
- Rapid City 2.7
- Yankton 2.0

Tennessee:
- Chattanooga 3.2
- Knoxville 3.1
- Memphis 3.5
- Nashville 3.0

Texas:
- Austin 4.5
- Corpus Christi 4.6
- Dallas 4.2
- El Paso 2.0
- Galveston 4.7
- Houston 4.6
- San Antonio 4.4

Utah:
- Modena 2.1
- Salt Lake City 1.3

Vermont:
- Burlington 2.3
- Northfield 2.5

Virginia:
- Lynchburg 3.3
- Norfolk 4.0
- Richmond 4.0

Washington:
- Seattle 1.0
- Spokane 1.0
- Walla Walla 1.0

West Virginia:
- Elkins 2.9
- Parkersburg 3.0

Wisconsin:
- Green Bay 2.5
- LaCrosse 2.9
- Milwaukee 2.7

Wyoming:
- Casper 1.9
- Cheyenne 2.5
- Yellowstone Park 2.5

Rates given in this table are based on U.S. Weather Bureau Technical Paper No. 40, Chart 14/ 100-year one-hour rainfall (inches)

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Figure 7-17

Maximum rainfall rates in inches per hour

Review Questions for Chapter 7 (answers are on page 286)

1. By what means may wastes from fixtures, appliances and devices not regularly classed as plumbing fixtures be drained?
2. What is the purpose of the indirect drainage method for special fixtures?
3. Name three plumbing fixtures or appliances that can be drained by indirect means.
4. Name two devices that may be drained by indirect means.
5. Why must overflow pipes on the water supply system always be indirectly connected to the sanitary drainage system?
6. What is it called when there's the possibility of a potable water supply system becoming contaminated through an unsafe source?
7. What restriction applies to any indirect waste piping that, in jurisdictions under the *UPC*, exceeds 5 feet but is less than 15 feet, or under the *IPC*, that exceeds 2 feet but is less than 4?
8. When a vent is required in indirect waste piping, how must it be installed?
9. What is the minimum size for indirect waste pipes?
10. What are the two ways of terminating indirect waste piping?
11. What type of indirect waste piping arrangement is required to form an *air break* installation?
12. What type of indirect waste piping arrangement is used for an air gap installation?
13. What is the minimum separation required between the fixture outlet and the rim of the receptor for an *air gap* installation?
14. What is always required as part of an indirect waste receptor installation to allow for cleaning and inspection?
15. What factor determines the type receptor to use for *air gap* indirect waste pipe?
16. What kind of strainer can be installed in a floor sink to prevent solids from entering the drainage system?
17. What type receptor is commonly used where *air break* indirect waste pipe is installed?
18. How do most codes categorize automatic clothes washer standpipes?
19. What must be included in the installation of a standpipe receptor for an automatic clothes washer?
20. Name one place the code prohibits the installation of an indirect waste receptor.
21. In places where drainage by gravity isn't possible, what may you use to receive indirect waste pipe?
22. What equipment is needed to lift liquids from a sump to a place of disposal?
23. How must clear water wastes empty into the building drainage system?
24. In cases where air conditioning waste is connected to the building storm system, what type connection should you use?
25. Name two acceptable methods of disposing of air conditioning wastes.
26. What's the maximum water temperature that can be discharged directly into a drainage system?
27. How must wastes from swimming pools, wading pools and spas be connected to the building sanitary system?
28. What type of waste disposal system can never be used to receive waste from a swimming pool?
29. What might be the result of improperly collecting and disposing of rainwater?
30. In previous years, what type of drainage system was commonly used in older cities located near lakes, rivers or the ocean?
31. What would you need in order to connect new construction into an existing combined sewer system?
32. What must roof drains be equipped with?
33. In what locations do most codes require installation of deck drains?
34. Name two features that are unique to the design of deck drains.
35. What's the maximum area most codes permit an area drain to handle?
36. What type drain must you use where there's a flat surface between a window and an outside wall?
37. When a planter drain is used, what may be required by your local authority?

38. What's the purpose of subsoil drains?
39. Who usually determines the sizing of storm water drainage pipes?
40. What are the two determining factors in sizing storm water drainage pipes?
41. As a plumber, why should you learn all you can about sizing commercial storm drainage and disposal systems?
42. Why do storm drainage tables differ in various local codes?
43. Why is it better to install a larger quantity of smaller roof drains and leader pipes than a smaller quantity of large roof drains and leader pipes?
44. Once you know the maximum anticipated rainfall where you work and the square feet to be drained, what can you use to determine the sizing of storm drainage pipes?
45. How does increasing the slope affect the sizing of horizontal storm drainage pipes?

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8

Installation of Drainage and Vent Pipes

Plumbing codes exist to protect public health, welfare and safety. They outline the acceptable procedures for the safe design, installation and maintenance of plumbing systems. Although installation details may vary from code to code, the basic principles of sanitation and safety remain the same.

This chapter explains the installation requirements for most drain, vent and waste systems. Of course, it won't cover every situation, but it will make the intent of the code clear and understandable. These basics are absolutely essential to every plumber. If you violate even one of these principles, it's a safe bet the plumbing inspector won't pass your work.

Plumbing fixtures mark the end of the potable (drinkable) water supply system and the beginning of the sewage system. It's crucial that your drainage system design prevents any kind of fouling or solids being deposited along the walls of drainage pipes. Provide adequate venting to allow for free air circulation. (See Chapter 3.) This prevents siphonage or forcing of trap seals.

But even if your drainage design is fault-free, stoppages can occur. That's why you have to provide enough cleanouts so that all portions of the drainage system are accessible to cleaning equipment. (See Chapter 5.)

Make changes of direction in drainage pipes with 45-degree wyes, long or short sweeps, quarter bends, sixth, eighth or sixteenth bends, or a combination of these (or other approved fittings). You can use single and double sanitary tees, quarter bends and one-fifth bends in vertical sections of drainage pipes only where the direction of flow is from the *horizontal to the vertical*.

Never use a tee branch or a fitting that has a hub in the opposite direction of flow as a drainage fitting. There are also two other prohibitions you should be aware of. You can't have running threads, bands or saddles in the drainage system. And drainage and vent piping can't be drilled or tapped.

Install your plumbing drainage pipes in open trenches and keep them open until the plumbing inspector has tested, inspected and accepted them. You may have to remove cleanout plugs or caps so the inspector can make sure the pressure has reached all parts of the system.

Standards for Plumbing Materials

In the plumbing code, the accent is always on protection. But even if your system has an excellent design and admirable workmanship, it may not do its job — unless your materials provide satisfactory service. That's why the code sets minimum standards for plumbing system materials.

In general, the materials must be free from defects and meet the standards of the building department. All pipe, fittings and fixtures have to be listed or labeled by one or more organizations listed in Figure 8-1.

AHAM Association of Home Appliance Manufacturers 1111 19th Street, N.W., Suite 402 Washington, D.C. 20036 (202) 872-5955 www.aham.org	**IAPMO** International Association of Plumbing & Mechanical Officials 5001 E. Philadelphia Street Ontario, CA 91761 (909) 472-4100 www.iapmo.org
ANSI American National Standards Institute 25 W. 43rd Street, 4th Floor New York, NY 10036 (212) 642-4900 www.ansi.org	**ICC** International Code Council 200 Massachusetts Ave, NW, Suite 250 Washington, DC 20001 (888) 422-7233 www.iccsafe.org
ASME American Society of Mechanical Engineers Two Park Avenue New York, NY 10016 (800) 843-2763 www.asme.org	**ISEA** Industry Safety Equipment Assoc. 1101 Wilson Boulevard, Suite 1425 Arlington, VA 22209 (703) 525-1695 https://safetyequipment.org
ASTM American Society of Testing & Materials 100 Barr Harbor Drive, PO Box C700 West Conshohocken, PA 19428 (610) 832-9500 www.astm.org	**MSS** Manufacturers Standardization Society 127 Park Street, N.E. Vienna, VA 22180 (703) 281-6613 https://msshq.org
AWS American Welding Society 8669 NW 36 Street, #130 Miami, FL 33166 (800) 443-9353 www.aws.org	**NFPA** National Fire Protection Association One Batterymarch Park Quincy, MA 02169 (800) 344-3555 www.nfpa.org
AWWA American Water Works Association 6666 West Quincy Avenue Denver, CO 80235 (303) 794-7711 www.awwa.org	**NSF** National Sanitation Foundation Intl. 789 N. Dixboro Road Ann Arbor, MI 48105 (734) 769-8010 www.nsf.org
CISPI Cast Iron Soil Pipe Institute 2401 Fieldcrest Dr. Mundelein, IL 60060 (224) 864-2910 www.cispi.org	**UL** UL Solutions 333 Pfingsten Road Northbrook, IL 60062 (847) 272-8800 www.ul.com
CS and PS Commercial Standards and Product Standards U.S. Government Printing Office 732 N. Capitol Street, N.W. Washington, D.C. 20402 (202)512-1800 www.gpo.gov	**WQA** Water Quality Association 2375 Cabot Dr. Lisle, IL 60532 (630) 505-0160 www.wqa.org
These organizations issue standards and specifications for materials as listed in the codes. All standards and specifications are subject to change, so designations indicating years of issue may become obsolete.	

Figure 8-1
Abbreviations for plumbing-related organizations

A material is considered approved if it meets one or more of the standards cited in Figure 8-2. (Look in Table 14-1, *Uniform Plumbing Code* and Chapter 13 of *International Plumbing Code*.) Of course, you must be able to decipher the standards table in your code. If you can't get the listed materials, you can substitute materials only if the building department gives you the green light. Your local plumbing supplier should stock only materials that meet code standards.

You need to be familiar with the abbreviations in Figure 8-1 and the standards in Figure 8-2. Most journeyman and master examinations include at least one question from these tables.

Permitted Uses for Materials

The most common materials for drainage, waste and vent systems are listed in Figure 8-3. This chart covers sanitary and storm drainage, vent piping, and chemical and acid system materials. You'll see in the footnotes that you can't use certain materials in some locations, and that the use of other materials is limited or restricted. So how do you make your decision? Actual conditions determine your final choice: the building type and location, the type of fill material, the traffic expected over piping, and the waste conveyed.

Plumbing material standards are always subject to change. There's a steady stream of new material coming on the market. Check with your local authority about code changes that occur from time to time. Always buy the updated code supplement sheets and insert them in your code book.

Building Sewers

Cast iron You can use tar-coated, centrifugal-spun service weight or extra-heavy cast iron soil pipe. Use pipe that's the same weight as the underground pipe inside the building. If your job calls for extra-heavy underground soil pipe in the building, it's likely your code will require extra-heavy building sewer pipe, also.

Vitrified clay pipe You can also use standard or extra-strength vitrified clay pipe and fittings.

Plastic pipe The building sewer may be ABS or PVC Schedule 40 plastic pipe and fittings.

Concrete drain pipe The building sewer may be concrete drain pipe and fittings. However, since concrete pipe is highly susceptible to corrosion from acids and sewer gases, it's not usually recommended for ordinary building sewers.

Asbestos-cement sewer pipe Contrary to some environmentalists' belief, asbestos-cement pipe is still listed as an approved piping material by some local codes, though only in outside drainage systems, and for repairs on already-existing installations.

Bituminous fiber pipe You won't find this kind of pipe listed in the standards of most codes. It's just too fragile. The government housing authority (HUD) sometimes specifies it, however, since it's less expensive than most other sewer materials. Chances are you'll never have to install it.

Copper pipe The building sewer may be copper pipe and fittings, Type DWV, L, M, and K. Because of its cost and fragility, you'll seldom have to install it.

Underground Drainage Piping Within a Building

You can use any of these materials for underground drainage piping inside a building: ABS or PVC Schedule 40 plastic, brass, cast iron soil pipe, copper Type DWV, lead or vitrified clay pipe extra strength. Some codes also list ductile iron.

Some codes allow the use of plastic pipe in only the first two or three floors of a building. Underground piping for a building higher than three stories must be of one of the other materials listed above.

You'll find other special requirements for buildings in areas originally below high tide or where the fill produces hydrogen sulfide gas. You shouldn't use materials subject to corrosion. But if you do install them in corrosive soils, take care to protect them by coating or wrapping them with approved material. This type of material and material protection must extend out to the point of disposal (a public sewer or septic tank).

Material	Underground drain, waste, vent pipe and fittings	Aboveground drain, waste, vent pipe and fittings	Building sewer pipe and fittings	Referenced standard(S) pipe	Referenced standard(S) fittings
ABS (Schedule 40)	X	X	X	ASTM D2661 ASTM D2680*	ASME A112.4.4 ASTM D2661 ASTM D2680*
Cast-Iron	X	X	X	ASTM A74 ASTM A888 CISPI 301	ASME B16.12 ASTM A74 ASTM A888 CISPI 301
Co-Extruded ABS (Schedule 40)	X	X	X	ASTM F628	ASME A112.4.4 ASTM D2661 ASTM D2680*
Co-Extruded Composite (Schedule 40)	X	X	X	ASTM F1488	ASME A112.4.4 ASTM D2661 ASTM D2665 ASTM F794* ASTM F1866
Co-Extruded PVC (Schedule 40)	X	X	X	ASTM F891 ASTM F1760	ASME A112.4.4 ASTM D2665 ASTM F794* ASTM F1336* ASTM F1866
Copper and Copper Alloys (Type DWV)	X	X	X	ASTM B43 ASTM B75 ASTM B251 ASTM B302 ASTM B306	ASME B16.23 ASME B16.29
Galvanized Malleable Iron	—	X	—	—	ASME B16.3
Galvanized Steel	—	X	—	ASTM A53	—
Polyethylene	—	—	X	ASTM F714 ASTM F894	—
PVC (Schedule 40)	X	X	X	ASTM D1785 ASTM D2665 ASTM F794*	ASTM A112.4.4 ASTM D2665 ASTM F794 ASTM F1866
PVC (Sewer and Drain)	—	—	X	ASTM D2729	ASTM D2729
PVC PSM	—	—	X	ASTM D3034	ASTM D3034
Stainless Steel 304	—	X	—	ASME A112.3.1	ASME A112.3.1
Stainless Steel 316L	X	X	X	ASME A112.3.1	ASME A112.3.1
Vitrified Clay (Extra strength)	—	—	X	ASTM C700	ASTM C700

Notes:
[1] Although this standard is referenced in UPC Table 701.2, some of the pipe, tubing, fittings, valves, or fixtures included in the standard are not acceptable for use under the provisions of the *Uniform Plumbing Code*.

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Figure 8-2
Materials for drain, waste, vent pipe and fittings

Above-Ground Drainage and Vent Pipe	
Material	**Standard**
Acrylonitrile butadiene styrene (ABS) plastic pipe in IPS diameters, including Schedule 40, DR 22 (PS 200) and DR 24 (PS 140); with a solid, cellular core or composite wall	ASTM D2661; ASTM F628; ASTM F1488; CSA B181.1
Cast-iron pipe	ASTM A74; ASTM A888; CISPI 301
Copper or copper-alloy pipe	ASTM B42; ASTM B43; ASTM B302
Copper or copper-alloy tubing (Type K, L, M or DWV)	ASTM B75; ASTM B88; ASTM B251; ASTM B306
Galvanized Steel Pipe	ASTM A53
Glass Pipe	ASTM C1053
Polyolefin pipe	ASTM F1412; CSA B181.3
Polyvinyl chloride (PVC) plastic pipe in IPS diameters, including Schedule 40, DR 22 (PS 200), and DR 24 (PS 140); with a solid, cellular core or composite wall	ASTM D2665; ASTM F891; ASTM F1488; CSA B181.2
Polyvinyl chloride (PVC) plastic pipe with a 3.25-inch O.D. and a solid, cellular core or composite wall	ASTM D2949; ASTM F1488
Polyvinylidene fluoride (PVDF) plastic pipe	ASTM F1673; CSA B181.3
Stainless steel drainage systems, Types 204 and 316L	ASME A112.3.1

Underground Building Drainage and Vent Pipe	
Material	**Standard**
Acrylonitrile butadiene styrene (ABS) plastic pipe in IPS diameters, including Schedule 40, DR 22 (PS 200) and DR 24 (PS 140); with a solid, cellular core or composite wall	ASTM D2661; ASTM F628; ASTM F1488; CSA B181.1
Cast-iron pipe	ASTM A74; ASTM A888; CISPI 301
Copper or copper-alloy tubing (Type K, L, M or DWV)	ASTM B75; ASTM B88; ASTM B251; ASTM B306
Polyethylene (PE) plastic pipe (SDR-PR)	ASTM F714
Polyolefin pipe	ASTM F714; ASTM F1412; CSA B181.3
Polyvinyl chloride (PVC) plastic pipe in IPS diameters, including Schedule 40, DR 22 (PS 200), and DR 24 (PS 140); with a solid, cellular core or composite wall	ASTM D2665; ASTM F891; ASTM F1488; CSA B181.2
Polyvinyl chloride (PVC) plastic pipe with a 3.25-inch O.D. and a solid, cellular core or composite wall	ASTM D2949; ASTM F1488
Polyvinylidene fluoride (PVDF) plastic pipe	ASTM F1673; CSA B181.3
Stainless steel drainage systems, Type 316L	ASME A112.3.1

Building Sewer Pipe	
Material	**Standard**
Acrylonitrile butadiene styrene (ABS) plastic pipe in IPS diameters, including Schedule 40, DR 22 (PS 200) and DR 24 (PS 140); with a solid, cellular core or composite wall	ASTM D2661; ASTM D2680; ASTM F628; ASTM F1488; CSA B181.1
Acrylonitrile butadiene styrene (ABS) plastic pipe in sewer and drain diameters, including SDR 42 (PS 20), PS 35, SDR 35 (PS 45), PS 50, PS 100, PS 140, SDR 23.5 (PS 150) and PS 200; with a solid, cellular core or composite wall	ASTM D2751; ASTM F1488
Cast-iron pipe	ASTM A74; ASTM A888; CISPI 301
Concrete pipe	ASTM C14; ASTM C76; CSA A257.1; CSA A257.2
Copper or copper-alloy tubing (Type K or L)	ASTM B75; ASTM B88; ASTM B251
Polyethylene (PE) plastic pipe (SDR-PR)	ASTM F714
Polypropylene (PP) plastic pipe	ASTM F2736; ASTM F2764; CSA B182.13
Polyvinyl chloride (PVC) plastic pipe in IPS diameters, including Schedule 40, DR 22 (PS 200) and DR 24 (PS 140); with a solid, cellular core or composite wall	ASTM D2665; ASTM F891; ASTM F1488;
Polyvinyl chloride (PVC) plastic pipe in sewer and drain diameters, including PS 25, SDR 41 (PS 28), PS 35, SDR 35 (PS 46), PS 50, PS 100, SDR 26 (PS 115), PS 140 and PS 200; with a solid, cellular core or composite wall	ASTM F891; ASTM F1488; ASTM D3034; CSA B181.2; CSAB182.4
Polyvinyl chloride (PVC) plastic pipe with a 3.25-inch O.D. and a solid, cellular core or composite wall	ASTM D2949; ASTM F1488
Polyvinylidene fluoride (PVDF) plastic pipe	ASTM F1673; CSA B181.3
Stainless steel drainage systems, Types 304 and 316L	ASME A112.3.1
Vitrified clay pipe	ASTM C4; ASTM C700

Pipe Fittings	
Material	**Standard**
Acrylonitrile butadiene styrene (ABS) plastic pipe in IPS diameters	ASME A112.4.4; ASTM D2661; ASTM F628; CSA B181.1
Acrylonitrile butadiene styrene (ABS) plastic pipe in sewer and drain diameters	ASTM D2751
Cast-iron	ASME B16.4; ASME B16.12; ASTM A74; ASTM A888; CISPI 301
Copper or copper-alloy	ASME B16.15; ASME B16.18; ASME B16.22; ASME B16.23; ASME B16.26; ASME B16.29
Glass	ASTM C1053
Gray iron and ductile iron	AWWA C110/A21.10
Polyethylene	ASTM D2683
Polyolefin	ASTM F1412; CSA B181.3
Polyvinyl chloride (PVC) plastic pipe in IPS diameters	ASME A112.4.4; ASTM D2665; ASTM F1866
Polyvinyl chloride (PVC) plastic pipe in sewer and drain diameters	ASTM D3034
Polyvinyl chloride (PVC) plastic pipe with a 3.25-inch O.D.	ASTM D2949
Polyvinylidene fluoride (PVDF) plastic pipe	ASTM F1673; CSA B181.3
Stainless steel drainage systems, Types 304 and 316L	ASME A112.3.1
Steel	ASME B16.9; ASME B16.11; ASME B16.28
Vitrified clay	ASTM C700

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Figure 8-3

The fittings you use must match the material and type of piping in the drainage system. For quality installation, all joints must be gastight, watertight and root-proof.

Footing and Subsoil Drains

When the design calls for subsoil drains under a cellar or basement floor, or around the outer walls of a building, they must be at least 4 inches in diameter. The most common materials are:

- clay drain tile
- concrete drain tile
- perforated or horizontally split concrete pipe
- corrugated polyethylene tube
- perforated or horizontally split SR plastic drain pipe
- PVC sewer pipe
- vitrified clay pipe (standard or extra strength)

Aboveground Drainage Within a Building

Aboveground drainage pipes may be ABS or PVC Schedule 40 plastic, borosilicate glass, brass, cast iron soil pipe, Type DWV, copper, galvanized steel, wrought iron or lead (Figure 8-3).

Your fittings in drainage systems must be compatible with the pipe you've used. Make sure they have no ledges, shoulders or reductions that could restrict or obstruct flow. Check your threaded fittings to see that they're the recessed drainage type.

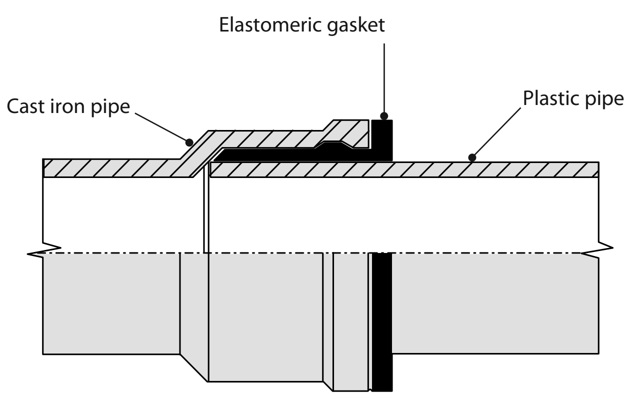

Figure 8-4
Typical transition joint — plastic to cast iron pipe

Underground and Aboveground Vents Within a Building

Vent pipes can be made of ABS or PVC Schedule 40 plastic, borosilicate glass, brass, cast iron soil pipe, copper Type DWV, galvanized steel, wrought iron or lead pipe. See Figure 8-3.

All your fittings must match the materials and type of piping used. When you use threaded pipe, your fittings must be recessed drainage type fittings only. Do not use water distribution fittings for drainage pipe installations.

In general, codes place these restrictions on drainage, waste and vent piping within a building, aboveground or underground:

- Some state or local codes limit plastic pipe to no more than three floors above grade.
- Plastic pipe or fittings can't support the weight of any plumbing fixture.
- You can't mix or combine different types of plastic materials (ABS or PVC) in any plumbing system.
- To extend, relocate or add to any existing soil, waste or vent pipe, use material of like grade and quality.
- When you've got to join together different piping materials in new work, you must do it with an approved transition fitting. Figure 8-4 shows plastic pipe joined to cast iron pipe with a compression gasket.
- You can't use galvanized steel or galvanized wrought iron pipe underground in a drainage or vent system. Install it at least 6 inches aboveground.
- You can't use vitrified clay pipe above ground or where pressurized by a pump or sewage ejector. Keep it a minimum of 12 inches below ground.

Chemical Waste and Acid Systems

All piping for chemical waste and acid systems must be made of corrosion-resistant materials approved by your local authorities. These materials are usually acceptable: borosilicate glass, PP, CPVC, ABS and PVC Schedule 40 plastic.

Indirect Waste Piping

For indirect waste piping, you can use any materials approved for potable water, or sanitary or storm drainage. The most common materials are cast iron soil pipe, galvanized steel, wrought iron, brass, copper Type DWV, K, L or M, ABS or PVC plastic and lead pipe. Figures 8-2 and 8-3 show where you can use each material, above or below ground.

Storm Drainage Systems

Most codes accept the materials listed in Figure 8-3 for storm drainage systems.

For the building sewer, you can use asbestos-cement, ABS and PVC Schedule 40 plastic, cast iron, concrete, vitrified clay, or copper Type DWV. But unless there are extraordinary circumstances, you'll never install copper drains. They're just too expensive.

For underground storm drain piping within a building, choose from ABS and PVC Schedule 40 plastic, cast iron soil pipe, copper Type DWV, and vitrified clay extra strength. Some of these materials require advance approval by your plumbing official. And *some codes will accept only cast iron or ferrous-alloy piping*. Always check the local code for acceptable materials in your area.

Acceptable materials for aboveground storm drains and leaders within a building are ABS and PVC Schedule 40, brass, cast iron, copper Type DWV, galvanized steel, lead and wrought iron pipe.

Rainwater drains conveying runoff from leaders that discharge directly into a soakage pit must have an overflow fitting. In fact, each rainwater leader requires an overflow fitting at its base. It must be the same size as the leader pipe, up to 4 inches. See Figure 8-5.

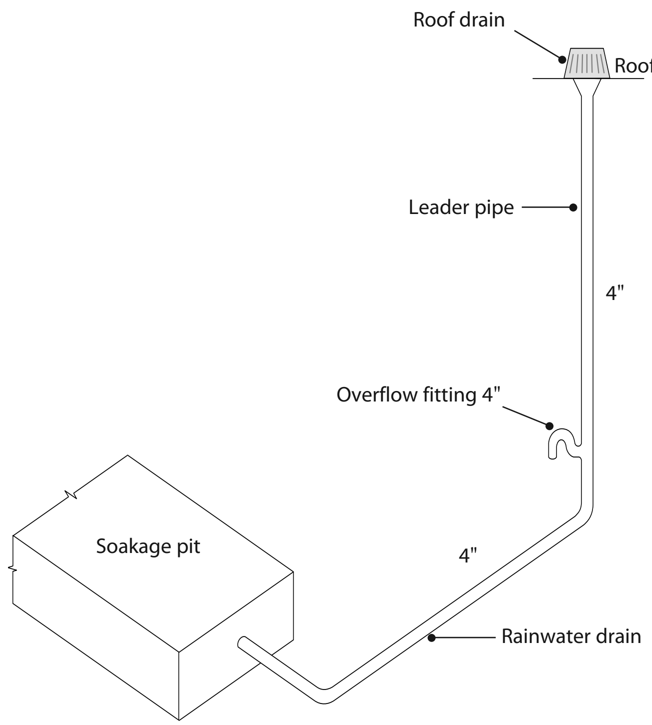

Figure 8-5
Rainwater overflow

Plan to protect all exposed rainwater leaders you install in parking garages, alleys, driveways or any place subject to damage. The conventional protection is a 3-inch galvanized steel pipe supported in a concrete base, placed in front of the leader. You can protect fragile materials (sheet metal conductors or plastics) by installing a cast iron pipe boot on the lower 5-foot portion of the leaders. And use fittings that conform to the materials and pipe you're using.

Standards for Plumbing Materials

All plumbing materials used in the construction, installation, alteration or repair of any plumbing or drainage system must comply with the standards in your code. For easier reference, I've organized the standards for plumbing materials to match the categories of materials you'll use in a plumbing sys-

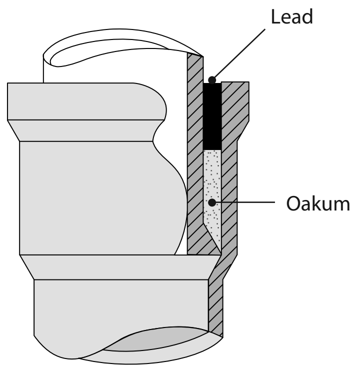

Figure 8-6
Lead and oakum joint

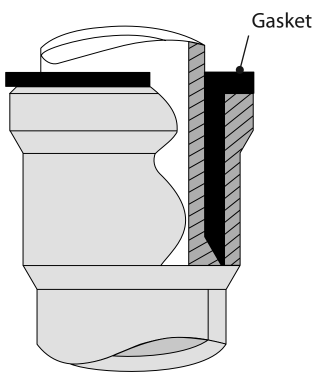

Figure 8-7
Compression joint

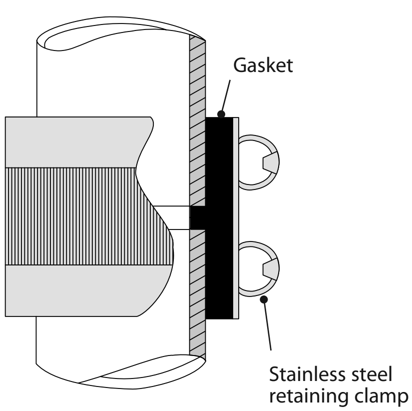

Figure 8-8
No-hub joint

tem. That means that in this chapter I'll cover only those materials you use in drainage, waste and vent systems.

Joints and Connections

Joints and connections in the DWV system must be gastight and watertight at the pressure required for testing or for the intended use. The code makes an exception for those parts of a drainage system which use perforated or open-joint piping designed to collect and convey underground water to a legal point of disposal.

Types of Joints

Cast Iron Caulked Joints

Every lead caulked joint for cast iron bell-and-spigot soil pipe must be firmly packed with oakum or hemp and filled with molten lead at least 1 inch deep (Figure 8-6). The lead can't extend more than $^1/_8$ inch below the rim of the hub. You should run the lead in one pouring and caulk it tight. Don't use paint, varnish or other coatings on the jointing material until after the joint's tested and approved.

Cast Iron Compression Joints

Neoprene rubber compression gaskets for bell-and-spigot cast iron soil pipe and fittings must be compressed when the spigot is inserted into the hub of the pipe. You can use this kind of joint as an alternate for lead and oakum joints. See Figure 8-7.

Cast Iron Hubless Joints

Make joints for hubless cast iron soil pipe and fittings with an approved elastomeric sealing sleeve and stainless steel clamp (Figure 8-8). Any clamp assembly you use to join a hubless cast iron soil pipe for DWV and building sewer lines must meet the standards of the Cast Iron Soil Pipe Institute (CISPI), or the recommendation of the manufacturer.

Asbestos-Cement Sewer Pipe Repairs

You can't generally install this type of pipe any more; it's prohibited in both model codes. But it still exists in old installations and you *are* allowed to make necessary repairs. All joints in asbestos-cement pipe must be made with sleeve couplings of the same composition as the pipe, sealed with preformed rubber rings (Figure 8-9). Make joints between asbestos-cement pipe and metal pipe with an adapter coupling caulked with lead and oakum. Joints between asbestos-cement pipe and clay pipe need an adapter coupling with approved rubber rings or a preformed bituminous ring approved by your local authority. Joints between asbestos-cement pipe and plastic pipe should always have an approved adapter coupling with approved rubber rings.

Join asbestos-cement pipes used for subsoil or storm sewer pipe with plastic couplings designed to fit snugly over the ends of the pipe.

When you need to cut asbestos-cement pipe for a repair, use a tapering tool designed to taper the pipe so it'll make a watertight joint. Tapered couplings of the same material as the pipe will provide a tight joint. See Figure 8-10.

Plastic Pipe Joints

For joints connecting plastic pipe to plastic fittings, you'll usually use solvent-cemented or heat-joined connections. If you choose ABS or PVC threaded joints, use only approved thread tape or lubricant seal recommended by the manufacturer. Never use regular pipe dope to seal plastic threaded joints.

You can also use a stainless steel clamp and elastomeric gasket joint or a push-on elastomeric gasket joint (Figure 8-11). Make this joint by pushing the pipe end into the hub which contains the gasket. It's a common joint for building drains and sewers.

When you need a connection between plastic pipe and any other material, use only approved transition fittings. The manufacturer will probably recommend the type of fitting and installation method. And finally, remember that you can't mix ABS or PVC plastic pipe and fittings in the same system without the correct transition fittings.

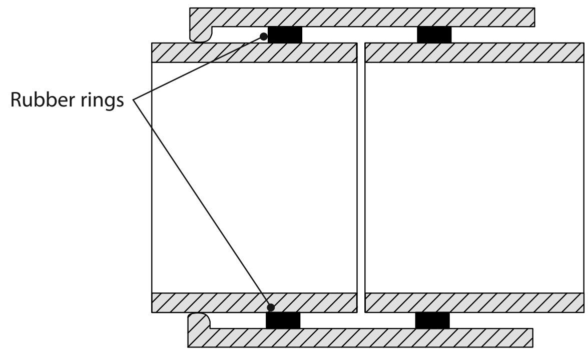

Figure 8-9
Asbestos-cement pipe coupling

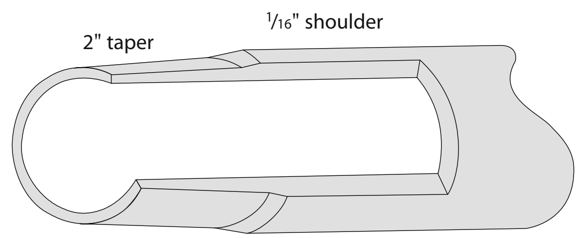

Figure 8-10
Tapered pipe end

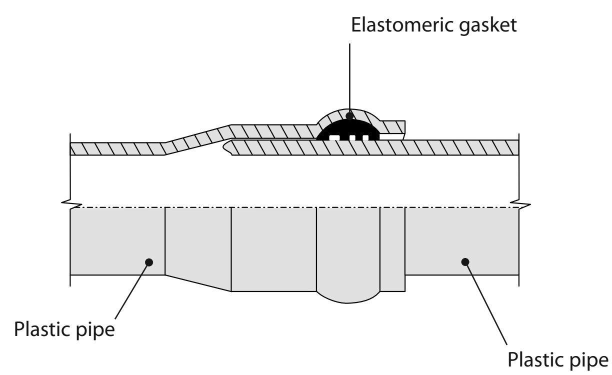

Figure 8-11
Typical push-on elastomeric gasket joint

Bituminous Fiber Pipe Joints

When you're allowed to use bituminized fiber pipe joints, make them with tapered couplings and fittings of the same material as the pipe. Be sure to use the specially-designed tapering tool when you need to cut the pipe. See Figure 8-10. Make your joints between bituminized fiber pipe and metal pipe with an adapter coupling caulked with lead and oakum. You'll need to use approved transition fittings to make the joints between bituminous fiber pipe and other materials.

Vitrified Clay Sewer Pipe Joints

Use neoprene preformed elastomeric rings to join vitrified clay pipe with bell-and-spigot connections. Join plain ends with a flexible coupling. It has an approved oil-resistant gasket attached to the pipe with adjustable stainless steel clamps and bolts (Figure 8-8).

Some codes let you use this method to seal vitrified clay pipe with bell-and-spigot joints: Use hot poured bitumastic compound if it has a bond strength of at least 100 psi in shear. Fill approximately 25 percent of the joint space at the base of the socket with jute or hemp. Pour each joint in one operation until it's filled. Don't try to test the joint for at least one hour after pouring. This joint is about like a lead and oakum joint (Figure 8-6), but with less hemp and more bitumastic compound. Vitrified clay sewer pipe joints have to be flexible to avoid breakage.

Concrete Sewer Pipe Joints

For new construction, most codes prohibit installing concrete pipe and fittings with cement mortar joints. But you can use mortar joints and connections for repairs or for connections to existing lines that have mortar joints.

The code is very specific on how to make this joint. First, pack a layer of jute or hemp into the base of the cement mortar joint space. Then dip the jute or hemp into a slurry of portland cement before inserting it into the bell. This prevents mortar from getting into the interior of the pipe. Fill only 25 percent of the joint space with jute or hemp. Fill the remaining space in one continuous operation with a thoroughly mixed mortar made of one part cement and two parts sand.

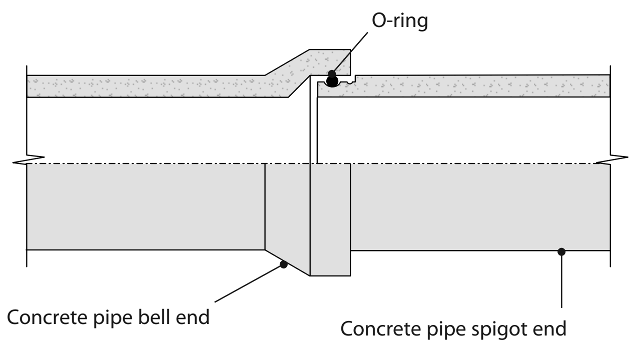

Figure 8-12
Concrete pipe joint made with O-ring

Use only enough water to make the mixture workable by hand. Apply additional mortar to form a 1 to 1 slope with the barrel of the pipe. Swab the interior of the pipe to remove any material that dripped into the pipe. Trowel more of the same mortar on your joint to form a 45-degree taper with the barrel of the pipe.

You can make a joint in concrete pipe using approved compression elastomeric materials. That's simply an O-ring that's located in the bell that makes a tight joint when the spigot end is forced into the hub. See Figure 8-12.

Trap Slip Joints

In a drainage system slip joint, you can use connectors (nuts and washers) on both sides of the trap and in the trap seal. However, some codes prohibit the use of slip joint connectors on the outlet side of the trap above the water seal. Why? Over a period of time the washer may decay or the seal of the joint may break. This would permit sewer gases to enter the building. You can see some approved traps back in Chapter 4.

Wiped Joints

The use of wiped joints is rare today. But be aware that wiped joints are required for these connections: lead pipe or fittings with lead, and lead pipe with brass or copper (includes ferrules, solder nipples or traps). Be sure your wiped joint has an exposed surface on each side of the joint no less than $^3/_4$ inch and at least as thick as the material being joined. Joints between lead pipe and cast iron, steel or wrought iron pipe require a caulking ferrule, soldering nipple or bushing. The minimum length of lead from wiped joint to fixture connection is 4 inches.

Borosilicate Glass Joints

Make glass-to-glass connections with a bolted compression-type stainless steel coupling that has a contoured acid-resistant elastomer compression ring and fluorocarbon polymer inner seal ring.

When you connect glass pipe joints to other types of piping material, use only approved adapters with a TFE seal, installed to manufacturer's recommendations.

Make your glass caulked joints like cast iron caulked joints, with this exception: you must use acid-resistant oakum or hemp rope and acid-proof cement. Check your local code for verification.

Burned Joints

Lap burned (welded) lead joints and fuse the sections together uniformly to make one continuous piece. Make the weld as thick as the lead pipe you're joining, using the same welding material as the material being joined.

Ductile Iron Gravity Sewer Pipe, Bell-and-Spigot Joints

Always join ductile iron bell-and-spigot joint gravity sewer pipe with a push-on type single oil-resistant gasket. The specially designed bell end of the pipe is shaped so the gasket can lock into place. This prevents displacement and avoids leakage.

Plain-End Ductile Iron Gravity Sewer Pipe

You can join plain-end ductile iron gravity sewer pipe the same way as no-hub cast iron pipe — with an elastomeric gasket joint and stainless steel retaining sleeve. See Figure 8-8.

Threaded Joints

Any threaded joints you use in DWV systems must conform to approved standard pipe threads shown in Chapter 14. Always use recessed drainage fittings. The manufacturer taps the threads to allow $^1/_4$ inch fall per foot. Fittings must have a smooth interior waterway.

Copper Soldered Joints

Use approved cast brass or wrought copper fittings when joining copper pipe in a DWV system. Make your joints with approved solder containing no more than 0.2 percent lead. See Figure 8-13.

Special Joints in DWV Systems

You need to have a working knowledge of several special joints used in a DWV system, including:

- *Slip joints* — They're located in fixture drains and traps. Use only approved materials.
- *Expansion joints* — They're permitted in vent piping or drainage stacks when necessary for expansion and contraction of pipes. They don't need to be accessible.
- *Joints of different types of materials* — Various materials for drainage piping can be joined together by using approved adapters or prefabricated sealing rings or sleeves.

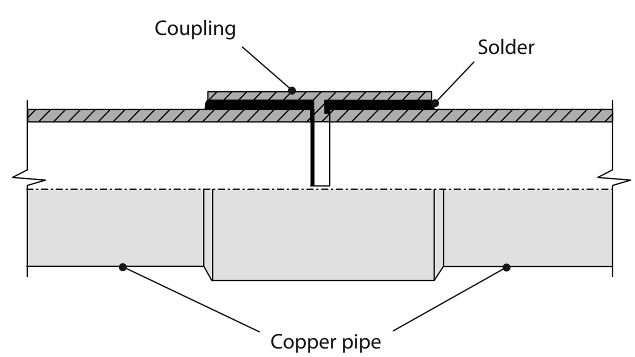

Figure 8-13
Typical copper soldered joint

- *Joints with different outside diameters* — You can join pipe materials with different outside diameters with an approved elastomeric sealing sleeve and clamping device. Provide continuous support between the two pipes.
- *Plastic threaded joints* — You can't thread Schedule 40 plastic pipe on the job site. For transitions, use only approved male or female threaded adapter fittings.

Increasers and Reducers

When you connect different size pipes or different size pipes and fittings, take care to select the proper size increaser, reducer or reducing fitting.

Changes in Direction

Make changes in direction in horizontal or horizontal-to-vertical drainage systems with 45-degree wyes, long or short sweeps, quarter bends, sixth, eighth or sixteenth bends, or with a combination of these or other approved fittings. When the direction of flow is from horizontal to vertical, use sanitary tees, quarter bends and one-eighth bends. All the fittings in Figure 8-14 are the no-hub type.

Prohibited Joints and Connections in Drainage Systems

Never use fittings or connections with an enlarged chamber, or a ledge, shoulder or reduction of pipe area which might obstruct the drain flow.

Installation Methods

New materials are constantly being developed, approved and accepted by local authorities for use in DWV systems. New concepts in pipe and fitting materials often have advantages in performance, versatili-ty, low-cost installation and product availability. There are drawbacks, however. These pipes and fittings are manufactured of fragile substances. You've got to strictly follow the manufacturer's installation instructions.

Always get advance approval from your local authority before you use materials that aren't yet included in the standards cited in your code.

Securely support your piping in trenches and above ground to avoid sagging, misalignment and breaking. We'll take a closer look at support later in this chapter.

Building Sewers

Cast iron soil pipe is a very common material for sewers because of its strength, durability and resistance to trench loads. There are three types of cast iron pipe and fittings:

1) Lead caulked joints for hub and spigot pipe
2) Compression gasket joints for hub and spigot pipe
3) Stainless steel shield with elastomeric gasket joints for no-hub pipe.

The two grades of piping material still in use today are centrifugally-spun service weight and extra-heavy cast iron.

ABS and PVC pipes have grown in popularity and have excellent resistance to corrosion. They do however require a trench and back-fill that must be very carefully designed to prevent damage to the pipe due to weight and debris.

Sewer Installation

When installing cast iron soil pipe, be sure to keep the pipe barrel in firm contact with solid ground. To do that, you have to excavate for the hub (bell) or coupling. That distributes the weight evenly along the full length of the pipe. See Figure 8-15. The depth of the excavation isn't too important because cast iron has a high resistance to trench loads. But don't backfill with large boulders, rocks, cinder or other materials which could damage or corrode the pipe.

Vitrified clay, plastic, asbestos-cement, copper and bituminous fiber pipe are considered fragile sewer materials. Where they're permitted, these pipes require special installation methods. Here are some precautionary measures that most codes require:

- Make sure the trench base continuously and uniformly supports the bottom quarter of these pipes.
- Support the pipe with fine material free of stones.

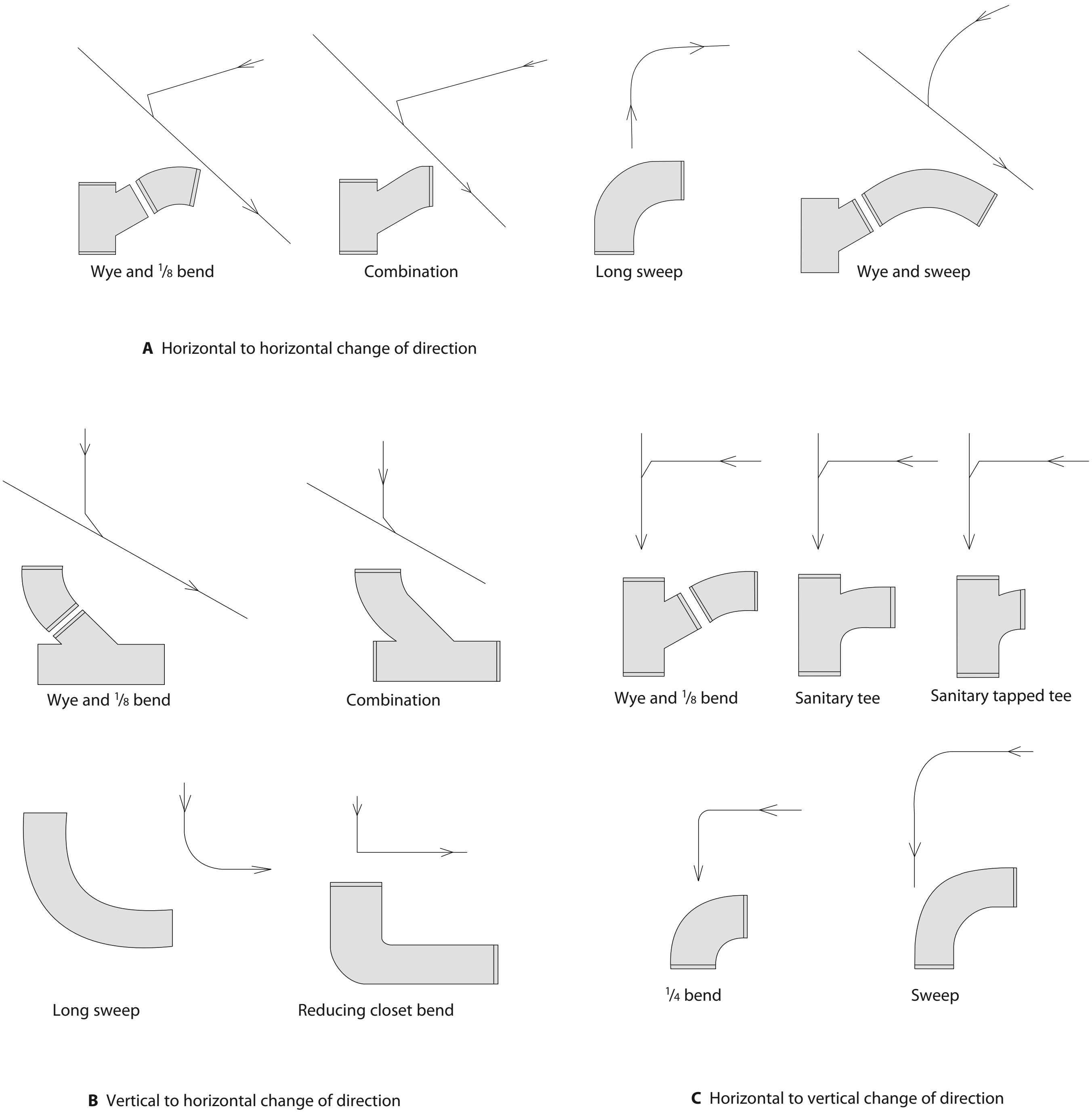

Figure 8-14

Changes of direction

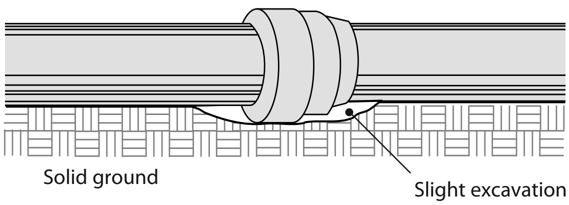

Figure 8-15
Excavation for piping hub projection

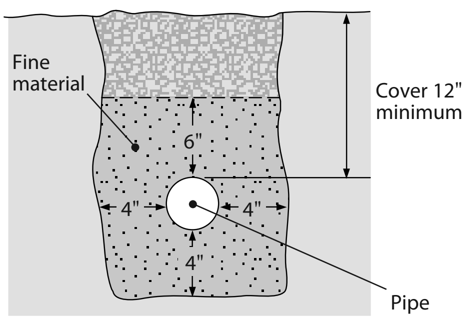

Figure 8-16
Protecting fragile piping materials

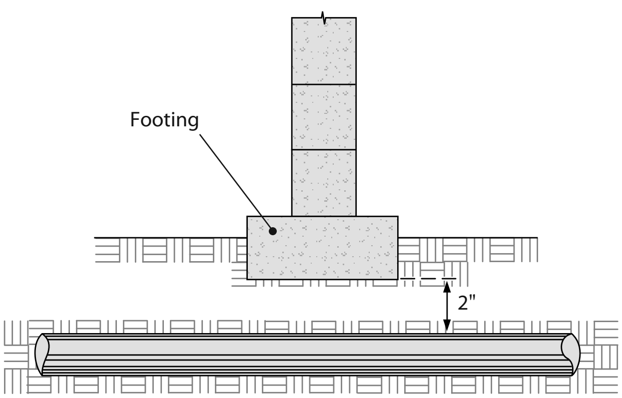

Figure 8-17
Clearance for building drains beneath foundations

- Excavate for hub and coupling projections so no part of the pipe load is supported by the hub or coupling. The supporting material must extend 4 inches on each side of the pipe.
- Firmly compact the backfill with selected fine material. Extend it from the trench bottom to a point 6 inches over the top of the pipe. Make sure your pipe is at least 12 inches below ground. See Figure 8-16.
- Make sewer pipe trenches wide enough to provide adequate work space for placing and joining the pipe.
- Prepare the trench bottom so that in final position, the pipe is true to line and grade.

Drainage, Waste and Vent Piping Within a Building

For underground or aboveground installation within a building, there's a greater variety of piping materials to choose from. But there are restrictions on the use of certain pipe and fitting materials, especially in regard to the building height. Here are some of the restrictions:

- Underground or horizontal drainage, waste and vent piping must be adequately supported. It's possible you'll need approved hangers or masonry supports to keep the pipe in alignment and to prevent sagging.
- Support the bases of stacks with masonry or concrete.
- When drainage pipe passes through cast-in-place concrete, provide sleeves that create $^1/_2$ inch of annular space around the entire circumference of the pipe. Tightly caulk the space between the sleeve and the pipe with coal tar or asphaltum compound, lead or other approved material.
- Building drains that pass beneath foundations need a clearance of at least 2 inches from the top of the pipe to the bottom of the footing. See Figure 8-17.
- Building drains and vent pipe passing through a fire wall or penetrating poured-in-place concrete floors must be sleeved (Figure 8-18). Seal the

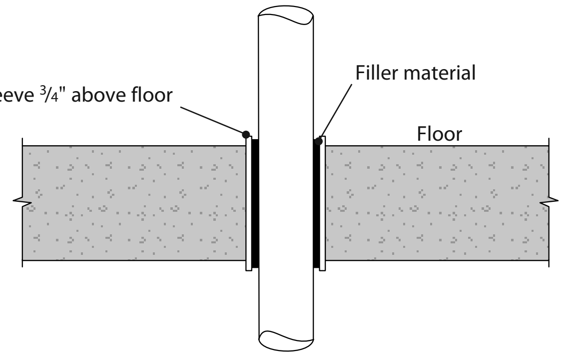

Figure 8-18
Approved floor penetration

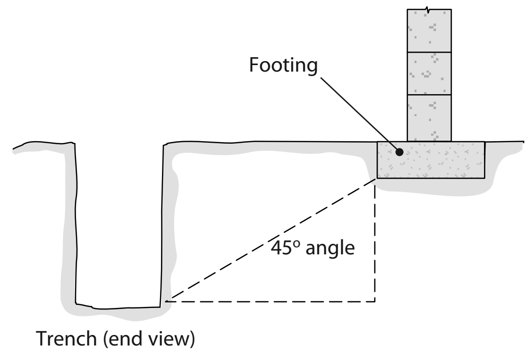

Figure 8-19
45-degree angle of pressure

annular space between sleeve and pipe with fire-resistant material so it's watertight. The filler material must meet fire and building code requirements.

- Unless the building official approves a special design, you can't place any excavation for drainage piping within a 45-degree angle of pressure from the base of an existing structure to the sides of the trench. In other words, you can't dig a drainage pipe trench that's deeper than the base of the structure and parallel to the structure's foundation within the 45-degree angle illustrated in Figure 8-19.
- When installing drainage piping in contact with cinders, concrete or other corrosive materials, use sleeves, coating, wrapping or other approved methods to protect it.
- Close any openings for pipes through walls, floors or ceilings by fastening approved metal collars securely to the structure.
- All waste pipes installed in exterior walls and other areas must be protected from freezing.
- Never install used drainage piping which doesn't conform to your code's specifications.
- Make all joints and connections gastight and watertight to withstand any required pressure testing.
- Don't install fittings or connections that present any abnormal obstruction to the flow of waste.
- Never drill or tap any waste or vent pipe for the purpose of rodding or making a connection to it.
- Never make a waste connection to a closet bend, stub of a water closet or similar fixture.
- Never use a vent pipe to convey any kind of waste and never use a soil or waste stack as a vent.
- When joining pipe or pipe and fittings of different sizes, always use increasers or reducers.

Pay special attention to these two limitations: First, some local codes limit the use of plastic DWV pipe to buildings not over three stories high. Check local code requirements. Second, buildings that exceed three stories may use centrifugally-spun service weight or extra-heavy cast iron, copper or galvanized steel pipe.

Drainage, Waste and Vent Piping Supports

Make certain that all hangers and anchors that support horizontal and vertical piping are secure enough to maintain pipe alignment and prevent sagging. Figure 8-20 shows five common pipe supports for horizontal and vertical DWV pipe. You can check your hanger rod sizes by looking at Figure 8-21. They won't be acceptable if they're smaller than the sizes shown in that table.

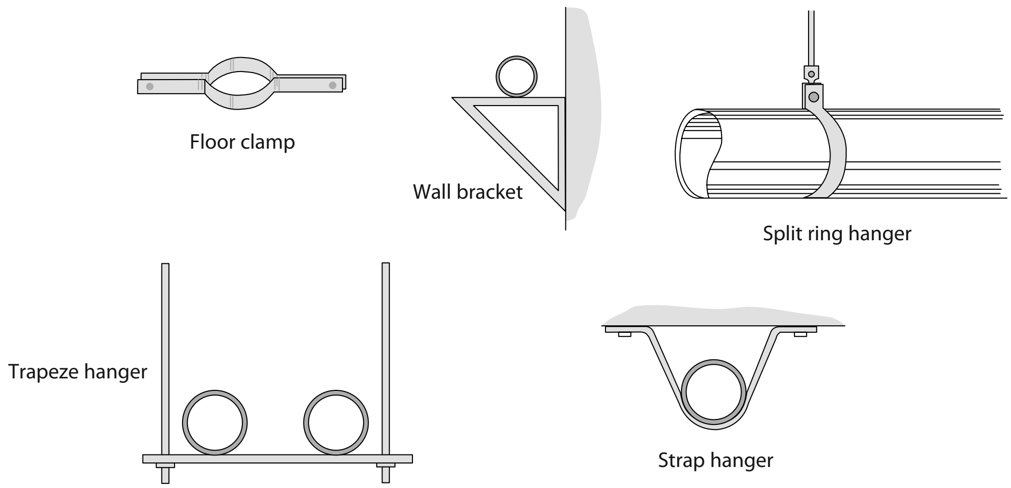

Figure 8-20
Five common horizontal and vertical pipe supports

We'll look at the specific requirements for supporting horizontal and vertical piping constructed of different materials.

Horizontal DWV Piping Supports

Always support cast iron soil pipe that has lead and oakum joints with hangers or other approved means at every hub. If you're using 5-foot lengths of pipe, that's at least every 5 feet. When you use pipe lengths over 5 feet, your support hanger intervals can be 10 feet. Your supports must be within 18 inches of the hub or joint. Support cast iron soil pipe with hubless or compression gasket joints every other joint, unless the developed length exceeds 4 feet, then support at each joint.

Pipe and tube size (in)	Rod size (in)
$\frac{1}{2}$ to 4	$\frac{3}{8}$
5 to 8	$\frac{1}{2}$
10 to 12	$\frac{5}{8}$

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Figure 8-21
Hanger rod sizes

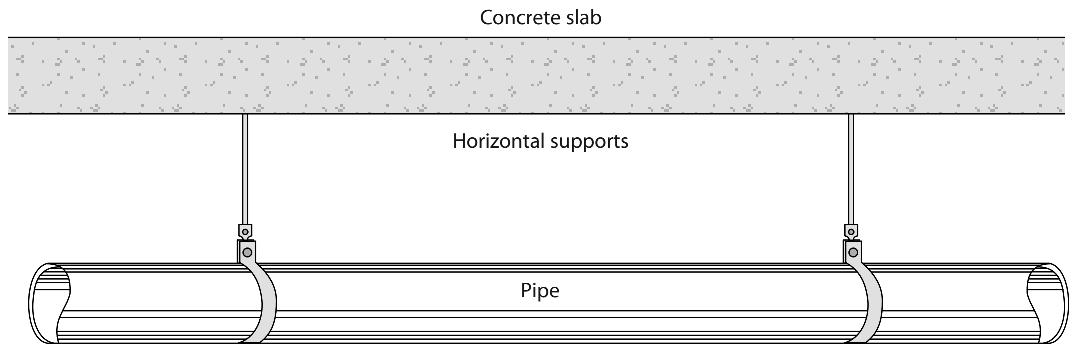
- *Screwed pipe:* For $\frac{3}{4}$ inch and smaller, you need 10-foot interval supports. Pipe this small is used mostly as indirect waste piping. Pipe 1 inch and larger requires 12-foot interval supports.
- *Copper pipe or tubing:* Provide supports at about 6-foot intervals for copper pipe or tubing that's $1\frac{1}{2}$ inch or smaller. When using 2-inch and larger copper pipe or tubing, you'll need supports at 10-foot intervals.
- *Schedule 40 PVC and ABS solvent-cemented pipe:* Regardless of pipe size, support it every 4 feet.
- *Lead pipe:* This must be supported for its entire length.
- *CPVC pipe:* For 1 inch and smaller, provide supports every 3 feet. For $1\frac{1}{4}$ inch and larger, provide supports every 4 feet.

Figure 8-22 shows a summary of the horizontal piping support intervals.

Vertical DWV Piping Supports

For all metal DWV piping, the size of the pipe isn't a factor in the support requirements. Here are the supports you'll need to provide for these vertical pipes:

- *Cast iron DWV pipe:* Support at its base and at each floor, at intervals that don't exceed 15 feet.



Distance between hangers for:

A Cast iron lead and oakum joints, 5' pipe	5'
B Cast iron lead and oakum joints, 10' pipe	10'
C Cast iron compression joints, every other joint, unless over 4', then each joint	—
D Cast iron hubless joints (same as C above)	—
E Copper pipe or tubing $1\frac{1}{2}$" and smaller	6'
F Copper pipe or tubing 2" and larger	10'
G Screwed or welded pipe 1" and larger	12'
H Schedule 40 plastic pipe ABS and PVC all sizes	4'
I Lead pipe continuous support	Entire length
J CPVC 1" and smaller	3'

Notes: 1. Support adjacent to joint, not to exceed 18". 2. To prevent horizontal movement, brace every 40'. 3. Support at each horizontal branch connection. 4. Do not place hangers on the coupling.

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Figure 8-22
Horizontal piping support intervals

- *Screwed vertical DWV pipe:* Support at least every other story, never exceeding 25 feet.
- *Copper pipe or tubing:* Support at each floor, but intervals must never be more than 10 feet apart.
- *Schedule 40 PVC and ABS pipe:* Install supports at the base and at each floor. Provide mid-story guides and expansion fittings each 30 feet.
- *Lead DWV pipe:* Your support intervals can't exceed 4 feet. The size of the pipe doesn't affect the support requirements.
- *CPVC:* Install supports at the base and at each floor. Provide mid-story guides as required by the Authority Having Jurisdiction.

Figure 8-23 shows a summary of the support requirements for vertical DWV pipe.

Vent Piping

Install horizontal vent piping with enough slope that gravity will drain it to the soil or waste pipe. Inadequate slope or sags in the pipe allow condensation to collect in low places and restrict air circulation. That reduces venting capacity.

When your horizontal vent pipe connects to a stack vent or vent stack, make sure you have an upward slope. This prevents entrapment of warm, moist air which restricts free air circulation. Trapped moist air

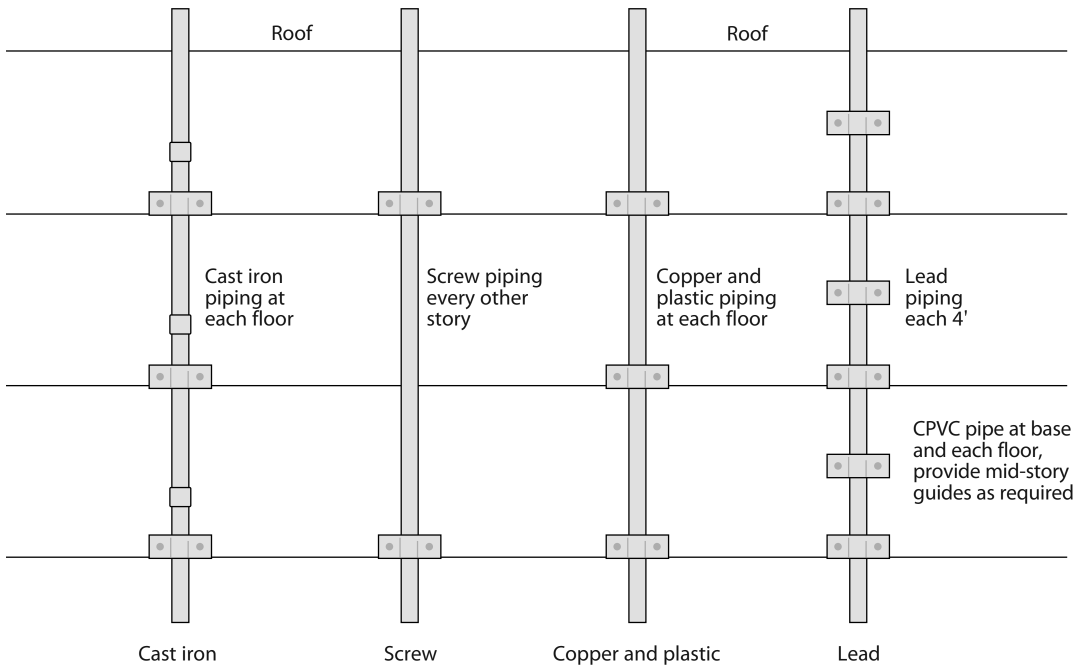

Figure 8-23
Vertical piping supports

accelerates metal pipe corrosion and greatly reduces its life. Review Chapter 3 for additional vent installation requirements.

Indirect Waste Piping and Special Waste

Size and install all indirect waste piping to accommodate the outlet drainage of any fixture or appliance. You don't need to vent indirect waste piping that doesn't have its own trap, but never connect it directly to the sanitary drainage system.

Special indirect waste piping can carry some offensive odors to the receiving fixture floor sink or floor drain. The liquid content, flowing slowly, may create slime deposits. Install all indirect drain piping without sags to eliminate the potential for slime buildup and stoppage. Gravity should cause it to drain dry. You can further reduce slime formation by locating the receiving fixture in a well-ventilated area. Always provide accessible cleanouts for cleaning and flushing purposes.

When practical, install indirect waste pipe below the floor. Install any indirect waste pipe through the receiving fixture above the water seal of the trap. This is known as an *air break* installation. See Figure 8-24.

When an above-floor installation is required, install the pipe at least 3 inches above the floor to allow room for floor cleaning. Terminate the outlet with an *air gap* of 1 or 2 inches above the receiving fixture. See Figure 8-25.

Use pipe that's at least $^3/_4$ inch diameter, but never smaller than the outlet drains of fixtures or appliances served. If you're installing indirect waste pipe below the floor, most codes require $1^1/_4$-inch pipe.

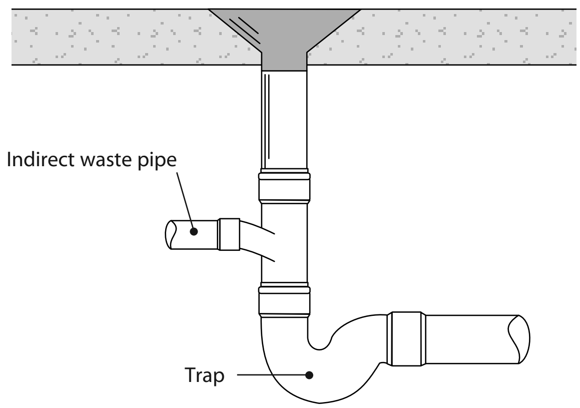

Figure 8-24
Air break type indirect waste pipe connection beneath floor

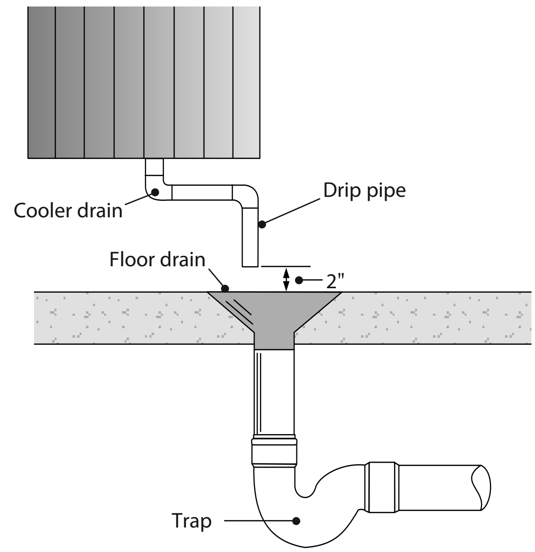

Figure 8-25
Air gap

When your installation serves *special fixtures rated more than 1 fixture unit*, use these minimums for the pipe size:

- 2 fixture units: 1 1/2 inch minimum
- 3 fixture units: 2 inch minimum

Place receiving fixtures in accessible locations for inspection and cleaning. Make sure workers can get to them without moving or disconnecting equipment or heavy objects. Don't put them in a closet, cupboard or storeroom.

You'll usually have to directly trap indirect waste pipe that's between 5 and 15 feet if you're working under the *UPC*, or 2 to 4 feet if you're under the *IPC*, but you don't need to vent the traps. Some local codes don't require trapping or venting on indirect waste pipes of any length, as long as they're graded to drain dry.

If you're working under the *UPC*, always connect a commercial dishwashing machine directly to the building waste drain line unless local health code mandates it to be indirect. And many codes, including the *UPC*, require an air gap assembly device on a domestic dishwashing machine when it's connected to the sink tail piece. See Figures 8-26 and 8-27.

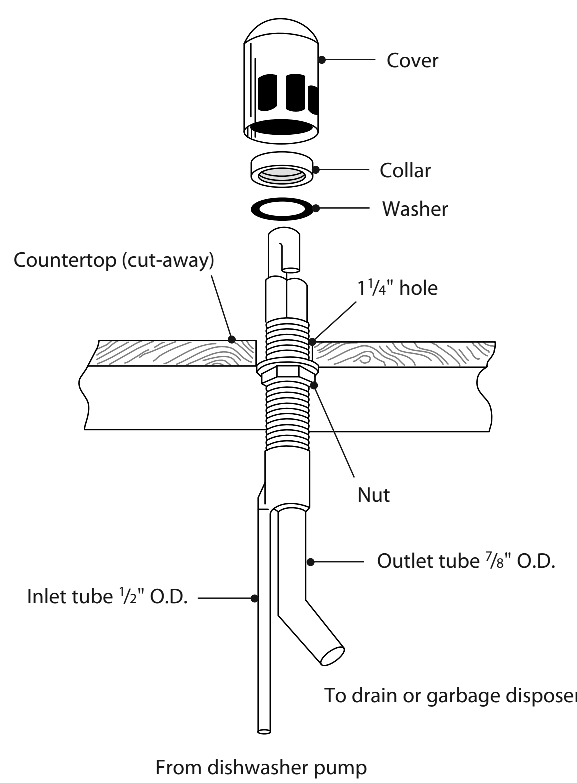

Figure 8-26
Domestic dishwasher air gap assembly device

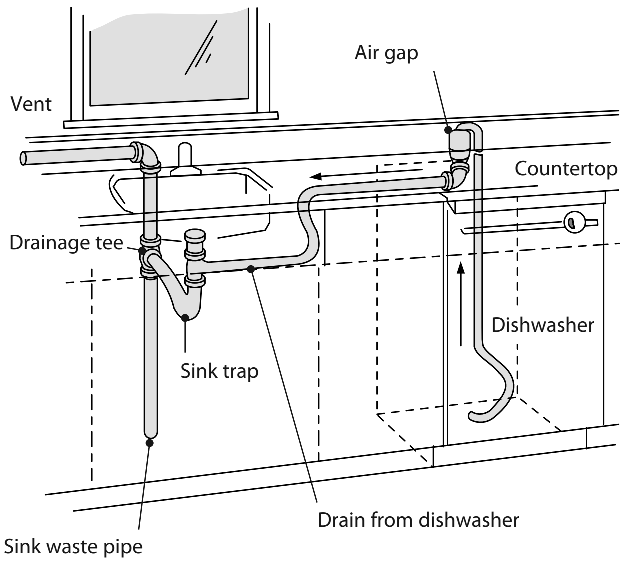

Figure 8-27
Domestic dishwasher with air gap device

Never install a floor drain or floor sink which serves as indirect waste pipe in a toilet room.

Install the floor drainage from a walk-in cooler, freezer or food storage room indirectly to the floor drain installed outside of the room. The indirect waste pipe must have a flap check valve, and the room floor must be 2 inches above the receiving fixture (Figure 8-28).

When a drinking fountain is located outside a toilet room, you can indirectly connect it to a floor drain, for the purpose of resealing the trap (providing a source of water so the trap doesn't evaporate).

Air Conditioning Condensate Drains

Always locate indirect waste piping for air conditioning units at least 2 inches below the bottom of the floor slab. Don't install it until *after* fill and compaction are complete. Lay it on a firm base for its entire length, backfilled with 2 inches of sand. Be sure to protect all risers passing through the slab with sleeves.

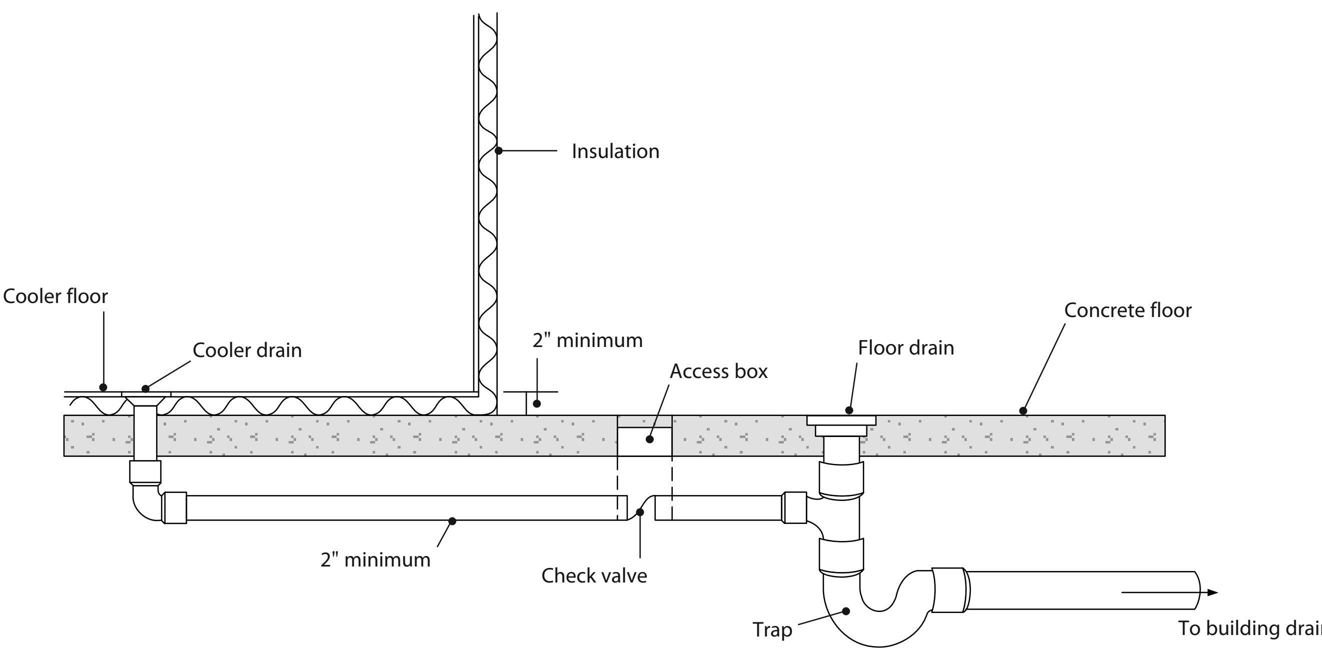

Figure 8-28
Special cooler floor drainage by air break method

Most codes require an air conditioning unit's vertical condensate drain line to be vented and trapped. Some codes will accept a perforated cap on the riser pipe about 2 feet above the topmost unit. Others require the riser to extend through the building roof. See Figure 8-29. Always check your local code requirements.

Note that the waste or condensate from an air conditioning unit is classified as a plumbing fixture only if it's connected to the plumbing drainage system. For a continuous flow like this, allow 2 fixture units per gallon per minute. Look back to Figures 2-10 and 2-11 in Chapter 2 to size the fixture drain or trap that will accommodate those fixture units.

Never use the air conditioning condensate waste to reseal the trap of the floor drain.

Any air handling equipment located in a room must be indirectly connected to the floor drain located outside the room. See Figure 8-30.

Sometimes sanitary or storm water drainage pipes aren't readily available. When that happens, your code may permit one of the following for air conditioning condensate waste disposal:

- Air conditioning units not exceeding 5 ton capacity may discharge their waste onto a pervious area such as bare soil.
- Air conditioning units over 5 tons but less than 10 tons may discharge their waste into a buried pipe filled with $^3/_4$-inch rock. The pipe must have a minimum 10-inch diameter and be 24 inches long. No cover is required.
- Air conditioning units 10 tons or larger may discharge condensate into a drainage well, storm water system, adequate-size soakage pit, drainfield or the building sanitary drainage system.
- When an air conditioning unit is centrally located below the roof of a building, it may indirectly connect to a rain leader pipe. See Figure 8-31. You can never use this method on a sanitary drainage, waste or vent pipe.

Remember these restrictions on air conditioning equipment or condensate drains: They can never discharge onto the roof of a building, across a sidewalk to the curb gutter, or onto any impervious area such as a parking lot.

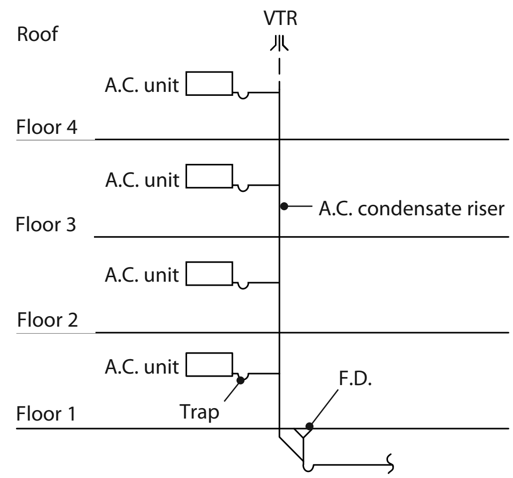

Figure 8-29
Typical air conditioning riser condensate drain connected to building drain by air break method

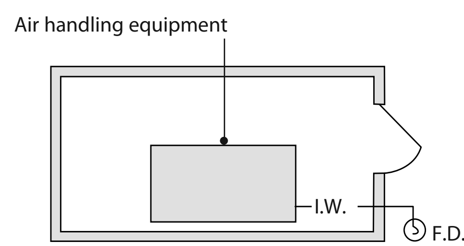

Figure 8-30
Indirect waste pipe connected to floor drain located outside of room

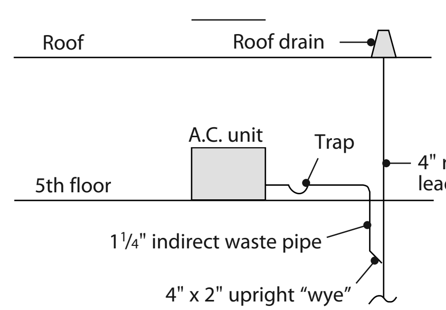

Figure 8-31
Indirect waste connection to inside rain leader

Review Questions for Chapter 8 (answers are on page 289)

1. What is the purpose of a written plumbing code?
2. Give a general description of what the plumbing code covers.
3. Where does the potable water supply system end and the sewage system begin?
4. Why is it important to design a proper drainage system?
5. Why must a drainage system be properly vented?
6. What does a properly vented drainage system prevent?
7. Why must you provide adequate cleanouts on a drainage system?
8. Name three fittings that are acceptable for making changes in direction in drainage pipes.
9. Name two of the five fittings that aren't acceptable for use in a drainage system.
10. Until when after the installation of drainage pipes in open trenches must the trenches remain open?
11. Who sets the minimum standards for plumbing system materials?
12. If listed or labeled materials aren't available, when can you use a substitute material?
13. There are certain organizations that approve various plumbing materials. If you see the abbreviation ASTM on a cast iron soil pipe and fitting, you would know that these materials were approved by what organization?
14. Why is it important that you familiarize yourself with the abbreviations of organizations that approve plumbing materials?
15. What organization approves most standards for drainage materials?
16. Why is it important to keep your copy of the code updated?
17. If you're using extra heavy cast iron pipe for soil piping underground within a building, what weight cast iron sewer pipe will most codes require for the sewer?
18. Why is copper pipe not widely used for building sewers?
19. Why is concrete pipe not generally recommended for ordinary building sewers?
20. The use of asbestos-cement pipe in a building drainage system is limited to what area?
21. In what situations can bituminous fiber pipe be used as a building sewer?
22. Where, other than in building sewers, can you use extra-strength vitrified clay pipe?
23. On which floors in a multistory building can you install plastic drainage piping?
24. What kind of piping material should you not use where the fill is known to be deleterious?
25. According to the code, fittings used in a drainage system must conform to what?
26. The joints in a drainage system must meet what three conditions?
27. What is the minimum size required for subsoil drains?
28. Name three of the approved materials most commonly used for a building subsoil drain.
29. Besides being compatible with the pipe used, what other standards must fittings in a drainage system meet?
30. What type of threaded fittings must be used in a drainage system?
31. What types of fittings may be used with threaded pipe in a vent system?
32. The code prohibits the mixing or combining of what type of piping materials in the same plumbing system?
33. What type of material must you use when adding to an existing DWV system?
34. When joining different piping materials together in new work, what kind of fitting must you use?
35. Galvanized steel pipe can't be used underground in a DWV system. How far aboveground must it be kept?
36. What is the minimum depth below grade that vitrified clay pipe must be kept?
37. Name two types of materials that are acceptable for use in a chemical or acid system.
38. The same materials are approved for use in indirect waste piping as are approved for what other systems?

39. What must you install at the base of a rain leader when it discharges directly into a soakage pit?

40. What is the conventional protection for exposed rainwater leaders located in areas where they may be subject to damage?

41. For what purpose are joints and connections in DWV systems pressure tested?

42. What type of packing is used in every lead-caulked joint with cast iron bell-and-spigot soil pipe?

43. How, specifically, should you pour a lead joint?

44. What material can you use besides lead and oakum to seal bell-and-spigot cast iron soil pipe joints?

45. The clamp assembly used in joining hubless cast iron soil pipe and fittings for DWV systems must comply with the standards set by what organization?

46. How should joints between asbestos-cement pipe and plastic pipe be made?

47. When it's necessary to cut asbestos-cement pipe for a repair, what tool must be used to dress the pipe so that the fittings will be watertight?

48. What two types of joints are used most often to connect plastic pipe and plastic fittings?

49. What type of sealant should never be used to seal plastic threaded joints?

50. What type fitting must be used when joining bituminous fiber pipe with other types of materials?

51. What kind of fitting is used to join the plain ends of vitrified clay sewer pipe?

52. What's the only type of construction in which you can use cement mortar joints and connections for concrete sewer pipe and fittings?

53. On what part of a regular fixture trap do some codes prohibit the use of slip joint connectors (nuts and washers)?

54. Joints between lead pipe and cast iron pipe may be made with which kinds of fittings?

55. Caulked glass joints are made in the same manner as caulked cast iron joints with what exception?

56. What type materials should you use to make a burned (welded) lead joint?

57. Plain end ductile-iron gravity sewer pipe may be joined in the same manner as what other type pipe?

58. What type fittings must be used in a threaded DWV system?

59. What types of fittings are approved for copper DWV systems?

60. Expansion joints may be used in vent piping or drainage stacks for what purpose?

61. When piping materials have different outside diameters, how may they be joined together?

62. How are pipes and fittings of different sizes connected in a plumbing system?

63. When you need to make changes of direction in horizontal systems or in horizontal-to-vertical drainage systems, what are two of the acceptable fittings that you can use to accomplish these changes?

64. Name the three fittings that are acceptable for use where the direction of flow is from the horizontal to the vertical.

65. Under what condition may you use materials not covered by the standards cited in your code?

66. There are three types of cast iron soil pipe and fittings approved for building sewers. Name two of these.

67. What are the two grades of cast iron soil pipe used today?

68. What characteristics make cast iron soil pipe an often used material for building sewers?

69. When you lay pipe with hubs or couplings, what must you do to protect it from damage in the trench?

70. What is the minimum code-required depth for installing plastic pipe or any one of the other fragile pipes that are approved for building sewers?

71. Why must underground or horizontal drainage, waste and vent pipe be adequately supported?

72. How must the bases of stacks be supported?

73. How should drainage pipe passing through cast-in-place concrete be protected?

74. What is the required clearance from the top of a drainage pipe to the bottom of the footing?

75. How should drainage piping be protected when it's installed in corrosive materials?

76. What must you ensure that used drainage piping conforms to before installing it in any plumbing system?

77. Under what circumstances will the code permit you to drill or tap a waste or vent pipe for the purpose of rodding?

78. Under what circumstance might the code permit a lavatory waste to connect to a water closet stub?

79. What is the maximum number of stories in which some state and local codes allow plastic DWV systems to be installed?

80. What are the two types of supporting methods you must consider in drainage, waste and vent systems?

81. What two requirements must be met when placing hangers for support of horizontal and vertical piping?

82. When pipe lengths exceed 5 feet, what's the maximum distance you should allow between hangers for horizontal cast iron soil pipe with lead and oakum joints?

83. What's the maximum distance you should allow between hangers for horizontal copper pipe $1^1/_2$ inches and smaller?

84. What is the maximum allowed distance between supports for horizontal Schedule 40 PVC and ABS solvent-cemented pipe?

85. What maximum distance is allowed between supports for vertical copper piping?

86. How should horizontal vent piping be installed and sloped?

87. Why must you not allow moist air to be trapped in a horizontal vent pipe?

88. What must you always accommodate when you size and install indirect waste piping?

89. When practical, where should indirect waste pipe be installed?

90. What do you call the type of indirect waste pipe installation that is made below the floor and connects through the receiving fixture above the water seal of the trap?

91. The outlet for above the floor indirect waste pipe should terminate in what kind of installation?

92. What minimum size indirect waste pipe should you use for an above-floor installation?

93. What is the minimum indirect waste pipe size most codes require for a below-floor installation?

94. Where should you locate receiving fixtures for indirect waste piping?

95. By what means must commercial dishwashing machines be connected to the building greasy waste drain line?

96. For what purpose may a drinking fountain be indirectly connected to a floor drain?

97. How far below the bottom of the floor slab must indirect waste piping for A/C units be installed?

98. How is an A/C unit classified when its waste or condensate connects to the plumbing drainage system?

99. Where may an air conditioning unit that's over 5 tons but less than 10 tons discharge its waste?

100. Name three of the five acceptable areas into which air conditioning units 10 tons and larger can discharge waste.

9

Septic Tanks and Drainfields

There was a time when cesspools and outhouses were the most common means of human waste disposal in this country. But they just weren't adequate as population densities increased. In rural areas, where drinking water comes from wells, contamination from sewage is a real possibility. That can spread diseases like cholera and typhoid. Local authorities no longer accept outhouses or cesspools as an acceptable method of waste disposal.

If public sewers aren't available, the only acceptable method for sewage disposal is the septic tank system. And there's still some controversy about whether the septic tank is truly safe. The Septic Tank Association contends that there's never been a proven case of a septic tank contaminating drinking water. But the Department of Environmental Resource Management (DERM) has questioned septic tank safety. The controversy and field testing continue. DERM established strict guidelines that have been adopted by most model code organizations.

Few plumbing contractors handle septic tank and drainfield installation any more. Licensed septic tank contractors usually do the installation and maintenance work for these systems. The most you're likely to do is connect the building drainage system to the inlet tee of a septic tank. But you still need to know the basic principles about septic tanks and drainfields, since you're sure to find questions about them on the journeyman's and master's examinations.

Definition of the Septic Tank

A septic tank is a watertight receptacle that receives the sewage discharge of a drainage system. It's designed to separate solids from liquid wastes. (There's usually about $^{3}/_{4}$ pound of solids in each 100 gallons of water.) The heavier portions settle to the bottom of the tank while lighter particles and grease rise to the top. They're not designed to receive storm water, as that could overload the system.

The tank's capacity should hold approximately 24 hours of anticipated flow. This retention period allows the bacterial action to digest most of the solids. That transforms the sewage waste into gases and harmless liquids. As new sewage enters the septic tank, it forces the gases up through the drainage vent pipes and into the atmosphere above the building roof. An equal amount of treated liquid is forced out through the tee of the septic tank as *effluent*. This effluent flows into the drainfield, a subsurface system of open-joint or perforated piping installed on a bed of washed rock. As the effluent seeps out between the joints or holes in the perforated piping, it oxidizes and finally evaporates.

When the bacterial process is complete, a small amount of solids remains in the tank and settles to the bottom as sludge. Lighter undigested particles rise and form scum on top of the liquid. Periodically the tank has to be cleaned of these undigested materials by a certified professional with the proper equipment.

Septic Tank Construction

Most modern codes prohibit sectional septic tanks or tanks made of blocks, brick or wood. Precast concrete or cast-in-place septic tanks are most common. In some areas, local authorities will approve steel or fiberglass septic tanks. The more fragile fiberglass tanks must meet strict installation guidelines to protect them from damage.

Concrete septic tanks must be protected from corrosion with an approved bituminous coating or other acceptable means. You can't have voids, pits or protuberances on the inner wall of a septic tank. All septic tanks must be watertight and produce a clarified effluent that meets code standards. They must be large enough to accommodate sludge and scum accumulations.

Figure 9-1 shows the criteria that most codes require for designing septic tanks. Here are the main points:

- Septic tanks must have at least two compartments (although some codes accept one).
- The inlet compartment should be at least two-thirds of the total capacity of the tank and must retain a minimum of 500 gallons of liquid. (The smallest approved tank size has a 750 gallon liquid capacity.)
- The secondary compartment (outlet compartment) should be at least one-third of the total capacity of the tank, with a minimum 250 gallon liquid capacity.
- Minimum septic tank size is 3 feet by 5 feet. Liquid depth must be between $2^1/_2$ feet and 6 feet. (Some codes require a liquid depth of 4 feet.)
- There must be a 9-inch air space above the liquid level in the septic tank (8 inches in some codes).
- The secondary compartment (outlet compartment) of a septic tank holding over 1,500 gallons must be at least 5 feet in length.
- A cover slab in removable sections is acceptable for cleaning a residential septic tank.
- Commercial septic tank manholes must be brought to grade for cleaning access. One manhole must be located over the inlet (inlet tee) and one over the outlet (outlet tee).
- When the first compartment is longer than 12 feet, add an additional manhole over the baffle wall.
- Manhole sizes vary from 20 to 24 inches in diameter, depending on the code used.
- A septic tank inlet and outlet pipe should never be smaller in diameter than the connecting sewer pipe.
- The vertical legs of the inlet and outlet tees must be as large as the connecting building sewer pipe, at least 4 inches in diameter.
- When you use a baffle-type fitting, its cross-sectional area should be the same as the connecting building sewer pipe.
- The inlet and outlet pipe or baffle must extend at least 4 inches above and at least 12 inches below the liquid level of the septic tank.
- The inlet pipe should be at least 2 inches higher than the outlet pipe.
- The inlet and outlet pipe or baffle must allow free ventilation above the liquid level. This provides circulation of air from the disposal field and septic tank through the building drainage and vent system.
- Partitions or baffles between compartments must be of solid, durable materials and extend 4 inches above the liquid level. To allow liquids to pass from the inlet to the secondary compartment, there's an inverted fitting midway in the liquid depth. (Some codes accept a slot.) The opening must be equivalent in size to the connecting building sewer.
- Septic tanks must be strong enough to withstand all anticipated earth or other loads. Septic tank covers must be able to support an earth load of at least 500 pounds per square foot.
- Septic tanks in parking lots or other areas with vehicular traffic must have a traffic cover acceptable to the building department.

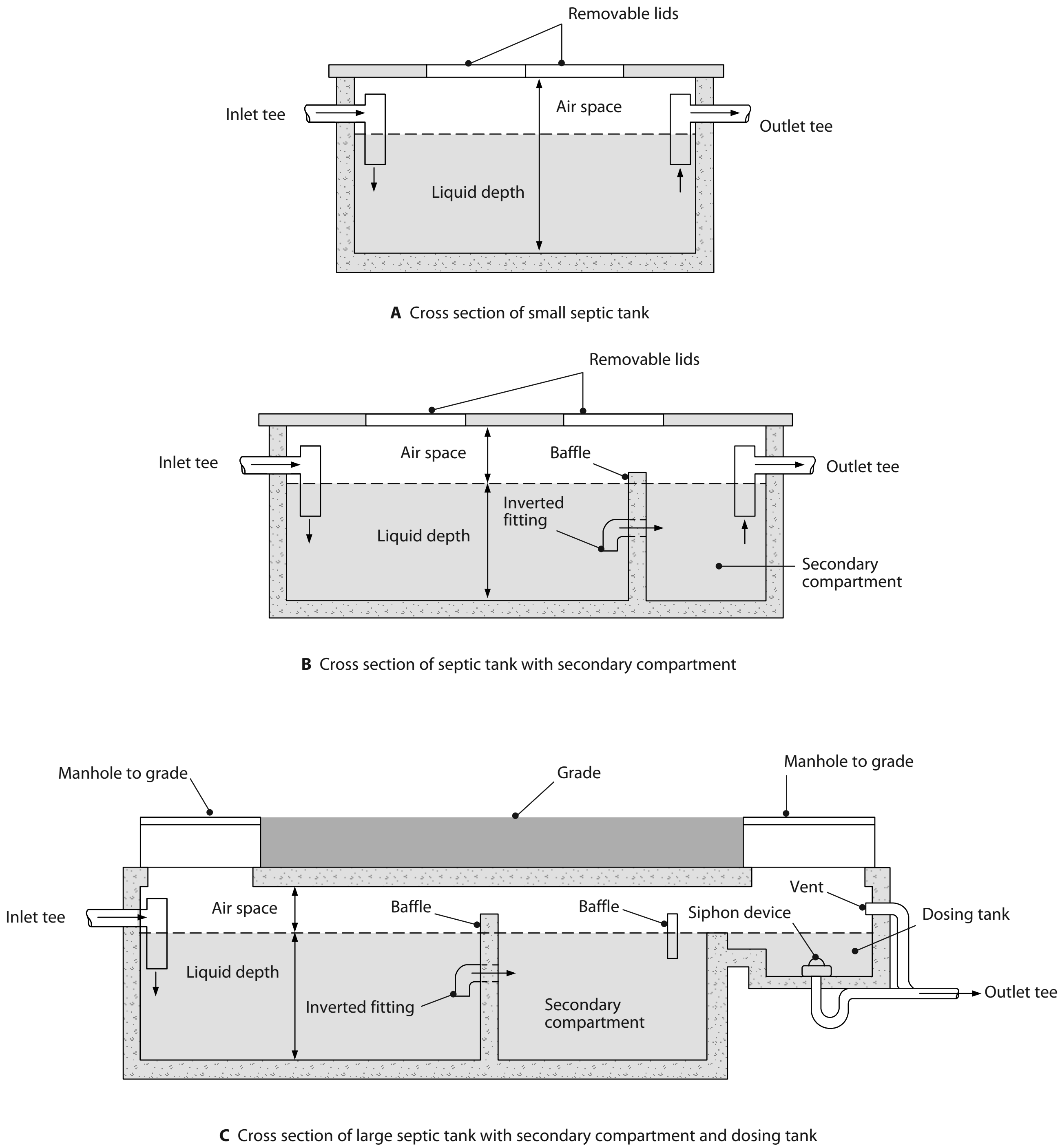

Figure 9-1
Typical septic tank construction

Single-family dwellings — number of bedrooms*	Minimum septic tank capacity (gal)
1 or 2	750
3	1,000
4	1,200
5 or 6	1,500

* For extra bedrooms, add 150 gallons each. Septic tank sizes in this figure include sludge storage capacity and the connection of domestic food waste disposal units without further volume increase. The minimum size of any septic tank is 750 gallons.

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Figure 9-2
Required capacity of septic tanks for single-family residences

Multiple dwelling units or apartments — one bedroom each	Minimum septic tank capacity (gal)
2 units	1,200
3 units	1,500
4 units	2,000
5 units	2,250
6 units	2,500
7 units	2,750
8 units	3,000
9 units	3,250
10 units	3,500

For each extra bedroom within any unit, add 150 gallons. For extra dwelling units over 10, add 250 gallons each. Septic tank sizes in this figure include sludge storage capacity and the connection of domestic food waste disposal units without further volume increase.

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Figure 9-3
Required capacity of septic tanks for multiple residential units

Sizing Septic Tanks

For single-family or multiple *residential* units, the minimum capacity is based on the number of bedrooms (Figures 9-2 and 9-3). For *commercial* buildings the septic tank capacity is based on the maximum fixture units for public use.

But there are fixture unit code differences when applied to public use. This can affect your septic tank sizing. In Figure 9-5, notice that the *UPC* assigns urinals a fixture unit value of 5. The *IPC* uses a fixture unit value of 4 for the same type of urinal. Variations like this can affect septic tank sizing, particularly on large jobs.

The septic tank sizes listed in Figures 9-2 and 9-3 include sludge storage capacity. They also allow for the use of garbage disposals.

Let's work through some examples, both residential and commercial, based on the *UPC*. We'll consider several types of construction and compute the septic tank liquid capacity for each.

Example 1, Single-Family Residence

Let's figure the capacity for a seven-bedroom house. Check Figure 9-2 for the required tank capacity for up to six bedrooms. For each additional bedroom, just add 150 gallons to the six-bedroom capacity. So for a seven-bedroom house, add 150 gallons to the 1,500-gallon tank. You'll need a 1,650-gallon tank.

Example 2, Multiple Residential Unit

Figure 9-3 shows the required liquid tank capacity for up to 10 one-bedroom units. For each bedroom above one per unit, add 150 gallons to the minimum liquid tank capacity. Let's look at a four-unit apartment building with a total of six bedrooms. For the two extra bedrooms at 150 gallons each, add 300 gallons to the septic tank liquid capacity for four one-bedroom units (2,000 gallons). You'll need a 2,300-gallon tank.

Maximum fixture units, commercial use	Minimum septic tank (gal)
15	750
20	1,000
25	1,200
33	1,500
45	2,000
55	2,250
60*	2,500

*For fixture units exceeding 60, see your local code for septic tank capacities in gallons.

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Figure 9-4

Maximum fixture units and minimum septic tank capacities for commercial use

Fixture type*	Number of fixture units for public use
Lavatories (wash basins)	1
Urinals (wall-mounted)	2
Water closet	6

* These fixtures are for the purpose of illustrating Figure 9-6, only. More complete tables are listed in your code. Fixture units may vary slightly from one code to another. Check local code.

Note: Water closets must be computed as 6 fixture units when determining septic tank size.

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Figure 9-5

Fixture units for commercial use

Example 3, Multiple Residential Unit with More Than 10 Units

According to Figure 9-3, you must add 250 gallons for each unit above 10. Let's look at a unit with 14 one-bedroom apartments. Four extra units at 250 gallons each equals 1,000 gallons. Add 1,000 gallons to the septic tank liquid capacity opposite the 10 units (3,500 gallons). You'll need a 4,500-gallon septic tank. If any unit has more than one bedroom, add an additional 150 gallons for each extra bedroom.

Example 4, Commercial Building

Minimum septic tank capacities for normal use are shown in Figure 9-4. These sizes will generally meet the requirements of the DERM and the local health department. Always check with local authorities if there's any doubt.

The minimum septic tank size is 750 gallons for any commercial use up to 15 fixture units. Of course, the septic tank capacity increases as the type and number of fixtures increase. Figure 9-5 shows the fixture units assigned by the *UPC* for some fixtures.

In our example, we'll use a restaurant with men's and women's bathrooms. Figure 9-6 shows the total fixture units (48). For commercial use, a septic tank that handles 48 fixture units needs a 2,250 gallon tank. That's the number opposite 55 F.U. in Figure 9-4. For fixture units exceeding 60, you'll need to check your local code.

Installing Septic Tanks

You can install cast-in-place septic tanks where they're subject to overburden loads, such as parking lots. The tank lid must be designed and installed to support an anticipated load equal to the weight of a 10-ton truck. You can't use precast septic tanks in parking lots or any area where vehicular traffic is anticipated unless it's designed with a traffic lid that's supported by the soil, not the tank itself. If you're installing a septic tank under any kind of paving, all cast-in-place lids must have 20- or 24-inch manholes located directly above the inlet and outlet tees. The manhole cover must be brought up to grade level.

No matter where you're installing a septic tank, it's essential that it be installed level.

Minimum septic tank size for eat and drink establishments with men's and women's toilet rooms		
Fixture type	**Fixture units**	**Min. septic tank capacity (gal)**
Men's		
4 lavatories (public) 1 F.U. each	4	
2 water closets (public) 6 F.U. each	12	
2 urinals (wall mounted) 2 F.U. each	4	
Women's		
4 lavatories (public) 1 F.U. each	4	
4 water closets (public) 6 F.U. each	24	
Total fixture units	48	2,250

Figure 9-6
Required septic tank capacity in gallons for commercial use

Restrictions for Septic Tanks

Here are some locations where you *can't* install septic tanks:

- Under or within 5 feet of any building.
- Within 5 feet of any water supply lines.
- Within 5 feet of property lines other than public streets, alleys or sidewalks, if you're working under the *UPC*, or within 2 feet if you're under the *IPC*.
- Within 50 feet (*UPC*), or 25 feet (*IPC*) of the shoreline of open bodies of water.
- Within 50 feet (*UPC*) or 25 feet (*IPC*), of a private water supply well which provides water for human consumption, bathing or swimming.

You can't excavate for a septic tank within the angle of pressure as transferred from the base of an existing structure to the sides of an excavation on a 45-degree angle. (Look back to Figure 8-19 in Chapter 8.)

Air must circulate within the septic tank and drainfield through the plumbing system and then through the inlet and outlet tees of the septic tank. No other circulation is permitted.

Types of Drainfields

There are several ways to distribute the effluent from septic tanks evenly throughout the drainfield bed. The most common are open-jointed or perforated drain tile, block or cradle-type drain units, and corrugated plastic perforated tubing. We'll look at the installation requirements for each type. The end of each distribution line must be sealed by capping or cementing a block to the ends.

Tile Drainfields

Drainfield tile must have a minimum inside diameter of 4 inches, installed on a slope not more than 3 inches per 100 feet. Lay drainfield tile on a bed of washed rock ($^3/_4$ to $2^1/_2$ inch) that's 12 inches deep under the tile. Then fill the trench with another 6 inches of rock. You need 2 inches of rock over the top of the tile. You'll have a total depth of 18 inches for the full width of the trench. See Figure 9-7.

Lay the tile with a space of $^1/_4$ inch between the tile ends. Use a strip of 4- by 16-inch 30-pound bituminous saturated paper to cover that gap to prevent sand or other small particles from filtering into the openings.

Each trench for drainfield tile must be at least 18 inches wide. The maximum width is 36 inches. But regardless of the width of the trench, each linear foot of drainfield tile is considered to be 1 square foot. We'll cover that later in the section on sizing drainfields.

The maximum length of a single tile drainfield trench is 100 feet. Where the job requires more than one trench, space the trenches at least 6 feet apart from center to center.

Reservoir-Type Drainfields

Block or cradle drain units are used in single excavations based on the square footage (length x width) rather than in individual trenches like drainfield tile.

Install block or cradle drain units to a maximum slope of 3 inches per 100 feet. Lay them on a bed of $^3/_4$- to $2^1/_2$-inch washed rock which extends from 12

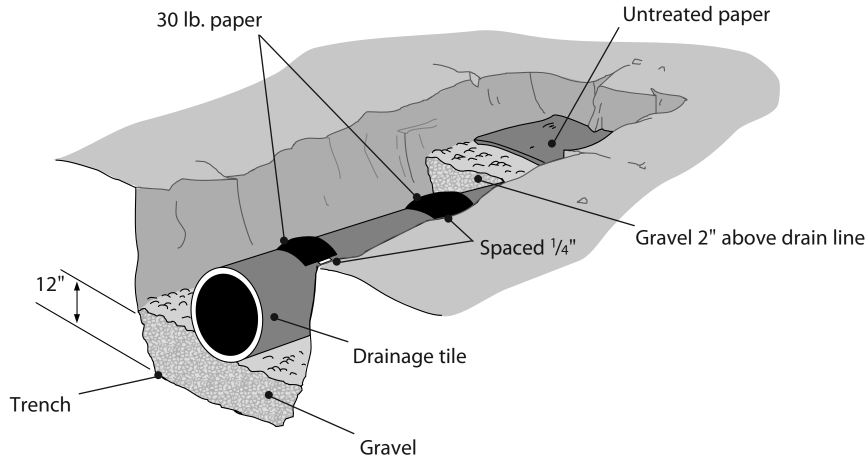

Figure 9-7
Tile drainage trench installation

inches under the drain units to 10 inches above the bottom of the units. This gives a total of 22 inches of rock for the full width of the drainfield.

Where drain units have a fixed opening to provide seepage, you can butt the units tight against each other. Where there's no fixed opening, lay the units with a 1/4-inch space between the ends. Cover the gap with a strip of 30-pound bituminous saturated paper, 4 inches wide, to protect the top seam. The paper must extend down 4 inches on each side of the units. (See Figure 9-8.) Cover the entire area of washed rock with untreated paper to prevent sand and other small particles from filtering down and through the rock.

The maximum distance between the centers of the distribution lines can't exceed 4 feet. The outside distribution line must be a minimum of 2 feet from the excavated wall of the filter bed. Each drain unit is considered to occupy 4 square feet.

Distribution lines can't exceed 100 feet in length. Where you're using two or more lines, make them as near the same length as possible, and connect them with a distribution box. A tight-jointed pipe must

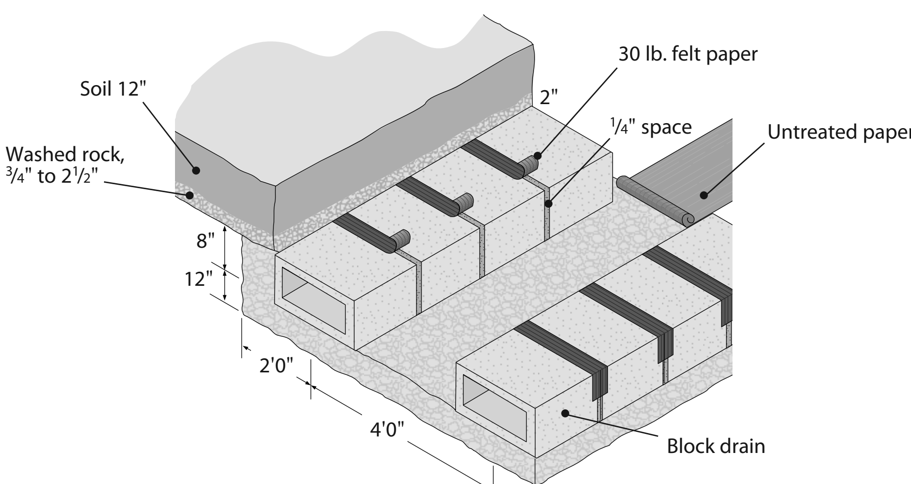

Figure 9-8
Cross section of reservoir-type drainfield

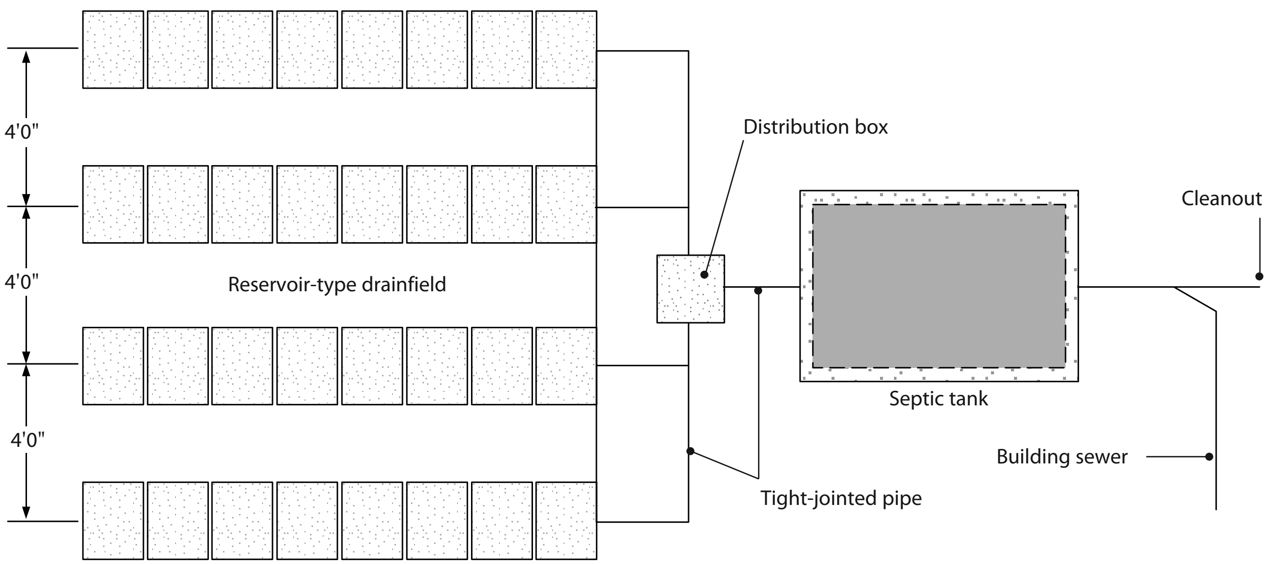

Figure 9-9
Detail of septic tank distribution box and drainfield

connect the septic tank's outlet tee to the distribution box and the distribution box to the fixed reservoir distribution lines. (See Figure 9-9.)

Corrugated Plastic Perforated Tubing Drainfield

Plastic tubing drainfields are generally used in single excavations based on the square footage (length x width) rather than in individual trenches. Like the others, it must slope a maximum of 3 inches per 100 feet, on a bed of $^3/_4$- to $2^1/_2$-inch washed rock 12 inches deep under the tubing. Cover it with 6 inches of rock over the tubing bottom, for a total depth of 18 inches for the full width of the drainfield.

Since the tubing has adequate fixed openings, all joints are tight. Cover the entire area of washed rock with untreated paper.

The distance between centers of the distribution lines must be between 48 and 72 inches. The outside distribution line should be a minimum of 36 inches from the excavated wall of the filter bed. See Figure 9-10. Don't make distribution lines more than 100 feet long. If there are two or more lines, make them as near the same length as possible. You don't need a distribution box to connect more than one plastic tubing distribution line, but you may use tees.

Sizing Drainfields

The drainfield won't work unless the soil can absorb the effluent properly. The best soils are those made up of coarse sand or gravel. They absorb water the fastest. The next best soil is fine sand. In areas where the soil has limited porosity (such as clay with some sand), a percolation test is usually required. The test will tell you how long it takes for water to be absorbed into the soil. That determines the size of the leaching area. Figure 9-11 shows the design criteria for five common soil types.

Codes vary in how to size a drainfield. *Always check your local code.*

Let's use the *Uniform Plumbing Code* to size some drainfields with different soils and different types of buildings.

Residential Drainfields

First, we'll size a drainfield for a three-bedroom, single-family house on a site with fine sand. The first column in Figure 9-2 shows the number of bedrooms for a single-family residence. The other columns are the minimum capacity for the septic tank in gallons in the *Uniform Plumbing Code*. For our three-bedroom house, that's 1,000 gallons.

Now look at Figure 9-11. The second column gives the minimum square feet of leaching area per 100 gallons for each soil type. Since we have fine sand, it's 25 square feet.

Here's how to size the drainfield: Multiply the required capacity, 1,000 gallons, by the required leaching area, 25 square feet, then divide by 100 gallons:

$$\frac{\textit{1,000 gal.} \times \textit{25 SF}}{\textit{100 gal.}} = \textit{250 SF total leaching area}$$

Let's look at another example. We'll use the same three-bedroom house, but this time the site is clay with a small amount of sand or gravel. According to Figure 9-11, that requires 120 square feet of leaching area for each 100 gallons. We know that a three-bedroom house requires a 1,000 gallon tank (Figure 9-2). Multiply required capacity times required leaching area, then divide by 100:

$$\frac{\textit{1,000 gal.} \times \textit{120 SF}}{\textit{100 gal.}} = \textit{1,200 SF total leaching area}$$

The percolation rate determines the size of the leaching area — and the cost. Naturally, the larger the leaching area, the more expensive it is.

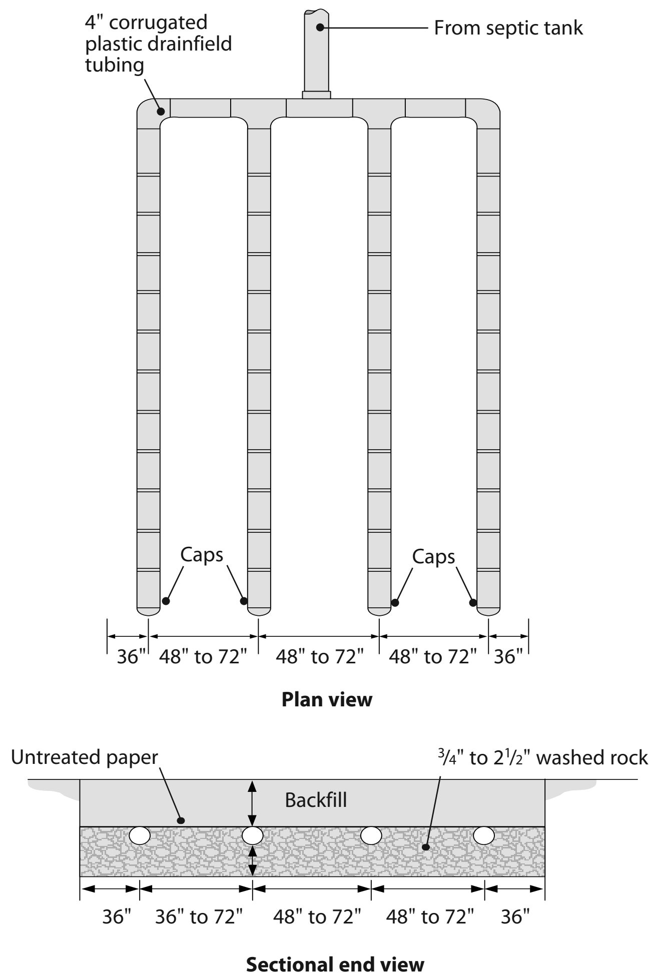

Figure 9-10
Spacing the drain lines

Type of soil	Required SF of leaching area/100 gallons	Maximum absorption capacity gal/SF of leaching area for a 24-hour period
Coarse sand or gravel	20	5.0
Fine sand	25	4.0
Sandy loam or sandy clay	40	2.5
Clay with considerable sand or gravel	90	1.1
Clay with small amount of sand or gravel	120	0.8

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Figure 9-11
Design criteria of five typical soils

Commercial Drainfields

Drainfields for commercial establishments are usually sized by DERM or by the local health department. Their size is based on the daily sewage flow (which you can find in a table of flow rates in your code book). Figure 9-12 is similar to the table in your code book, although your code may have more data.

We'll size the drainfield for a church building with a kitchen. The sanctuary seats 500. Sewage flow per seat according to Figure 9-12 is 7 gallons. The soil is coarse sand or gravel, so we need 20 square feet of leaching area per 100 gallons (Figure 9-11).

Using our formula, multiply 500 (seats) times 7 gallons per seat (required capacity) times 20 square feet (required SF of leaching area), and divide by 100 gallons:

$$\frac{500 \text{ seats} \times 7 \text{ gal.} \times 20 \text{ SF}}{100 \text{ gal.}} = 700 \text{ SF total leaching area}$$

Now let's do the same church building on soil made up of clay with considerable sand or gravel. The only difference is that you need 90 square feet of leaching area (Figure 9-11) per 100 gallons instead of 20:

$$\frac{500 \text{ seats} \times 7 \text{ gal.} \times 90 \text{ SF}}{100 \text{ gal.}} = 3{,}150 \text{ SF total leaching area}$$

Type of occupancy	Gallons per day
Airports	15 per employee 5 per person
Bowling alleys (snack bar only)	75 per lane
Day camps (no meals served)	15 per person
Churches: Sanctuary With kitchen waste	 5 per seat 7 per seat
Factories: No showers With showers	 25 per employee 35 per employee
Hotels (no kitchen waste)	60 per bed (2 persons)
Nursing homes	125 per person
Motels: No kitchen With kitchen	 50 per bed space 60 per bed space
Offices	20 per employee
Mobile homes	250 per space
Schools: Staff and office Elementary students Intermediate and high	 20 per person 15 per student 20 per student
Theaters: Auditorium Drive-in	 5 per seat 10 per space

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Figure 9-12
Estimated sewage flow rates

Number of bedrooms	Drainfield required (SF)	Conventional block drain (LF)	Corrugated 4" plastic tubing (LF)
2	100	25	40
3	125	32	50
4	150	38	60
5	175	44	70

Figure 9-13
Typical drainfield conversion table

We need to look at Figure 9-4 to size the drainfield for a commercial building, since the septic tank size is based on the fixture units. We'll try a restaurant, using the fixture units from Figure 9-6. The total fixture units are 54, requiring a 2,250-gallon septic tank. Here's how to size the drainfield using the septic tank size in gallons and a soil of fine sand (25 SF):

$$\frac{2{,}250 \text{ gal.} \times 25 \text{ SF}}{100 \text{ gal.}} = 562.5 \text{ SF total leaching area}$$

When drainfields are located under pavement, you have to increase the absorption area by these percentages:

Percolation rate	Area increase (%)
0 to 5	10
6 to 10	17
11 to 15	25

For example, if the required drainfield for a three-bedroom house is 300 square feet and the percolation rate is 3, you'd have to increase the drainfield area by 10 percent, an additional 30 square feet.

Drainfield Restrictions

Here are the locations where you generally can't locate a drainfield. Jurisdictions may have their own distance requirements, so always check your local code.

- Under any building or within 8 feet of any building.
- Within 5 feet of a seepage pit.
- Within 8 feet of a basement wall or terraced area.
- Within 5 feet of water supply pipe lines.
- Within 5 feet of property lines other than public streets, alleys or sidewalks.
- Within 50 feet of shorelines of open bodies of water.
- Within 100 feet of any private water supply well which provides water for human consumption, bathing or swimming.

A drainfield must have a minimum earth cover of 12 inches and a maximum of 24 inches.

Drainfield Conversion Table

In some cases drainfields become *dead* and the soil can't absorb the effluent properly. This requires replacement of the drainfield. You can use Figure 9-13 to calculate the square feet of drain block or linear feet of plastic tubing you'll need to replace a drainfield for an existing building.

Review Questions for Chapter 9 (answers are on page 294)

1. Under present code standards, what two former disposal methods are no longer acceptable as a permanent means of dealing with human waste?

2. Even today, drinking water can be contaminated by untreated sewage. Which two diseases can be spread as a result of this type of contamination?

3. When public sewers aren't available, what's the most acceptable method for sewage disposal?

4. What governmental department has established guidelines for septic tank safety?

5. Although septic tank and drainfield installations are important areas of plumbing work, who usually does the installation and maintenance work for these systems?

6. Since you probably won't do the work, why is it important that you be informed about the basic principles of septic tank and drainfield installation?

7. What are septic tanks designed to accomplish?

8. What is the approximate amount of solid waste for each 100 gallons of water in a septic tank?

9. A septic tank is sized to have a capacity equal to approximately how many hours of anticipated flow?

10. How are the solids in a septic tank digested?

11. What happens to the effluent when it enters the drainfield?

12. What remains when the bacterial process is completed within the septic tank?

13. What do you call the lighter, undigested particles that rise to the top of the liquid after the bacterial process in the septic tank is complete?

14. Who cleans out the undigested materials remaining in the septic tank?

15. Name two materials that are not code-approved for septic tank construction.

16. What are the two most common types of septic tanks?

17. How are concrete septic tanks protected from corrosion?

18. In order to prevent contamination by leaking sewage, what does the code require of all septic tanks?

19. What must be taken into consideration when sizing a septic tank?

20. How many compartments do most codes require septic tanks to have?

21. What is the liquid capacity of the smallest approved septic tank?

22. The secondary compartment (outlet compartment) of the tank should have a minimum liquid capacity of how many gallons?

23. On a *residential* septic tank, what type of cover slab is acceptable for cleaning purposes?

24. How many manholes are needed for a 1,500-gallon-capacity commercial septic tank?

25. When the first compartment of a *commercial* septic tank exceeds 12 feet in length, how many manholes are required?

26. What is the minimum size requirement for the vertical legs of the inlet and outlet tees of a septic tank?

27. At least how many inches higher than the outlet pipe should a septic tank inlet pipe be?

28. How much air space must be provided above the liquid level in a septic tank?

29. When a septic tank is located in a parking lot, what does the building department require it to have?

30. What determines the size capacity for septic tanks installed for single-family or multiple *residential* units?

31. What determines the capacity requirements for septic tanks for *commercial* buildings?

32. How do you determine the capacity requirement of a septic tank for a single-family residence that has more bedrooms than there are listed in your code table?

33. How do you determine the capacity requirement of a septic tank for multiple *residential* units when the number of units exceeds those listed in your code table?

34. A septic tank can't be located within how many feet of any water supply line?

35. A septic tank can't be located within how many feet of the shoreline of an open body of water?

36. Name two drainfield materials commonly used to distribute the effluent from septic tanks.

37. What is the minimum inside diameter of drainfield tile?

38. What is the minimum slope for drainfield tile per 100 feet?

39. What is the minimum width for each drainfield trench?

40. What is the maximum length of a single tile drainfield trench?

41. What is the required depth of washed rock under the drain units of a reservoir type drainfield?

42. What is the maximum distance between centers of the distribution lines of a reservoir-type drainfield?

43. What are the best soils for absorbing drainfield effluent?

44. What is determined by a percolation test?

45. Other than the type of soil, what else is used to determine the sizing of a *residential* drainfield?

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10

Mobile Home and Travel Trailer Parks

Local agencies regulate plumbing systems for mobile home parks that serve the growing number of mobile homes and recreational vehicles. They set specific minimum sanitary plumbing facilities and installation methods for the parks. These standards vary considerably from the requirements for conventional permanent structures. You'll notice this immediately when you study the standards for designing and installing sanitary collection and water distribution systems for these parks. And study them you should. The odds are that you'll do this kind of work sooner or later.

Some of the terms used in this chapter are unique to this kind of work. I'll define any that aren't self-explanatory as we come to them, but look in the glossary at the end of the book for the complete list.

A *mobile home* or *RV trailer park* is land designated and improved to accommodate one or more trailers, used either for temporary or permanent living quarters. There are two kinds of parks under the code, depending on whether the trailers served are *dependent* or *independent*.

Dependent Trailers

Recreational vehicles (RVs) and motorized homes are generally defined in the code as *dependent trailers*. That's any motorized vehicle used as a temporary dwelling unit for travel, vacation and recreation. They're portable structures built on a chassis for traveling public roads. As a rule, they have limited built-in sanitary facilities (usually, but not always, including a toilet). They don't have a plumbing system that can permanently connect to a park sewage and water supply system. Most of today's motor homes are equipped with a water storage tank to operate the plumbing fixtures and a holding tank to retain the waste water.

Independent Trailers

A mobile home is defined by code as an *independent trailer coach*. That's any trailer coach designed for permanent occupancy, equipped with kitchen and bathroom facilities and a plumbing system that can connect to the park sewage, water and gas supply system. It's built on a permanent chassis and designed as a dwelling. Most mobile home owners lease or buy space in a mobile home park. The park provides each space with a water, electrical, gas and sewer connection, and is responsible for maintaining these services.

Toilet Facilities for Trailer Parks

Let's look at the code requirements for toilet facilities, the DWV system, and the water distributing system for both kinds of parks.

Dependent Trailer Parks

The code doesn't require a *dependent trailer park* to provide individual water/sewer connections, but it must have a separate *service building*. It's required to have toilet facilities and a waste disposal station equipped to empty intermediate waste holding tanks. Some codes even require limited laundry facilities. The service building must be located within 500 feet (200 feet in some codes) of the most distant trailer site and must have an individual sewer connection.

Any park's service building or buildings must provide a minimum number of fixtures for each sex. Here's what the *Uniform Plumbing Code* requires:

- For the first 25 sites, there must be one toilet for each sex. They need an additional toilet for each additional 25 sites (when they don't have individual sewer connections).
- Each toilet room must have a floor drain and be protected with an automatic trap seal.
- For each toilet up to six, the service building must have an equal number of lavatories. For each two toilets above six, they must provide one lavatory. For example:

  Eight toilets require seven lavatories (6 + 1 = 7)

  Ten toilets require eight lavatories (6 + 1 + 1 = 8)
- In men's facilities, the park can replace one-third of the required toilets with urinals. For example, if six toilets are required, you may install four toilets and two urinals. When nine toilets are required, you may install six toilets and three urinals. When only two toilets are required, the code permits one toilet to be replaced with a urinal.
- Toilets must be the elongated type with open front seats.
- Toilets must have separate stalls with a door and latch for privacy.
- Urinals must be either the individual stall or wall-hung type.
- Showers, if provided, must have a floor area at least 36 by 36 inches. Each shower stall and dressing area must be screened from view. Shower water can't flow into the dressing area.
- If laundry facilities are required, they must be installed in a room separate from the toilet rooms.
- Drinking fountains aren't usually required. If they're provided, they must be an approved type.

Independent Trailer Parks

Some local or state codes require minimum toilet facilities for independent trailer parks, while others don't. You may find that your particular code requires a service building even when each trailer has its own facilities. Here are typical local or state requirements:

1) The service building must have one laundry tray.

2) For women, there must be one toilet, one lavatory, and one shower or bathtub.

3) For men, there must be one toilet, one lavatory, and one shower or bathtub.

The Park Drainage and Vent System

All drainage materials must comply with the code standards. (Look back to Figures 8-2 and 8-3 in Chapter 8.) In Figure 8-3, you'll find a list of materials you can use in a park drainage system in the column labeled *Building sewer*.

Sizing a Park Drainage and Vent System

There's a big difference between fixture unit loads for a park drainage system and a conventional building. In a conventional building you always total each plumbing fixture separately. In a trailer park, your local code assigns the total fixture units for each site drainage inlet. The *Uniform Plumbing Code* assigns 12 units, while some local or state codes assign 15 units to each site.

You'll find tables in your code for sizing park drainage systems. Figure 10-1 shows the maximum number of fixture units permitted on each size pipe.

Size of drainage pipe (in)	Maximum fixture units
2*	8
3	35
4	256
5	428
6	720
8	2640
* Except six unit fixtures.	

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Note: Special fixtures and equipment which are rated 6 F.U. or more can't use a 2-inch pipe. (More complete tables are in your code)

Figure 10-1
Drainage pipe sizes and number of fixture units permitted

Pipe size (in)	Slope per 100 feet (in)
2	25
3	25
4	15
5	11
6	8
8	4

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Note: The larger the pipe, the less slope required per 100 feet. (More complete tables are in your code)

Figure 10-2
Minimum pipe size and slope of drainage pipe

Here's an example that illustrates the differences in two of the major codes. Let's use a 4-inch drainage pipe. According to Figure 10-1, it will carry a maximum of 256 fixture units.

Uniform Plumbing Code:

Total fixture units (256) divided by 12 F.U. per site = 21 trailer sites.

Local or state code:

Total fixture units (256) divided by 15 F.U. per site = 17 trailer sites

You can see that the *Uniform Plumbing Code* accommodates four more trailer sites than the local or state, even though the number of fixture units and pipe sizes are identical.

Figure 10-2 shows the minimum slope per 100 feet (in inches) for each size pipe. While it's important, it's not a factor in determining the number of sites you can connect to the park's drainage system.

Installing the Drainage and Vent System

You'll install, backfill and use the same type of materials for this system as for building sewers. Provide each trailer site with a sewer lateral no smaller than a 3-inch diameter pipe (4 inches in some codes). Cap the line when it's not in use. Locate vent pipes on building drainage systems at least 10 feet from adjoining property lines, and extend them 10 feet above ground level. Securely anchor the vents to the equivalent of a 4 × 4 post driven into the ground. Be sure your supports are rot- and deterioration-resistant.

Make your first vent 3 or 4 inches in diameter and install it not more than 5 feet downstream from the first sewer lateral. The park sewer main must be re-vented at intervals of not more than 200 feet. See Figure 10-3.

Install cleanouts at no less than 100-foot intervals. They'll have to be the same nominal size as the pipe they serve but no larger than 3½ inches (4 inches in some codes).

Terminate your sewer laterals at least 4 feet outside the left wheel and within the rear third of the trailer coach. This should allow a short trailer drain connection between the trailer outlet and sewer inlet.

For trailers that are properly trapped and vented, make the lateral terminate with a sweep that has a 3- or 4-inch sanitary tee caulked into it. The tee should end 4 to 6 inches above grade. Be sure you caulk a cleanout in the top of the sanitary tee.

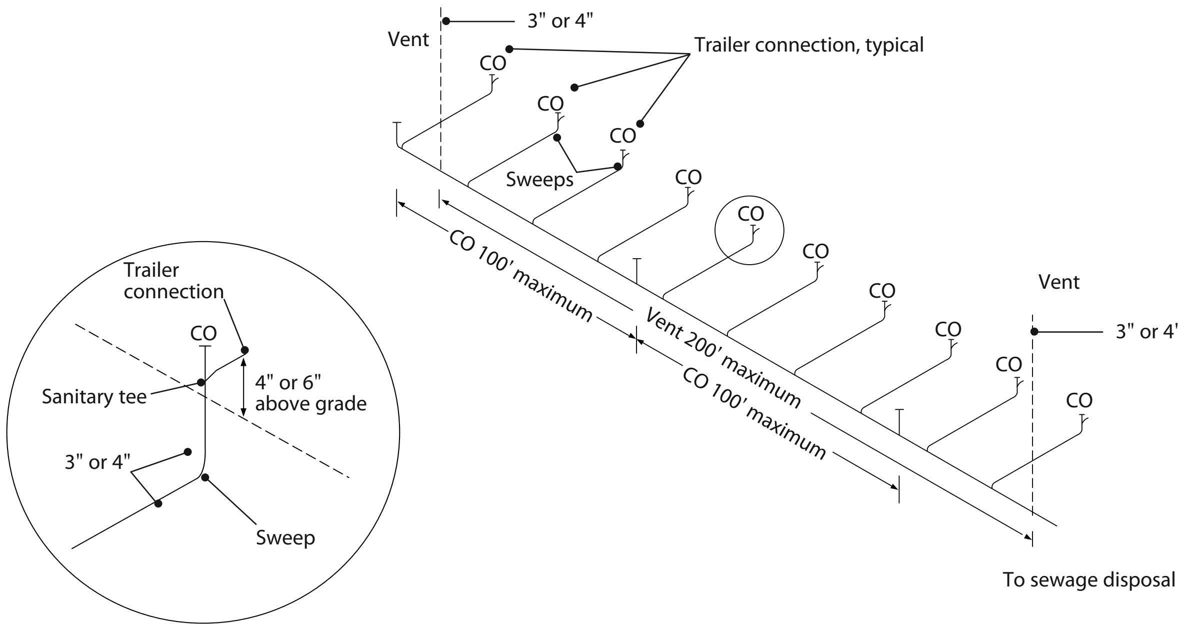

Figure 10-3
Sewage collection system for properly trapped and vented trailers

Trailers that aren't properly trapped and vented should have a lateral that terminates with a 3- or 4-inch P-trap into which is caulked a sanitary tee that ends 4 to 6 inches above grade. Caulk a cleanout in the top of the sanitary tee as shown in Figure 10-4. Since a P-trap is required at the end of the lateral (branch line), the measured horizontal distance from a vented sewer without a re-vent can never exceed 15 feet. Don't place the P-trap more than 24 inches below grade unless you get specific permission from local authorities.

The Park Water Distributing System

A $^3/_4$-inch branch service line connected to the park main supplies potable water to each trailer site. The line terminates on the same side of the trailer site as the trailer sewer lateral.

The park's distributing system should provide a minimum pressure of 20 psi at each trailer site. The service connection to each trailer must be a minimum of $^1/_2$ inch diameter.

When a backflow preventer is required, install a pressure relief valve on its discharge side. Manufacturers must ensure that pressure relief valves release pressure at a maximum of 150 psi. Locate the backflow preventer and pressure relief valve at least 12 inches above grade. See Figure 10-5.

On each branch service line, connect the trailer to the park's water distributing system with a separate shutoff valve and a spring-loaded, soft-seat check valve. Locate the valve near the service connection for each trailer.

Use an approved flexible tubing with a quick disconnect fitting at either end for each service connection. No special tools or knowledge are required to install and remove these fittings.

You'll use the same materials and installation methods here as for the water systems in Chapter 14. Be sure that any piping materials you use in the park water distributing system meet the requirements listed in Figure 14-1.

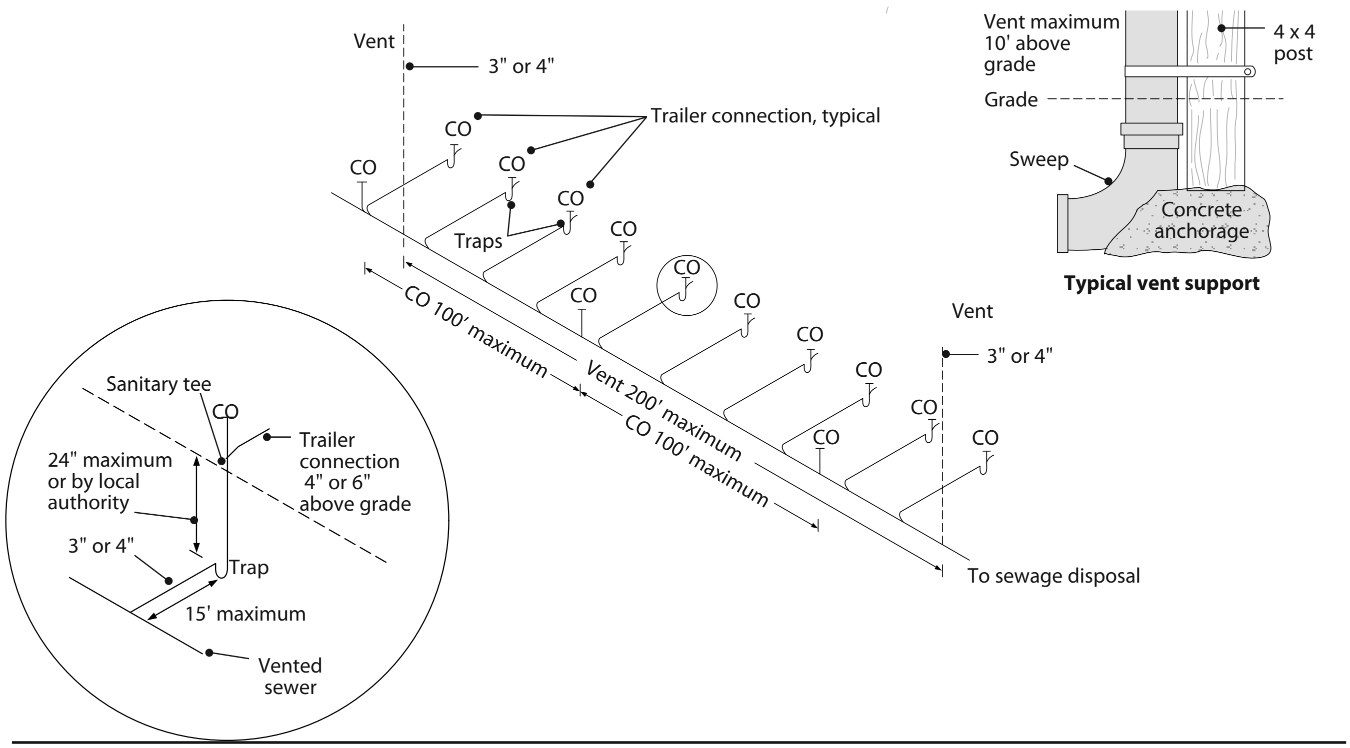

Figure 10-4

Sewage collection system for trailers not properly trapped and vented

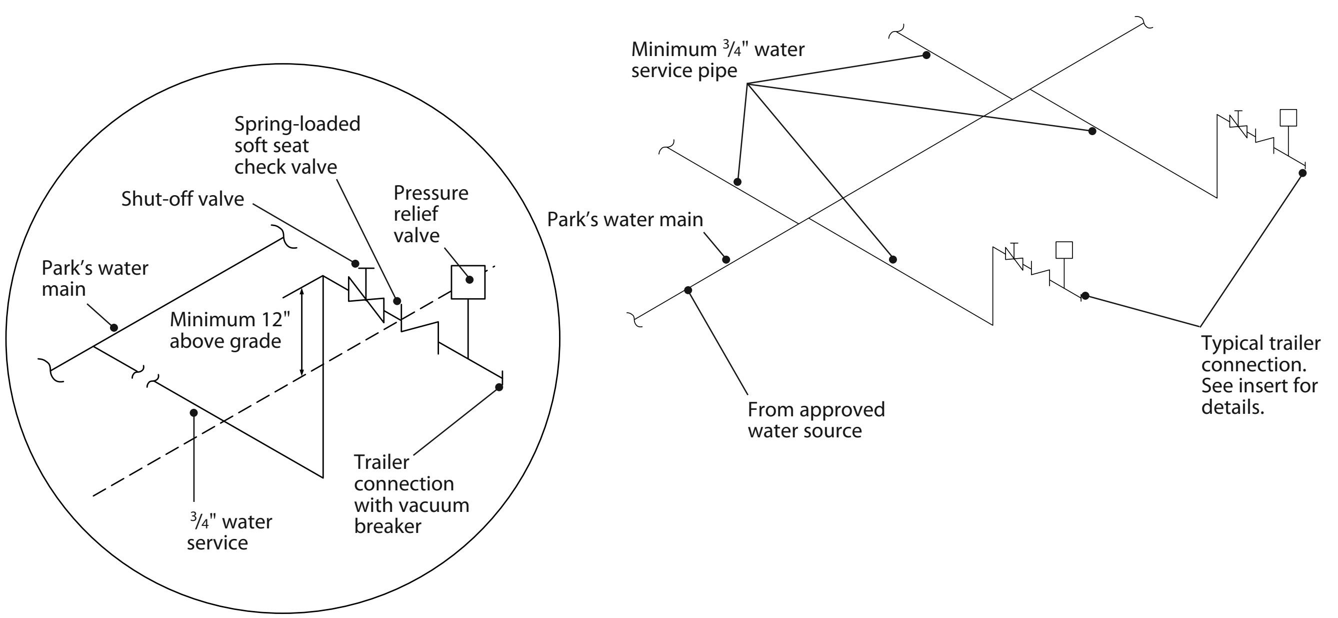

Figure 10-5

Typical trailer water service outlet with approved controls

Review Questions for Chapter 10 (answers are on page 296)

1. Who regulates the plumbing standards and installation methods for mobile home and RV parks?
2. How are recreational vehicles defined in the code?
3. Recreational vehicles have limited plumbing facilities, usually not including which fixture?
4. How is a mobile home defined in the code?
5. What does the code *not* require dependent trailer parks to provide?
6. What type of building facility must a dependent trailer park provide?
7. What type of individual connection must a dependent trailer park service building have?
8. What particular segregated facilities must a dependent trailer park service building provide a minimum number of?
9. According to the *Uniform Plumbing Code*, how many sites in a dependent trailer park may be served by one toilet for each sex?
10. What must each toilet room in the service building of a dependent trailer park have?
11. In a dependent trailer park service building, how many lavatories must be provided for each toilet, up to six toilets?
12. In the men's toilet room of a dependent trailer park service building, what portion of required toilets may be replaced with urinals?
13. What toilet design must be used in the toilet rooms of a dependent trailer park?
14. What must each toilet installed in a dependent trailer park have?
15. What is the required floor area of a shower installed in a dependent trailer park?
16. What area in a dependent trailer park's shower room must be protected from water overflow?
17. According to some local and state codes, what are the minimum fixtures required in the women's area of an independent trailer park?
18. How are fixture units assigned in a trailer park?
19. What criterion is used in sizing a park drainage system?
20. How many fixture units are permitted on a 3-inch pipe in a trailer park drainage system?
21. In a trailer park, what's the minimum slope for a 4-inch pipe per 100 feet?
22. The installation and backfill for a trailer park drainage system is the same as for what other system?
23. In a trailer park drainage system, where should the first vent be located?
24. When a park lateral terminates with a 4-inch P-trap and a sanitary tee, where should a cleanout be installed?
25. What's the minimum pressure required at each trailer site for the park's water distribution system?

11

Graywater Recycling Systems for Single-Family Residences

By far, most water for public use comes from lakes, rivers and deep wells. Although many people seem to think the earth's water supply is endless, it's actually a finite resource. Without long-range planning today, America could face a critical water supply shortage tomorrow.

For years the primary water source for single-family and multifamily residential buildings has been the municipal water treatment plant. But in virtually all major cities, water treatment plants are overloaded. Some of them, because of neglect and careless maintenance, are beginning to fail. Moratoriums on new construction and other restrictions are clear indications that cities are waking up to the inadequacy of their available water sources.

Since several areas have experienced water shortages, water conservation is increasingly becoming a national issue. Plumbing codes are just now beginning to wrestle with this problem. In recent years, their major weapon has been to formulate regulations that conserve water through maximum allowable water usage for plumbing fixtures. Figure 11-1 shows the maximum allowable water usage for plumbing fixtures based on the *International Plumbing Code*.

Some codes are presently exploring new water recycling technologies. We'll look at older and newer solutions to the growing water shortage that our nation must resolve in the coming years.

The Older Water Conservation Methods

As I write this, many local codes still employ only *older* water conservation methods. While having been minimally helpful, they'll never be totally adequate. Using this approach, plumbing fixtures and their fittings must comply with these standards:

- All faucets, showerheads and their packing must be marked by the manufacturer to comply with the provisions of ANSI Standard A112.18.1M. Water closets and urinals and their packaging must be marked to meet the provisions of ANSI A112.19.2M. They're listed in Chapter 21, on plumbing fixtures.
- New or replacement water closets, urinals, faucets and showerheads must have a flow rate or flush volume no greater than those listed in Figure 11-1.

Besides these conservation efforts, many areas limit landscape irrigation (even on wells) to certain days of the week and/or hours of the day. But these restrictions are hard to enforce and have been largely unsuccessful.

Considerable water is lost in older buildings that have leaking pipe joints and faucets. Most people don't realize that a hidden cause like that can create such great waste. But when you consider that it takes only $2^1/_2$ seconds to form one drip, one leak can waste

Maximum flow rates and consumption for plumbing fixtures	
Plumbing fixture or fixture fitting	**Maximum flow rate or quantity**
Lavatory, private	2.2 gpm at 60 psi
Lavatory, public (metering)	0.25 gallon per metering cycle
Lavatory, public (other than metering)	0.5 gpm at 60 psi
Shower head[a]	2.5 gpm at 80 psi
Sink faucet	2.2 gpm at 60 psi
Urinal	1.0 gallons per flushing
Water closet	1.6 gallons per flushing

[a] A hand-held shower spray is a shower head.
[b] Consumption tolerances shall be determined from referenced standards.

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Figure 11-1
Maximum allowable water usage for plumbing fixtures

about 365 gallons of water per year. If you multiply that by all the hidden leaks throughout the country, it's a staggering loss. And unfortunately, code enforcement can't do anything to solve this problem.

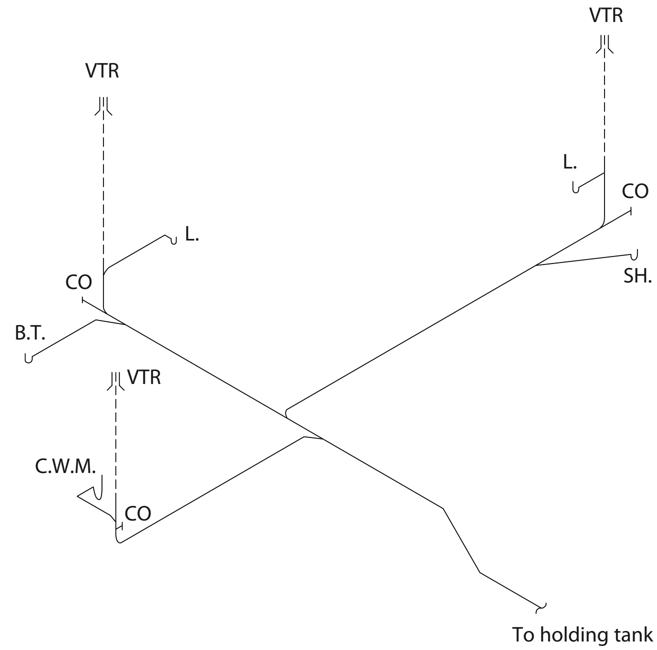
A New Water Conservation Method: Graywater Recycling

One solution being explored by the *Uniform Plumbing Code* and the *International Plumbing Code* is known as graywater recycling. Graywater is untreated household waste water that has had no contact with toilet waste. It includes used water from bathtubs, showers, lavatories, laundry trays and clothes washing machines, but not dishwashers or kitchen sinks. See Figure 11-2. So far, its use is limited to ornamental landscaping such as lawns and flowerbeds, and in agriculture to subsurface underground irrigation for crops other than root crops such as potatoes, carrots, onions, and the like.

Graywater piping can't connect to potable water piping. It must be installed in a way that prevents any of the graywater from surfacing. The location, the soil type and the groundwater table determine which type of system you can use. Any system must properly dispose of all graywater generated by the building.

A graywater recycling system consists of a holding tank which discharges the waste into underground irrigation piping or disposal fields. If installed underground, your holding tank must rest on dry, level, compacted soil. See Figure 11-3. If you install your holding tank above ground, it must rest on a 3-inch-thick concrete slab sized to give adequate support. See Figure 11-4, which shows both pumped and gravity systems installed above ground.

After you install any holding tank, fill it with water to the overflow line for inspection. Then perform a flow test through the system to the point of disposal. Make sure all lines, components, seams and joints are watertight.



Note Kitchen sink, dishwasher and toilets on separate system

Figure 11-2
Isometric drawing of a typical two-bath residence graywater drainage system

Estimating Graywater Discharge

Here's the procedure in the *Uniform Plumbing Code* for estimating graywater discharge from single-family residences. The waste water is based on the number of occupants and bedrooms:

1) First bedroom: 2 occupants

2) Each additional bedroom: 1 occupant

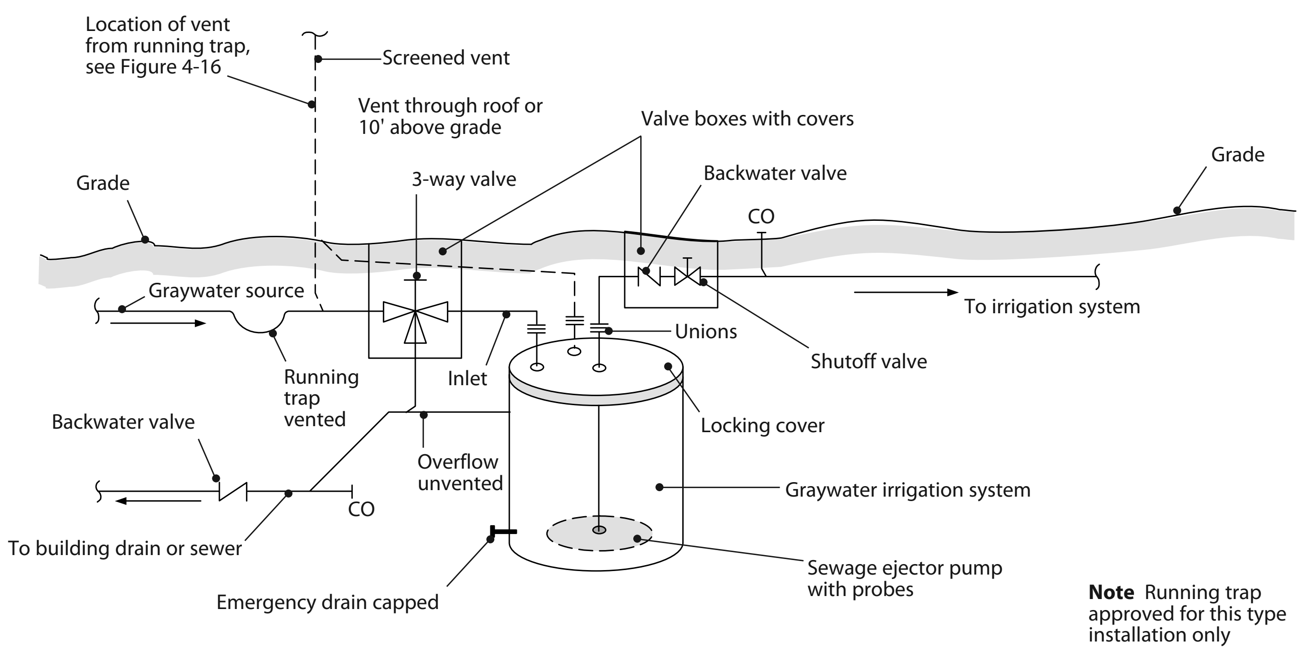


Figure 11-3
Underground graywater system tank, pumped

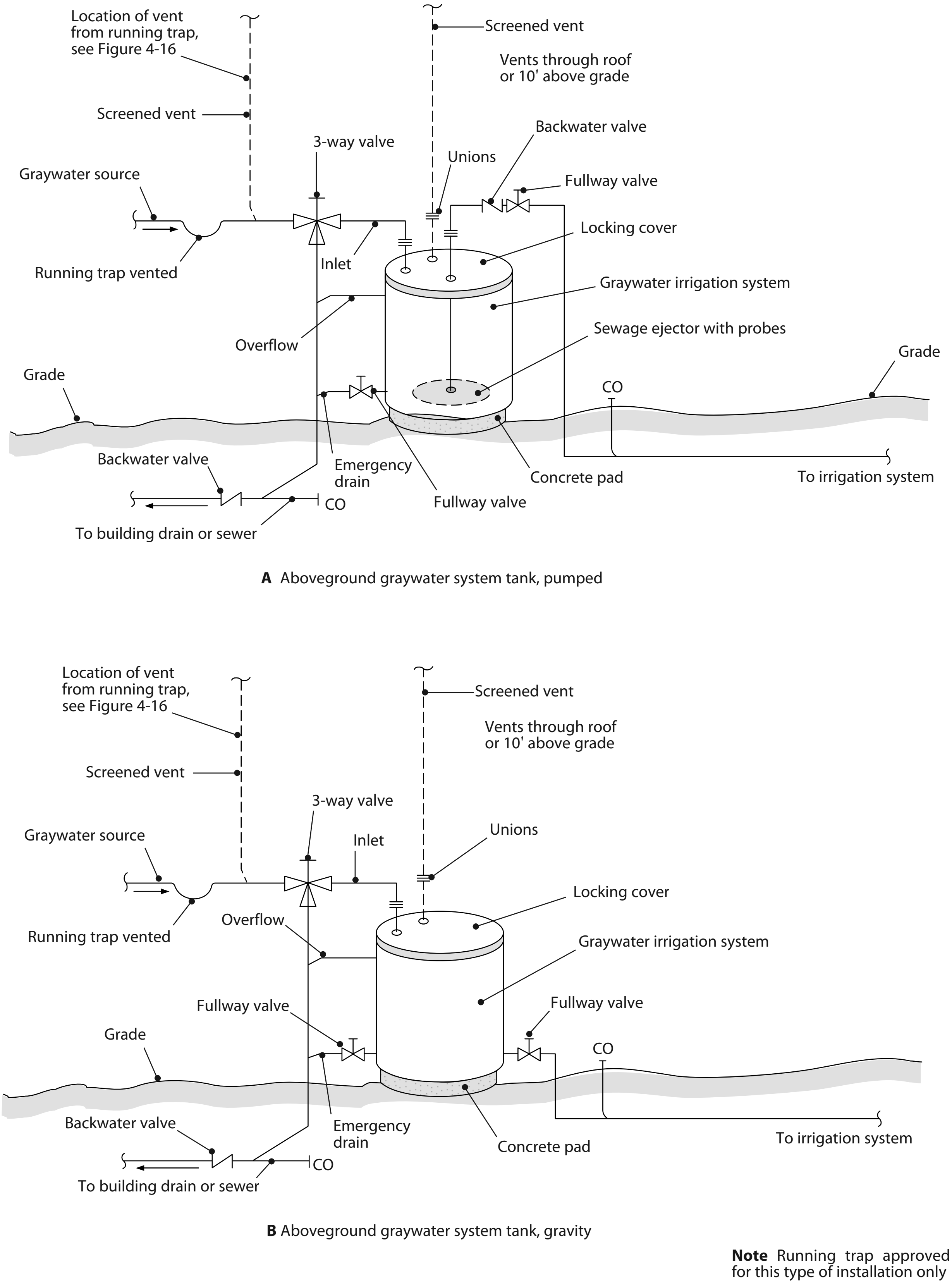
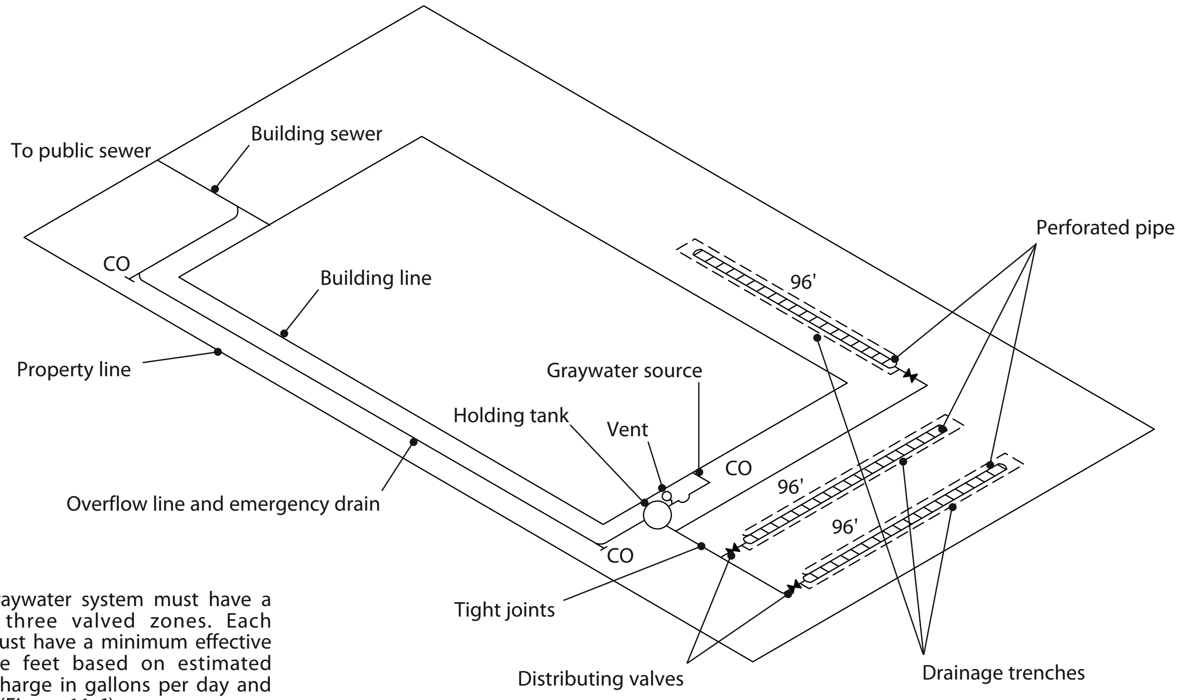


Figure 11-4

Code-approved trap on aboveground graywater system tank



Note Each graywater system must have a minimum of three valved zones. Each valved zone must have a minimum effective area in square feet based on estimated graywater discharge in gallons per day and on type of soil (Figure 11-6)

Figure 11-5
Three valved zones, graywater system

To estimate your graywater flow, calculate the usage for each occupant using the following information:

1) Showers, bathtubs and lavatories: 25 gallons per day per occupant

2) Laundry: 15 gallons per day per occupant

Now we'll try a couple of examples, beginning with a four-bedroom house:

1) Number of occupants: 2 + 1 + 1 + 1 = 5 occupants

2) Estimated graywater flow: 5 occupants × (25 + 15) = 200 gpd

For the second example, we'll consider a three-bedroom residence with only the laundry facilities connected to the graywater system.

1) Number of occupants: 2 + 1 + 1 = 4 occupants

2) Estimated graywater flow: 4 occupants × 15 = 60 gpd

Graywater Subsurface Irrigation/Disposal Fields

Use the information above to calculate the sizing of graywater discharge for irrigation/disposal fields. See Figure 11-5. Each valved zone requires a minimum effective irrigation area (in square feet) based on the estimated graywater discharge (gpd) and soil type. Figure 11-6 shows the design criteria in the *Uniform Plumbing Code*.

Never let your excavation come within 5 vertical feet of the highest known seasonal groundwater. It can't reach a depth where graywater could contaminate the groundwater or ocean water.

Construction of Holding Tanks

- Each holding tank must be watertight, and constructed of materials not subject to excessive corrosion.

Type of soil	Minimum SF of irrigation/leaching area per 100 gallons of estimated graywater waste per day	Maximum absorption capacity in gallons per SF of irrigation/leaching area for a 24-hour period
Coarse sand or gravel	20	5.0
Fine sand	25	4.0
Sandy loam	40	2.5
Sandy clay	60	1.7
Clay with considerable sand or gravel	90	1.1
Clay with small amounts of sand or gravel	120	0.8

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Figure 11-6
Design criteria of six typical soils

- The holding tank must be vented, and have a locking, gasketed access opening which permits inspection and cleaning.
- Each holding tank must have a permanently marked sign: *Graywater irrigation system, danger — unsafe water*.
- The minimum capacity of each tank is 50 gallons. Its rated capacity must be permanently marked on the unit.
- Aboveground holding tanks need an emergency drain and an overflow drain. The overflow drain can't have a shut-off valve. The tanks must be permanently connected to the building drain or sewer, and upstream from septic tanks, if any. See Figures 11-3 and 11-4.
- Neither the emergency nor the overflow drain can be smaller than the inlet pipe.
- A holding tank vent must be sized by total fixture units.
- For replacement purposes, all connecting pipes to holding tanks must be equipped with unions or other approved effective fittings. See Figures 11-3 and 11-4.
- An underground holding tank must be structurally designed to withstand an earth load of 300 pounds per square foot.
- Underground holding tanks require a backwater valve to protect against sewer backups.
- All holding tanks must be constructed of steel and protected from external and internal corrosion by an approved coating or other acceptable means.
- To protect the building from any possible drainage gases, a vented running trap must be installed upstream from its connection to the holding tank. See Figures 11-3 and 11-4.
- All valves, including the three-way valve, must be accessible.

Construction of Irrigation/Disposal Fields

The materials and installation methods for irrigation or disposal fields for graywater systems are similar to the requirements for septic tank drainfields. The differences are minor. The *Uniform Plumbing Code* requires the following:

- *Piping material:* The piping can't be smaller than 3 inches in diameter. Approved materials include perforated ABS or PVC pipe, perforated high-density polyethylene pipe or other approved materials. The pipe must have enough openings for the proper distribution of the graywater into the trench area.
- *Filter material*: The filtering material must be clean stone, gravel, slag or other approved filtering material. The size may vary from 3/4 inch to no more than 2 1/2 inches.
- *Installation methods:* Lay the perforated piping on a bed of properly sized filtering material. This material must extend 3 inches beneath the pipe

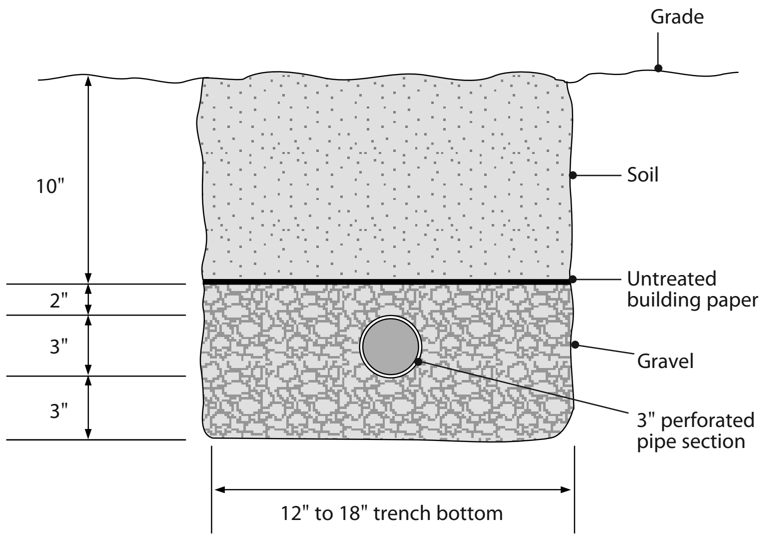

Figure 11-7
Graywater irrigation absorption trench (end view)

and at least 2 inches above the pipe, and be covered with untreated building paper, straw or similar porous material. This prevents backfill soil from filtering down and obstructing the drainage. Lay the piping with a slope of 3 inches per 100 feet. See Figure 11-7 for an end view detail of an absorption trench.

- *Irrigation/disposal field requirements:* When installing an irrigation or disposal field for a graywater system, make certain you follow the guidelines listed in Figure 11-8. There are times when you'll encounter steep grades in the leaching area. This might cause the graywater waste to pass too quickly through the drain lines, without enough time to seep into the soil. In those regions, the code will require that you step the irrigation or disposal lines. Make certain that the lines joining each horizontal leaching section have watertight joints. Also, they must be installed on natural or unfilled ground. See Figure 11-9.
- *Location of graywater systems:* If you're following the *Uniform Plumbing Code*, use the guidelines in Figure 11-10 for locating the holding tank and irrigation/disposal field.

	Minimum	**Maximum**
Number of drain lines per valved zone	1	—
Length of each individual line	—	100 ft.
Width of trench bottom	12 in.	18 in.
Lines center-to-center	4 ft.	—
Earth cover over lines	10 in.	—
Filter material over lines	2 in.	—
Filter material beneath lines	3 in.	—
Slope of perforated pipe	3 in. per 100 ft.	—

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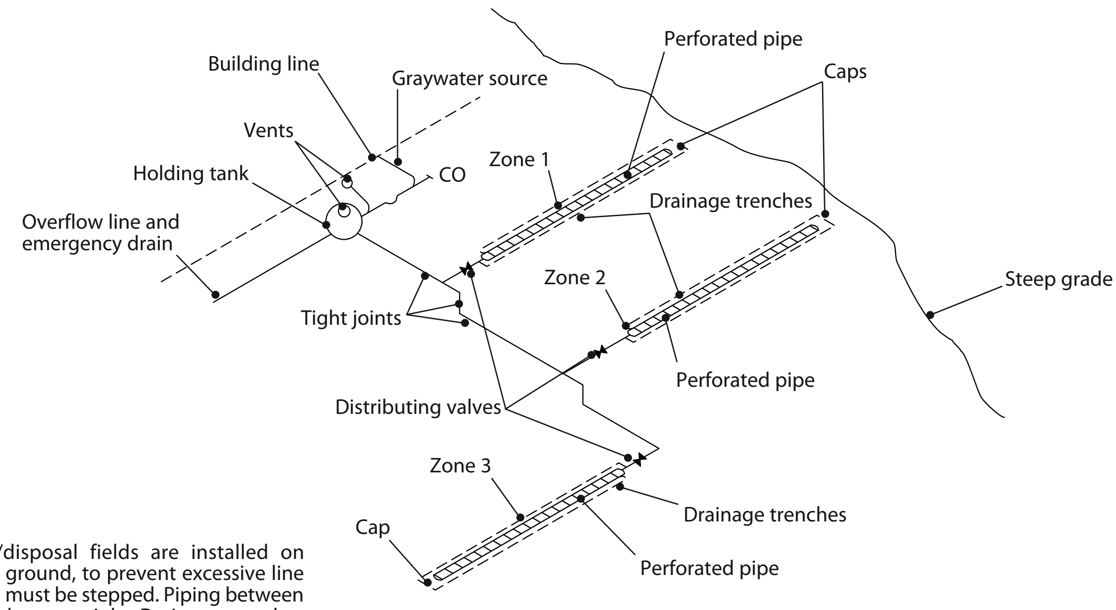
Figure 11-8
Irrigation/disposal field requirements



Note When irrigation/disposal fields are installed on steep grades or sloping ground, to prevent excessive line slopes, perforated pipes must be stepped. Piping between drainage trenches must be watertight. Drainage trenches must be installed on natural or unfilled ground.

Figure 11-9
Graywater drainage trenches (stepped)

Minimum horizontal distance in clear required from:	Holding tank(s) (ft)	Irrigation/ disposal field (ft)
Building structures[1]	5[2]	2[3]
Private line adjoining private property	5	5
Water supply wells[4]	50	100
Streams and lakes[4]	50	50[5]
Sewage pits or cesspools	5	5
Disposable field and 100% expansion area	5	4[6]
Septic tank	0	5
On-site domestic water service line	5	5
Pressurized public water main	10	10[7]

Note: When irrigation/disposal fields are installed in sloping ground, the minimum horizontal distance between any part of the distribition system and the ground surface shall be 15 feet.

[1]Including porches and steps, whether covered or uncovered breezeways, roofed porte-cocheres, roofed patios, carports, covered walks, covered driveways and similar structures or appurtenances.

[2]The distance may be reduced to zero feet for aboveground tanks when first approved by the Authority Having Jurisdiction

[3]Assumes a 45-degree (0.79 rad) angle from foundation

[4]Where special hazards are involved, the distance required shall be increased as may be directed by the Authority Having Jurisdiction.

[5]These minimum clear horizontal distances shall also apply between the irrigation/disposal field and the ocean mean higher hightide line.

[6]Plus 2 feet for each additional foot of depth in excess of 1 foot below the bottom of the drain line.

[7]For parallel construction/for crossings, approval by the Authority Having Jurisdiction shall be required.

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Figure 11-10
Location of graywater system

For graywater irrigation/disposal systems in typical soils, you'll use the same design criteria as for septic tank drainfields, with one exception. Graywater systems use six typical soils, while septic tank drainfields use five typical soils.

Once you've established the flow in gallons per day and you know the type of soil, you're ready to calculate the piping material and drainage trenches. Let's try an example using a five-bedroom residence with laundry facilities.

1. Total number of occupants: 2 + 1 + 1 + 1 + 1 = 6 occupants

2. Estimated graywater flow: 6 occupants × (25 + 15) = 240 gpd

The soil is sandy loam. According to Figure 11-6, sandy loam needs 40 square feet of leaching area per gallon of graywater waste.

$$\frac{240\ gpd \times 40\ SF}{100} = 96\ SF$$

The Future of Graywater Systems

Graywater systems are designed to manage wastewater by returning it to the natural water table underground. That makes it safe to use.

As long-term water shortages continue to increase, we can expect the use of graywater systems to expand. The water we conserve may prove to be lifesaving for generations to come.

Review Questions for Chapter 11 (answers are on page 297)

1. From what origins do we obtain by far the most water for public use?
2. What methods are being used in many large cities to extend their available water resources when they are faced with an inadequate supply of water for human consumption?
3. What has to be done to protect our present water sources and search for additional fresh water sources?
4. What is the primary source of water for single-family and multifamily residential buildings?
5. Is water conservation a local issue or a national issue?
6. Until recently, local codes have only considered water conservation methods that involve what?
7. If the average drop of water takes only $2^1/_2$ seconds to form, how much water is wasted in a year by one leaky faucet?
8. What new water conservation method is now being tried in many areas?
9. Graywater is typically routed to a disposal field or used for what purpose?
10. What is graywater?
11. What piping system cannot be connected to a graywater recycling system?
12. Name three fixtures that can connect to a gray water system.
13. Name the three things that determine the type of graywater recycling system that may be used.
14. Where must a graywater recycling system for a residential building discharge the waste?
15. When a holding tank is installed above ground, what kind of base is required to support it?
16. What test must you perform on a graywater system after you install the holding tank and piping?
17. On what do you base your estimate of the amount of graywater discharge from a single-family residence?
18. In estimating graywater discharge for a single-family residence, how many occupants are considered for the first bedroom?
19. In estimating graywater discharge for a single-family residence, how many occupants are considered for each bedroom after bedroom number one?
20. What is the allowance per occupant (excluding laundry) that you use to estimate the total number of gallons of graywater flow from a single-family residence?
21. To estimate the total number of gallons of graywater flow from a single-family residence, what is the allowance you use per occupant, including laundry facilities?
22. How is a graywater holding tank protected from overfilling?
23. When you excavate for a graywater subsurface irrigation/disposal field, you must not allow your excavation to extend within how many vertical feet of the highest known seasonal groundwater?
24. Why must each graywater holding tank have a locking gasketed access opening?
25. What must be permanently marked on each graywater holding tank?
26. What's the minimum capacity for a graywater holding tank?
27. What determines the size of a holding tank vent?
28. For replacement purposes, how must all connecting pipes to holding tanks be fitted?
29. A holding tank must be designed to withstand what amount of earth load?
30. What does an underground holding tank require to protect against sewer backups?
31. What material must all holding tanks be constructed of?
32. What's the minimum pipe size for use in graywater system irrigation/disposal fields?
33. Name two piping materials that are acceptable for graywater irrigation/disposal fields.
34. What does the code require that graywater irrigation/disposal field piping have?
35. What's the minimum size filter material required for a graywater irrigation/disposal field?

36. What's the minimum depth of filter material that's required beneath the pipe in a graywater irrigation/disposal field?

37. How far above the pipe must the filter material in a graywater irrigation/disposal field extend?

38. With what slope must graywater piping be laid?

39. In a graywater disposal system, what's the maximum length of each individual line?

40. When graywater irrigation/disposal lines are installed in areas having steep grades, what does the code require?

41. What's the minimum distance required from a private property line to a graywater system holding tank?

42. What is the minimum distance required from a graywater irrigation/disposal field to streams and lakes?

43. Who must approve the work if it's necessary to install a graywater irrigation/disposal field parallel to a public water main?

44. How does the design criteria regarding typical soils differ between graywater irrigation/disposal fields and septic tank drainfields?

45. What is a graywater system designed to do?

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12

Public Water Supply and Distribution Systems

Two thousand years ago, the people of Rome constructed overhead aqueducts and underground tunnels to bring water into the city from mountains 50 miles away. These masonry aqueducts are ranked among the world's engineering triumphs.

To distribute the water carried in by the aqueducts, the Romans took the next logical step. They developed the first lead pipes to carry water by gravity flow to the private bathrooms of the wealthy. Some sections of these lead pipes still exist today. A recent hydraulic test was conducted on a section of ancient 4-inch diameter pipe with walls ¼ inch thick. It didn't fail until it reached a pressure of 250 pounds per square inch.

In 1652, the first gravity water supply system in America was built in Boston, using hollowed hemlock logs as pipes. In about 1700, New York City installed a gravity water supply system with wood pipes laid under streets. They carried the water to street pumps or hydrants, where it could be sold.

Plumbing fixtures weren't generally installed in buildings until the 1800s. That's when the first pressurized water system was installed. For the first time, a safe and abundant supply of water was available at the turn of a handle. Today, water is supplied to nearly every home and every neighborhood in the U.S. Local authorities usually require users to connect to a public water supply system if one is available.

Raw water from lakes, rivers and deep wells is almost never safe for human consumption until it's filtered and treated. The treatment system removes unpleasant tastes, odors and impurities before the water is distributed through mains. The result is *potable water*, which meets the requirements of the health authority for drinking, culinary and domestic purposes. Local health departments monitor public water supply systems on a regular basis to assure pure and wholesome water is available.

Water System Components

The code uses specific definitions for most components of the water-distributing system. You'll find these in the glossary in your code book and a general one at the end of this book. In this chapter, I'll describe the important parts (in simpler language than the code uses) and include some diagrams to clarify the code requirements.

Water Main

A water main is a public water distribution system located in a street, alley or dedicated easement adjacent to each owner's parcel. The main carries *public water for community use*. This means that the main is a common pipe installed, maintained and controlled by local authorities. For a fee, property owners can tap into this public water system after the utility company approves the connection. The larger the connection, the larger the fee so there is an advantage to sizing to the minimum code required sizes.

The service connection must have a curb stop (valve) and will connect to a water meter at the property line. Knowing the water pressure provided to the site by the water main is a critical part of properly sizing a water piping system.

Water Service Pipe

This pipe begins at the outlet side of the water meter at the property line and ends where the line reaches the first water-distributing pipe. Each property owner must install and maintain his own service pipe. Be sure to bury the pipe at a depth of at least 12" in a warm weather climate and below the frost line in a cold weather climate. Use material allowed by the code. Some plastic pipes such as CPVC, PE and PEX come in rolls up to 300 feet and are a great choice for making an easy and effective water-tight installation. Some areas have corrosive soils, and the piping will need to be protected in a sleeve. Be sure to factor in additional connections and water demands that are on the water service such as irrigation demands or fire service demands.

Water Distributing Pipe

This is the pipe within a building that conveys water from the water service pipe to the plumbing fixtures, appliances and other water outlets. Pipe materials must comply with the adopted code and are typically listed in a table and the referenced standards of the code. Recently, the cost of copper has driven the market to plastic piping systems such as CPVC and PEX. Each material whether metallic or plastic has its benefits and downsides. Properly designing the distribution system in a way that accounts for hard water, static pressure, and proper velocities is essential to installing a system that will endure time.

Water Supply System

This term includes the water service pipe, water distributing pipes, standpipe system, the necessary connecting pipes, fittings, control valves, and all appurtenances on private property.

Water Outlet

As defined in connection with the water distributing system, the water outlet is the discharge opening for water:

- To a plumbing fixture
- To atmospheric pressure (except into an open tank which is part of the water supply system)
- To a boiler or heating system
- To any water-operated device or equipment, not a part of the plumbing system but which requires water for operation

Sizing the Water System

Water systems can be designed using the tables and graphs found in the plumbing code adopted by your local jurisdiction. Most, if not all jurisdictions allow for a design using accepted engineering practices with supporting calculations as long as the pipe sizes still meet the minimum requirements of the code.

You can't always predict the water demand in a building's water supply system. After all, you don't know how many fixtures the occupants will be using at the same time, and the types of buildings vary significantly. Currently, our codes do not give much credit to the fact that buildings rarely, or more likely never, have all the water fixtures open at the same time. *IAPMO* is making progress on this issue with their "water demand calculator" that is in the *UPC* appendix. It may be part of the code soon. For now, you must size for the maximum water demand which will definitely provide an adequate water supply to all fixtures at all times. Your goal is to properly use sizing tables to avoid undersizing and oversizing to be as economical as possible. Oversizing can also increase the risk of the water in the piping sitting for too long and going stagnant. Legionella can grow in a water system so keeping the water moving by properly sizing water piping can help avoid serious health risks.

When plumbing a simple water system, the tables in the code are fairly easy to work with and are conservative. Most homes in the U.S. only have a few common pipe sizes such as ½", ¾" and 1". In working with more elaborate water supply systems with longer runs, you'll need to calculate carefully to avoid excessive pressure loss. The physical properties of water — density, viscosity, poor compressibility, boiling point, minimum available pressure, friction loss and velocity flow — all have an effect on a water supply system. Many plumbers never have to calculate large complex systems, but you do need to be familiar with the basic principles. This chapter will focus on showing you the basics of using the tables found in the *UPC* and *IPC*/*IRC* to create a water distribution system for a single-family home.

Before we get started on sizing examples, please take some time to fully understand the basic principles that apply to sizing a water system for effectiveness.

1. Water quality can dictate which material is best for your region.
2. When designing using friction rate tables, they are different for each material so start by selecting a material before sizing the system.
3. You will likely need to justify your pipe sizing to a code official, so prepare an isometric prior to starting work and get it approved by the code official. If you provide an isometric diagram, it will also help you determine how much material you need such as pipe and fitting counts.
4. Oversizing is generally a bad practice since it is costly and can increase the likelihood of water born illness due to stagnation.
5. Undersizing can cause the velocity of the water to be higher than permitted by the pipe manufacturer and can lead to early pipe failures as well as inadequate water supply.
6. Carefully read and understand the installation instructions for plastic piping systems. A plumbing inspector will use the code and manufacturer's instructions for inspections. The manufacturer will not cover pipe failures due to non-compliant installation.
7. Know your incoming water pressure at the meter and elevation height of the highest fixture in the system. Reduce the water pressure before it goes into a building with a pressure regulator if it is excessive. Both the *IPC* and *UPC* consider a pressure in excess of 80 PSI to be excessive. Excessive pressure will lead to the premature failure of faucets, toilet fill valves and appurtenances such as dishwashers, ice makers and water heaters.
8. For most water supply outlets at common plumbing fixtures, a minimum of 8-30 psi is required depending on which code you are using.
9. Low water pressure will require larger pipe sizes than high water pressure.
10. Water pressure does not increase with larger piping. Water volume increases but the pressure does not. For example: 80 PSI in a ½" pipe is the same as 80PSI in a 1" pipe. It is a pressure measurement only.
11. Understand the effects of water pressure increases due to the expansion of the hot water in the system. Water is not compressible and expands when heated. Every system needs to have a method to control expansion such as an expansion tank. Failing to provide an expansion tank causes the pressure to fluctuate dramatically and can lead to the early failure of piping and fixtures.
12. Choose piping supports that secure the pipe in a way that does not cause damage to the pipe or cause excessive noise. Follow the manufacturer's instructions carefully.

Alright, let's get started sizing!

The *UPC* and *IRC*/*IPC* utilize very different methodologies for sizing water piping, yet the result is often the same size service, building main, and branches. Figures 12-1 and 12-2 are sizing tables like those you'll find in the *UPC*. Figure 12-3 is a sizing example using the *UPC*.

Figures 12-4, 12-5 and 12-6, are like those you would find in the *International Residential Code* (*IRC*). Figure 12-8 is a sizing example using the *IRC* tables.

Sizing the Water Service Pipe

The water service pipe is the first part of the water supply system you'll size, and it is based on the total number of water fixture units downstream of the meter. For the fixtures to operate properly, this pipe must carry sufficient volume and pressure to the water distribution pipes throughout the building.

The water service pipe size continues within the building and is then renamed as the building water main. After you connect the water-distributing branch pipes to the building main, using proper fittings, you can reduce the size of the main as the main progresses through the building since the demand likely to be placed on the line decreases.

Some Sizing Examples

Now you can work through two examples to learn from and test your knowledge. You'll size these water supply systems using Figures 12-1 through 12-8.

Let's start with an example using the tables and methodology of the *Uniform Plumbing Code*.

Sizing with the *UPC* begins with establishing that you have the minimum pressure needed to use the following tables. One of the tables starts with 30PSI as the minimum pressure permitted. If you do not have the required pressure available, installing a booster pump is a common solution.

In order to ultimately determine the available working pressure, we begin with discovering the available pressure at the meter. This can be measured with a gauge or a water district pressure map. Subtract the pressure loss due to elevation from the available water pressure at the meter and now we have a working design pressure for use with the *UPC* sizing tables.

Determining the water pressure correctly is the first critical step and there is an important calculation to perform that takes into consideration pressure loss due to a change in elevation.

Here is an example of how to calculate pressure loss due to elevation. Figure 12-3 depicts a home on a hill that is 30 feet above the meter. As water is pushed up the hill it loses pressure due to the difference in elevation. Every 10 feet of elevation results in a pressure loss of 4.33 PSI. For calculation purposes, we can consider that a 5PSI drop so the math is easy and the result is slightly conservative. In this example, the pressure loss for 30 feet of elevation is 5psi X 3=15 PSI.

The *UPC* provides two tables that are used together for sizing water pipes. Portions of these tables are in this book and are shown in Figures 12-1 and 12-2.

Appliances, Appurtenances or Fixtures[2]	Minimum Fixture	Private
	Branch Pipe Size [1, 4] (inches)	WSFU's
Bathtub or Combination Bath/Shower (fill)	½″	4
¾ inch Bathtub Fill Valve	¾″	10
Clothes Washer	½″	4
Dishwasher, domestic	½″	1.5
Hose bibb	½″	2.5
Hose bibb, each additional[8]	½″	1
Lavatory	½″	1
Sinks, Kitchen, domestic with or without dishwasher	½″	1.5
Sinks, Laundry	½″	1.5
Shower, per head	½″	2
Water Closet, 1.6 GPF Gravity Tank	½″	2.5

Notes:
1. Size of the cold branch pipe, or both the hot and cold branch pipes.
2. Appliances, appurtenances, or fixtures not referenced in this table shall be permitted to be sized by reference to fixtures having a similar flow rate and frequency of use.
4. The listed minimum supply branch pipe sizes for individual fixtures are the nominal (I.D.) pipe size.
8. Reduced fixture unit loading for additional hose bibbs is to be used where sizing total building demand and for pipe sizing where more than one hose bibb is suplied by a segment of water distribution pipe. The fixture branch to each hose bibb shall be sized on the basis of 2.5 fixture units.

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Figure 12-1

Water supply fixture units (WSFU) and minimum fixture branch pipe sizes

Meter and Street Service (inches)	Building Supply and Branches (inches)	Maximum Allowable Length (feet)					
		40	60	80	100	150	200
Pressure Range - 30 to 45 psi[1]							
3/4″	1/2″[2]	6	5	4	3	2	1
3/4″	3/4″	16	16	14	12	9	6
3/4″	1″	29	25	23	21	17	15
1″	1″	36	31	27	25	20	17
3/4″	1-1/4″	36	33	31	28	24	23
1″	1-1/4″	54	47	42	38	32	28
Pressure Range - 46 to 60 psi[1]							
3/4″	1/2″[2]	7	7	6	5	4	3
3/4″	3/4″	20	20	19	17	14	11
3/4″	1″	39	39	36	33	28	23
1″	1″	39	39	39	36	30	25
3/4″	1-1/4″	39	39	39	39	39	39
1″	1-1/4″	78	78	76	67	52	44
Pressure Range - Over 60 psi[1]							
3/4″	1/2″[2]	7	7	7	6	5	4
3/4″	3/4″	20	20	20	20	17	13
3/4″	1″	39	39	39	39	35	30
1″	1″	39	39	39	39	38	32
3/4″	1-1/4″	39	39	39	39	39	39
1″	1-1/4″	78	78	78	78	74	62

For SI units: 1 inch = 25 mm, 1 foot = 304.8 mm, 1 pound-force per square inch = 0.8947 kPa
Notes:
1. Available static pressure after head loss.
2. Building supply, not less than ³⁄₄ of an inch (20mm) nominal size.

Data from the *UPC*™ with permission of the *IAPMO* ©2021

Figure 12-2

Fixture unit table for determining water pipe and meter sizes

Familiarize yourself with Figure 12-1. This portion of a table from the *UPC* has two important columns next to some typical plumbing fixtures found in a home.

The first column lists the plumbing fixture and the middle column lists the minimum branch size require which is also the *UPC* minimum pipe size required for each fixture. The supply piping serving any fixture must be at least the size of the inlet.

The next column over at the far right has the number of water supply fixture units (WSFU's) that are assigned to each fixture. This is important for sizing individual branches as well as the main distribution pipes and water service.

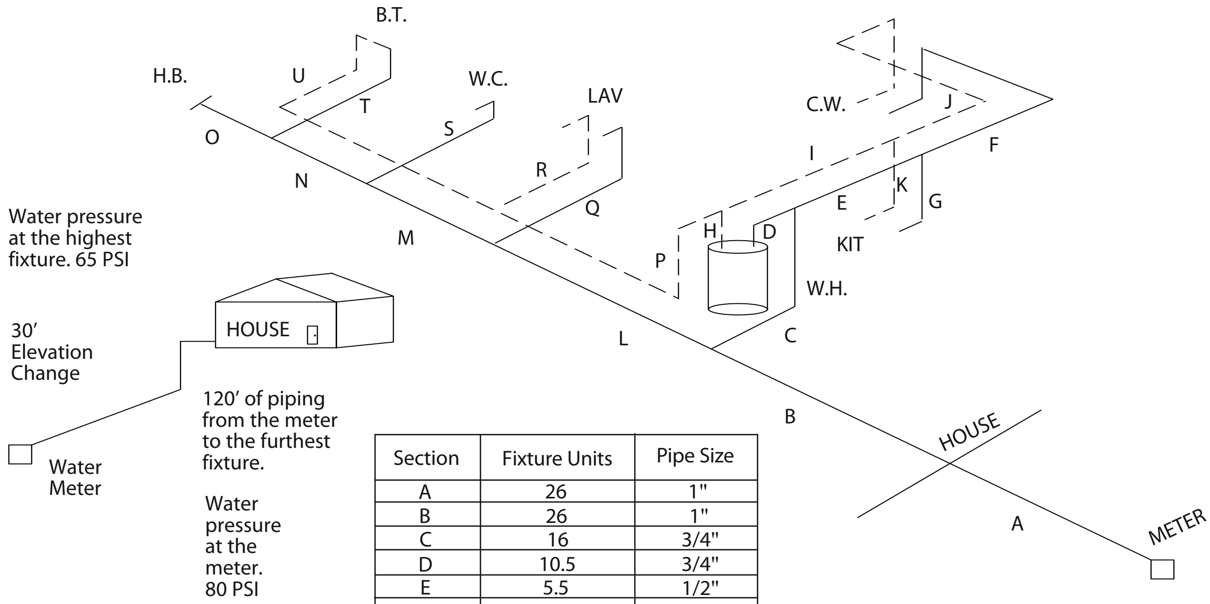
The next table is shown in Figure 12-2 and has the number of fixture units a pipe can serve given the available water pressure and distance to the furthest fixture in the system. This table is great because it accounts for friction rates and works for all material types.

Using these two tables together is not difficult, however, be sure to account for pressure loss due to elevation as discussed earlier.

Figure 12-3 is an isometric sizing example of a single-bathroom house with a copper piping system.

After working on this sizing example, you should spend some time practicing drawing water supply isometric drawings until you feel competent. Remember, a vertical line always represents a vertical pipe.

In this example, we have a home located above the meter, and the highest fixture in the home is determined to be 30 feet above the meter. The distance to the furthest fixture is 120'. The available pressure at the meter is 80 PSI. After deducting for pressure loss due to elevation, the available working design pressure is 65 PSI.



Section	Fixture Units	Pipe Size
A	26	1"
B	26	1"
C	16	3/4"
D	10.5	3/4"
E	5.5	1/2"
F	4	1/2"
G	1.5	1/2"
H	10.5	3/4"
I	5.5	1/2"
J	4	1/2"
K	1.5	1/2"
L	10	3/4"
M	9	3/4"
N	6.5	3/4"
O	2.5	1/2"
P	5	1/2"
Q	1	1/2"
R	1	1/2"
S	2.5	1/2"
T	4	1/2"
U	4	1/2"

Figure 12-3

Isometric sizing example of a single-bathroom house with copper piping system

To size the water service, add all the fixture units together and this number is the water supply total demand as shown in Figure 12-3. As you can see, pipe section A represents the water service, and the total water supply fixture load is 26. Now you can use 26 WSFU's in the Table in Figure 12-2. Use the table with the correct corresponding water pressure range, (Over 60 PSI) and then tabulate the pipe size using the distance column of 150 feet. The tabular value results in a ¾" meter and 1" pipe

Within the building, use the same pressure table (Over 60 PSI), and the distance to the furthest fixture (150 feet) is used again to size the mains and individual branches. See Figure 12-3 for the pipe sizes shown in this example. Now take some time to practice finding a pipe size for a fixture using different elevation changes, working pressures and furthest fixture lengths.

Now let's use the International Code Council's methodology found in the *International Residential Code* (*IRC*) which applies to single-family homes and duplexes.

Sizing with the *IRC* begins with establishing that you have the minimum pressure needed to use the following tables. If you do not have the required pressure available, installing a booster pump is a common solution. Figure 12-4 lists typical plumbing fixtures and the flow rate in gallons per minute with the minimum design pressures required.

See Figure 12-5. This table lists typical plumbing fixtures, and the loads placed on the system in terms of water supply fixture units. The hot and cold columns are used for branch and main sizing and the column for combined WSFU is used for water service sizing and piping within the building that serves both the hot and cold system to a fixture.

Required Capacities at Point of Outlet Discharge		
Fixture Supply Outlet Serving	**Flow Rate (gpm)**	**Flow Pressure (psi)**
Bathtub, balanced-pressure, thermostatic or combination balanced-pressure/thermostatic mixing valve	4	20
Bidet, thermostatic mixing valve	2	20
Dishwasher	2.75	8
Laundry tray	4	8
Lavatory	0.8	8
Shower, balanced-pressure, thermostatic or combination balanced-pressure/thermostatic mixing valve	2.5[a]	20
Sillcock, hose bibb	5	8
Sink	1.75	8
Water closet, flushometer tank	1.6	20
Water closet, tank, close coupled	3	20
Water closet, tank, one-piece	6	20

For SI: 1 pound per square inch = 6.895 kPa, 1 gallon per minute = 3.785 L/m.
a. Where the shower mixing valve manufacturer indicates a lower flow rating for the mixing valve, the lower value shall be applied.

Data from the *IRC*™ with permission of the *ICC* ©2021

Figure 12-4

Required capacities at point of outlet discharge

Water Supply Fixture Unit Values for Various Plumbing Fixtures and Fixture Groups			
Type of Fixtures or Group of Fixtures	**Water-Supply Fixture-Unit Value (w.s.f.u.)**		
	Hot	**Cold**	**Combined**
Bathtub (with/without overhead shower head)	1.0	1.0	1.4
Clothes washer	1.0	1.0	1.4
Dishwasher	1.4	—	1.4
Full-bath group with bathtub (with/without shower head) or shower stall	1.5	2.7	3.6
Half-bath group (water closet and lavatory)	0.5	2.5	2.6
Hose bibb (sillcock)[a]	—	2.5	2.5
Kitchen group (dishwasher and sink with or without food-waste disposer)	1.9	1.0	2.5
Kitchen sink	1.0	1.0	1.4
Laundry group (clothes washer standpipe and laundry tub)	1.8	1.8	2.5
Laundry tub	1.0	1.0	1.4
Lavatory	0.5	0.5	0.7
Shower stall	1.0	1.0	1.4
Water closet (tank type)	—	2.2	2.2

For SI: 1gallon per minute = 3.785 L/m
a. The fixture-unit value 2.5 assumes a flow demand of 2.5 gallons per minute, such as for an individual lawn sprinkler device. If a hose bibb or sill cock will be required to furnish a greater flow, the equivalent fixture-unit value may be obtained from this table or Table P2903.6(1).

Data from the *IRC*™ with permission of the *ICC* ©2021

Figure 12-5

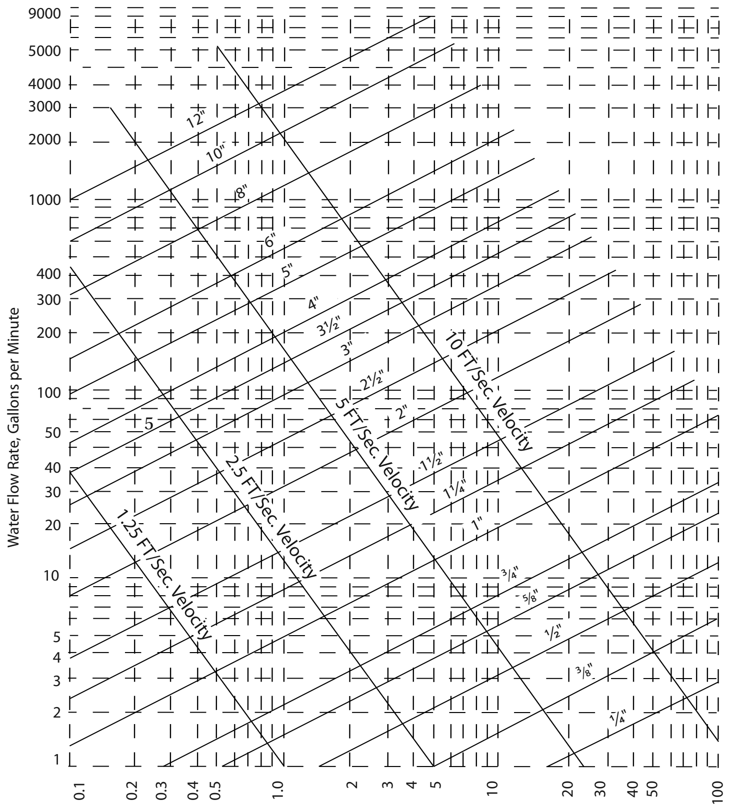
Maximum flow and water consumption

Supply Systems Predominantly for Flush Tanks		
Load	**Demand**	
(Water supply fixture units)	**(Gallons per minute)**	**Cubic feet per minute**
1	3	0.04104
2	5	0.0684
3	6.5	0.86892
4	8	1.06944
5	9.4	1.256592
6	10.7	1.430376
7	11.8	1.577424
8	12.8	1.711104
9	13.7	1.831416
10	14.6	1.951728
11	15.4	2.058672
12	16	2.13888
13	16.5	2.20572
14	17	2.27256
15	17.5	2.3394
16	18	2.90624
17	18.4	2.459712
18	18.8	2.513184
19	19.2	2.566656
20	19.6	2.620128
25	21.5	2.87412
30	23.3	3.114744
35	24.9	3.328632
40	26.3	3.515784
45	27.7	3.702936
50	29.1	3.890088

Data from the *IRC*™ with permission of the *ICC* ©2021

Figure 12-6

Conversions from WFSU unit to GPM



Pressure drop per 100 feet of tube. Pounds per square inch

Note: Fluid velocities in excess of 5 to 8 feet/second are not usually recommended.

For SI: 1inch = 25.4 mm, 1 foot = 304.8 mm, 1 gpm = 3.785 L/m, 1 psi = 6.895 kPa, 1 foot per second = 0.305 m/s.

a. This chart applies to smooth new copper tubing with recessed (streamline) soldered joints and to the actual sizes of types indicated on the diagram.

Data from the *IPC*™ with permission of the *ICC* ©2021

Figure 12-7

Friction loss in smooth pipe

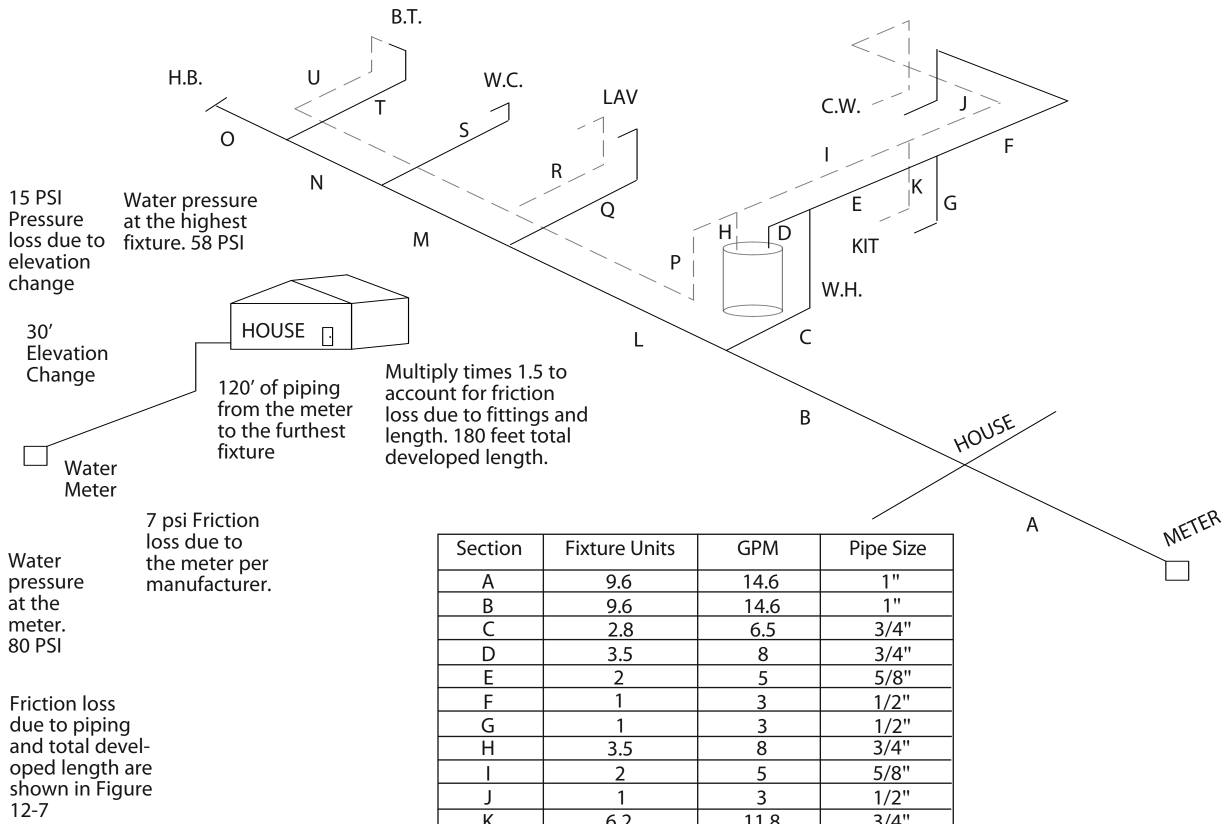
Figure 12-6 shows the table that converts water supply fixture units into GPM and also shows the velocity of the water in cubic feet per minute.

Lastly, table 12-7 is a pipe sizing chart for copper pipe. There are different charts for different materials in the code. This table helps the user select a pipe size using 3 different criteria that we need to stay within an acceptable range on the chart.

1. Gallons per minute are shown on both the left and right sides of the chart. Calculating the required GPM is relatively easy and uses the tables in Figures 12-5 and 12-6. When using Figure 12-7, start with the GPM you need for a section of pipe and then work to the right to find a pipe size within the velocity and pressure loss sections. All piping needs to serve fixtures through service and branch lines that provide enough gallons per minute for acceptable operation.

2. The velocity of the water in the pipe is also very important and is shown as cubic feet per second. In general, cold-water piping should be sized large enough to keep the velocity below 8 feet per second, and hot-water piping should have a velocity of 5 feet per second or less. Higher velocities can damage the pipe from the inside out. Velocity lines are shown in the center of the table, and we need to select a pipe size that keeps our velocities in range and also provides the GPM we need.

3. The total loss in pressure due to the total developed length is shown at the bottom of the table. This is an important number because the longer the pipe run, the more pressure drop there is. We need to stay in an acceptable range as determined by our available pressure and the subtraction of losses due to pressure. In our example, we start with 80 psi and subtract 7 psi for the meter and 30 psi for the elevation change. We are left with



Section	Fixture Units	GPM	Pipe Size
A	9.6	14.6	1"
B	9.6	14.6	1"
C	2.8	6.5	3/4"
D	3.5	8	3/4"
E	2	5	5/8"
F	1	3	1/2"
G	1	3	1/2"
H	3.5	8	3/4"
I	2	5	5/8"
J	1	3	1/2"
K	6.2	11.8	3/4"
L	5.7	10.7	3/4"
M	5.7	10.7	3/4"
N	3.5	8	3/4"
O	2.5	6.5	3/4"
P	1.5	5	5/8"
Q	0.5	3	1/2"
R	0.5	3	1/2"
S	2.2	6.5	3/4"
T	1	3	1/2"
U	1	3	1/2"

Notes: Sized for a 5 psi pressure loss due to friction.

Figure 12-8

58 psi. In general, 58 psi is an adequate pressure, however, we still need to apply the friction rate at the bottom of the table. As we move to the right, the pressure loss increases, and we need to select a velocity and pipe size that can serve the needed GPM and leave us without significant pressure losses due to the total developed length of the piping. You can see on the far-right side of the pressure drop numbers; the numbers increase from 30 to 100 psi of pressure loss due to friction. We need to avoid using columns that have this much pressure loss and stick to columns that keep our pressure satisfactory. 58 minus 40 psi results in an available pressure of 18 psi. Figure 12-4 shows that 18 psi is not adequate for some of the listed fixtures.

Let's continue with gathering the correct sizing data using our example in Figure 12-8 and then using the sizing chart.

Example 2: To keep it simple, let's use the same one-bathroom house used for the *UPC* sizing example as shown in Figure 12-8.

I have placed the values for each pipe section using the tables provided in Figures 12-5. 12-6 and 12-7. You can compare the pipe sizing of *UPC* figure 12-3 and *IRC* figure 12-8 and see they have very similar results.

This would be a good time to practice sizing by selecting different pressures and total developed lengths.

Review Questions for Chapter 12 (answers are on page 299)

1. In which American city was the first gravity water supply system built?
2. What did the installation of a pressurized water system make possible?
3. In order to make raw water safe and pleasant for drinking, name two things that are removed by treatment.
4. What is potable water?
5. What agency is generally responsible for monitoring our public water supply systems?
6. What is the purpose of a public water main?
7. What is a private service connection to a public water main required to have?
8. Where does a building water service pipe begin?
9. What are the pipes called that carry water from the water service pipe to the plumbing fixtures and other outlets?
10. Name three components of a water supply system.
11. In a water distributing system, how does the code define a discharge opening for water?
12. In sizing a water system, what won't you ever be able to predict exactly?
13. When you size water supply piping, it's important to be economical, but what cost-saving measure must you be sure to avoid?
14. Name two physical properties that can affect water in supply pipes.
15. What size pipes are most common in a home in the U.S.?
16. How do you justify your proposed pipe sizes to a code official?
17. Why is it bad practice to undersize water piping?
18. What amount of water pressure is considered excessive by both the *UPC* and *IRC*?
19. What device would you use to reduce water pressure?
20. Name a device that is installed to control water as it expands?
21. For the proper operation of fixtures, the water service pipe must carry sufficient volume and pressure to the building in order for what result?
22. Per the *UPC*, given a pressure of 40 PSI and maximum allowable length of 100 feet, how many water supply fixture units can a ¾" service with a 1" supply serve?
23. Per the *UPC*, given a pressure of 65 PSI and maximum allowable length of 60 feet, how many water supply fixture units can a ¾" service with a 1" supply serve?
24. The PSI required to operate an ordinary faucet properly according to the *IRC* is:
25. According to the *IRC*, what is the required flow rate for a lavatory faucet?

13

Hot Water Systems

These days almost all buildings have a hot water system, and such systems are required by code to include specified safety devices. Properly installed, they'll help prevent damage to property and injury to people from excessive pressure and temperature.

Professional engineers and plumbers typically design hot water heating systems using available codes, standards and manufacturers' installation requirements.

In large commercial buildings, a professional engineer usually designs the hot water supply system and the plumber just installs it. In residential and smaller commercial buildings, the installing plumber usually designs the hot water system. This chapter will help you design safe and functional hot water systems for residential and small commercial buildings.

Design Objectives

There are three principal objectives in designing a good hot water system:

1) The system must satisfy the hot water demand for the particular type of occupancy.

2) It must include safety features to guard against the hazards of excessive pressure and temperature.

3) Energy conservation

I've included several sample diagrams at the end of this chapter to show you how to plan simple hot water systems.

The Water Heater

The normal design temperature of hot water in most plumbing fixtures is between 110 and 140 degrees Fahrenheit.

In recent years, scalding hazards have received a lot of attention and new code provisions have been added in order to minimize the risk of scalding. Certain fixtures such as showers, soaking tubs, public lavatories and bidets are now required to provide scald protection through certified temperature limiting or pressure balancing devices. A tank type water heater thermostat doesn't provide adequate assurance that the water delivered is at non-scalding temperatures.

Most direct heating units you'll install will use gas, oil, or electricity. Whatever the fuel, the energy transfer rate must be adequate to heat all the water stored in the tank. Modern commercial and residential storage tanks now have enough insulation to prevent excessive heat loss.

In today's homes, electric water heaters are the most common. They're clean and attractive enough to install nearly anywhere in a building. Gas or oil water heaters must be located in a well-ventilated area with flues to carry away combustion gases. See Figure 13-1. That limits the possible locations in a building. Combustion air vents must provide enough air for combustion, ventilation and dilution of flue gases. Heat-pump water heaters are becoming a popular option because they are both energy efficient and are environmentally safe. These water heaters need a good amount of ventilation for the exchange of heat from the air.

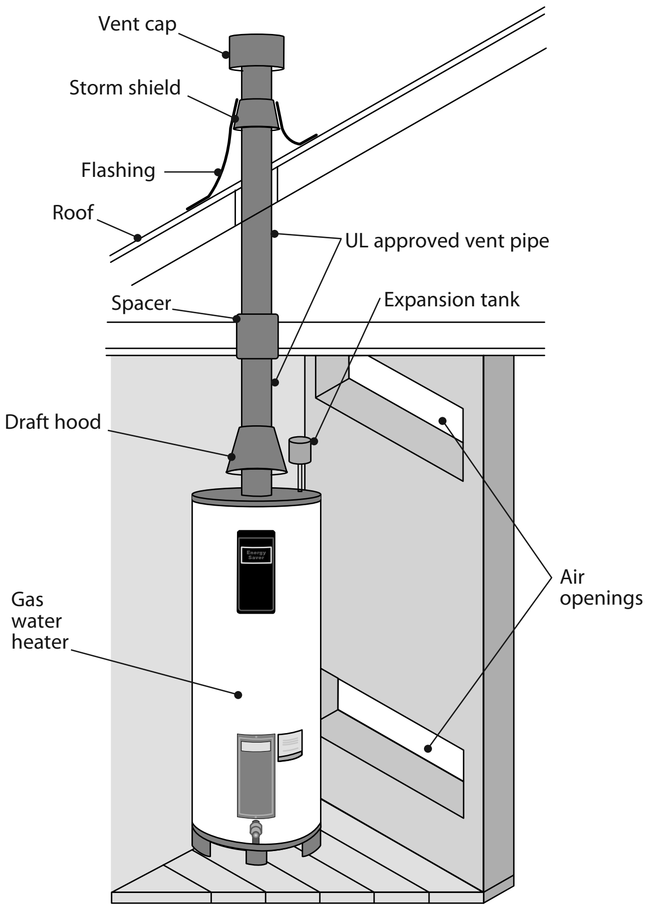


Figure 13-1
Installing a fuel-burning water heater

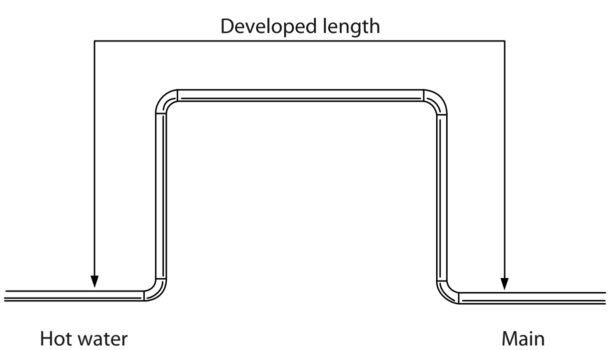


Figure 13-2
Horizontal U bend (four-elbow loop)

In apartment buildings with a central hot water generating system, be sure to install a return line and circulating pump for greater efficiency. Without them, there's a long waiting time for hot water, and a lot of water wasted. Always insulate the hot water feed and hot water return lines to prevent heat loss.

Traditionally, there was no need to constantly circulate hot water in a system designed for a one- or two-family dwelling. But today, modern homes now often have recirculating systems to minimize water waste while waiting for hot water to come out of a faucet. Some local codes and energy conservation codes require hot water recirculation and insulation on the loop.

Expansion

Every water system must have a device to control the increase of water pressure due to the expansion of hot water. As water is heated, it expands and without a proper device, pressure can increase to levels that can be harmful to piping and fixtures. An expansion tank is shown in Figure 13-1 and is a common device that controls pressure by utilizing an air bladder.

Piping materials expand and contract with temperature changes, so your design for hot water lines in a large system must allow for lengthening and shortening of the runs. In hot water riser supply pipes and circulating lines, expansion and contraction can pose a serious problem. Depending on the piping materials, 100 linear feet during a 100-degree F temperature rise may expand as little as $^3/_4$ inch or as much as 2 inches. Allow an expansion variance of $1^1/_2$ inches for each 100 feet of piping materials. The common four-elbow loop shown in Figure 13-2 provides adequate developed length to prevent excessive stress in a hot water piping system.

Heater Capacities

Modern electric and gas water heaters have small storage tanks. That's all they need, because they can provide enough heating capacity to keep the water at 110 to 140 degrees F during the peak draw period. The peak draw period is usually assumed to be one hour, though in many homes it's as little as 20 minutes.

Number of Bathrooms	**1 to 1.5**			**2 to 2.5**				**3 to 3.5**			
Number of Bedrooms	1	2	3	2	3	4	5	3	4	5	6
First Hour Rating, [2] Gallons	38	49	49	49	62	62	74	62	74	74	74

Figure 13-3
First hour rating

When sizing hot water tank capacity, here are the assumptions you should make:

- Assume that only 75 percent of the tank's hot water supply is available during the peak draw period of one hour. A 40-gallon water heater should provide 30 gallons at temperatures of 110 to 140 degrees F.
- If you think the peak demand rate may extend over a two-hour period, assume that 37.5 percent of the tank's capacity is available per hour. A 40-gallon water heater should provide 15 gallons per hour.
- If the peak demand rate could last three hours, assume that 25 percent of the tank's capacity is available per hour (75 percent over the entire three-hour period). A 40-gallon water heater should provide 10 gallons per hour.

For a storage tank heater, the heating capacity per hour determines the amount of hot water that's available during the peak demand periods. The *UPC* tank storage capacities in Figure 13-3 are economical and satisfactory for the average dwelling unit *when the peak draw period doesn't exceed one hour.* If there are special demands that may last more than one hour, consider moving up to the next larger size.

The number of bedrooms and bathrooms is the best indication of the quantity of water needed. You may want to split the system and install two water heaters, especially if the layout needs long pipe runs.

For multifamily dwellings with a central hot water system, a packaged *high recovery rate* heater with these capacities is generally adequate:

- A 75-gallon storage tank for up to 12 living units
- A 100-gallon storage tank for up to 18 living units

Tankless Water Heaters

Tankless water heaters are fairly common and can be a great option when space is limited and continuous hot water is desired. There are many different manufacturers now and each product has differences, be sure to read the manufacturers installation instructions carefully before installing a tankless water heater.

Safety Devices

Pressure Relief Valves

The code requires a pressure relief valve to relieve excess storage tank pressure in all equipment used for heating or storing hot water. The pressure portion of the relief valve will be either 75, 100, 125 or 150 psi.

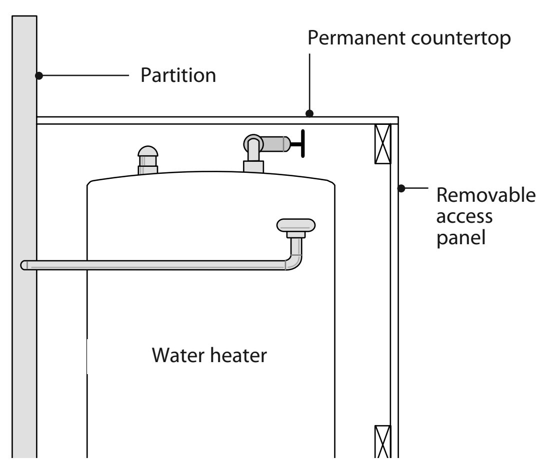
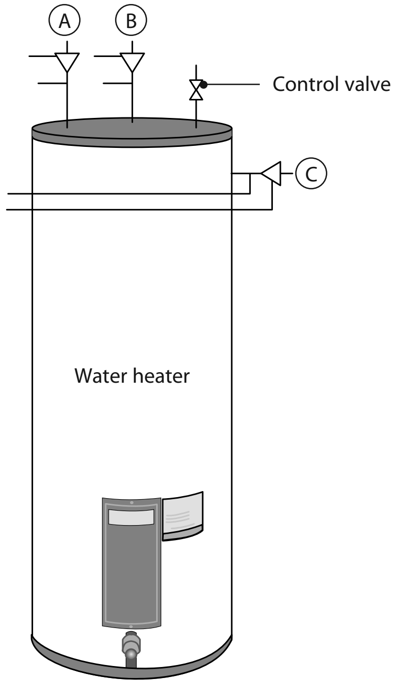


Figure 13-4
Installation of undercounter hot water heater



Note Positions illustrated at A, B, or C are acceptable

Figure 13-5
Locate relief valves in the top 6 inches of the water heater

Always install water heaters so the plates with the maximum working water pressure and other data are visible. Locate the heater where it's accessible for servicing or replacement without removing any permanent part of the building. See Figure 13-4.

The rate of discharge for the pressure relief valve must limit the pressure rise for any given heat input to within 10 percent of the pressure that opens the valve. Most standard hot water storage tanks are designed to withstand working pressures up to 150 psi. The pressure relief valve should open at 25 psi above the maximum working pressure, but under no circumstances should it exceed 175 psi.

Temperature Relief Valves

Temperature relief valves are required on all equipment that heats or stores domestic hot water. The temperature portion of the valve releases at a temperature of 210 degrees F. This valve must be the *reseating* type, rated by its Btu capacity. The Btu rating of the temperature relief valve must always be greater than the Btu rating of the appliance it serves. This prevents premature opening of the valve.

In some cases you'll know the wattage of an electric water heater but not its Btu rating. So how do you choose the correct temperature relief valve and size the relief valve discharge line? It's simple! You can find the Btu rating with this formula:

1 watt = 3.4 Btu

Just multiply the watts by 3.4 to find the Btu rating of the appliance or combination of appliances.

Domestic packaged hot water heaters don't need separate pressure and temperature relief valves. You can use a combination pressure and temperature relief valve that meets the requirements of the American Gas Association, ASME, or other recognized authority.

Install the relief valves so the temperature sensing element is immersed in the top 6 inches of the tank (Figure 13-5). That's where the hottest water is. The code says you can't install a check valve or shut-off valve between the relief valve and the water heater or storage tank it serves. Why? If the check valve fails to operate or if someone accidentally closes the shut-off valve, the relief valve wouldn't work. The tank could rupture, causing property damage and perhaps personal injury.

Relief Valve Drip Lines

Don't connect relief valve drip pipes (*popoff lines*) directly to any plumbing drainage or vent system. Not only could they contaminate the potable water system, they may also conceal any continuous discharge. And never terminate them above a water closet, urinal, bidet, bathtub or shower stall where anyone would be scalded if they suddenly discharge.

Water heater pressure and temperature relief piping for most buildings should terminate outside the building whenever possible, at an observable point approximately 6 inches above the ground. You can't thread the end of relief valve drip pipes. You don't want to make it easy for someone to cap or connect something to this pipe.

When a building covers the entire lot, you can terminate the drip pipe in an indirect connection above a floor drain or other suitable fixture approved by local authorities. If hot water storage tanks are placed above the roof of a building, the relief valve drip pipe may discharge to a floor sink.

Relief valve discharge piping may never be smaller than the opening of the relief device.

Other Safety Features

Hot water heaters and storage tanks must have the drain cock in an accessible location. This allows both flushing sediment from the tank and emptying it for repairs or replacement.

The cold water supply pipe to hot water heaters must have a shut-off valve in an accessible location. The shut-off valve must be full-way, so it doesn't reduce the flow through the valve.

Water Heater Drain Pans

When water heaters or hot water storage tanks are located above the ground floor level of a building, you have to provide a drain pan. This helps prevent injury to the building occupants or damage to the building. See Figure 13-6. Here are some qualitites of a good pan:

- They must be of a high-impact plastic at least 60 mil (1/16 inch) thick. You can also use galvanized sheet steel or other corrosive-resistant metal that's at least 24 gauge.
- They must be at least 1 1/2 inches deep.
- They must have a minimum 3/4-inch drain outlet (1 inch in some codes) located 1/2 inch above the bottom of the pan.
- You must provide a minimum 2-inch clearance between the drain pan sides and the heater.
- In a multiple vertical installation, make sure the drain from pans runs downward a minimum of 6 inches before connecting into the main riser. See Figure 13-6.

Under a floor slab on grade, increase horizontal pipes that receive drain pan waste by one size. Some codes allow water heater relief lines and safe pan lines to use a common vertical riser. Use only approved materials and always check local code requirements. See Figure 13-6. Like the relief lines, drain pan lines must terminate over a suitable waste receptor or extend outside the building in a visible location 6 inches above grade.

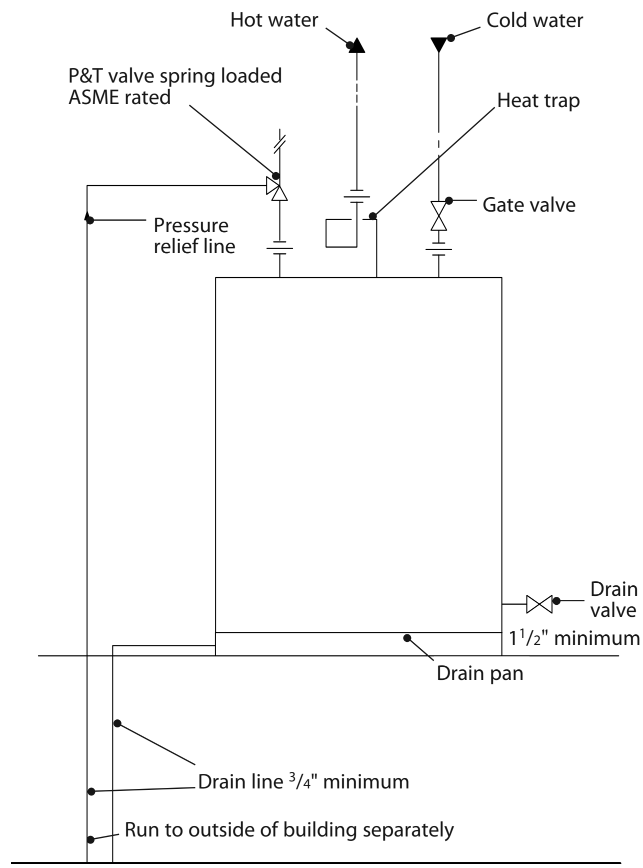


Figure 13-6
Electric water heater detail and drain pan

Energy Conservation

Water heaters account for approximately 25 percent of the energy used in the average household. That's why codes have adopted stringent methods to conserve energy. These are typical of most code requirements:

- Heat traps are required on hot water lines leading away from water heaters. See Figure 13-6. The heat trap prevents hot water from rising into the hot water line, saving approximately 2 percent of the cost to generate hot water.
- Water heaters must be equipped with an energy shut-off device. This will cut off the supply of heat energy to the water tank and prevent temperatures from exceeding 210 degrees F.
- Water heaters are required to have efficient heating devices and controls.

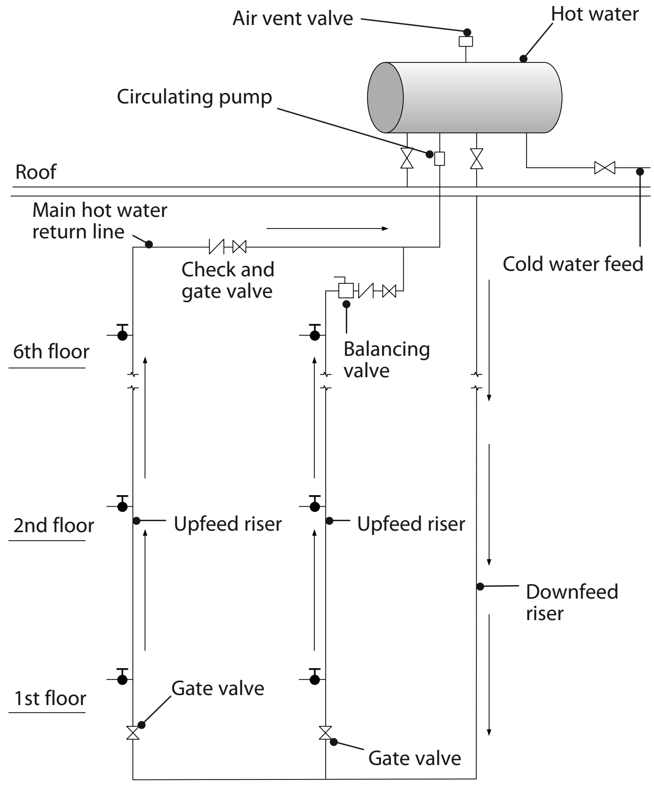
There are stringent standards for water heater insulation to prevent excess heat loss from hot water storage tanks.

Three Common Hot Water Circulating Systems

Now let's look at the piping diagrams for hot water circulating supply. They illustrate the three most conventional systems: the inverted upfeed system, the looped system, and the downfeed system.

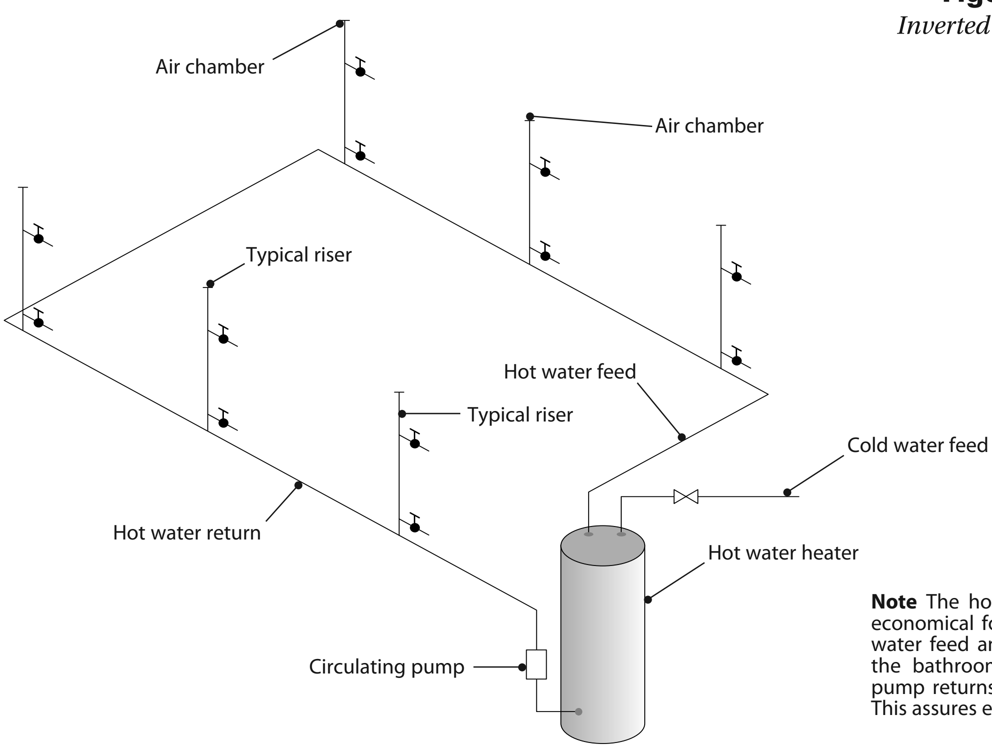
The inverted upfeed system (Figure 13-7) conveys hot water to the lowest part of the system. Then a circulating pump returns the water through the upfeed risers to the hot water generator.

The hot water looped system (Figure 13-8) is simple and economical for small apartment buildings. Install the hot water feed and return directly beneath the bathrooms of each apartment. A circulating pump returns the water to a high-recovery heater.



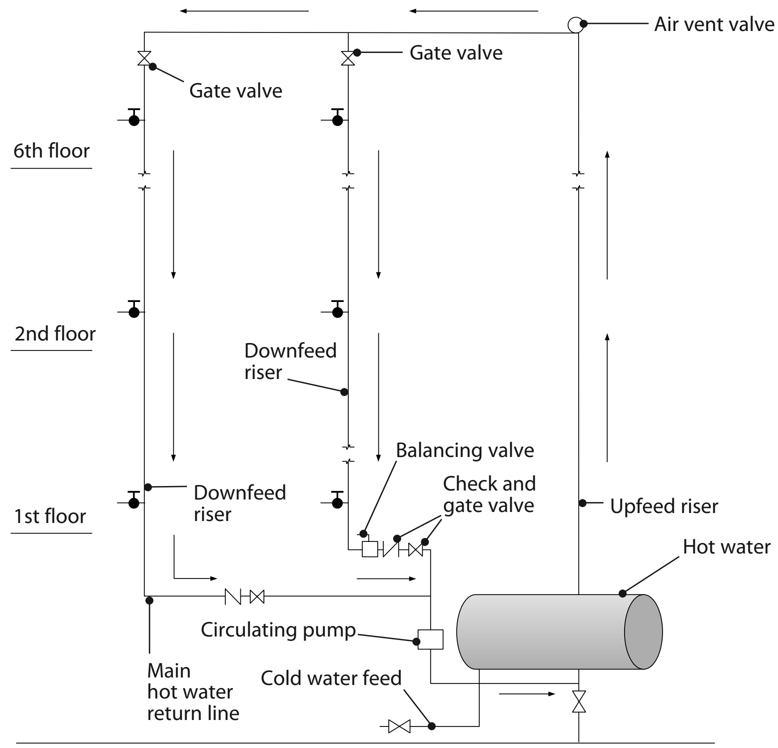
Note The inverted upfeed system conveys hot water to the lowest part of the system. The circulating pump returns the water through the upfeed risers to the hot water generator.

Figure 13-7
Inverted upfeed system



Note The hot water looped system is simple and economical for small apartment buildings. The hot water feed and return is installed directly beneath the bathrooms of each apartment. A circulating pump returns the water to a high-recovery heater. This assures each apartment of adequate hot water.

Figure 13-8
Hot water looped system



Note The upfeed riser from the hot water source conveys hot water to the downfeed risers. The circulating pump returns this water to the hot water generator.

Figure 13-9
Downfeed system

In the downfeed system shown in Figure 13-9, the upfeed riser from the hot water source conveys hot water to the downfeed risers. The circulating pump then returns this water to the hot water generator, where it is reheated.

Hot water piping materials and installation methods are the same as those described for water distribution in Chapter 14, *Installing Water Systems*. The only exception is that hot water piping supports must allow for the anticipated expansion and contraction.

Review Questions for Chapter 13 (answers are on page 300)

1. What very common water system do you find in most buildings?
2. When a hot water system is installed, what does the code specifically require?
3. Why is it important to install safety equipment on hot water systems?
4. Who is typically responsible for designing and sizing the hot water system?
5. Who usually designs hot water supply systems for large commercial buildings?
6. Who usually designs hot water systems for small commercial and residential buildings?
7. What are the two principal objectives in designing a good hot water system?
8. What is the normal design range for hot water temperatures in most plumbing fixtures?
9. What devices are now required pertaining to the temperature of water serving certain fixtures
10. What three fuels are used in most direct water-heating units?
11. Why are electric water heaters the most common type used in homes today?
12. What is important about the location for gas- or oil-fueled water heaters?
13. What must be installed on water heaters designed to burn gas or oil?
14. What conservation measure is advisable when installing hot water pipes in large buildings with circulating lines?
15. What device, previously used only on large buildings with a central hot water system, are now common, and sometimes required, as a water-conservation method for one- and two-family dwellings?
16. Though not needed in a cold water system, what must a hot water system design allow for?
17. How much expansion variance should be allowed for each 100 feet of piping?
18. In the average home, how long is the peak draw period for hot water assumed to be?
19. When sizing hot water storage tank capacity, what percentage of the tank's hot water supply is assumed available during the one-hour period of peak draw?
20. For a peak draw period of one hour, how many gallons of hot water should a 40-gallon water heater provide?
21. For a peak draw period of three hours, how many gallons of hot water per hour must a 40-gallon water heater provide?
22. For a storage tank heater, what determines the amount of hot water that's available during the peak demand periods?
23. What is the recommended first hour rating for a gas water heater installed in a two-bedroom, two bathroom house?
24. What is the recommended first hour rating for an oil-burning water heater installed in a three-bedroom, three bathroom house?
25. What is the recommended first hour rating for an electric water heater installed in a four-bedroom, two bathoom house?
26. What is the determining factor in choosing the storage capacity for any water heater, regardless of fuel type?
27. When might it be wise to split the hot water system and install two water heaters?
28. What size packaged high-recovery rate heater will generally be adequate for up to 12 living units?
29. What does the code require all equipment used for the heating or storage of hot water be equipped with?
30. What purpose does the pressure relief valve on a hot water heater serve?
31. What should remain visible when you install a water heater?
32. In locating a water heater, you must ensure that it's accessible for servicing or replacement without doing what?
33. What type of relief valve must you install on a domestic hot water heater?
34. What type of relief valve is commonly used today?

35. Where, on a hot water heater pipe, is the placement of a shut-off or check valve prohibited?

36. Because of possible contamination, what part of a plumbing system does the code prohibit the hot water relief valve drip pipe from connecting to?

37. Name three fixtures above which a water heater relief valve drip pipe can never terminate.

38. Where should a water heater relief valve drip pipe terminate?

39. What type of end is prohibited on a water heater relief valve drip pipe?

40. If hot water storage tanks are placed above the roof of a building, where may the relief valve pipe discharge?

41. What governs the size of the relief valve discharge piping?

42. Under what conditions is a water heater drain pan required?

43. What's the required depth of a water heater drain pan?

44. What's the minimum size drain pan outlet?

45. How much clearance must there be between the drain pan sides and the water heater?

46. In a vertical installation, what's the maximum number of water heater drain pans that you can connect to a 1-inch riser?

47. In what location must a heat trap be installed on a water heater?

48. What's the purpose of a heat trap on a water heater?

49. How does the support of hot water piping differ from the support of cold water piping?

50. Name two of the three conventional hot water circulating systems.

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14

Installing Water Systems

The plumbing code regulates the materials, size and installation methods for water piping. The basic requirement is for an adequate supply of potable water to all fixtures so they flush properly and stay clean and sanitary. The code also establishes safeguards to prevent pollution of the water supply due to backflow or cross connection. We'll discuss them in this chapter, as well as other requirements, limitations and restrictions.

Materials for Water Systems

All materials used in water service pipe and water distribution pipe, tubing and fittings must comply with the standards listed in Figure 14-1. Consider the quality of water in your area before selecting the material and size for the water supply system. Many communities have water that corrodes or leaves deposits on the interior walls of some kinds of pipe, and some soils and fills can corrode the exterior of certain pipe.

There's a wide variety of water piping materials that will meet code requirements. Some you can use only in underground installations, and others above ground only. Some materials are acceptable both above and below ground, for both hot and cold water use. Figure 14-2 shows the common water system materials and where you can use them.

There are two kinds of pipe that you can't use in a potable water system:

- Any pipe that can leave toxic substances in the water supply
- Any piping that has been used for other than a potable water supply system

For example, in a potable water supply system you can't use pipe or fittings that were once used in a gas system.

Water Service Supply Pipe

For a water service supply, you can use cast iron water pipe, cast iron threaded pipe, wrought iron pipe or steel pipe. Wrought iron and steel pipe and fittings must be galvanized inside and out. Other materials you can use for water service supply pipe under most codes are brass or copper pipe, Type K, L, or M copper tubing, and pressure-rated plastic pipes including CPVC, PVC, PE, and PEX pipe and tubing.

All plastic pipe and fittings must carry permanent identification markings from the ASTM (American Society for Testing Materials) or another national standard of acceptance (Figure 14-1). They also need a minimum working pressure of 160 psi.

Water Pipe in a Building

Water piping which is permanently inaccessible in a building, such as pipe installed under floor slabs, must be one of the following: wrought iron pipe, steel pipe, brass, or Type K or L copper tubing. Wrought iron and steel pipe and fittings must be galvanized, and you can use only the appropriate approved

Data from *Uniform Plumbing Code* Table 1701.1					
Materials	**ASTM**	**AWWA**	**IAPMO**	**CSA**	**ASSE**
Nonmetallic pipe and fittings					
Chlorinated poly (vinyl chloride) (CPVC) plastic hot and cold water distribution system	D 2846				
Joints for plastic pressure pipes using flexible elastomeric seals	D 3139				
Threaded chlorinated poly (vinyl chloride) (CPVC) plastic pipe fittings, Sch. 80	F 437				
Chlorinated poly (vinyl chloride) (CPVC) plastic pipe, Sch. 40 and 80	F441				
Chlorinated poly (vinyl chloride) (CPVC) plastic pipe (SDR-PR)	F 442				
Cross-linked polyethylene (PEX) plastic hot and cold water distribution systems	F 877				
Poly (vinyl chloride) (PVC) pressure pipe, 4 in. through 12 in. for water distribution		C 900			
Polyethylene (PE) pressure pipe and tubing, $^1/_2$ in. through 3 in. for water service		C 901			
Poly (vinyl chloride) (PVC) pressure fittings for water, 4 in. through 8 in.		C 907			
Dielectric waterway fittings					1079
Fiberglass (glass fiber-reinforced thermosetting resin) fittings	D 2310				
Polyethylene pipe, tubing and fittings for cold water pressure services	D 2239			B 137.1	
Water pressure-reducing valves for domestic water supply systems					1003
Ferrous pipe and fittings					
Pipe, steel, hot dipped, zinc-coated, welded and seamless	A 53				
Seamless copper tube	B 75				
Brass, copper and chromium-plated pipe nipples	B 53				
Ductile-iron pressure pipe		C 151			
Seamless brass tube (metric)	B 135				
Ductile-iron pipe centrifugally cast, for water		C 151			
Ductile-iron and gray-iron fittings, 3 in. through 48 in. for water and other liquids		C 110			
Gate valves for water and sewerage systems valves		C 500	PS 59		

Notes:
[1]Although this standard is referenced in *UPC* Table 1701.1, some of the pipe, tubing, fittings, valves or fixtures included in the standard are not acceptable for use under the provisions of the *Uniform Plumbing Code*.

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Note: Always check your local code standards.

Figure 14-1
Plumbing material standards for potable water systems

Material	Water service pipe	Underground within buildings	Aboveground within buildings	Cold water piping	Hot water piping
Brass pipe	X	X	X	X	X
Cast iron water pipe	X	X			
Copper water tube, Type K and L	X	X	X	X	X
Copper water tube, Type M	X		X	X	X
CPVC plastic water pipe	X	X	X	X	X
Ductile iron pipe, cement lined	X				
Fiberglass pressure pipe	X				
Galvanized steel pipe	X	X	X	X	X
PE plastic pipe	X		X	X	
PVC plastic pipe, Schedule 40, 80	X				
Stainless steel water pipe, Grade H			X	X	X
PEX	X	X	X	X	X

Notes

- Potable water piping shall have a minimum 160 psi at 73° F.
- Hot water piping shall be within the limits of its listed standard and the manufacturer's recommendations.
- Other codes may list materials that don't appear in above chart.
- Always check local code requirements.

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Figure 14-2
Common potable water system materials and locations where they can be used

fittings. Chlorinated polyvinyl chloride (CPVC), or cross-linked polyethylene (PEX) plastic pipe or tubing must be installed with approved fittings or bends. Your code will tell you what's approved for your area.

For water piping installed above first-floor slabs, you can use brass, copper Type K, L or M, wrought iron or steel. Wrought iron and steel pipe and fittings must be galvanized inside and out. Use only approved fittings for the type of pipe you install.

It's now common to use approved plastic pipe and fittings below and above ground within buildings. The first plastic pipe and fittings approved by most codes was CPVC. It's a high-temperature vinyl plastic designed for use in both hot and cold water systems, available only in rigid lengths. It can withstand pressures up to 100 psi and temperatures up to 180 degrees F.

Plastic pipe and fittings have a distinct advantage over metallic pipe and fittings; they resist corrosion, scale, sediment buildup, and are not affected by electrolysis. Some soil conditions can be harmful to plastic piping so installing a sleeve is sometimes required.

Installing Water Service Supply Pipe

If done properly, you can install the water service supply pipe in the same trench as the building sewer. See Figure 14-3. If you use a single trench for both the sewer and the water service, the installation must meet these conditions:

- Place the water service supply pipe on a solid shelf excavated at one side of the common trench and above the sanitary sewer line.

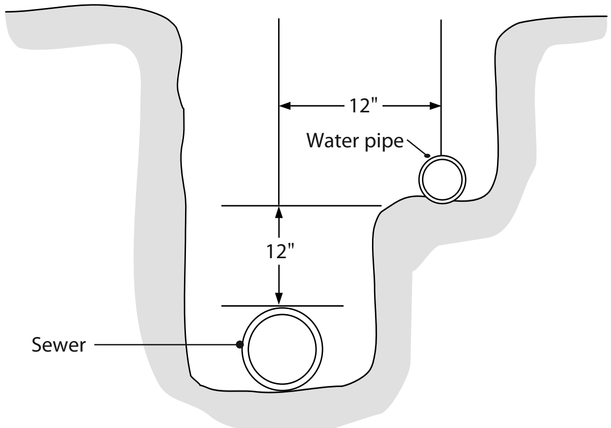

Figure 14-3
Water service supply pipe in sewer trench

- The bottom of the water service supply pipe must be at least 12 inches (some codes require 10 inches) above the top of the sewer line.
- Keep the joints in the water service supply pipe to a minimum.

When installing metallic pipe on filled corrosive soil or where hydrogen sulfide gas is known to be present, protect the pipe with one or two coats of asphaltum paint or other approved coating. And protect the fittings by painting, wrapping with an approved material or applying other approved coatings.

Install water service supply piping in open trenches, laid on a firm bed of earth for its entire length. Make sure it's securely supported to prevent sagging, misalignment and breaking.

Cast iron water pipe, cast iron threaded water pipe, wrought iron pipe and galvanized steel pipe are preferred for their strength, durability and resistance to trench loads. They're especially good for outside use in water service supply piping. Because they resist trench loads, the depth of placement isn't critical except as protection against freezing. Avoid backfilling with large boulders, rocks, cinder fill or other materials that might physically damage the pipe, or encourage corrosion.

Most codes specify 12-inch minimum depth for copper pipe, or Type K, L, or M copper tubing. Naturally, the pipe must also be deep enough to avoid freezing. These materials are soft and easily damaged. Select the backfill material with care. Use fine, rather than coarse, backfill that doesn't contain anything that promotes corrosion of the pipe exterior.

PVC, PE and PEX plastic pipes can be easily damaged by improper backfill materials. When installing them in open trenches, follow the installation methods recommended for plastic pipe used in building sewers. See Figure 8-16 back in Chapter 8.

Codes set a minimum separation distance for water service supply pipe installed in a separate open trench. Look at Figure 14-4. Check your local code, but some require these separations:

- 5 feet from the sewer line unless the sewer is made of a material that is approved for use within a building such as PVC, ABS, or cast iron.
- 10 feet from any septic tank or drainfield

In climates where buried pipe is subject to freezing, the water pipe must be 12 inches below the frost line. Thoroughly insulate pipe that enters a building above ground or in areas not protected from the cold to prevent freezing.

Where freezing isn't a problem, bury water pipe to at least a 12-inch depth.

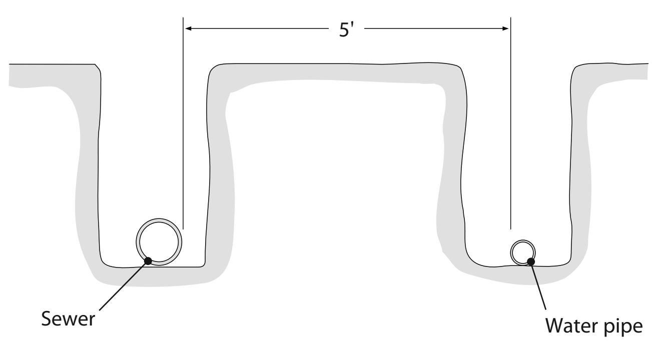

Figure 14-4
Water service supply pipe in separate trench

Water pipe passing under a building foundation must have a clearance of 2 inches between the top of the pipe and the foundation or footing. Refer back to Figure 8-17. Water supply pipe that passes through a basement wall or other cast-in-place concrete needs a sleeve to provide 1/2-inch clearance around the entire pipe. This prevents damage or breakage due to the building settling or the normal expansion and contraction of the pipe. This also protects the pipe from the corrosive effects of concrete.

When you connect a lawn sprinkler system to the potable water supply, install an approved backflow preventer on the discharge side of each valve. The backflow preventer must be at least 6 inches above the highest sprinkler head, and not less than 6 inches above the surrounding ground. This should eliminate the possibility of a cross connection. See Figure 14-5.

Each building must have a separate water control valve, independent of the water meter valve, installed in the water pipe. The control valve must be accessibly located at or near the foundation line outside the building, either above ground or in a separate approved box with a cover. Look back to Figure 12-1 in Chapter 12. Some codes require two control valves:

1) An accessible control valve near the curb

2) A control valve with a drip valve near where the water supply pipe enters the building. The drip valve is needed in cold climates to drain off water to prevent the pipes from freezing and bursting.

Water service supply piping must be electrically isolated from all other pipe, conduit, soil pipe, building steel and steel reinforcing. When the pipe comes in contact with other metals, you must wrap it with approved materials. The only exception is where an electric ground is required by the code.

No private water supply, such as a well, can be interconnected with the water service of any public water supply. If you come across such a situation, you need to disconnect the well supply and cap it off.

If a swimming pool water supply is connected to the potable water service pipe, provide a positive air gap to prevent a cross connection. There's more on this in Chapter 17, *Swimming Pools and Spas*.

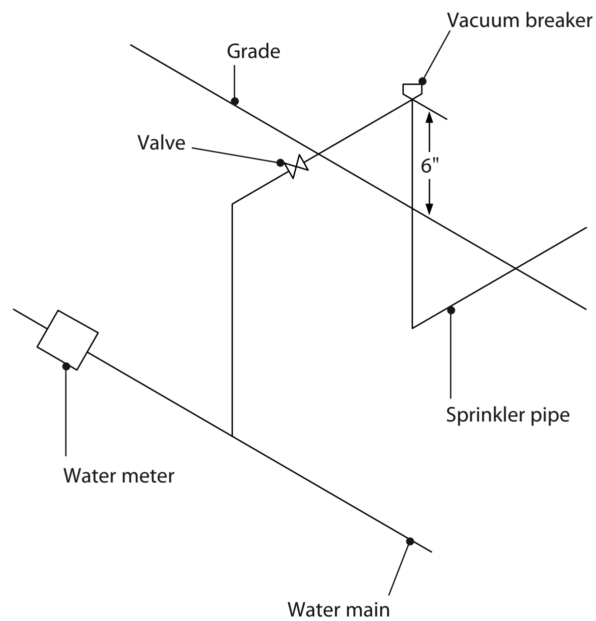

Figure 14-5
Placement of backflow preventer

Installing Water Distribution Piping

Most code sections that cover water distribution piping make good sense if you take the time to understand them. Unfortunately, it's not always easy for you or your tradesmen to take that time when you're trying to get a job done on schedule and within budget. When you're rushed, you can overlook important points. The purpose of the code is to ensure that the owners and occupants of a building have an effective, trouble-free plumbing system. If you comply with the code, you can be fairly sure that the owner is getting good value for each dollar he spends on plumbing.

Make sure underground water distribution pipe installed under a slab inside a building is firmly supported for its entire length on well-compacted fill. Lack of support can cause misalignment and sagging. That can lead to traps or depressions in the pipe that collect sediment or mineral deposits. Some mineral deposits solidify over a period of time, reducing the flow of water and causing premature failure of the system. Use fine rather than coarse backfill in the trench so compaction doesn't damage the pipe.

If at all possible, install the entire system so it will drain dry. This can be important if you have to make repairs or replace lost air in air chambers.

When you install the pipe, remember that the building will settle and the pipe will expand and contract during use. Make sure this movement doesn't damage the pipe. Provide sleeves for water supply piping that passes through cast-in-place concrete slabs or walls to provide $^1/_2$-inch clearance around the entire pipe. Be sure to caulk the sleeve with an approved flexible sealing compound so crawling insects can't get in.

You must protect water pipe installed under a concrete slab from corrosion. You also have to protect pipe in any location inside the walls of a building constructed on filled ground if hydrogen sulfide gas or other corrosive substances are known to be present. You can do that by painting the pipe and fittings with two coats of asphaltum paint or other approved coating. It's better still to install water pipe overhead in the attic if you're working on filled ground. In fact, some codes require it.

In climate zones where water pipe is subject to freezing, avoid installing pipe in crawl spaces or other unheated areas unless it's protected with adequate insulation. And in restaurants, packing houses and other commercial buildings with walk-in cold storage facilities, don't install the water pipe through the cold storage room.

Metal water piping within a building is required to be bonded to the service panel and or the service grounding electrode. Plastic water distribution piping is not capable of carrying current and does not need to be bonded.

Here are some additional restrictions on the installation of water distribution piping:

- The code usually prohibits water supply piping under elevators or in elevator hoistways.
- Hot and cold water pipe must not contact each other when installed underground or within partitions. Contact or close installation can transfer the heat from the hot water pipe to the cold water pipe.
- Domestic cold water piping installed above a roof or within 10 inches of the roof must be adequately insulated with approved materials.
- Each separate apartment or store in a building must have its own independent control valve or individual fixture control valve controlling all the fixtures in that apartment or store.
- Each water closet and urinal supply must have an independent control valve installed above the floor.

  Some jurisdictions permit, instead of a shutoff valve at each fixture, a central control panel, usually located in a laundry room or garage, where supply to any fixture in the building can be turned off and on; much like a circuit breaker panel for electricity. There are a number of disadvantages with this setup, so it's not widely adopted.
- Hotels, office buildings, hospitals, clinics, places of public assembly and manufacturing plants require either separate fixture control valves or a single control valve for each group of fixtures in a single room.
- Residential buildings with more than two units and a single water service must have a separate control valve for each hose bibb (sill cock). This allows you to make repairs without interrupting the water supply to the residential units.
- No more than two fixtures can be connected to a $^1/_2$-inch cold water supply pipe.
- Water pipe installations must be protected from water hammer with approved devices. Air chambers are no longer recognized as adequate protection in either the *IPC* or the *UPC*. They eventually fill with water and lose their ability to absorb water hammer. Both codes now specify use of an approved mechanical arrestor certified to ASSE 1010.
- Where water pressure within a building is in excess of 80 psi, install an approved water pressure regulator with a strainer to reduce the pressure in the building water distribution system to 80 psi or less.

Pipe Supports

Secure water piping inside walls and partitions with pipe straps or clamps to prevent pipes from moving as they contract or expand. Water supply pipes installed above ground or in a vertical position must be securely supported by the building structure.

Supporting water piping with clamps that have rubber, plastic or felt inserts greatly helps limit the transmission of noise and protects fragile water piping from damage.

Horizontal water pipe requires the same type of support and separation as in drainage, waste and vent applications. See Figure 8-22. Here are the maximum distances between supports for horizontal water supply piping above ground:

- Screwed pipe must be supported approximately every 12 feet.
- Copper tubing $1^1/_2$ inches or smaller must be supported at intervals no more than 6 feet apart.
- Copper tubing 2 inches and larger must be supported at no greater than 10-foot intervals.
- CPVC pipe must be supported every 3 feet for pipe sizes 1 inch and smaller; 4 feet for pipe sizes larger than 1 inch.
- PEX piping must be supported every 32 inches for pipe sizes 1 inch and smaller; 4 feet for pipe sizes larger than 1 inch.

Vertical water piping also requires the same type of support and separation as in drainage, waste and vent applications. Look back to Figure 8-23. Vertical water pipe requires the following support:

- Screwed pipe carrying cold water must be properly supported at the base and at every other story height.
- Screwed pipe carrying hot water must be properly supported to provide for expansion.
- Copper tubing $1^1/_4$ inches and smaller that carries cold water must be supported at each floor level.
- Copper tubing $1^1/_2$ inches and larger that carries cold water must be supported at each story height.
- Copper tubing carrying hot water must be properly supported to provide for expansion.
- CPVC, PEX and PE plastic pipe carrying cold water must be supported at each story height.
- CPVC plastic pipe carrying hot water must be properly supported for expansion.

Give good support to the base of water pipe risers, particularly in high-rise construction where the pipe is expected to last for the life of the building. Don't let the riser weight fall on the smaller water pipe branches. This would crack the joints of the smaller pipes.

Avoiding Cross Connection

The code requires the potable water supply outlet to terminate above the overflow rim of each fixture. This provides an air gap which prevents siphoning of the fixture contents back into the water outlet or faucet.

All water outlets equipped for hose connections (other than clothes washers) must have approved backflow preventers. Hose connections are common on restaurant faucets and service sinks.

Codes prohibit the use of fixtures with water supplied below the rim. But some special fixtures can't function properly without a below-rim supply — water-cooled compressors and degreasers, for example. For those fixtures, install a backflow preventer in the water supply pipe and individual backflow preventers in each individual special fixture.

Connect copper tubing to threaded pipe or fittings with a special brass or copper converter fitting. Unions in the water supply system must have metal-to-metal joints and ground seats.

Remember the importance of water hammer arrestors in water supply pipes. A system with water shock or hammer won't pass the final inspection. After the water distribution system is installed, it must be tested, inspected and proved to be tight. It'll be tested to at least the maximum working pressure it's designed for.

Threaded Pipe, Fittings and Valves

All standard pipe and fitting threads must conform to the standards adopted by the American Standards Association. The standard pipe thread has a taper of $^3/_4$ inch per foot. The last column in Figure 14-6 shows the number of threads that must be engaged on

Pipe size (in)	Threads per inch	Approximate length of threads (in)	Approximate thread engagement (in)
1/4	18	5/8	3/8
3/8	18	5/8	3/8
1/2	14	13/16	1/2
3/4	14	13/16	1/2
1	11 1/2	1	9/16
1 1/4	11 1/2	1	5/8
1 1/2	11 1/2	1	5/8
2	11 1/2	1 1/16	11/16
2 1/2	8	1 9/16	15/16
3	8	1 5/8	1
4	8	1 3/4	11/16

Figure 14-6
Standard pipe threads

Pipe size (in)	Pipe wrench size (in)
1/8, 1/4, 3/8	6 or 8
1/2, 3/4	10
1	14
1 1/4, 1 1/2	18
2	24
2 1/2, 3	36
4	48
* Larger sizes usually use chain tongs or special equipment.	

Figure 14-7
Pipe wrench sizes

screwed pipe. Use the right size wrench when joining valves or fittings on threaded pipe. A wrench too small for the job will require unnecessary effort for your hands, arms and back. A wrench too large will force the fitting too far onto the threaded pipe. This can result in a bad joint or a cracked fitting. The wrenches listed in Figure 14-7 should be adequate for the pipe sizes given.

Cutting, Reaming and Threading Pipe

Use heavy-duty pipe cutters to cut iron and steel pipe. The most common pipe cutter is the single wheel cutter. Begin each cut by *lightly* rotating the cutter completely around the pipe. This will give a "bite" or groove for the cutter wheel to follow. After each turn of the cutter wheel, tighten the handle slightly. Tightening the handle too rapidly will break the cutter wheel or spring the cutter frame, ruining the cutter. Occasionally put thread-cutting oil on the cutter wheel and rollers.

The pipe cutter wheel leaves a bur on the inside of the pipe (Figure 14-8). Mineral deposits can collect at the bur and cause premature failure of the line. Use a pipe reamer to remove the bur on threaded pipe up to 2 inches. On larger pipe, use a coarse half-round file.

Modern pipe threaders make plumbing installation much less exhausting than it used to be. Threaders cut the required standard threads and then disengage the dies.

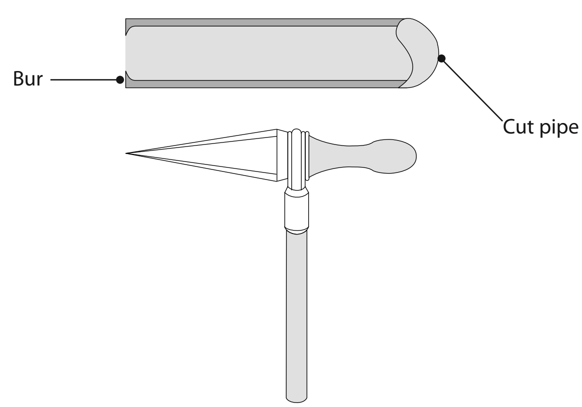

Figure 14-8
Pipe reamer

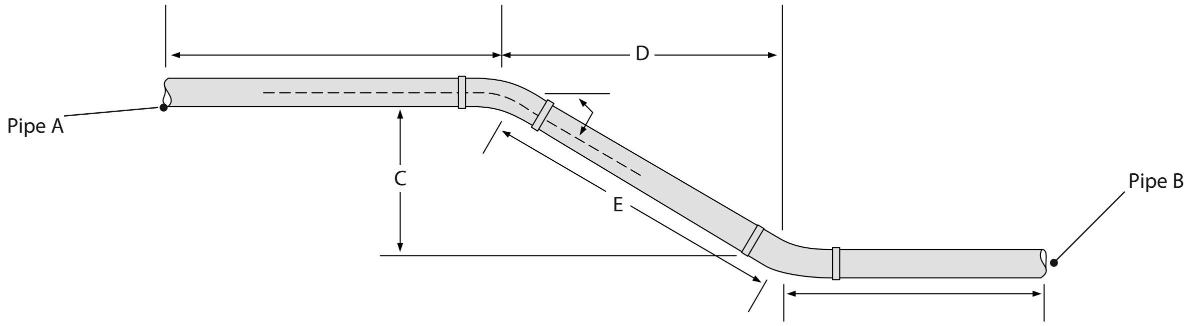

Figure 14-9
Measuring offsets

Degree of offset	When C = 1, D =	When D = 1, C =	When C = 1, E =
60	0.5773	1.7320	1.1547
45	1.0000	1.0000	1.4142
30	1.7320	0.5773	2.0000
22½	2.4140	0.4142	2.6131
11¼	5.0270	0.1989	5.1258
5⅝	10.1680	0.0983	10.2170

Figure 14-10
Finding the length of pipe to connect two parallel runs

Use plenty of thread-cutting oil on the threader dies when threading pipe to prevent overheating. Occasionally check to be sure you're cutting clean threads. Chipped or torn threads mean that the pipe at this location is too soft, too hard, has impurities in it, or that the dies are worn and need replacing. Always cut new threads when this happens. *Don't use pipe that has bad threads.*

Only the plumber who makes the fitting knows whether the bur was removed and whether the pipe has good threads. The contractor paying his salary doesn't know, the plumbing inspector checking the job doesn't know, and the people relying on his workmanship don't know. You and your crew demonstrate your integrity, good workmanship, and personal pride on every joint on every job.

When you're satisfied that you've made a good joint, apply pipe compound (known as *pipe dope*) and screw the fitting snugly but firmly onto the threaded pipe. When installation is complete, open the house valve to test for leaks.

Measuring Offsets

When you're laying out and dimensioning piping arrangements, offsets are a problem anywhere you don't use 90-degree elbows. It takes careful calculation to find the exact distance between centers of the fittings in offsets.

Figure 14-9 shows a common pipe offset between parallel runs of pipe. The center-to-center offset (C) is 10 inches, the distance between the centers of pipes A and B. Assume that you're connecting pipes A and B with 45-degree elbows. You need to find the length of pipe required for E. Use Figure 14-10. (The letters refer to the letters on Figure 14-9.) On the line for the 45-degree offset, you'll find the figure 1.4142 in the last column. Multiply distance C (assume 10 inches for this example) by 1.4142. The length of pipe E is 14.14 inches.

Cutting, Reaming and Joining Copper Tubing

You can cut copper tubing, both rigid and flexible, with a tubing cutter or a hacksaw. It's easier to get a clean square cut with a tubing cutter. Copper tubing cutters are similar to pipe cutters, though much smaller. Apply oil to the cutter wheel and rollers sparingly, as excessive oil will cause trouble when you're preparing the copper tubing for soldering. Be careful to remove the bur the cutter wheel leaves in the tubing. Use a reamer attached to the tubing cutter frame for copper tubing up to 2 inches in diameter. For larger tubing, use a file to remove the bur.

The most common joint for copper pipe is the sweat joint. Clean the inside of the copper fittings with a wire brush designed for this purpose, or with emery cloth. Also polish the pipe end bright with emery cloth. Use cleaned parts as soon as possible and don't handle them with dirty or sweaty fingers. The bright surface oxidizes very quickly.

Apply a thin coat of noncorrosive soldering flux to the inside of the cleaned fitting and the outside of the cleaned pipe. That joins the fitting and pipe, ready for soldering.

Soldering joins the two metallic surfaces with a fusible alloy (solder) that has a melting point lower than that of the pipe to be joined. All solder and fluxes must meet approved standards. In a potable water supply system, you're prohibited from using solders and fluxes with a lead content exceeding 0.2 percent.

The soldering torch is fired from a tank of gas that's easy to move from one area to another. The tank and gas weigh only about 20 pounds when full but provide enough gas for three days of continuous soldering. The tank's regulator controls the flow of gas through a 6-foot-long rubber hose, and another valve controls the flame at the burner tip. Select a tip appropriate for the size of copper tubing you're joining. Too large a tip will overheat and burn the copper tubing and fitting, preventing the solder from joining the two surfaces. Too small a tip will heat the pipe and fitting unevenly and won't draw the solder into the joint. In either case, the result is a bad joint. That means that sooner or later the joint will leak. If you're lucky, it'll happen when it's first tested. If you're not, it'll be months later, after the piping's enclosed by the building walls.

It's more difficult to work with a system that's been pressurized because there's usually still some water present. The heat from the torch will turn the moisture in the tubing to steam. This can make pinholes in the newly-applied solder before it hardens. You can dry the pipe long enough to make a good joint if you apply heat to several inches on each side of the fitting and work quickly.

If you can't keep water away from the joint while you're working, stuff a piece of plain white bread (not the crust) as far into the pipe as possible in the direction the water's coming from. The bread will absorb the water, giving you time to make a good joint. When water pressure is returned to the system, the bread flushes out easily.

If the joint is properly cleaned and heated, surface tension will spread the solder to all parts of the joined surfaces. This results in a sound joint that will last as long as the tubing.

Soldering is an art in itself. It looks easy but requires care and precision. Apprentice plumbers should solder only under the supervision of an experienced journeyman. It takes a lot of practice in soldering before you have the knowledge and skill necessary to solder copper water systems properly.

Copper tubing is measured the same way as threaded pipe. The only exception is that you can heat and bend the smaller copper tubing when an offset is needed. In many minor offsets, you don't need fittings if you're using copper tubing up to 1-inch diameter.

Occasionally you'll have to make a flare joint on flexible copper tube to connect some fixtures and appliances. For example, you might install a connector for a gas range with a flare fitting. First, cut the tubing to the desired length. Then slip the flare nut that will make the connection onto the cut tubing. Use a flaring tool to flare the tubing ends so you get a perfect fit. Slide the nuts to each end of the flared pipe and gently bend or shape the tubing by hand so the ends fit together. Then firmly screw the flare nuts by hand on the male thread of each fitting. Tighten with the proper type and size wrench until the fitting is snug. Finally, test it for leaks.

Cutting, Reaming and Joining Plastic Pipe

Today you can use pressure-rated plastic pipe and fittings in all phases of the water distribution system. Plastic pipes are lightweight, easily handled by one person, yet rigid once cemented into place.

You can cut plastic pipe with a hacksaw blade or a special cutter similar to the copper tubing cutter. A square end cut is essential with plastic pipe. If you're using a hacksaw, use a fine-tooth blade and a miter box. A freehand cut is an invitation for trouble.

Remove the bur with a reamer if you're using a pipe cutter. A hacksaw doesn't leave a bur, but the interior and exterior of the pipe are left with a rough ridge. Remove this roughness with a knife or file.

You can measure offsets for rigid plastic pipe and fittings the same way as for threaded pipe. Refer back to Figures 14-9 and 14-10.

You'll always use special plastic cement to join rigid plastic pipe and fittings, though you may hear it referred to as a "welded" joint. First, check the fittings and pipe. Don't use any pipe or fittings that have gouges, deep abrasions or cracks. After cutting the pipe to the proper length, check the dry fit before cementing. The pipe must enter the fitting socket smoothly, but must not be so loose that the two surfaces don't make good contact.

Use liquid cleaner (developed for plastic pipe and fittings) or fine sandpaper to remove impurities and gloss from the surfaces to be joined. Use only the cement recommended by the manufacturer of the pipe and fittings you're using. Don't use cement that won't pour from the can or that has a rusty or dark brown color.

Plastic cement sets very quickly once it's applied to plastic surfaces, so you can only do one joint at a time. You have less than one minute to do all this:

- Brush a light coating of cement on the plastic pipe with the brush supplied with the can.
- Brush a thin coat in the fitting socket and quickly brush the plastic pipe a second time.
- Push the pipe fully into the fitting and then give the pipe a quarter turn. If a direction is required (a tee facing up, etc.), adjust the pipe at once. This is your last chance to make corrections.
- Wipe excess cement from the fitting and close the cement can immediately to prevent drying.
- Hold the pipe and fitting together for approximately 15 seconds until the cement sets.

Since a cemented joint looks like a dry-fit joint, check all joints to make sure that they have been cemented.

Wait at least half an hour after cementing the last joint before testing the system. If time isn't critical, it's best to let the joints harden overnight. Check for leaks after turning on the house valve and releasing trapped air from the ends of each branch.

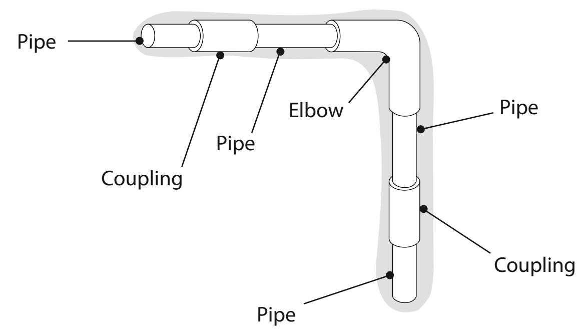

Figure 14-11
Replacing a bad joint

If a leak occurs in a rigid plastic system, cut out the bad joint and replace it with a new fitting. Remove enough pipe to allow room for two couplings and the fittings. Figure 14-11 shows how much pipe to cut out if there's a leak in a joint at the elbow. In this case it takes three fittings, two short lengths of pipe and six joints to make the repair. Do a first class job when cementing plastic pipe and fittings. *Plastic pipe fittings shouldn't be reused if they don't work the first time.*

Use approved male-threaded plastic adapters if you have to connect plastic pipe or valves. And use only the thread compound recommended by the manufacturer.

PE and PEX are the newest plastic pipes approved for use in water distribution systems in many states and by local codes. Their use for both hot and cold water piping is unrestricted.

You can cut the piping into desired lengths with the same tools and methods for other plastic pipe. You can join it with compression fittings, crimped fittings, or special heat fusion methods. It can also be flared (like soft copper) and joined together with flare fittings. When installation is complete, there's no waiting for joints to cure as in other plastic systems. You can turn on the water immediately to check out the system.

When the water system is complete, open a hose bibb on each section to flush out sand, pieces of pipe shavings and other impurities that may have collected inside the pipe during installation. This will save time when fixtures are set and prevents the damage sand and grit can do to washers.

Review Questions for Chapter 14 (answers are on page 302)

1. What three things does the plumbing code regulate for water piping?
2. Why does the plumbing code require that there be an adequate supply of potable water to all fixtures?
3. How do code-established safeguards protect our water supply?
4. Name two reasons why you should consider the kind of water and soil in your area before you select and size the material for water supply pipes.
5. What pipes are specifically prohibited in a potable water supply system?
6. All plastic pipes and fittings must display identification/acceptance from what standard?
7. What's the minimum working pressure required by code for plastic water service piping?
8. What plastic pipe and fittings were first approved for a building water distribution system?
9. What's the highest water temperature that CPVC plastic pipe can withstand?
10. What type of copper water tube is not permitted underground within buildings?
11. List three advantages that plastic pipe and fittings have over metallic pipe and fittings.
12. Where must you place a water service pipe when installing it in the same trench as the building sewer?
13. How must you protect metallic water service pipe when you install it on filled corrosive soil?
14. Why should water service supply piping be securely supported?
15. Name two materials that are considered superior for outside water service supply piping.
16. Why shouldn't you use large boulders, rocks or cinder fill to backfill a metallic water service supply trench?
17. Why must you treat, PVC, PE and PEX plastic pipe with special care?
18. What is the minimum separation distance required between a water service supply pipe and a sewer line when they are installed in separate open trenches?
19. How deep should water service supply pipe be buried in climates where the pipe is subject to freezing?
20. How much clearance must you have between the bottom of a building foundation or footing and the top of the water service supply pipe?
21. What must you install on the discharge side of each valve when connecting a lawn sprinkler system to a potable water service supply pipe?
22. What must you install in each building's water service supply pipe, independent of the water meter valve?
23. From what must you electrically isolate water service supply piping?
24. What type of water supply does the code prohibit from interconnecting with a public water supply?
25. When you connect a swimming pool water supply to the potable water service pipe, what must you provide to prevent cross connection?
26. When mineral deposits in the water solidify in the distribution pipes over a period of time, what happens to the system?
27. How much clearance should you provide around the circumference of a pipe when it passes through cast-in-place concrete?
28. What do you need to do to protect water pipe installed in crawl spaces or other unheated areas if you work in a climate that's subject to freezing temperatures?
29. Why should you not allow hot and cold water pipes to come into contact with each other in underground or partition installations?
30. What does the code in most jurisdictions require that each water closet supply pipe have?
31. How many residential plumbing fixtures can you connect to a $^{1}/_{2}$-inch cold water supply pipe?
32. How do you protect water pipe installations from water hammer?
33. What protective device must you install when the water pressure within a building is more than 80 psi?
34. At what intervals must you support horizontal screwed water pipe?

35. What is the maximum distance allowed between supports for horizontal CPVC plastic pipe?

36. What's the maximum distanceallowed between supports for vertical $1^1/_4$-inch copper tubing carrying cold water?

37. Why does the code require that potable water supply outlets terminate above the overflow rim of a fixture?

38. What must you install on all water outlets (except for clothes washers) equipped for hose connections?

39. In the water supply system, what kind of joints must unions have?

40. What standards must all pipe and fitting threads meet?

41. What can result when you use a wrench that's too large for a fitting?

42. What wrench size is recommended to tighten a fitting on a 2-inch pipe?

43. What type of heavy-duty steel pipe cutter is the most common?

44. When a pipe cutter wheel leaves a bur on the inside of a pipe up to 2 inches, what tool should you use to remove it?

45. Who's the only person who knows for certain whether an installed pipe has good threads?

46. When you're laying out and dimensioning piping arrangements, which offsets aren't difficult to calculate?

47. Name the two tools usually used to cut copper tubing.

48. What's the most common joint for copper pipe?

49. In a potable water supply system, what's the maximum allowable lead content for solders and fluxes?

50. Why does properly cleaning and heating a copper joint help make a sound solder joint?

51. When cutting plastic pipe, how can you be sure of getting a square end?

52. What's the common term for a cemented plastic pipe joint?

53. What should you use to remove impurities and gloss from the surfaces of plastic pipe and fittings before joining them?

54. In a plastic water system, why can you make only one joint at a time?

55. After you cement the last joint, how long should you wait before testing a plastic water system?

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15

Private Water Supply Wells

According to the Environmental Protection Agency, nearly one home in ten isn't connected to a public water supply. Many suburban homes and practically all rural homes use water from private wells. The rapid spread of urban communities around large metropolitan areas has often outstripped the capacity of public water distribution systems. Many smaller towns and cities have lower population densities, which make the cost of public water systems prohibitive.

Domestic wells are regulated by either the local health department or the Department of Environmental Protection (DEP). These authorities set guidelines on how deep to dig a well, and how far it must be separated from sources of contamination. Then they inspect each well to make sure the owner has complied with the regulations. You need a permit for any drilled or driven well, regardless of whether the water is intended for domestic or irrigation purposes.

Well Water

Well water is ground water that has filtered down through the soil to the water table level. Rain water soaks into the ground and moves slowly down to the underground water reservoir. It's called meteoric water and makes up most of the estimated two million cubic miles of ground water in the upper crust of the earth.

The underground water table may be only a few feet or hundreds of feet below the surface. When you drive or drill a well, the bottom of the well casing must extend into the dry weather water table. Otherwise, during prolonged droughts, the water table may fall below the level of the well. See Figure 15-1.

Since it's been filtered through sand and rock, well water is usually cool, low in harmful bacteria and high in dissolved minerals. It's generally classified as *hard water* because of that high mineral content. Many people have to acquire a taste for this untreated water because it has a distinctly different taste from city water. It doesn't have the chlorine or other chemicals that city dwellers are accustomed to. Hard water also requires more soap to make a lather. Hard water can be treated with a water softener.

The minerals in untreated well water often stain the surface of plumbing fixtures a dark reddish brown. These stains are virtually impossible to remove. Minerals can also cause a buildup of scale in water heater storage tanks and water distribution pipes. This can lead to premature failure. You can greatly reduce scale buildup and improve the taste and smell of the water by installing a water filter on the building water service line. See Figure 15-2. Water filtration systems are now widely used for homes in areas that have water with some objectionable qualities such as poor color, odor or taste.

If you install a water filter or softener on an existing system, install a full bypass. Otherwise the pressure drop will reduce the quantity of water available to operate the fixtures. On new installations, you don't

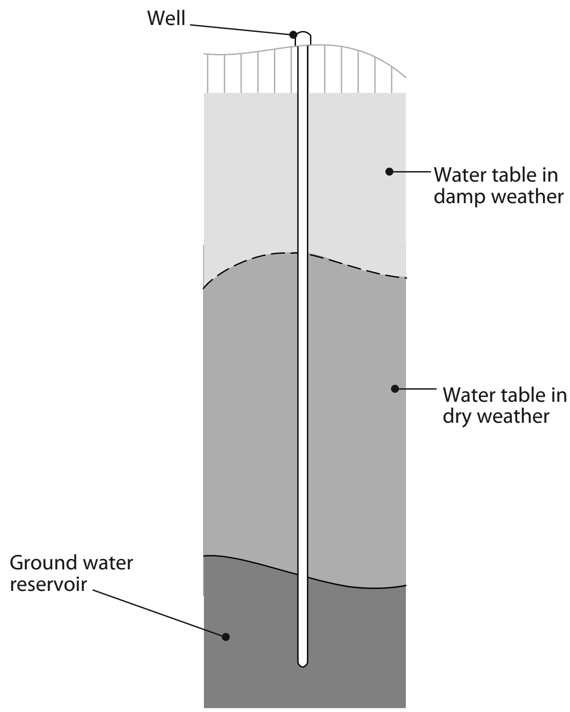

Figure 15-1
Well extended to dry weather water table

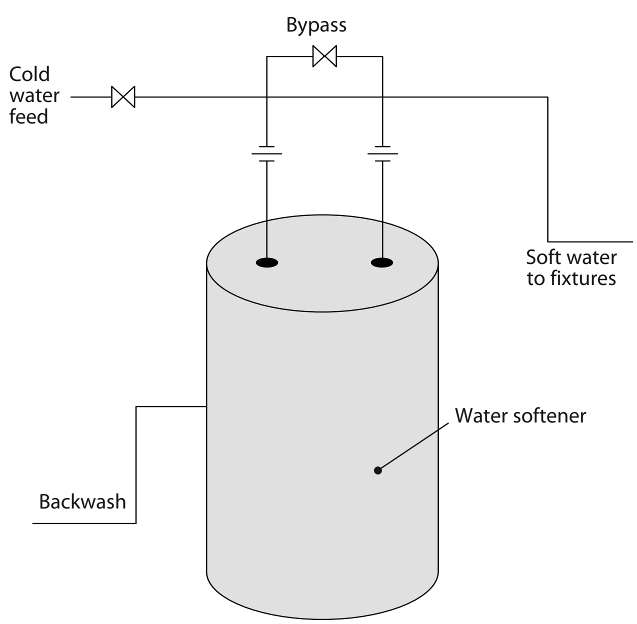

Figure 15-2
Water softener installed in a building water service line

need a full bypass. But you must consider the pressure drop through the filter or softener when sizing the water pipe system. The local authority will have to approve your backwash disposal method.

Well Installation

Generally, professional well drillers install wells, suction lines, pumps, and water pressure tanks. They're certified and licensed as a specialty contractor, permitted to do only this type of work. Although in some states plumbing contractors are also licensed to do this work, they rarely do. If your contract includes a complete well supply system, you'll usually subcontract that part of the job to a professional well driller. But there are a couple of good reasons why you should be familiar with well systems. First, many of the people you deal with will assume you know something about wells. Second (and maybe more important), plumber's examinations include questions on well systems.

Local authorities will determine the depth of potable water supply wells, based on the depth of the water table. Even when the underground water table is within a few feet of the ground surface, the local authority may require a 30-foot minimum depth. The authority may also require a domestic well to be sep-arated from a source of contamination (such as a sep-tic tank, drainfield, soakage pit or discharge well) by 100 feet. Some codes may require more, some less.

Dug or Driven Wells

Wells that are dug or driven are classified as *shallow wells*. They're used where the water table is within 22 feet of the ground surface. The well must penetrate deep enough below the existing water table to assure a dependable supply of water, even in very dry seasons. In some parts of the country, plumbers install these shallow wells.

There are two types of driven wells, those with an open end casing and those with a casing equipped with a well point.

Open End Casings

Use an *open end casing* for domestic and irrigation wells in areas when the water table is close to the ground surface and located in a good rock formation.

In some areas, rock or corrosion will clog the protective screening of a well point in a short time. When this happens, the well won't draw water. The open end well casing is preferable under these conditions.

With an open end casing, drive the pipe to the desired depth and then flush loose soil and rock from the driven section. You can flush with a smaller pipe with a sharpened point at one end for chipping into the rock. Attach a garden hose to the other end. Insert the smaller pipe into the open end casing and use water pressure to flush loose debris out of the casing. The pressure forms a water collecting pocket in the rock at the lower end of the well casing during the flushing.

When you're sure that a good well has been installed, connect a three-horsepower gasoline-driven centrifugal pump to the top of the well casing. Pump water out of the well until the water is free of rocks and sand.

Well Points

A well point is best in areas where the water table is in loose shale or sand. There are two types of well points. One, used in sand, has a screen or fine perforations. The other type, for gravel or loose rock formations, has larger openings. Attach the well point to the well casing and drive it to the desired depth. See Figure 15-3.

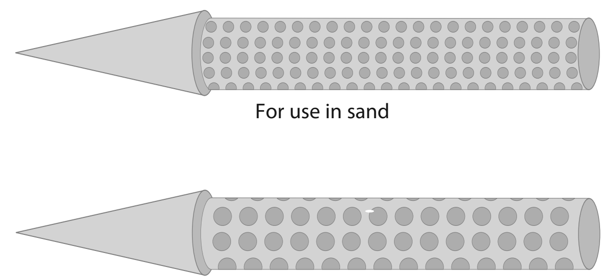

Figure 15-3
Well points

Drilled Wells

Drilled wells are classified as *deep wells* and may penetrate hundreds of feet into the earth. The water from deep wells may be better because there's less chance of contamination in a well that deep. And the water level in these wells is little affected by seasonal rainfall or dry years.

You're expected to know the installation methods and local code requirements for well drilling even though you may never have to do this work. Be aware of the following requirements:

- Unless specifically approved by the local authority, you can't locate a well within any building or under the roof or projection of any building or structure.
- The well casing must be continuous, of new pipe, and must terminate in a suitable aquifer. Well casing pipe 6 inches or less in diameter must be of galvanized steel.
- Pour a concrete collar a minimum of 4 inches thick and 36 inches wide around the top of the well casing. The concrete pad must be placed immediately below the tee and suction line. This collar must slope away from the casing to prevent surface water from carrying pollutants down the well casing to the water reservoir. See Figure 15-4.
- Install a tee the same size as the well casing at the top of the well. This provides access to the casing for inspections, adding disinfecting agents, measuring well depth and testing the static water level. See Figure 15-4.

Suction Lines

The suction line must be large enough to provide the water volume and pressure required to operate the plumbing fixtures in the building. The suction line or water service pipe from the well to the pump can't be smaller than 1 inch. It must be installed with a pitch toward the well. If the well requires a suction line longer than 40 feet, increase the suction pipe to the next pipe size shown in Figure 15-5. This table is primarily for residences or small commercial buildings with flush tanks.

As an example, consider a residence with 30 fixture units and a suction line 65 feet long. The table shows a suction pipe size of $1^1/_4$ inches. Since the suction line is longer than 40 feet, use the next pipe size — $1^1/_2$ inches.

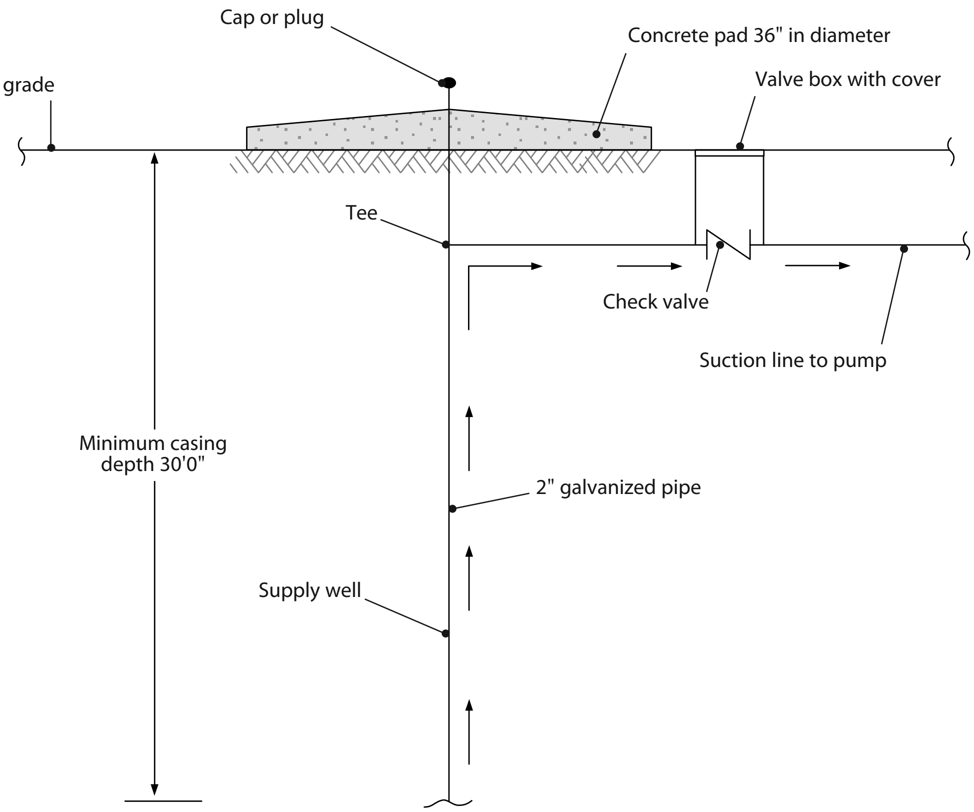

Figure 15-4
Supply well detail (potable water) isometrically illustrated

Fixture units	Supply required (GPH)	Diameter of suction pipe	Diameter pressure pipe	Diameter service pipe	Size of tank	Horsepower	Well size
23	720	1	3/4	3/4	42	1/2	1 1/2
30	900	1 1/4	1	1	82	3/4	2
40	1200	1 1/2	1	1	120	3/4	2

Figure 15-5
Tank and pump size requirements

Install a soft seat check valve rated at 200 pounds water test as close as practical to the well. You can use either spring-loaded or flapper-type brass check valves up to a 2-inch diameter. The suction line must have a union or slip coupling installed just before the pump.

Materials and installation methods for the suction line are usually the same as for the water service piping described in Chapter 14.

Pressure Tanks

The two types of pressure tanks most commonly used today are the hydropneumatic tank and the diaphragm pressure tank. Let's take a closer look at each.

The Hydropneumatic Tank

The *hydropneumatic tank*, with its pressure switch, has been the dominant well water supply system since the 1920s. See Figure 15-6. While the tank itself has given good service, an unattended system isn't reliable. It's essential that air in hydropneumatic tanks be maintained automatically with air chargers and air volume controls. The air pressure and volume controls need regular service.

A hydropneumatic tank uses compressed air to control water pressure. Compressed air acts like a huge spring to drive water out of the tank to any needed location. When the pressure drops in the system, say to 20 pounds, the pump starts up. This forces more water into the tank and compresses the air in the tank to the set pressure of approximately 40 pounds.

Unfortunately, some of the air in the tank is gradually absorbed by the water passing through the tank. If the lost air isn't replaced, eventually there won't be enough air available to pressurize the tank. Water itself is nearly incompressible. If the tank loses air, it causes the pump to cycle on and off too often.

Manually draining the water from the tank will cause it to refill with air at atmospheric pressure. Then as the pump fills the tank with water, it traps a normal supply of air for proper operation of the water supply system. Figure 15-6 shows a typical pressure tank.

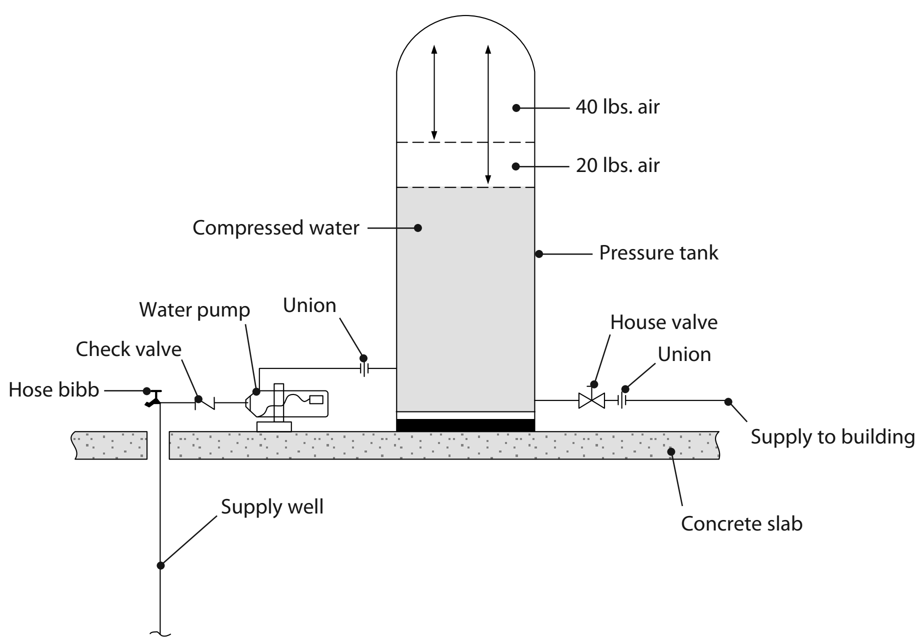

Figure 15-6
Typical pressure tank (hydropneumatic) installation

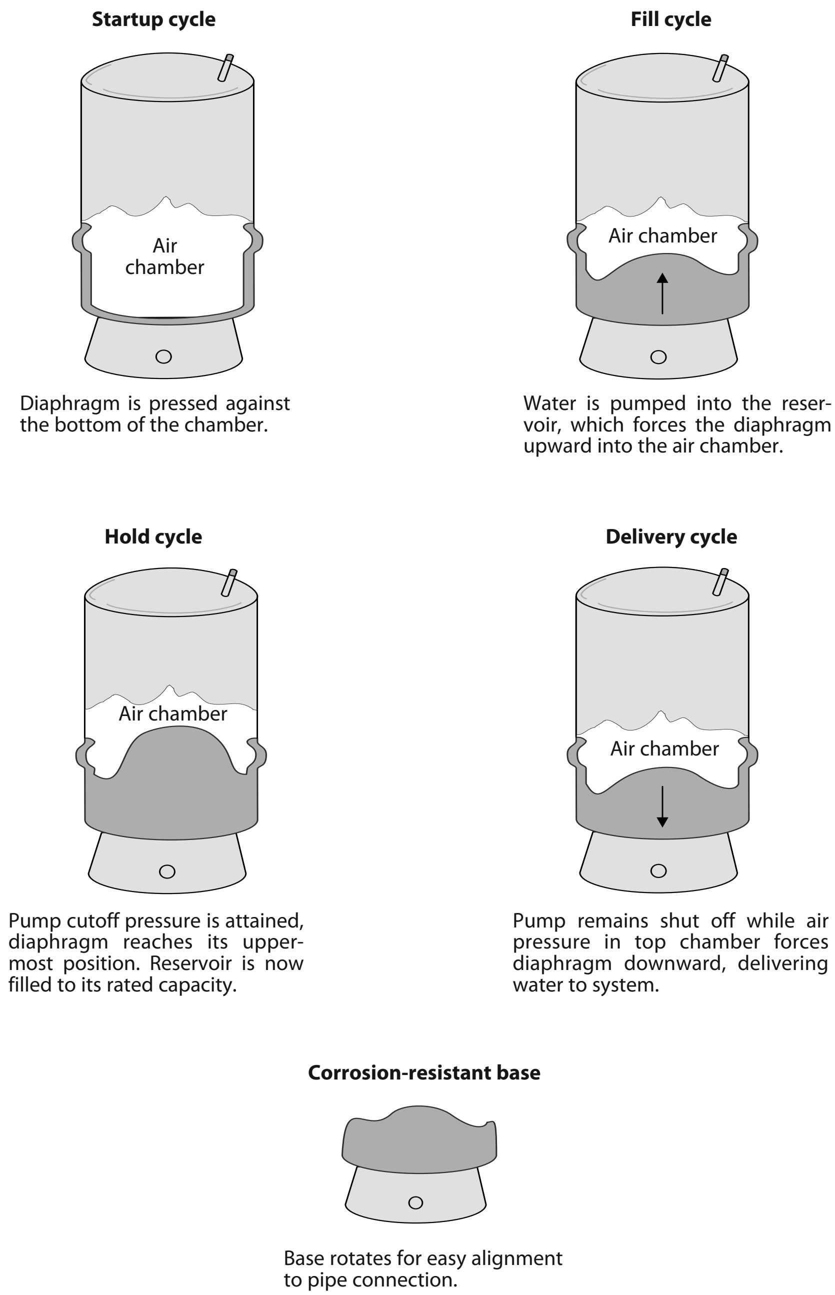

Figure 15-7
How a diaphragm tank works

Hydropneumatic tanks should be large enough to prevent excessive cycling of the pump. When sizing the tank, it's important to consider these points:

1) The draw-off capacity of the tank between the "cutout" and "cut-in" limits. (The tank size should provide a draw-off of 6 gallons of water while maintaining an operating range of 20 to 40 psi water pressure.)
2) The pump capacity must be large enough to quickly refill the tank.
3) Tanks are sized by the fixture units of a building. That's the best indicator of the amount of water used. For other sizes of tanks and specific requirements, see Figure 15-5. The minimum size hydropneumatic tank for a single-family residence is 42 gallons.

The Diaphragm Tank

The diaphragm tank, also known as a breather, has been around since the 1950s. The tank shell is constructed of lightweight drawn steel, with an epoxy finish and a bonded plastic lining for extra corrosion resistance. It has a replaceable air charge valve at the top of the tank for safe and easy operation, and a strong, flexible butyl diaphragm with a locking retainer ring for positive separation of air and water. The diaphragm tank is approved by most codes. See Figure 15-7.

Because a diaphragm tank is precharged with air, it will always occupy less space for similar amounts of pressurized water than a plain hydropneumatic galvanized steel tank. This kind of tank is suitable for most small systems. It gives consistent service and doesn't require air to be injected into the tank. The tank volume for a home may be as small as 14 gallons or as large as 119 gallons, depending on the water need.

Your sizing procedure is the same as for a hydropneumatic tank, based on the water-use habits of the occupants. It's usually wise to allow a little extra capacity because it adds very little to the tank cost. It also prevents too-frequent pump starts (excessive cycling).

The water piping from the pump to the pressure tank can't be smaller than the discharge outlet of the pump. Install a gate valve, with the handle removed, between the pump and the tank if the tank's capacity is more than 42 gallons.

Install a minimum $^3/_4$-inch gate valve on the discharge side of the tank. This serves as the house valve to control water in the building.

Be sure to set the tank level in an enclosed area, or on a concrete pad built for the pump and tank. Place them so there's reasonable access for repair or replacement. Interior water piping materials and installation methods are the same as described in Chapter 14 for water distribution pipes.

Review Questions for Chapter 15 (answers are on page 305)

1. Approximately what percentage of homes in the U.S. depend on private wells as their source of water?
2. Name one of the agencies that has the authority to approve and inspect domestic wells.
3. What document is required before you can drill or drive a well?
4. How far down must the bottom of the well casing extend when you drive or drill a well?
5. How is well water generally classified?
6. Why is well water considered hard water?
7. Why does well water have a distinctly different taste from "city water"?
8. What plumbing problems may the minerals in untreated well water create?
9. What can you do to improve the taste and smell of well water?
10. What tradesmen are most likely to install wells, suction lines, pumps and water pressure pumps?
11. Under what classification are professional well drillers certified and licensed?
12. Even though plumbing contractors very seldom install domestic wells, why should you learn about well systems?
13. What minimum depth will local authorities usually require for a potable water supply well?
14. How are wells that are dug or driven classified?
15. What are the two types of driven wells?
16. Where are open end well casings commonly used?
17. Once you're sure you've installed a good well, what must you do before it's ready for use?
18. Where would you use well casings equipped with a well point?
19. Where would you use a well point with a screen or with fine perforations?
20. Where would you use a well point with large openings?
21. How are wells that are drilled classified?
22. Why is water from deep wells more desirable than water from shallow wells?
23. Where may you not locate a well without specific approval from your local authority?
24. Where should the well casing in a drilled well terminate?
25. Why is a 36-inch-wide sloping concrete collar required around the top of the well casing?
26. What must you install in the top of the well to provide access for inspections, measure well depth, test the static water level, and allow disinfecting agents to be added?
27. What's the minimum size for a suction line from the well to the pump?
28. Where should you install the check valve on a well suction pipe?
29. Name one of the two types of check valves commonly used on suction lines.
30. What must you install on the well suction line just before the pump?
31. What two types of pressure tanks are commonly used today?
32. Which of the two commonly used pressure tanks has been the dominant well water supply system since the 1920s?
33. What's the psi operating range for a hydropneumatic tank?
34. What happens when there's not enough air to pressurize the tank in a hydropneumatic system?
35. What's the minimum size hydropneumatic tank needed for a single-family residence?
36. How long has the diaphragm tank been approved for use in domestic well water systems?
37. What problem can you usually prevent by adding a little extra capacity to a diaphragm tank?
38. What's the purpose of installing a gate valve on the discharge side of the tank?
39. What's the minimum size gate valve required?
40. What are two important considerations in locating the tank and equipment?

16

Fire Protection

Many plumbers have never worked on a fire protection system during their entire careers. With that said, recently, code sections have been added to both the *IRC* and *UPC* for installing residential fire sprinklers, so this can be considered the plumber's work in many parts of the United States.

As a code official for over 20 years, it has been my work to respond to fires in homes and other buildings soon after a fire event. It is always impactful on my heart to see the loss of life and property while evaluating if the building is still safe for habitation. I strongly support using fire sprinklers and believe the initial cost is well worth the substantial benefits of their operation during a fire event.

Codes now mandate fire sprinklers in single-family homes, and this is a relatively new requirement in most parts of the U.S. The requirement came to be in the 2009 version of the *IRC* and is widely enforced now.

Nearly every state requires fire sprinklers in new residential construction, so this can be a great opportunity to include these systems in a bid to plumb a new home.

Commercial fire protection systems are significantly more complex and always require a fire protection licensed engineer to design the system and a fire protection licensed installer to install and test the system. These systems are designed to a fire code, not a plumbing code, so we won't be covering these in this book.

This chapter will cover designing and installing a fire protection system for a single-family home using the codes and standards found in the *UPC*. The requirements are very similar for an *IRC*-compliant system and an NFPA 13d system.

Plan submittal requirements

Each fire department will have its own exact list of requirements that will typically include the following items.

- The contact information of those involved with the project, such as the name of the property owner, address, name of the contractor, address and name of plan preparer with a phone number and email address.
- All drawings should be to scale on paper that is of the same size, and the size needs to be acceptable to the AHJ.
- Show each floor level of the home.
- Show the room name of each room.
- Provide the dimensions of each room.
- Show the location of each head.
- Show any obstructions such as beams, large light fixtures such as chandeliers or ceiling fans.
- Clearly show any sloped ceilings or soffits.
- Show the street water pressure.
- Show the type of pipe that will be installed.
- Show the pipe sizes of each main run and branch.
- List the manufacturer of the heads and the coverage capabilities based on available pressure and GPM.

- Show the location of the alarm bell, test station and drain.
- Provide a detail for acceptable signage at locations that are required to be identified with signage.

Certifications

Fire protection systems are intended to save lives and therefore many jurisdictions will require an installer to be certified in addition to being a licensed plumber. The *UPC* specifies that these systems be installed by an ASSE Series 7000 installer. The course they provide takes approximately 40 hours and includes exams. ASSE contact information is shown in Chapter 8, Figure 8-1.

The piping used for fire sprinklers must be certified for this use. Typical certification agencies that are acceptable include Underwriters Laboratory (U.L.) and Factory Mutual (F.M.). Materials such as PEX and CPVC are common choices. PEX and CPVC are also compliant domestic water piping products which greatly reduces the risk of contaminating the domestic water system.

PEX and CPVC manufacturers both have training programs that are required for using their products.

Residential Fire Protection Systems

There are two types of residential systems covered in the *UPC*. Both are for use in single-family homes or duplexes only. Both are wet pipe, not dry, pipe systems and both are not permitted to use chemicals such as anti-freeze. First, we will look at sprinkler head types used in both systems and then their application in multi-purpose and stand-alone installations.

Sprinkler Head Types

Residential fire sprinklers are specially designed for residential applications. In general, they use less water than commercial sprinklers and are available in types that provide excellent coverage in homes. Figure 16-1 shows some common sprinkler heads in residential applications.

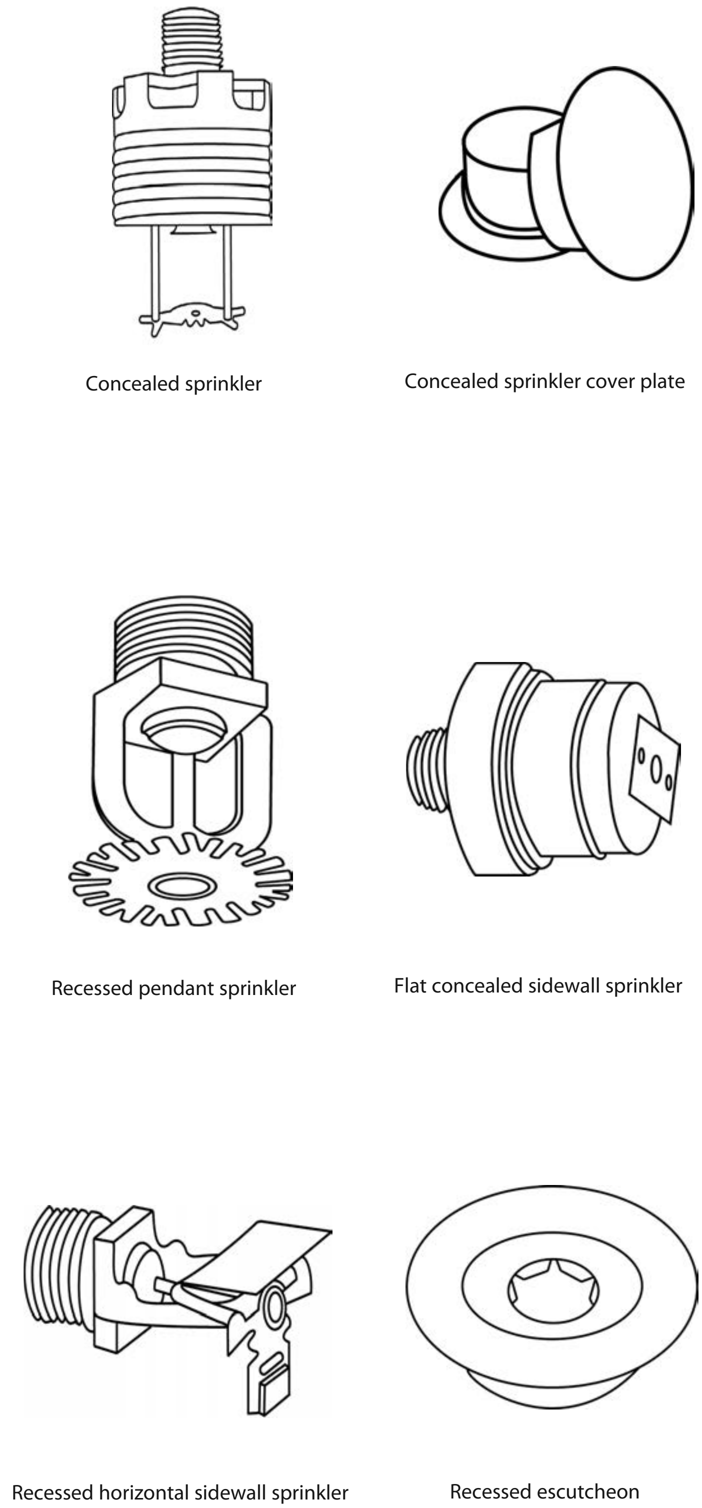

Figure 16-1
Common Sprinkler Heads

<table>
<tr><th rowspan="3">Max. Coverage Area [a] ft x ft (m x m)</th><th colspan="7">Wet Pipe System
Minimum Flow and Residual Pressure [b,c]</th></tr>
<tr><th colspan="2">Ordinary Temp. Rating 155°F (68°C)</th><th colspan="2">Intermediate Temp. Rating 175°F (79°C)</th><th rowspan="2">Deflector to Ceiling</th><th rowspan="2">Installation Type</th><th rowspan="2">Minimum Spacing ft (m)</th></tr>
<tr><th>Flow GPM (L/min)</th><th>Flow GPM (L/min)</th><th>Flow GPM (L/min)</th><th>Flow GPM (L/min)</th></tr>
<tr><td>12 x 12
(3,7 x 3,7)</td><td>8
(30,3)</td><td>7.1
(0,49)</td><td>8
(30,3)</td><td>7.1
(0,49)</td><td rowspan="5">Smooth Ceilings 1-1/4 in. to 4 in.

Beamed Ceilings per NFPA 13D or 13R 1-1/4 in. to 1-3/4 in. below bottom of beam.</td><td rowspan="5">Recessed using Style 20 Escutcheon or non-recessed per NFPA 13D, 13R or 13</td><td rowspan="5">8
(2,4)</td></tr>
<tr><td>14 x 14
(4,3 x 4,3)</td><td>11
(41,6)</td><td>13.4
(0,92)</td><td>11
(41,6)</td><td>13.4
(0,92)</td></tr>
<tr><td>15 x 15
(4,6 x 4,6)</td><td>12
(45,4)</td><td>16
(1,10)</td><td>12
(45,4)</td><td>16
(1,10)</td></tr>
<tr><td>16 x 16
(4,9 x 4,9)</td><td>13
(49,2)</td><td>18.8
(1,29)</td><td>13
(49,2)</td><td>18.8
(1,29)</td></tr>
<tr><td>18 x 18
(5,5 x 5,5)</td><td>17
(64,3)</td><td>32.1
(2,21)</td><td>18
(68,1)</td><td>36.0
(2,48)</td></tr>
<tr><td colspan="8">Notes:
a. For coverage area dimensions less than or between those indicated, use the minimum required flow for the next highest coverage area for which hydraulic design criteria are stated.
b. Requirement is based on minimum flow in GPM)LMP) from each sprinkler. The associated residual pressures are calculated using the nominal K-factor. See hydraulic Design under the Design Criteria section.
c. For NFPA 13 residential applications, the greater 0.1 gpm/ft^7 over the design area or the flow in accordance with the criteria in this table must be used.</td></tr>
</table>

Figure 16-2
Sprinkler Head Data Sheet

The sprinkler head design and its required flow rate are both critical parts of successful water coverage. This information is provided by the sprinkler manufacturer and is based on available pressure. See the example in Figure 16-2

The sprinkler head data sheet lets us know what the maximum coverage area is dependent on the available water pressure and temperature rating. This data sheet is for a 3-gallon-per-minute head.

When selecting a sprinkler head, your instinct may be to design a system with as few heads as possible and the greatest coverage area, but doing this could cause you to need larger piping than needed. The piping system needs to be designed to provide an adequate supply of water (Gallons per minute) without an unacceptable pressure drop. Selecting fewer heads that require greater GPM, rather than more heads with less GPM, results in larger piping. Unlike a plumbing system, more heads do not require larger piping. A system is designed to ensure that one or two heads have adequate flow at the same time. A single head, or in some cases two heads, should be adequate to stop a fire from spreading to other areas.

Typical residential fire sprinklers are not necessarily approved for sloped ceilings; they are designed for smooth horizontal ceilings. Some manufacturers design and test their heads for use on sloped ceilings. If you need to install a sprinkler on a sloped ceiling, be sure to use a head that is listed for that purpose.

Sprinklers installed under glass or plastic skylights can be subjected to rays from the sun and are typically designed with a temperature rating that is above the "ordinary" level, which is considered "intermediate."

Each residential fire sprinkler must be marked so it can be identified for its performance abilities and design limitations. The colors of the glass bulbs are typically orange or red, indicating that the sprinkler is an "ordinary" residential fire sprinkler. Colors such as yellow, green, blue, or black indicate that the sprinkler is designed for higher levels of hazards.

Multi-Purpose Fire Sprinklers

As the name indicates, these systems serve more than one function. They serve both the plumbing fixtures and the fire sprinklers with the same piping. These systems are economical to install since plumbing pipes are often in the vicinity of areas that require fire sprinkler coverage. PEX is the most common material for these systems, and a wide variety of manufacturers have certified their PEX products for use in a fire system. Most jurisdictions will accept multi-purpose installations; however, some will not due to local amendments that have stricter requirements.

Let's start at the beginning of the system.

- The pressure is typically unregulated unless the street pressure exceeds the rating of the pipe and heads.
- Booster pumps and storage tanks are common in areas with low pressure or low flow rates.
- A backflow protection device is never required since the systems are not separate and utilize the same piping throughout the home.
- A test tee will be needed to place a pressure gauge for testing.
- A shut-off valve is permitted only where it controls the entire water system. Other valves that could isolate a fire sprinkler are not allowed.
- Signage is required that lets the homeowner know the risks of shutting the water off. In the event they turn off the valve, the fire system will not work.
- The system is connected to the cold-water system and may need a bypass device if a water filtration system is installed.

As the system is installed beyond the water service connection, code requirements for materials and support are the same as for water distribution piping except for the additional support requirements at the sprinkler head locations. Be aware though, that manufacturers can and do have additional support requirements for their piping.

Plastic piping installed in exposed locations, such as a basement without a finished ceiling, is prohibited unless allowed by the pipe listing/certification agency.

Fire protection piping, regardless of material, is subject to freezing in some climates. Be sure to insulate and/or keep the piping within the conditioned space of a home. In some cases, a dry system or system with anti-freezing liquid will be needed.

The minimum pipe size serving a multi-purpose sprinkler head is ¾" and the minimum inlet size of the head is ½". An adapter for the connection from ¾" to ½" is allowable and necessary.

Multi-purpose system sizing

The system needs to be sized for the home's fire sprinkler demands and plumbing fixture demands. In general, you do need to always provide a pipe sized to the larger of the two load demands. For example, if your water distribution system to a lavatory allows for a ½" pipe by code, but the fire sprinkler on the same pipe requires a 3/4" pipe, you must install the larger of the two, ¾".

The piping system should be designed with as few dead ends as possible and terminate at a fixture that is used frequently. Water can become stagnant in long dead-end runs. See Figure 16-3 for a basic example of this concept.

Sizing is performed using friction rates provided by the piping manufacturer and available pressure.

As you can see in Figure 16-3, each room of a home is different, and that is why there are a variety of sprinkler head types and coverage areas. A multi-purpose installation generally has less material, requires less labor, and is less expensive to install.

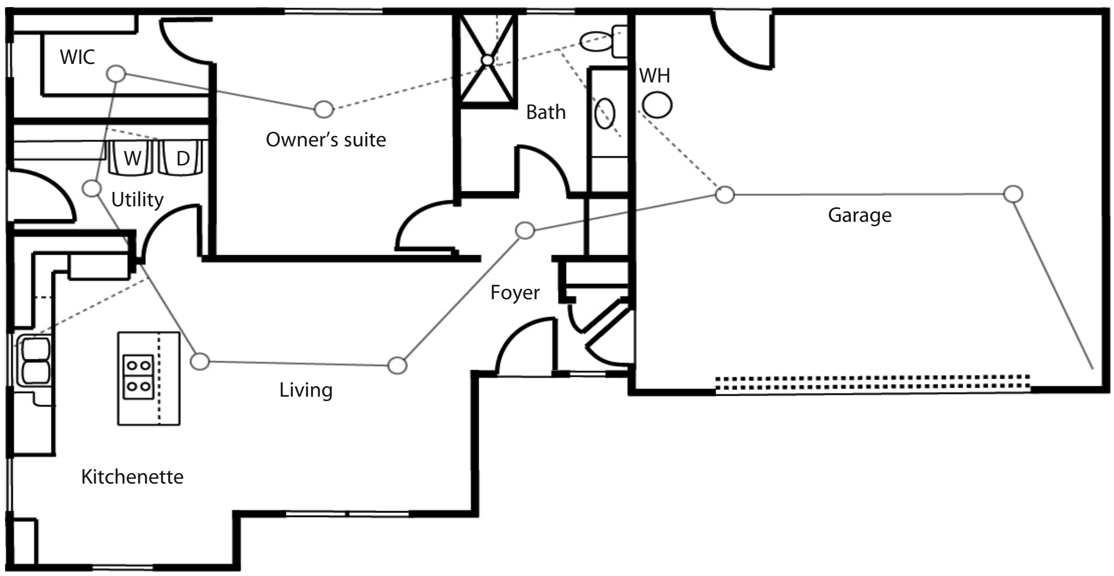

Figure 16-3

Multipurpose fire system layout

Stand-Alone Fire Sprinklers

Stand-alone fire sprinklers for homes often share the same water service but quickly separate from each other once in the building. Figure 16-4 shows a typical water service branching off to serve the domestic water needs in one direction, and fire system needs in the other direction.

Be sure to check with your local jurisdiction about their requirements for a connection to the municipal water system. Each fire and water district have its own standards for this connection.

Residential stand-alone systems are most commonly piped with CPVC which is certified for use in a fire system. Products such as black steel can also be used, however, you will need to add an approved backflow preventer with products that cannot be used in a potable water system.

In general, the code allows the support methods per the plumbing code, however, the manufacturer often has more restrictive requirements. The heads need excellent support since forces are placed on the heads and nearby piping when it discharges.

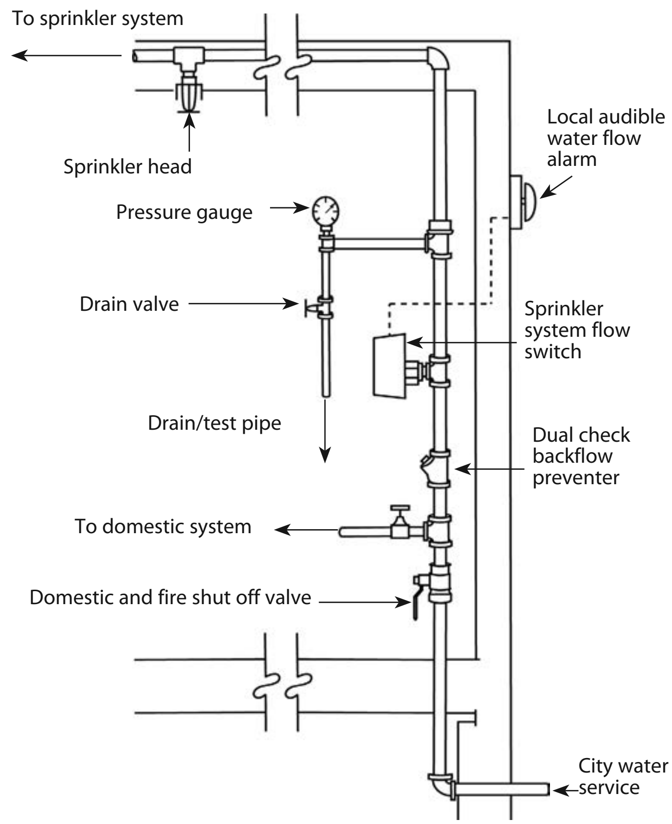

Figure 16-4

Typical stand-alone fire system

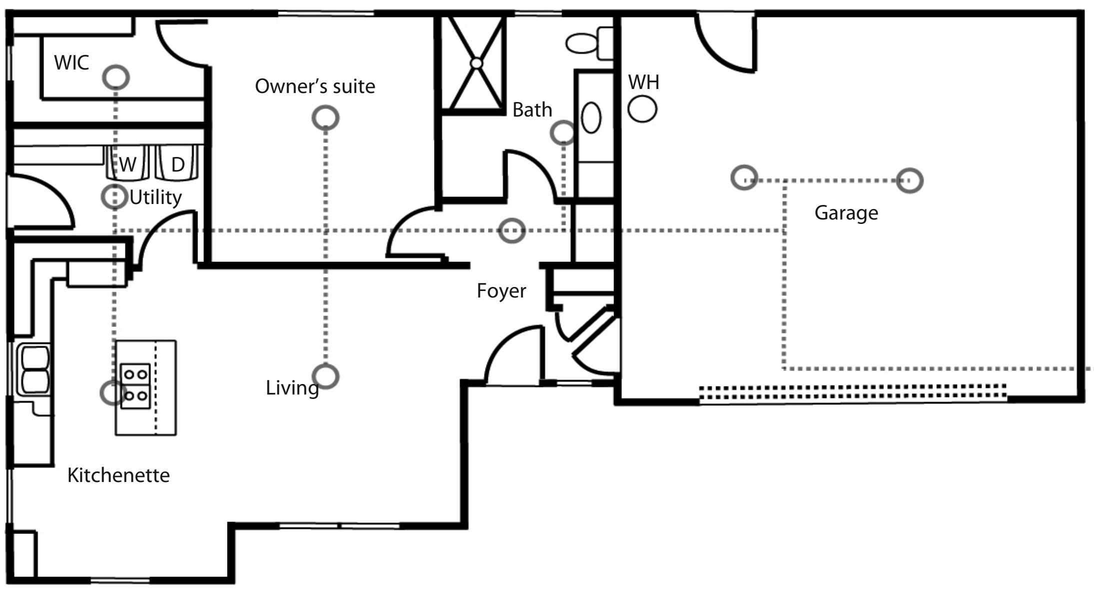

Figure 16-5

Stand-alone fire system layout

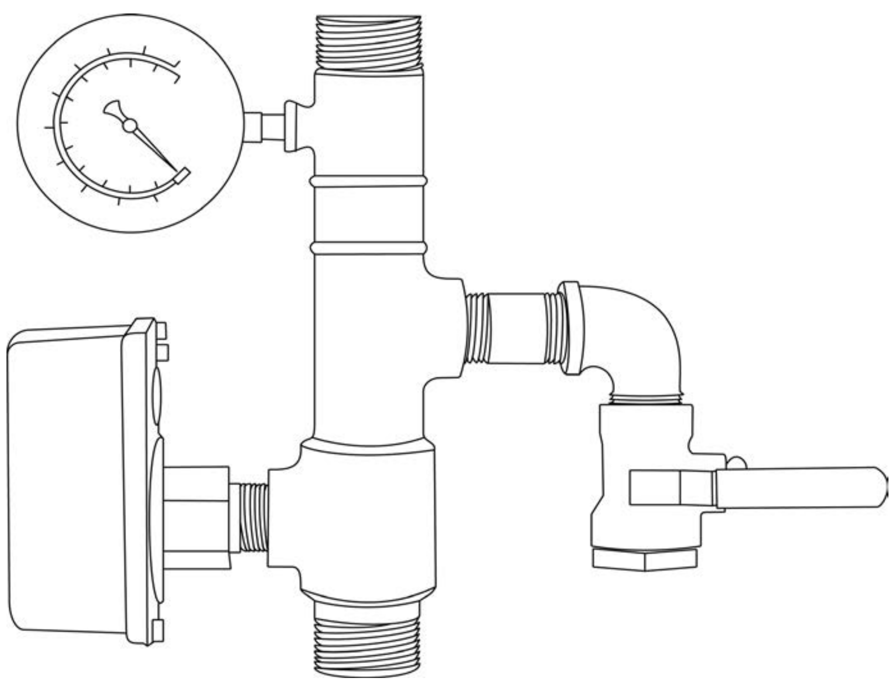

Figure 16-6

Sprinkler drain valve

When you install fire sprinkler piping, use straight runs that are parallel to walls and 90-degree fittings. Fire inspectors have high standards and expect quality workmanship.

Sizing is performed using friction rates provided by the piping manufacturer and available pressure.

Drain

A stand-alone system needs a drain in order to drain a system for servicing. It is important that the drain is labeled as the system drain and is not available for use by the occupants. See Figure 16-6 for typical signage.

Alarms

Many jurisdictions require a bell to be installed that is operated by a flow switch sensing water flow. See Figure 16-4 and observe the installation of a flow switch and bell.

Testing Residential Systems

Assuring adequate water in GPM and the necessary water pressure for the head to operate is done by performing a test on the system.

Most jurisdictions require enough water for the correct operation of two residential heads at a time, while others may require enough water flow for one.

The tools required for this test are shown in Figure 16-7

Once the system is pressurized with water at the designed pressure and observed not to have any leaks, then drain it and commence the test in this recommended order.

- Locate the most hydraulically demanding sprinkler. This will be either the head with the greatest flow in GPM or the farthest away with the most friction loss.
- With the system turned off and drained, remove the sprinkler from the sprinkler head adapter fitting.

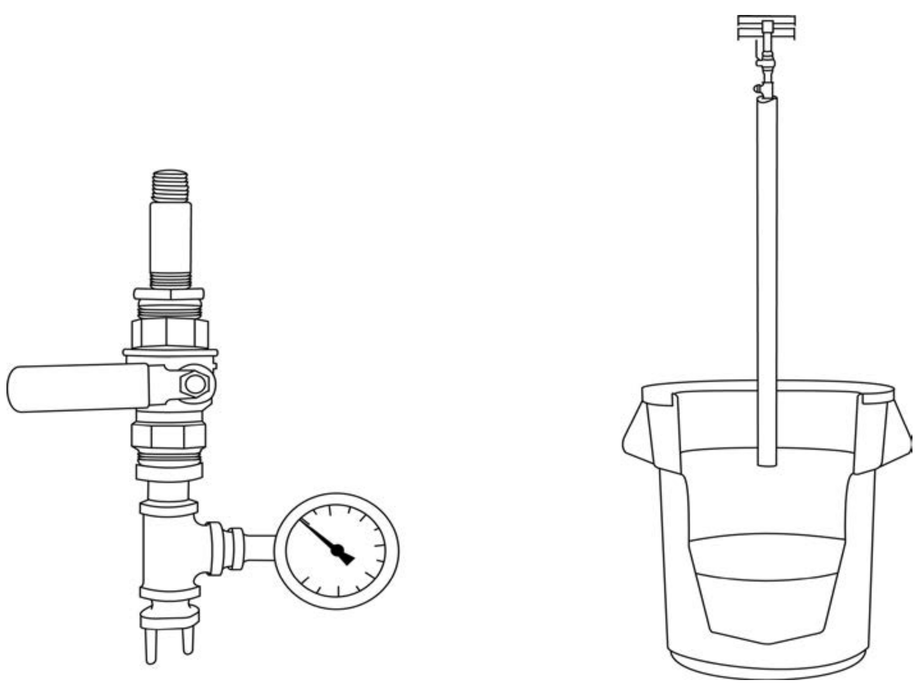

Figure 16-7

Flow test assembly and bucket

- Insert a flow test assembly and the test orifice to the end of the test assembly. The test orifice must match the size of the hydraulically demanding sprinkler head.
- Now refill the system with the designed water pressure by opening the valve on the test assembly and flow water until the air is completely out of the system. Trapped air will negatively affect the flow test.
- After all the air is purged, close the valve on the test assembly and prepare the test bucket. A test bucket is typically capable of holding 30 gallons of water and is marked on the inside with measurements in gallons.
- Open the test assembly valve and perform a timed flow for one minute.
- If the amount of water in the bucket matches or exceeds the calculated flow needed for correct head operation, the flow test is a success.

Inspections

Unlike plumbing inspectors, a fire inspector often will require a document such as a checklist or certification form to be completed for their files that certify the installation. This form is retained in public records in case there is an incident.

You will be required to have the approved plans on site for all inspections and your installation must be exactly as the plans were drawn.

Always be ready for your inspection in advance of requesting an inspection. Inspectors do not appreciate having their time wasted and can charge additional fees for reinspection.

Typical items on an inspection checklist include:

- Underground Inspection – An examination of the underground piping to determine that the calculated pipe material, diameter and water meter size has been installed and pressure tested.
- Overhead Hydrostatic Inspection /Rough Piping Inspection- The installation matches the approved plans. The piping is properly sized, supported, and free from defects and misuse from other trades. The system has passed the required static pressure test for leakage.
- Fire Sprinkler Final Inspection -A main drain and inspector's test valve are installed and identified with proper signage. A flow test has been witnessed and approved. The correct heads have been installed per the approved plans and are free from obstructions. A bell test has been witnessed and approved. Required signage has been installed.

Typical signage would include:

A permanent plate labeled "INSPECTOR'S TEST/MAIN DRAIN" shall be securely affixed at the inspector's test/main drain.

At the system control valve, provide a permanent plate that reads:

"WARNING: THE WATER SYSTEM FOR THIS HOME SUPPLIES A SPRINKLER SYSTEM THAT DEPENDS ON CERTAIN FLOWS AND PRESSURES TO FIGHT A FIRE. DEVICES THAT RESTRICT THE FLOW OR PRESSURE, SUCH AS PRESSURE REDUCERS AND WATER SOFTENERS SHALL NOT BE ADDED TO THE SYSTEM WITHOUT A REVIEW OF THE SYSTEM BY A QUALIFIED FIRE PROTECTION SPECIALIST."

A hydraulic calculation plate shall be provided and permanently attached to the riser, which indicates the system demand and pressure.

A sign at the fire bell stating "FIRE ALARM – CALL 911" or equivalent language.

Final Considerations

Never reuse a fire sprinkler. Always install new fire sprinklers to ensure they will work during a fire event.

Sprinkler heads are damaged by painting over them and must be replaced.

Fire sprinkler systems are not maintenance-free.

NFPA 25 is a maintenance code and dictates this fire sprinkler testing schedule:

Quarterly: To be as effective as possible, fire sprinkler mechanical devices should be tested quarterly.

Semiannually: Every six months, vane and pressure switch-type devices must be tested.

Annually: Full testing and tagging should be performed annually. During a complete fire sprinkler system test, the technician should perform physical checks on all parts of your fire sprinkler system. These checks include water flow tests, fire pump tests, antifreeze concentration tests (in applicable systems), alarm tests, and trip tests of dry pipe, deluge, and preaction valves.

Every 5 years: Sprinklers exposed to extra-high temperatures and harsh environments, along with gauges on all sprinkler system types, should be tested or replaced every five years.

Every 10 years or more: Dry sprinklers should be tested or replaced every 10 years. Fast-response sprinklers should be tested after 20 years in use and every 10 years after that. Standard response sprinklers should be tested after 50 years of use and in 10-year intervals after that.

Review Questions for Chapter 16 (answers are on page 307)

1. Commercial fire systems are designed by which type of professional?
2. When preparing a plan for submittal, does it need to be drawn to scale?
3. The UPC requires a residential fire sprinkler installer to be certified to which ASSE certification program.
4. Which fire sprinkler piping manufacturer have training programs for installing residential fire sprinkler?
5. Do commercial fire sprinklers use more or less water than residential fire sprinklers?
6. What data is important for selecting a fire sprinkler head?
7. What are some common types of residential sprinkler heads?
8. In Figure 16-2, what is the minimum spacing distance allowed between heads?
9. In Figure 16-2, what is the maximum coverage area allowed for the ordinary temp head rated at 13 gallons per minute?
10. Where is a shut-off valve permitted to be installed on a residential fire system?
11. When can a plastic piping fire system be installed outside of walls and ceilings?
12. In a multi-purpose system, what is the minimum size pipe serving a head adapter?
13. Why should long dead-end runs be avoided?
14. When is a backflow device required on a multi-purpose system?
15. What material is most common for a multi-purpose system?
16. Why is signage required at the main shut-off valve serving a multi-purpose system required?
17. What material is most common for a residential stand-alone system?
18. What device urns on a fire bell?
19. Which system requires a drain?
20. In very cold weather climates, how do you protect the piping from freezing?
21. In a stand-alone system, is a flow-sensing switch for a bell located before or after the supply to the domestic system?
22. Which two listing agencies typically certify fire piping products?
23. Why are PEX and CPVC commonly used in residential fire systems?
24. When designing a fire system, does adding additional sprinkler heads require installing larger piping?
25. Under what circumstances is a backflow preventer required for a stand-alone system?
26. Which system is more likely to contain stagnant water, multi-purpose or stand-alone?
27. What method is used for sizing sprinkler pipe?
28. Why is it important to install a drain on a fire sprinkler system?
29. Why is it important to place a sign at the shut-off informing a homeowner that the valve controls both the fire system and the domestic system?
30. Typically, what color do "ordinary" residential fire sprinkler bulbs have?
31. What effect do sloped wall surfaces have on a fire sprinkler system?
32. Does installing a sprinkler head next to a skylight have an effect on the sprinkler head choice?
33. What tools are needed to perform a flow test?
34. What is the desired result from a flow test?
35. During inspections, what document is required to be on-site?
36. Typically, what are the three inspection types performed on a residential fire sprinkler system?
37. Is reusing a sprinkler head acceptable?

38. Can fire sprinklers be damaged by paint?

39. Which Code has requirements for the maintenance of fire sprinklers?

40. What fire sprinkler system components should be tested semi-annually?

41. What does the sign placed at a bell state?

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17

Swimming Pools and Spas

Swimming pools and spas are big business for some plumbers. There are hundreds of thousands of swimming pools and spas in the United States, and most, by far, are privately owned.

Specialty swimming pool contractors with a certificate of competency usually install the necessary piping and equipment in new pools and spas. These specialists also repair and maintain existing pools and spas.

You should know that your plumbing contractor's license also qualifies you to perform all work usually done by a swimming pool contractor. Some plumbing contractors act as subcontractors on pool work. In most parts of the country, anyone who wants to be licensed as a plumber must be familiar with pools and spas to pass the journeyman's and master's examination.

Swimming Pools

In most local codes, a swimming pool is any structure that's suitable for swimming or recreational bathing that's over 24 inches deep. It can be permanent or nonpermanent, in the ground or above-ground. A private pool is located at a single-family residence, available only to the family and their guests. A public pool is used collectively by a number of persons for swimming or bathing, whether a fee is charged or not. There are more definitions for pools and spas in the glossary at the back of the book.

The most common type of mechanical system plumbed into swimming pools today is a recirculating system. It's equipped with a pump to recirculate water from the pool through a filter system. The recirculating piping (also known as *return piping* or *pool inlet piping*) connects to the discharge side of the pump. It returns water to the pool after filtering.

Some private pools have an automatic feeding device that adds chlorine or fluorine. But many private pool owners add their own chemicals, or use a professional pool company to maintain the quality of pool water.

Even when it's heavily used, a recirculating swimming pool uses a minimum of water. The owner just adds fresh water as needed when it's lost by evaporation, splashing or backwashing. Good filtration equipment assures the water is clean, free of organic matter, and safe from harmful bacteria.

Water Supply

Water for the pool can come from the public water system. Many private pool owners use a garden hose attached to a hose bibb to fill the pool. If so, there should be a vacuum breaker on the hose bibb to prevent cross-connection. Public pools and some private pools have a direct connection to the public water system. If there's a direct water supply, the fill spout must have an air gap above the overflow rim of the pool, or have an approved backflow preventer. See Figure 17-1.

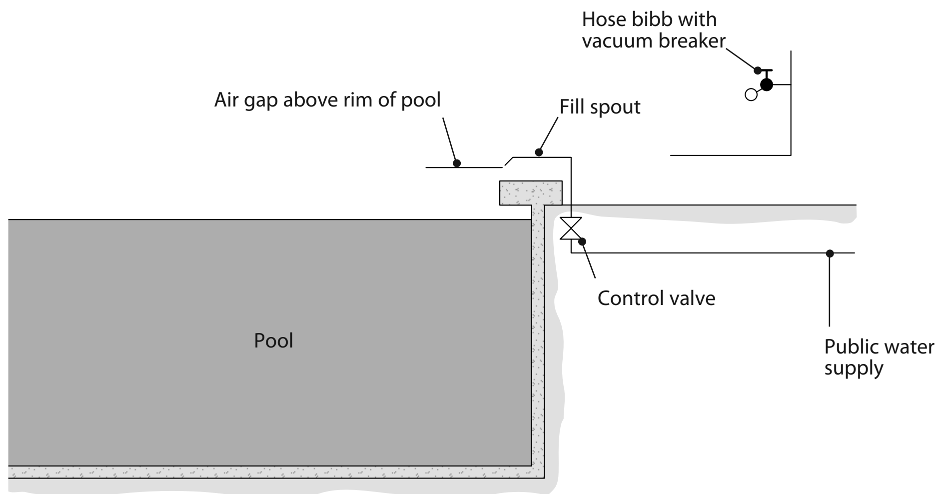

Figure 17-1
Water supply layout

If a well supplies the water for a swimming pool, the water must be clean and meet the bacterial requirements for a domestic water supply. If it's not reasonably free of objectionable minerals, the filtration system must remove them. The color of well water is also a concern. The iron content can't exceed 0.3 parts per million *before* filtration. If the raw well water doesn't meet these specifications, it's got to be treated before entering the pool.

Waste Water Disposal

Swimming pools must have some means of disposing of backwash water, and of being emptied. Pools equipped with pressure diatomite filters need piping to carry backwash waste to a settling basin before final disposal. Any of the following waste water disposal methods is allowed, as long as it's approved by the authority with jurisdiction:

- It can empty into a public or privately-owned sewage system. Typically, the water must be dechlorinated before disharge into a sewer. One common method is to stop adding chlorine a week or so before draining the pool. There are also chemical methods for dechlorinating a pool.
- It can flow into a disposal well.
- It can drain into an open waterway, bay or ocean, where this is permitted by the Director of Environmental Protection (DEP), or by the local health department, depending upon which agency has jurisdiction.
- It can empty into an adequately-sized drainfield, soakage pit or drainage trench.
- It can flow through a sprinkler system used for irrigation purposes. The waste must be confined to the property from which it originates. It can't flow on or across any adjoining property, public or private. In this instance, only the pool water may empty through a sprinkler system. The *backwash* water from the pool, containing hair and other bits of debris, *must not* be discharged through a sprinkler system or it will clog the system.
- Pool waste and backwash water may be puddled on private property provided the disposal area is big enough and properly graded to retain the waste water within the confines of the property. The pool of standing water can't remain for more than one hour after discharge. The disposal area must be a minimum of 50 feet from any supply well. Figure 17-2 gives percolation rates for soakage pits.

Pool capacity (gal)	Diameter S & G filter (in)	Soil percolation rates (minutes/in)											
		1		2		3		4		5		6	
		SF	Gal	SF	Gal	SF	Gal	SF	Gal	SF	Gal	SF	Gal
17,000	24	53.5	2,000	96	3,590	130	4,860	158	5,910	182	6,800	202	7,560
17,000 to 26,000	30	83	3,100	149	5,560	200	7,550	247	9,240	280	10,500	315	11,780
26,000 to 38,000	36	120	4,490	215	8,050	292	10,910	358	13,400	408	15,290	452	16,900
38,000 to 52,000	42	163	6,100	293	10,970	400	14,980	485	18,150	555	20,800	618	23,100
Note Effective depth of soakage pit is 5'0". SF refers to the area of the bottom of the soakage pit.													

Figure 17-2
Minimum area and volume of soakage pits for swimming pools

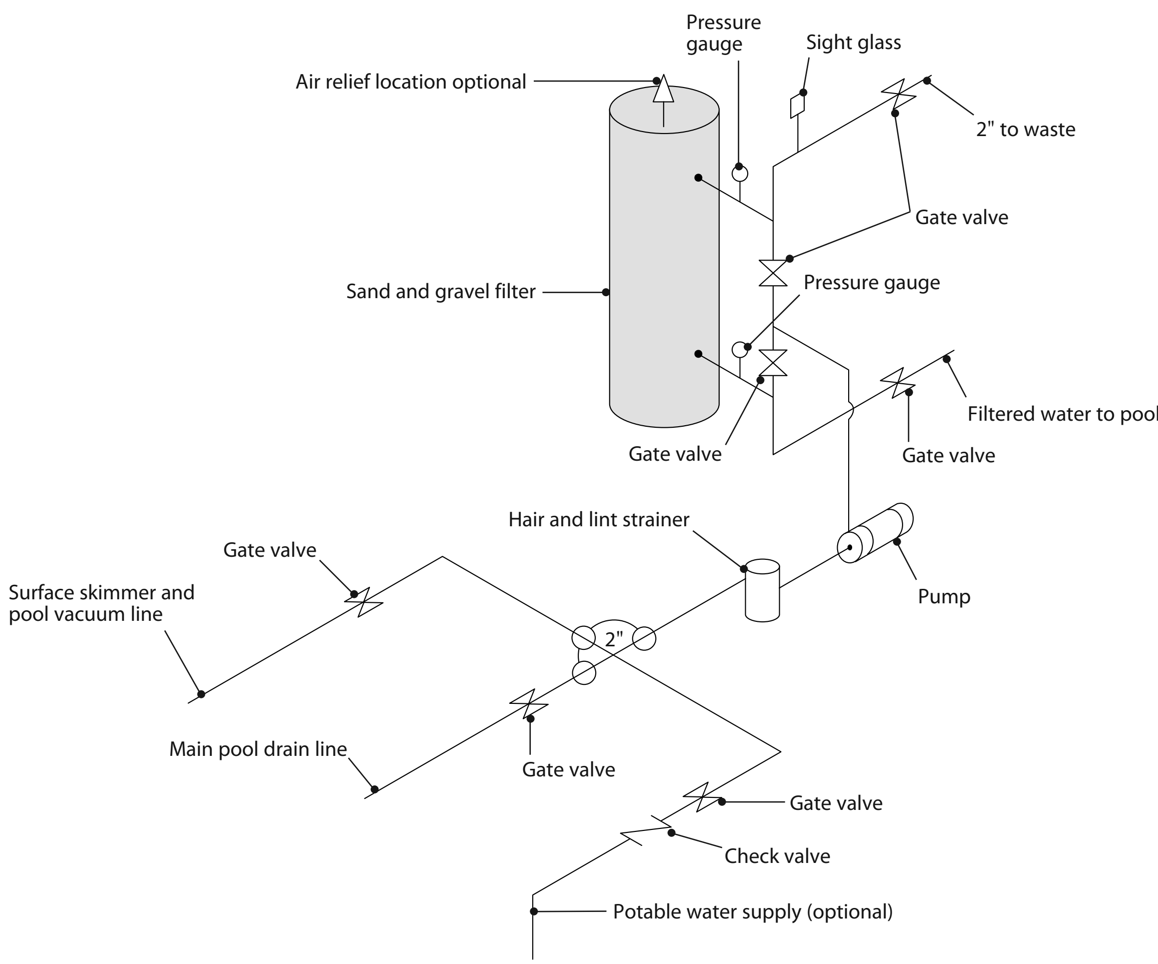

Figure 17-3
Pool equipment piping diagram

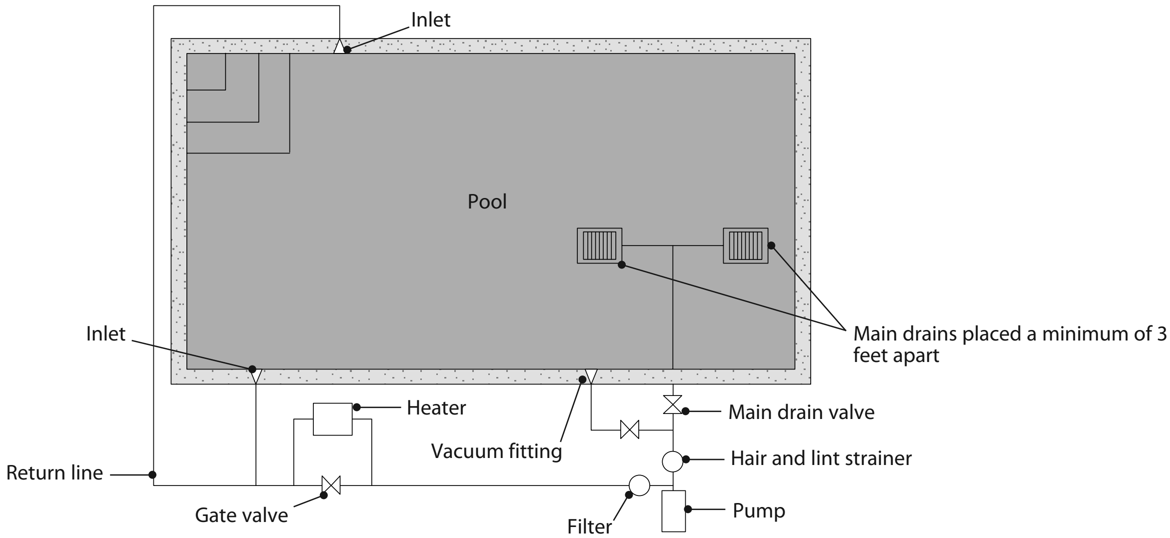

Figure 17-4
Plan view of swimming pool

Minimum Equipment for Swimming Pools

Figures 17-3 and 17-4 show a piping diagram and a plan view of a typical swimming pool. They show the equipment that's required for every pool.

Size and space the recirculation inlet or inlets to pro-duce uniform circulation of the incoming water throughout the pool. One inlet is required for each 350 square feet of pool water surface or fraction thereof, with a minimum of two inlets located at least 10 feet apart. Size the entire recirculation system so velocities don't exceed 10 feet per second (fps) at the design flow.

The suction line can't exceed 5 fps at the design flow during the filtration period. When the main drain is used for a return, it's considered an inlet, but you have to size it as a suction line. Install a hair and lint strainer in the suction line ahead of the pump. The strainer must have an easily-removable screen with a free area 5 times the cross sectional area of the suction pipe.

Provide a vacuum fitting that's $1^1/_2$ inches in diameter on all pools. Install it a maximum of 10 inches below the water line and in an accessible location. Some skimmers have the vacuum line built in. If it doesn't, connect the vacuum fitting to the piping that's connected to the pump's suction side.

Install a valve on the main drain (outlet, or suction) line, accessibly located outside the walls of the pool (see the gate valve in Figure 17-4). Residential pools must have a minimum turnover rate of once every 12 hours of operation.

Filters

Every pool needs filtration equipment. Most pools use a sand filter or a diatomite filter. They may use another type if tests show it's as efficient as a sand and gravel filter. Here are the requirements for *sand filters:*

- Pressure sand filters must have a filtration rate not over 5 gpm per square foot of filter area and a backwash minimum rate of 12 gpm per square foot of filter area.
- Sand filters must hold a minimum of 19 inches of suitable grades of screened, sharp silica sand properly supported on a graded silica gravel bed.
- They need sufficient free-board above the surface of the sand and below the overflow troughs or pipes to permit 50 percent expansion of the sand during the backwash cycle. There should be no loss of sand.
- The inflow and effluent lines must have pressure gauges.

- The backwash line must have a sight glass installed so backwash water can be visibly checked for clarity.
- Tanks larger than 24 inches must have an access hole measuring a minimum of 11 inches by 15 inches.

Diatomite filters must meet these requirements:

- They may be either the vacuum or pressure type.
- They must have a filtration rate of no more than 2 gpm per square foot of effective filter area.
- The installer must be able to introduce a filter aid into the filter tank to evenly precoat the filter septum or element before it's placed in operation.
- The filter piping must be designed and installed so the filter aid recirculates or discharges through the waste pipe during the precoating operation, and doesn't return to the pool waters.
- There must be a way to remove the caked diatomite, either by backwash or disassembly.
- The filter elements must be easy to remove.
- Install pressure or vacuum gauges on these filters to measure the differential across the filter. That shows when the filter needs to be cleaned.
- There has to be an air relief device at the highest point on each pressure filter tank.
- If discharge from the backwash line isn't visible, there must be a sight glass in the line to check the clarity of backwash water.

Surface Skimming for Pools

Provide at least one skimming device for each 1,000 square feet of pool surface or fraction thereof. Skimmers must be built into the wall of the pool and meet the following requirements:

- The rate of flow through each skimmer should be at least 25 gpm.
- The skimmer weirs must adjust automatically to variations in water level over a range of 3 inches. Skimmers must be at least 5 inches wide.
- Place a basket with a minimum of 75 cubic inches where it can be removed easily for cleaning.

Pumps must be able to filter and backwash the pool water at the pressure and rate for the filter and piping system you're using. All valves, pumps, filters and other installed equipment must be readily accessible for operation, maintenance and inspection.

Pool Piping

Figure 17-5 shows the types of pipe you can use in pool installations, and where you can use them.

Thermoplastic pipe must be continuously marked on opposite sides with the size, type, schedule, and the U.S. Commercial Standard and National Sanitation Foundation seal of approval. All fittings for ABS or PVC plastic pipe must be Schedule 40. Polyethylene pipe fittings must be the insert type connected with stainless steel clamps. All fittings used in gutter lines (usually in public pools) must be the drainage type.

If you're using thermoplastic pipe and fittings, the trenches and backfill must be free of rock. In general, you install and support pool piping the same as water piping of the same material. (See Chapter 14.)

Don't install short radius 90-degree piping elbow fittings on pool or spa suction piping below grade. And suction piping for pools and spas must be a minimum of 2 inches in diameter.

Type of pipe	Permitted use
Copper, Type K or L	All lines
Galvanized steel, standard weight	All lines
Wrought iron, standard weight	All lines
Brass pipe or tubing	All lines
Cast iron, service weight	Gutter lines only
Stainless steel, AISI, Type 300 series	All lines
Monel	All lines
Polyethylene pipe	Pressure lines only
ABS and PVC Schedule 40	All lines

Figure 17-5
Swimming pool materials and permitted installations

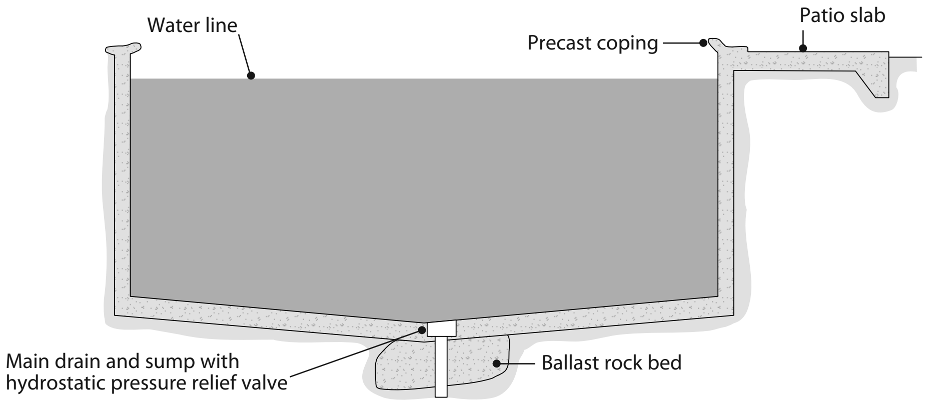

Figure 17-6
Swimming pool main drain

Dielectric fittings are required if you're installing dissimilar metals in pool and filter piping.

The entire pool pressure piping system, including the main drain, must be water-tested at 40 psi and proved tight before the installation is concealed.

The Main Drain

Every pool has a main drain to empty the pool. It must be at the lowest point of the pool so the pool will drain dry for cleaning, painting and general repairs. See Figure 17-6.

Unfortunately, the suction of water through the main drain in pools and spas seems to hold some kind of fascination for children. There have been numerous injuries and drownings when children sat on the main drain and were held under water by its strong suction. That's why most codes no longer accept the older, flat main drain previously used in pools and spas. All new pools and spas must meet the following requirements:

- They must have a certified antivortex cover with at least 6 square inches of open unobstructed area, securely fastened over the main outlet so it can't be removed without using tools, or
- They must have an open grate drain with a minimum open unobstructed area of 85 square inches, and
- All states now require two main drains in lieu of one. They must be placed at least 3 feet apart.

Pool Heaters

Gas-fired swimming pool heaters and swimming pool boilers must comply with AGA and ASME standards. Oil-burning equipment must be approved by Underwriters Laboratory or another nationally-recognized testing agency.

All pool-heating equipment must be at least 70 percent thermally efficient across the unit. Water heaters and boilers need either a thermostatic or high-temperature control with a maximum temperature differential of 15 degrees F (or some other acceptable overheat protection device). The temperature of the heated water can't exceed 105 degrees F.

Install pool water heating equipment the same way you install domestic water heaters. If you install the heater in a pit, provide drainage for its protection.

Spas

The growing popularity of spas has forced local authorities to compile and adopt codes to provide adequate protection for the users. The code defines a residential spa as one that's permanent or nonpermanent, and used by not more than two families and their guests. Spas are also defined by their capacity in gallons — a maximum of 3,250 gallons of water.

Spas and pools have many similar requirements, but here we'll focus on the ones that apply only to spas.

Spas more than $3^1/_2$ feet deep must have adequate and suitable handholds around 60 percent of their perimeter area. Some approved handholds include suitable slip-resistant coping, ledges, flanges or decks located along the immediate top edge of the spa. Ladders, steps, or seat ledges are also acceptable. They can't have any protrusions, extensions, means of entanglement or other obstructions that can entrap or injure bathers.

Spa materials and installation methods are the same as for swimming pools and domestic water systems of the same materials. (See Chapter 14.)

Spa Filter Requirements

Spa filters are similar to swimming pool filters. They're almost always designed by the manufacturer to meet these code requirements:

- Filters must maintain spa water under anticipated operating conditions, and the filtration surfaces must be easily inspected and serviced to restore them to the design capacity.
- Any filter or separation tank with an automatic internal air release as its principal means of air release must have, as part of its design, a way to provide a slow and safe release of pressure.
- Filters must meet the safety performance standards of the National Sanitation Foundation, or other approved testing agency.

Pumps for Spas

Every spa needs a pump to circulate the spa water. The pump must meet these conditions for filtering and cleaning of the water:

- There must be a hair and lint strainer (equipped with an easily removable screen) to filter out such things as solids, debris, hair, and lint, installed before the circulation pump.
- The design and construction of the pump and component parts must provide safe operation.
- Pumps must be mounted on a solid formed base, elevating the bottom of the motor at least 4 inches above the surrounding area.

Air Induction Systems

To prevent electrical shock hazards, be sure your air induction system does not allow any water backup. Also, the placement of air intake sources must minimize the possible introduction of deck water, dirt or other pollutants into the spa.

Surface Skimming Devices

Spas have the same requirements as pools when it comes to skimming devices, with these exceptions:

1) Spas must have at least one skimming device.

2) Spa skimmers must have a vacuum break.

Spa Heaters

The heater must include a thermostatic control that allows a maximum temperature of 105 degrees F. There must be a consumer use label posted on, or near, the spa, which includes the maximum spa water temperature limit.

Review Questions for Chapter 17 (answers are on page 309)

1. What type of certification does a contractor need in order to specialize in the installation of piping and equipment for swimming pools and spas?
2. Why should you be knowledgeable about swimming pools and spas if specialists do most of the work?
3. How does the code define a swimming pool?
4. How does code define a private swimming pool?
5. How does code define a public swimming pool?
6. What is the most common mechanical system plumbed into swimming pools today?
7. What basic equipment is required for a recirculating-type swimming pool?
8. What other terms may be used to identify recirculating piping?
9. What chemicals do you use to maintain the quality of swimming pool water?
10. Name two of the three ways that water is lost from a swimming pool.
11. What is the purpose of having a good swimming pool filtration system?
12. What must a homeowner install on the hose bibb to prevent cross-connection if he uses a garden hose to fill his swimming pool or spa?
13. What is required to prevent cross-connection if a swimming pool or spa has a direct connection to the public water supply?
14. What are two of the several approved methods for disposing of swimming pool water?
15. What is the minimum number of inlets required for a swimming pool?
16. What other function is the main swimming pool drain considered to have when it's used for a return?
17. How must you size the main swimming pool drain when it's used for a return?
18. What's the minimum diameter size for a swimming pool vacuum fitting?
19. To what part of a swimming pool pump do you connect a vacuum fitting?
20. What's the filtration rate for pressure sand filters?
21. What must you provide on the inflow and effluent lines for a swimming pool sand filter?
22. What must you provide on a swimming pool backwash line?
23. What two types of diatomite filters are used for filtering swimming pool water?
24. What's the filtration rate for a diatomite swimming pool filter?
25. What provisions must be made for removing caked diatomite from the swimming pool filter?
26. What must the design and installation of a diatomite filter permit?
27. What must you install on each swimming pool pressure filter tank at its high point?
28. How many square feet of swimming pool surface can one surface skimming device accommodate?
29. What's the required rate of flow through a swimming pool skimming device?
30. Where can you use copper, Type K or L pipe in a swimming pool installation?
31. Where can you use cast iron, service weight pipe in a swimming pool installation?
32. What weight fittings can you use with ABS or PVC plastic pipe in swimming pool installations?
33. What type fittings must you use in a swimming pool gutter line?
34. Where may you not install short radius 90-degree elbow fittings on swimming pool or spa piping?
35. What's the minimum size suction piping required for swimming pools and spas?
36. What kinds of fittings are required in swimming pool filter piping if you're installing dissimilar metals?
37. What pressure is required to water-test a swimming pool pressure piping system, including the main drain?
38. Where should the main drain for a swimming pool be located?

39. Why are the older, flat-type main drains for swimming pools no longer considered acceptable by most codes today?

40. What are the two code-accepted main drain covers used for swimming pools and spas today?

41. With what standards must gas-fired swimming pool heaters and swimming pool boilers comply?

42. Name a national testing agency that can approve oil-burning equipment for swimming pools.

43. What's the maximum temperature acceptable for heated swimming pool water?

44. What's the maximum gallon capacity acceptable for a spa to be considered a spa and not a pool?

45. What's the maximum temperature of a spa heater?

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18

Harnessing Solar Energy

The increasing cost of fossil fuels and the uncertainty of the foreign oil supply have spurred new interest in the search for alternate sources of energy. The investment in research to harness the sun for heating and cooling seems to be paying off.

It could, in fact, result in solar energy becoming the standard for most homes. Even now, solar energy is a competitive source for heating water for all domestic purposes. According to *Energy Star*, a federal program that promotes energy efficiency, a solar water heater can lower the average household's water-heating costs by 50 percent. And if you've ever paid the gas or electric bill for heating a swimming pool, you'll understand why more and more people are turning to solar energy for their pools. As solar energy systems become more practical and more widespread, you'll need to know how the professional plumber fits into the picture.

Plumbing codes are constantly being modified to protect consumers and contractors against untested or inferior products. That's why some local codes are adopting the new *Uniform Solar Energy Code* to cover solar energy systems. You can get a copy by contacting:

IAPMO Group World Headquarters
5001 E. Philadelphia Street
Ontario, CA 91761 USA

Phone (909) 472-4100
Order Phone (800) 854-2766
Order Fax (877) 852-6337
E-mail: puborders@iapmo.org
Website: http://www.iapmo.org

To install, repair or alter any solar energy system, you must first get a plumbing permit. When you're planning a solar energy system, the building department will probably require two sets of plans, one to file with the building department and one to be placed at the job site for inspection purposes. They usually require that the plans be done by a registered professional engineer, and show structural calculations, mounting frames and anchorage details. The plumbing drawings should show the entire solar system and specify only approved plumbing items and UL-approved electrical components.

When you've completed your installation, everything has to be tested and proved tight under a water-, fluid- or air-pressure test. The system must be able to withstand 125 psi for at least 15 minutes, without leaking. You won't want to call for an inspection until you're sure the system holds.

Domestic Hot Water Heating

In Florida and other sunny areas, solar energy has been used to heat water since the beginning of the 20th century. Since the systems are tested and proven, the cost of adding them in either existing buildings or new construction is relatively modest.

How the Solar Hot Water System Works

Have you noticed how water trapped in an ordinary garden hose gets extremely hot on a sunny day? That's how *solar energy* converts to *heat energy*. A solar system has three major parts: solar collector, circulation system and storage tank. If you're working with a pumped system, you'll have a fourth component, a *control center*. It consists of a circulating pump operated by an automatic controller with thermostat sensors, complete with drain, cutoff switch, check and pressure-temperature valves.

Some systems may have a fifth component — *a backup heat source* to ensure availability of hot water even during periods of peak water use and low solar radiation. This requires a built-in backup heater element in the solar storage tank.

The heat collector converts radiant solar energy into useful heat energy (Btu) as it heats water passing through copper pipes or other approved materials. The circulation system then sends the heated water into the storage tank. It's essential that this tank be properly sized and highly insulated. The water flows either through thermosiphon action or with the help of a pump. Both types are discussed and illustrated later in this chapter.

Let's take a closer look at each component of a solar system, beginning with the solar collector.

The Solar Collector

The heating element (source of energy) for a solar water heater is the solar collector. See Figures 18-1 and 18-2. The flat plate solar heat collector is the most practical and least expensive for residential use, producing temperatures up to 200 degrees F. Its heat deck consists of a metal plate, and tubing. The plate absorbs heat and transfers it to the liquid in the tubing.

Heat deck materials are usually copper, steel, and in some cases, aluminum. Thermally, these materials are the same. But *both the tubing and the collector plate should be of the same metal* so they expand and contract at the same rates. And take note of this: Codes generally won't permit potable water to flow through aluminum tubing, except in a closed system.

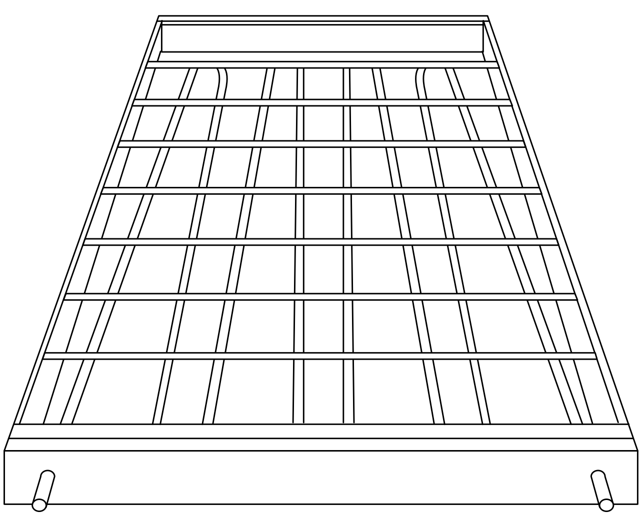

Figure 18-1
Flat plate collector

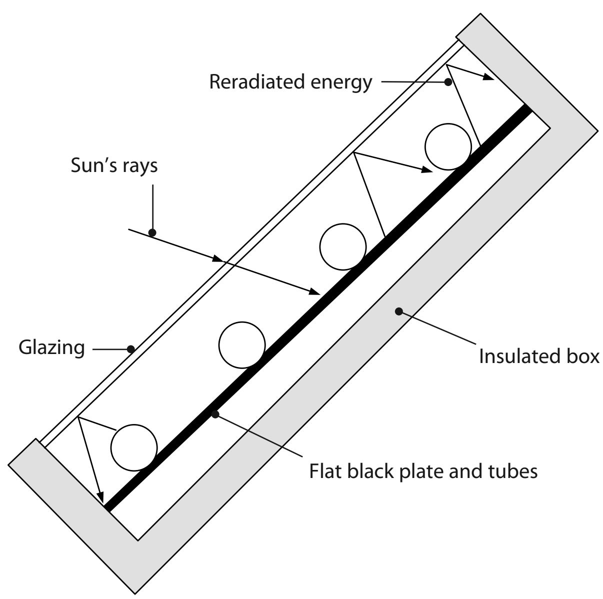

Figure 18-2
Collector cross section

Be sure the solar collector box is well insulated. This accomplishes two purposes: It shields the heat deck plate from the weather and it reduces heat loss. Paint the heat deck plate and tubing flat black to maximize absorption of the sun's energy. Never use light colors, which reflect the sun's rays.

The transparent cover on the collector box permits the sun's rays to strike the metal collector plate *and* reduces the loss of radiated heat back into the atmosphere. The best cover is glass with a low iron content so it's as transparent as possible to incoming rays. This glass admits solar radiation but is opaque to the long-wave energy trapped inside the collector box. The trapped heat is transferred to the fluid in the tubing.

A clear plastic sheet is better than no cover at all, but plastic has a couple of drawbacks. It tends to transmit both incoming and outgoing energy. And most plastics deteriorate quite rapidly under heat and moisture exposure. If a more heat-resistant plastic ever becomes available, it would be ideal because it's less breakable than glass. But most experts agree that glass is preferable for the time being.

In cold climates you'll need to use a collector with a double layer of glass. This is the only efficient way to prevent heat loss by convection when cold air strikes the transparent surface.

As a professional plumber you won't be expected to build solar collectors. But you'll want to have a good grasp of how they work so you can answer your customers' questions.

There are many companies that manufacture solar system components. It's your responsibility as the installer and permit holder to check for the approvals required by your local plumbing code *before you begin installation.*

Here are some of the requirements for solar heat collectors:

- Install only solar heat collectors approved by your local authority.
- Always use exterior-quality materials to secure frames and braces to solar heat collectors on a roof.
- Anchor a solar heat collector to a roof or other structure so it will resist dead loads, live loads, snow loads, wind loads and seismic loads.
- Make sure your installation doesn't impair proper roof drainage.
- Make sure all joints are watertight around pipes, ducts, bolts, or anything which penetrates the roof.
- If you install a solar collector panel that's not an integral part of the roof, mount it at least 3 inches above the roof surface.
- If you install a solar collector panel at ground level, it must be at least 6 inches above the ground to meet code requirements.
- Install all solar collector panels and related piping to drain dry.
- Take care that solar collector boxes have drainage holes at the low point to drain rain, condensation or other liquids that might collect there.
- Use only tempered glass with a low iron content.

Sizing Solar Heat Collectors

In most cases, you'll size a solar system to provide one day's supply of hot water. According to government figures, *each* of the first two people in a family uses 20 gallons of hot water (40 gallons for two people) per day. Each additional person should use 15 gallons per day. Here's how it works for a family of four:

20 + 20 + 15 + 15 = 70 gallons of hot water per day

You base the size of a solar heat collector on the number of bedrooms in a residence. For a one- or two-bedroom residence, never use a collector smaller than 4 feet by 12 feet (or 48 square feet of collector surface). A collector this size should heat approximately 80 gallons of water daily — usually plenty for a family of four.

For each additional bedroom, allow another 24 square feet of collector surface. Here's a word of caution. If you're working in a northern state, you may need a larger collector surface per bedroom. Check your local code requirements.

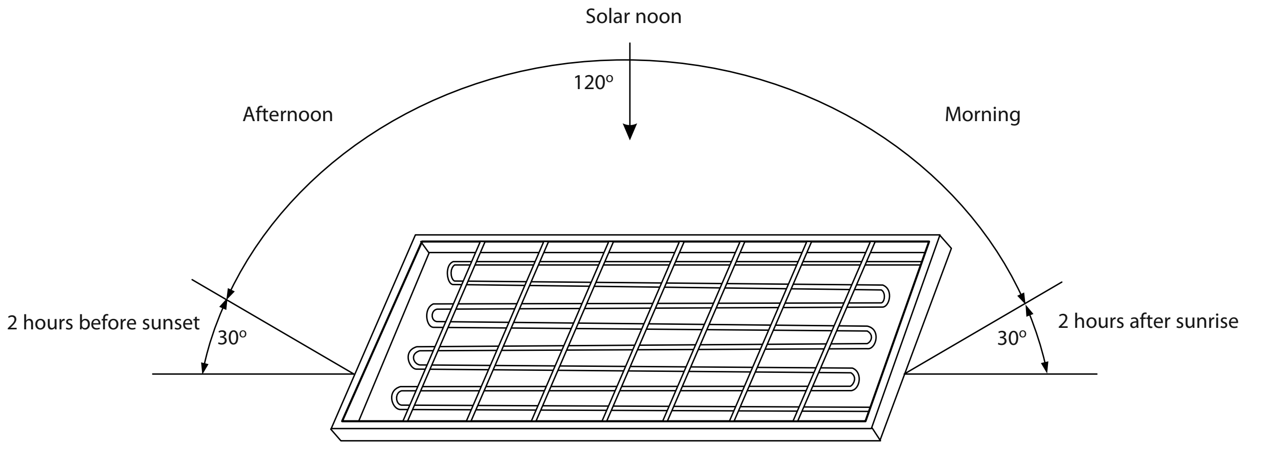

Figure 18-3
The optimum heat collection period

Locating the Solar Heat Collector

Only about 30 to 65 percent of the solar energy that strikes the glass surface of a collector actually heats the water circulating through the tubing. The rest is lost back into the atmosphere through the glass plate.

It's important to have the most efficient collector possible. Of course, the most efficient solar collector would be perpendicular to the sun's rays every moment of the day, every season of the year. There are motorized collectors that turn and tilt to follow the sun's path, but they're far too expensive for most homeowners.

The best compromise is to tilt the flat plate collector in the general direction of the sun's path across the sky at an angle to the particular latitude, plus 10 degrees. Try to make sure the collector faces south. If that's not possible, collectors facing southeast or southwest work about 75 percent as well as those facing due south.

Locate the collector wherever it's most convenient and most attractive, as long as it's in full sun during the major sunlight hours — from two hours after sunrise to two hours before sunset. If the collector is shaded only early or late in the day, when the sun is low on the horizon, it won't appreciably affect the solar system. At those times most of the sun's energy is reflected back into the atmosphere anyway. See Figure 18-3.

Mounting the Solar Heat Collector

In many areas, the plumber is responsible for mounting solar heat collectors. You'll find this especially true in new construction, where collector units are built into the roof as an integral part of the house. Built-in collectors look better because they're designed to blend with the exterior. They resist wind loads better because they're usually flush, or nearly flush, with the roof surface. For new construction, coordinate the installation with the roofer to minimize leaks.

Roofing contractors make several recommendations for mounting collectors on existing roofs. The collector should have a structural frame that's securely bolted to the roof rafters. Install flashing and a rain collar around the pipes and around the collector. Then fit the collector into the frame and anchor it.

Roof-mounted collectors invite roof leaks. Be sure to seal every hole drilled through the roof membrane. To prevent leaks, bore holes smaller than your securing bolts and caulk around each one very carefully.

A pitch pan is a practical solution on built-up roofs. If you use a pitch pan, seal it carefully before you secure it to the roof and fill it with pitch (hot tar). Otherwise, the pitch will heat up under the summer sun and create a pocket. Then water can get into the pocket and stay there. This moisture will eventually rust away the top of the securing bolt and cause a leak.

A pitch pan is ideal around pipes that penetrate the roof. Advise the owner to check the roof annually to be sure expansion and contraction haven't opened fissures where bolts and pipes penetrate the roof membrane.

Install a bearing plate under the cliff angle (the support that secures the heat collector to the roof) to prevent the collector from rocking. Screw the bolt all the way through the sheeting and well into the rafters. If you fasten lag bolts only to the sheeting, they'll pull out or loosen when the wind load causes a collector to vibrate. That's an instant leak.

On roofs with asphalt shingles, place a layer of plastic cement on top of the shingles, but beneath the cliff angle. Apply another layer of plastic cement to the top of the cliff angle. Then fasten the cliff angle securely to the roof rafters with lag bolts.

Mount the collector as close as possible to the storage tank to reduce heat losses and friction in the pipes. Make sure all piping is well insulated. In northern states, shield the transparent cover to protect it from winds that would otherwise cool the surface.

If you're considering installing a collector as an awning or a fixed overhang, be sure to get local authority approval before you begin working. This kind of installation may not be acceptable under your code.

Collectors can be mounted on the ground almost anywhere in full sun. They must be securely anchored, as in Figure 18-4. Unfortunately, any ground installation is much more vulnerable to accidental breakage and vandalism than a roof installation.

In climates subject to freezing temperatures, all the tubes should be installed so that they will drain dry. Draining the pipes is the best and least expensive way to keep water from bursting the pipes during a freeze.

Water Circulation

The most common way to move hot water from the collector piping to the storage tank is a circulating pump. But you can accomplish the same thing with a natural thermosiphon circulation system. This system requires no external energy source, no pumps, no controls, and no moving parts.

Here's how it works. The intensity of the sun controls the rate of movement of hot water from the collector to the storage tank, and of cold water from the tank to the collector. A thermosiphon results when hot water (which is lighter) rises to the storage tank and replaces the heavier cold water, which is drawn into the collector. See Figures 18-4 and 18-5.

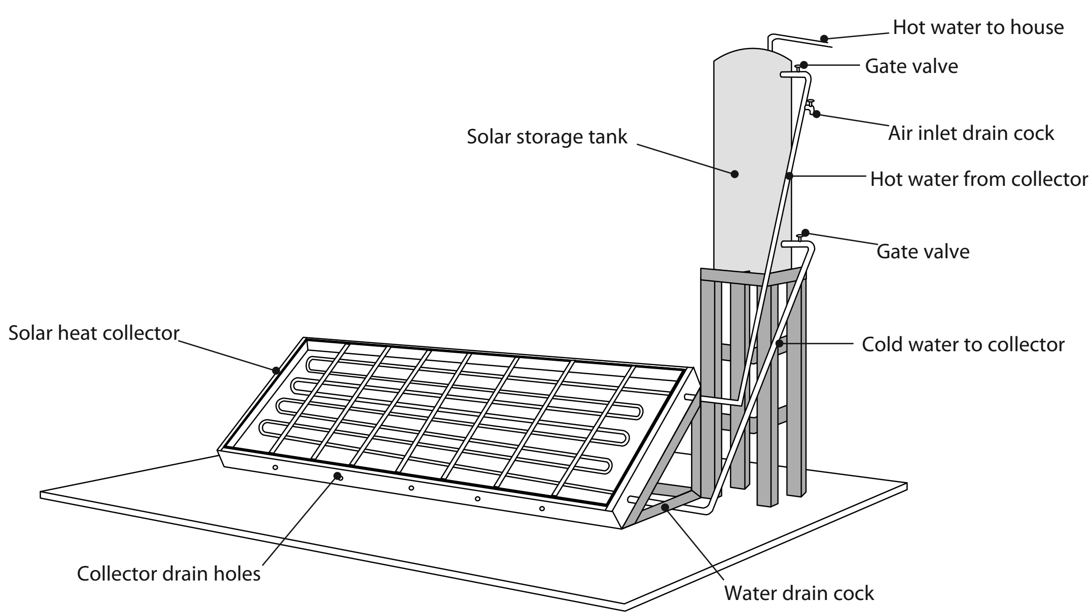

Figure 18-4
Ground-mounted thermosiphon solar water heating system

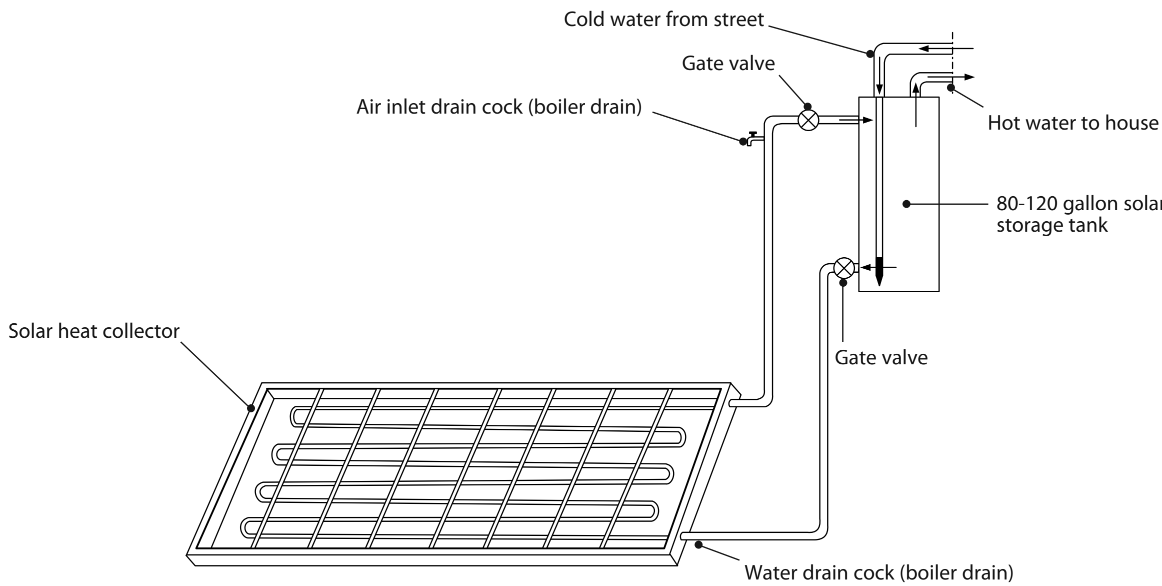

Figure 18-5
Thermosiphon solar water heating system

The thermosiphon won't work properly unless the storage tank bottom is located at least 2 feet higher than the top of the solar collector. That means you'll probably have to put a large, heavy storage tank on a roof or in an attic. This presents problems of weight, construction and appearance. A leak in an attic-mounted tank can cause considerable water damage inside the home. Solar energy codes usually require that you install a drain pan beneath any hot water storage tank located above the first floor. The drain pan should be at least as large as the base of the water storage tank, have a turn up of 2 to 4 inches, and be equipped with a $^3/_4$-inch drain pipe. The pan will catch any dripping water and the drain pipe will convey it safely to the exterior of the building.

In a thermosiphon system you must use a minimum $^3/_4$-inch inside diameter pipe in both the collector and the circulation system. This reduces flow resistance. Be sure the connecting pipe or tubing has a continuous fall with no sags that might allow the formation of an air pocket. An air pocket will stop the circulation.

A pumped system uses the same basic components as the thermosiphon system, but adds a circulating pump to force hot water from the heat collector to the large storage tank. See Figure 18-6.

An obvious advantage of a pumped system is that you can place the storage tank in any convenient place. You can avoid the problems which go with roof- or attic-mounted tanks. You may also use $^1/_2$-inch copper tubing in a pumped system. The pump must be controlled so that it circulates water through the heat collector only when water in the tank is cooler than the water leaving the collector. The added expense of installing the pump and controls may be offset by the lower cost of installing the heavy storage tank at ground level.

Closed Solar Heating Systems

In a closed solar energy collection system, a fluid like antifreeze, instead of water, is heated in the collector. A closed system has a built-in heat exchanger, either within the storage tank body or on the outside of the storage tank, as shown in Figure 18-7. As the fluid circulates through the solar collector, it transfers its heat to water in the storage tank through the heat exchanger.

A closed system does, however, have some disadvantages. It's less efficient, it's more complicated, and it's more expensive. Its one advantage is that in cold

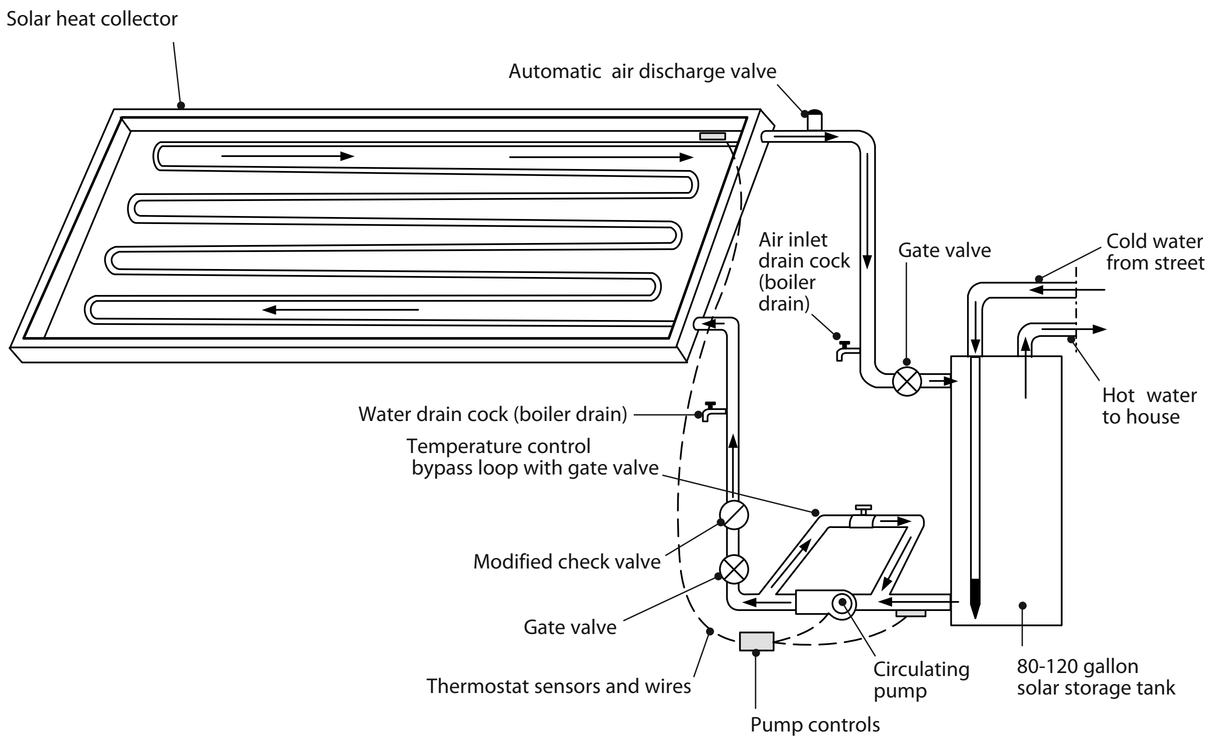

Figure 18-6
Pumped solar water heating system

climates it doesn't have to be drained, and because the system contains antifreeze instead of water, it won't freeze. Obviously, freezing can destroy the solar heat collector.

If your installation is in an area with freezing temperatures, it may be best to install a closed system. Whether you use the thermosiphon or pumped system, make sure it's protected from the cold and that it can be drained dry in winter.

Materials and Installation

The growing interest in solar energy for heating water for pools and domestic use has created a problem for many building code administrators. They're often faced with new installation problems not covered in some codes. If your particular code doesn't address this topic specifically, it will have some general provisions as to materials, types and installation methods. Be sure you follow them.

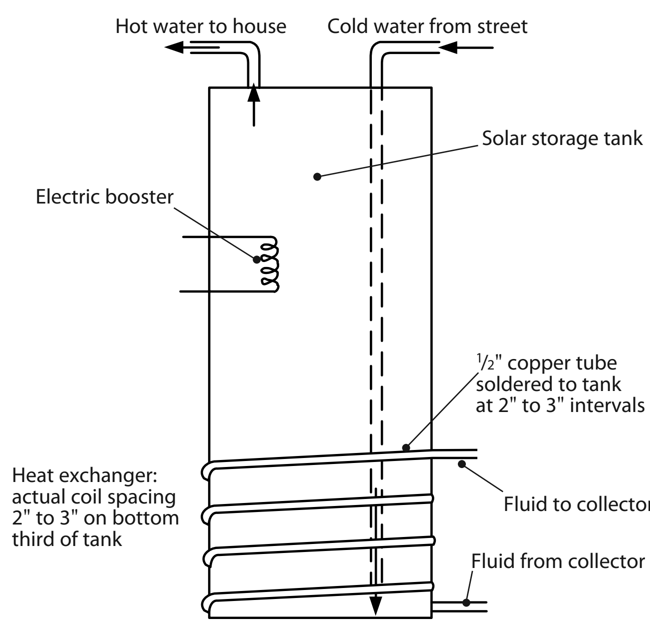

Figure 18-7
One type of heat exchanger

The Uniform Solar Energy Code

The *Uniform Solar Energy Code* is one of the few codes that addresses solar energy. It says that pipes and fittings used for conveying fluids within a solar system must comply with code standards for a potable water system. Look back to Chapter 14 for potable water systems.

Galvanized steel or Type K or L copper pipe and fittings are the most common materials for a solar circulation system. Also approved are cast iron and malleable iron pipe and fittings. These must be galvanized up to and including 2 inches in size, the largest size addressed by the *Uniform Plumbing Code*. Solar systems requiring larger pipe sizes would be unusual, and would need to be approved by your local authority.

There are two kinds of pipes you *can't* use for conveying heated fluids in a solar system:

- You can't use plastic pipe because it's prohibited where temperatures could exceed 180 degrees F.
- You can't use aluminum tubing in a potable water system. It's permitted in a closed solar heating system, *if first approved by the local authority.*

The piping in built-in heat exchangers in the body of the storage tank must be at least Type L copper tubing. The heat exchanger can't have seams, joints, fittings or valves. It must be constructed of double-wall material designed to prevent leaks which could create a cross-connection with the potable water supply.

Here are some additional requirements:

- Allow for expansion, contraction and normal pipe movement when installing piping.
- To minimize heat loss, insulate all piping which carries heated water, fluids or gases from a solar collector or heat exchanger to a storage tank. Use insulation that limits the maximum heat loss to 5 Btu per hour per linear foot of pipe.
- Make all threaded, soldered and flare joints in a solar system the same as for domestic water piping (Chapter 14).
- Make sure all piping in a closed solar heating system is isolated so that gases, fluids or other substances can't enter any portion of the potable water system.
- Use only approved plumbing items and UL-approved electrical components throughout the solar heating system.
- Your entire solar system must be tested and proved tight under a water-, fluid- or air-pressure test. It must be able to withstand 125 psi for 15 minutes without leaking.

All fittings in a solar piping system should be of the same material as the pipe. When you can't avoid using dissimilar materials, make sure they're electrically isolated with properly-installed approved fittings.

There's an exception to the "no dissimilar material rule" for valves or similar devices. Valves installed in a solar piping system up to 2 inches in diameter must be of brass or other approved materials. The fully-opened valve must occupy 80 percent of the cross-sectional area of the nominal size of the pipe to which the valve is connected. You'll have to install control valves so they can isolate the solar system from the potable water supply. As always, be sure they're readily accessible.

Install an approved pressure regulator where excessive water pressure is likely to occur. Since a solar energy system is an integral part of the building's water supply system, you can use the regulator in the water service pipe for that purpose. If you do, you won't need to install a second regulator in the solar supply pipe.

A combination temperature and pressure relief valve is required for each pressure-type water storage tank. It's important to install the temperature sensing element in the hottest water — that's in the top one-eighth of the tank. See Figure 13-5 back in Chapter 13. Please note that the temperature setting can't exceed 210 degrees F.

Also, the pressure setting can't exceed 150 percent of the maximum designed operating pressure of the solar system. Always check the relief valve setting to make sure it doesn't exceed the manufacturer's recommendations.

Relief valves inside a building must have a full-size discharge line of galvanized steel or hard drawn copper pipe and fittings. Your line should discharge to the outside and turn down to within 6 inches of grade. Make certain that no part of the drain pipe is trapped and that the end isn't threaded. Of course, the line

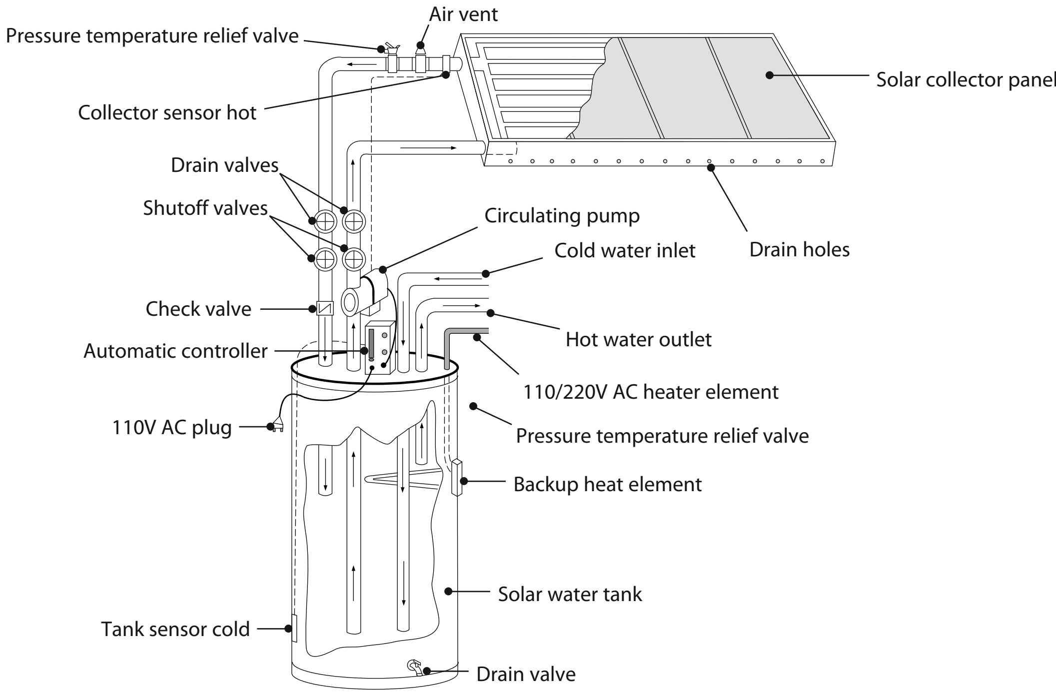

Figure 18-8
Typical pumped solar hot water system (solar collector, water tank and control center)

must be securely strapped to the building structure. A discharge line can terminate at other locations if you first get approval from your controlling authority.

Some authorities may require you to locate the pressure temperature relief valve at the highest point of the solar piping system, near the automatic air discharge valve (air vent). See Figure 18-8. When a relief valve is located on the roof, codes don't normally require a separate discharge line to the ground. They'll usually accept the discharge of the solar system's relief valve onto the roof.

You must install automatic air discharge valves at all high points of a solar piping system. See Figures 18-6 and 18-8.

Solar Storage Tanks

All solar storage tank plans must be submitted for approval, unless they're listed by an approved listing agency. Your plans must show dimensions, reinforcing, structural calculations and any other pertinent data that the building department requires.

In a conventional water heater (electric, gas or oil), the energy source works continuously to produce hot water. The storage tank can be rather small, often 30 or 42 gallons. The tank in a solar water heating system must be large enough to keep water warm through cloudy days and the hours of darkness. The usual recommendation for a family of four is an 80-gallon tank.

The guide in Figure 18-9 may be useful *if your work is in sunny areas* from Florida to California. But note that it gives the *minimum* recommended storage capacity for solar tanks. Since larger tanks are available at very little additional cost, it's worth it to have the extra hot water storage for times when demand is unusually high. The minimum recommended size for the average family of four (two bedrooms) is 70 gallons. Suggest an 80-gallon tank instead. It's always better to have more hot water than not enough.

If there's not enough space for a larger tank, install a solar storage tank with a backup heater element. See Figure 18-8.

Let's assume that you designed a system sized for three bedrooms and six people. You installed at least a 100-gallon storage tank. But eventually three or four of these people move away. The reduced water usage

Number of bedrooms	Number of people	Solar tank capacity (gal)
1	2 (20 + 20)	40
2	4 (20 + 20 + 15 + 15)	70
3	6 (20 + 20 + 15 + 15 + 15 + 15)	100
4	8 (20 + 20 + 15 + 15 + 15 + 15 + 15 + 15)	130

Figure 18-9
Sizing solar storage tanks

may cause water in the storage tank to get too hot. If this becomes a problem, you may need to install a tempering valve in the hot water pipe leading from the tank to the fixtures. This valve will temper the hot water flow so it combines with cold water and arrives at the fixture at a set temperature, usually about 140 degrees F.

Here are other requirements for solar storage tanks:

- They must be of sound, durable materials, watertight, not subject to excessive corrosion or decay, designed to withstand all anticipated loads and pressures, installed level, and on a solid bed. The required test pressure for tanks is two times the working pressure from utility mains (with or without a pressure-reducing valve) but never less than 300 psi.
- Use insulation that limits heat loss to no more than 2 percent of the stored energy in a 12-hour period.
- Install an adequate and accessible drain valve. See Figure 18-8.
- Make sure the tank and any devices attached to it are accessible for repair or replacement.
- Storage tanks must have a permanent label showing the maximum allowable working pressure and the hydrostatic test pressure designed into the tank. Install it so all markings are accessible to the inspector.

With prior approval from the controlling authority, you can locate a tank below the ground if its design and construction will resist trench load and corrosive soil effects. Obviously, you can't cover or conceal any part of the tank until it's inspected and approved.

Troubleshooting Guides for Solar Systems

If you're ever asked to check a malfunctioning solar system, it'll probably be a problem listed in the troubleshooting guide in Figure 18-10. For each problem, it offers a likely solution.

If the trouble's in the controller, follow these steps, in the order they're listed, to find the problem:

1) Short the two leads to the collector sensor. The controller will cause the circulating pump to run.

2) Short two leads to the solar tank sensor. The circulating pump should stop running.

3) If the solar controller checks out, do the same at each sensor. This should determine if there are any shorts or breaks in sensor wires.

4) Check to see that the sensors are properly wired and the wire nuts are sealed with silicone. Corrosion at the connection points can cause the solar controller to operate improperly.

5) If the solar controller and sensor wires check out, install new sensors, starting with the tank sensor.

6) If you've checked all of these and the problem appears to be with the solar controller itself, return it to the distributor or manufacturer. Install a new controller.

Problem	Likely solution
Water leaking from roof	Probably a leaking pressure temperature relief valve. Replace with a new pressure relief valve.
A solar system circulating pump runs all night	Probably caused by a faulty controller. Check the controller troubleshooting guide in the text.
A solar system circulating pump won't run	Make sure pump is plugged into controller. If it is, then check for faulty controller.
A solar system controller light is on but pump won't run	Make sure pump is plugged into controller. If it is, then check pump impeller. May be jammed with debris. Clean out impeller.
A solar system circulating pump is running but there's no hot water in tank	Probably air trapped in pump collector. Check automatic air discharge valve on collector. (Valve cap should be loose to allow trapped air to escape.) If automatic air discharge valve seems to operate properly, then purge system by manually opening pressure relief valve.
Solar system appears to be working, yet very little hot water available in the mornings	May have a leaking lower check valve. (It's best to check for this after sundown or before sunrise.) Feel along collector line for several feet from tank. If one line is hot to the touch, check valve may be leaking. Replace or clean check valve. (Clarification of problem: Hot water in tank rises to collector, having no sun to heat water. Cools water and drains it back into tank through leaking check valve.This dilutes temperature of stored hot water. If check valve proves okay, see if tank has backup heater element. Setting may be too low or element may be faulty. Set temperature to 120° Fahrenheit.)
Solenoid valve hums	Solar system performance is not affected but noise can be annoying. Tighten nut at solenoid drain connection.
Poor general performance	Most likely cause is inferior insulation or poorly-installed insulation. Check all pipes, fittings and tank. Make sure all insulation joints are tight. Glue or tape as necessary to seal properly.
Solar circulating pump runs periodically at night	System may be thermosiphoning. This is natural circulation due to temperature differential. May be caused by a leaking lower valve. Clean check valve or replace with new one.
Solar collector freezes	May be caused by flat horizontally-mounted collector whose pitch doesn't ensure drainage. Tilt collector so that output end is higher. Should work.

Figure 18-10

Troubleshooting guide for solar water heating systems

Review Questions for Chapter 18 (answers begin on page 311)

1. How is solar energy used in homes today?
2. Why should the professional plumber know about installing solar energy units?
3. What's the first requirement for installing, repairing or altering a solar energy system?
4. In most cases, who must prepare the plans for a solar water heating system?
5. What must be included in the plumbing drawings for a solar water heating system?
6. How much pressure should a solar energy system be able to withstand when tested?
7. Why is solar energy for heating domestic water not considered new?
8. By approximately what percentage could a solar water heater lower the average household's water-heating costs?
9. What are the three major components of a solar water heating system?
10. If you're dealing with a pumped solar system, what's the fourth component you'll need?
11. What type of solar heat collector is most practical for residential use?
12. How high are the water temperatures produced by solar water heating systems?
13. What three materials are acceptable for the heat deck of a solar heat collector?
14. What's the thermal difference between using copper, aluminum or steel as heat deck materials?
15. Why must both the tubing and the collector plate be of the same metal?
16. What two purposes do you accomplish by ensuring that the solar heat collector box is well insulated?
17. Why should you use glass with a low iron content in a solar heat collector?
18. What provision should you make to prevent heat loss in a solar collector in a cold climate?
19. What quality of materials should you use for the frames and braces needed to secure solar heat collectors to roof structures?
20. How high above the roof surface should you mount solar collector panels that aren't an integral part of the roof?
21. What must a solar collector panel box have at its lowest point?
22. According to U.S. government figures, how many gallons of hot water per day will each of the first two people in a family use?
23. According to U.S. government figures, how many gallons of hot water per day should you allow for each additional family member after the first two?
24. How many gallons of hot water per day will a 4- by 12-foot solar heat collector provide?
25. What's the minimum size solar storage tank recommended for a family of four?
26. What percentage of the solar energy that strikes the glass surface of a collector actually heats the water circulating through the tubing?
27. To be the most efficient, which direction should a flat solar heat collector face?
28. Why should a solar heat collector be mounted as close as possible to the storage tank?
29. Before you install a solar heat collector as an awning or as a fixed overhang on a residence, what must you get?
30. How does a natural thermosiphon solar water heating system work?
31. When a solar storage tank is attic-mounted, what do most codes require you to install?
32. What's the minimum size piping that you can use in a thermosiphon circulation system?
33. In a pumped solar system, where can you locate the hot water storage tank?
34. What size copper tubing is permissible for use with a pumped circulation system?
35. What fluid(s) can you use in a closed solar energy collection system?

36. In a closed solar energy collection system, how is heat transferred to the water in the storage tank?

37. What standards does the *Uniform Solar Energy Code* require for pipe and fittings used within a solar system?

38. What are the two most common materials used for pipe and fittings in a solar circulation system?

39. Why can't you use plastic pipe in a solar circulation system?

40. Why should you insulate the piping that carries heated water, fluids or gases from the solar collector to the storage tank?

41. What material is required for valves up to 2 inches in diameter installed in a solar piping system?

42. Where must you install control valves in a solar system?

43. What's the required location of the combination temperature and pressure relief valve in a solar hot water storage tank?

44. If authorities require a second relief valve, besides the mandated relief valve on the storage tank, where should you place it?

45. Where must you install automatic air discharge valves?

46. When water usage in a household is reduced, resulting in hot water being stored for longer periods of time, how can you prevent the water in the solar storage tank from becoming dangerously hot?

47. What's the minimum working pressure for a solar storage tank?

48. If a solar controller is malfunctioning and you've ruled out any shorts or breaks in the sensor wires, what may be the likely cause of the malfunction?

49. When the solar system circulating pump is running but the water in the tank isn't hot, what's most likely causing the problem?

50. What is the probable cause for a solar collector freezing?

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19

Gas Systems

Every substance known to man is in one of three states — a liquid, a solid, or a gas. Although gases are lighter than the other two, they do have weight. Gas is made of constantly-moving atoms, with neither a fixed shape nor a fixed volume. When these atoms are forced into a container, they'll take on the container's shape but occupy only about one thousandth of the container's interior space. The spaces between these atoms are empty. That's why gas can be forced through very small spaces.

Gas particles liquefy when they're cooled below their boiling point. When they reach this temperature, the gas particles are pulled together to form a liquid. This is the principle used to make liquid oxygen.

The first recorded discovery of natural gas was made by an ancient Greek shepherd. He discovered that a substance coming from the ground made him lightheaded and talkative, and caused his sheep to act strangely. The Greeks, believing these vapors were the breath of Apollo, built a temple at the site.

The Chinese are credited with being the first to use natural gas for industrial purposes, nearly 3,000 years ago. Using hollow bamboo, they piped natural gas for use in evaporating brine to make salt.

The first discovery of natural gas in America was in West Virginia in 1775. The first commercial use of natural gas was at Fredonia, New York, in 1821. By 1850 many cities and towns were using gas for lighting purposes. But the gas piped to these lighting outlets was yellow and gave off a poor light. This problem was solved when scientists learned to mix air with the gas to produce a better flame.

Today, gas is used in cooking, refrigeration, heating and many industrial applications. Texas produces about 25 percent of the natural gas found in the United States. Most of the rest comes from the Midwest and Rocky and Appalachian Mountain areas. A network of natural gas pipelines transports the gas all over the country.

Since natural gas is clean, dry, and has no odor, a gas leak could go undetected until it causes an explosion. Gas producers add a chemical scent to gas before it enters the pipelines. This odor warns anyone in the area of escaping gas before the concentration can reach a danger level.

Kinds of Gas

Natural gas (methane) contains chemical impurities, which are removed before the gas is piped to the consumer. They're valuable for uses other than as a fuel. The natural gas which millions of consumers use as fuel in homes and industries is known as *dry* or *sweet gas*. While natural gas isn't poisonous, it can cause suffocation in a closed space. It's also explosive under certain conditions.

Manufactured gas is produced chiefly from coal. It's generally added to other fuels to increase its heating capacity. Manufactured gas is also used by consumers as fuel in homes and industries. It can be poisonous, since it contains carbon monoxide, and it's explosive under certain conditions.

Liquefied petroleum gas is also known as *LP* or *bottled gas*. It's produced in plants that process natural gas. LP consists primarily of butane or propane, or a mixture of both. LP gas under moderate pressure becomes a liquid, which makes it easy to transport and store in special tanks. When an LP tank supplies a building's gas, the liquid returns to its original gaseous state when it drops to normal atmospheric pressure and temperature.

LP gas is heavier than air, colorless and nonpoisonous. Since it's easily containerized and transported, it's convenient to use as fuel for homes and businesses in remote areas.

Gas Piping and the Plumber

The plumber has different responsibilities when sizing and installing a building's gas supply system instead of a water supply system. For water service pipe, the plumber sizes and installs the pipe from the meter (located at the property line) to the building. For gas service pipe, on the other hand, the gas supplier sizes and installs the piping all the way to the gas meter. The plumber's only responsible for sizing and installing the gas supply piping within the building.

When it comes to sizing or installing gas supply systems, most plumbing codes will refer you to the local gas code. The *Uniform Plumbing Code* is an exception. Chapter 12 of the *UPC* includes specifications for gas supply systems.

Your local gas code is a separate book with a complexity all its own. Regardless of your experience level, complying with the gas code can be frustrating and discouraging. But even if you don't specialize as a gas fitter and installer, you must be familiar with all the key requirements of the gas code.

You'll find all the information relevant to the plumber included in your adopted national gas code or locally-written gas code. This chapter and the next will give you a working knowledge of the essential requirements. I've simplified the information and arranged it by the way it's used. But the information here doesn't replace the gas code. The code is always your final authority.

Sizing Gas Systems

You need two factors to size the gas main and branch lines of a building:

1) The maximum gas demand at each appliance outlet

2) The length of piping required to reach the most remote outlet

There are a few other variables, like pressure loss, specific gravity and diversity, but they're already accounted for in the code tables.

Gas appliance manufacturers always attach a metal plate in a visible location on each appliance. This data plate shows the Btu input rate (the maximum gas demand). *Btu* is the abbreviation for British thermal unit, the quantity of heat required to raise the temperature of 1 pound of water 1 degree F. While the appliances are rated in Btu, the code tables size gas piping in cubic feet per hour (cfh). So you'll have to convert each Btu input rating to cubic feet of gas before sizing the distribution piping.

For this example, let's assume that each cubic foot of natural gas releases 1,000 Btu per hour. Some gas has Btu ratings that vary slightly, but 1,000 Btu per cubic foot is generally a safe assumption. Assume you're sizing pipe for a gas range with a maximum demand of 68,000 Btu per hour. Divide the value in Btu by 1,000 to find the demand in cubic feet per hour:

$$68{,}000 \text{ Btu} \div 1{,}000 = 68 \text{ cfh}$$

(If you're taking a plumbing exam and there's a question that requires you to calculate such a conversion, make sure the question doesn't require you to use a different conversion factor.)

Occasionally you may be asked to install a used appliance where the Btu rating is missing or illegible. Here's a rule of thumb for a safe installation: Make the appliance inlet pipe at least as large as the supply pipe serving the appliance. You could use a larger supply pipe without violating the code, but it won't make the appliance function any better. Just don't make the supply pipe smaller than the appliance's inlet pipe, and never smaller than $^1/_2$ inch.

Figure 19-1 gives you a sizing method that's quick and easy. But a word of caution: Use it *only* to help you understand how to use the table in your local gas code. The low pressure gas table is the one most commonly used by plumbers. Low pressure gas is used in millions of home and business installations.

Table 1215.2(1) Schedule 40 Metallic Pipe [NFPA 54: Table 6.2.1(b)][1,2]													
												Gas	Natural
												Inlet Pressure	Less than 2 psi
												Pressure Drop:	0.5 in. w.c.
												Specific Gravity:	0.60

	Pipe Size (in)													
Nominal:	**1/2**	**3/4**	**1**	**1 1/4**	**1 1/2**	**2**	**2 1/2**	**3**	**4**	**5**	**6**	**8**	**10**	**12**
Actual ID:	0.622	0.824	1.049	1.380	1.610	2.067	2.469	3.068	4.026	5.047	6.065	7.981	10.020	11.938
Length (ft)	**Capacity in Cubic Feet of Gas per Hour**													
10	172	360	678	1,390	2,090	4,020	6,400	11,300	23,100	41,800	67,600	139,000	252,000	399,000
20	118	247	466	957	1,430	2,760	4,400	7,780	15,900	28,700	46,500	95,500	173,000	275,000
30	95	199	374	768	1,150	2,220	3,530	6,250	12,700	23,000	37,300	76,700	139,000	220,000
40	81	170	320	657	985	1,900	3,020	5,350	10,900	19,700	31,900	65,600	119,000	189,000
50	72	151	284	583	873	1,680	2,680	4,740	9,660	17,500	28,300	58,200	106,000	167,000
60	65	137	257	528	791	1,520	2,430	4,290	8,760	15,800	25,600	52,700	95,700	152,000
70	60	126	237	486	728	1,400	2,230	3,950	8,050	14,600	23,600	48,500	88,100	139,000
80	56	117	220	452	677	1,300	2,080	3,670	7,490	13,600	22,000	45,100	81,900	130,000
90	52	110	207	424	635	1,220	1,950	3,450	7,030	12,700	20,600	42,300	76,900	122,000
100	50	104	195	400	600	1,160	1,840	3,260	6,640	12,000	19,500	40,000	72,600	115,000
125	44	92	173	355	532	1,020	1,630	2,890	5,890	10,600	17,200	35,400	64,300	102,000
150	40	83	157	322	482	928	1,480	2,610	5,330	9,650	15,600	32,100	58,300	92,300
175	37	77	144	296	443	854	1,360	2,410	4,910	8,880	14,400	29,500	53,600	84,900
200	34	71	134	275	412	794	1,270	2,240	4,560	8,260	13,400	27,500	49,900	79,000
250	30	63	119	244	366	704	1,120	1,980	4,050	7,320	11,900	24,300	44,200	70,000
300	27	57	108	221	331	638	1,020	1,800	3,670	6,630	10,700	22,100	40,100	63,400
350	25	53	99	203	305	587	935	1,650	3,370	6,100	9,880	20,300	36,900	58,400
400	23	49	92	189	283	546	870	1,540	3,140	5,680	9,190	18,900	34,300	54,300
450	22	46	86	177	266	512	816	1,440	2,940	5,330	8,620	17,700	32,200	50,900
500	21	43	82	168	251	484	771	1,360	2,780	5,030	8,150	16,700	30,400	48,100
550	20	41	78	159	239	459	732	1,290	2,640	4,780	7,740	15,900	28,900	45,700
600	19	39	74	152	228	438	699	1,240	2,520	4,560	7,380	15,200	27,500	43,600
650	18	38	71	145	218	420	669	1,180	2,410	4,360	7,070	14,500	26,400	41,800
700	17	36	68	140	209	403	643	1,140	2,320	4,190	6,790	14,000	25,330	40,100
750	17	35	66	135	202	389	619	1,090	2,230	4,040	6,540	13,400	24,400	38,600
800	16	34	63	130	195	375	598	1,060	2,160	3,900	6,320	13,000	23,600	37,300
850	16	33	61	126	189	363	579	1,020	2,090	3,780	6,110	12,600	22,800	36,100
900	15	32	59	122	183	352	561	992	2,020	3,660	5,930	12,200	22,100	35,000
950	15	31	58	118	178	342	545	963	1,960	3,550	5,760	11,800	21,500	34,000
1,000	14	30	56	115	173	333	530	937	1,910	3,460	5,600	11,500	20,900	33,100
1,100	14	28	53	109	164	316	503	890	1,810	3,280	5,320	10,900	19,800	31,400
1,200	13	27	51	104	156	301	480	849	1,730	3,130	5,070	10,400	18,900	30,000
1,300	12	26	49	100	150	289	460	813	1,660	3,000	4,860	9,980	18,100	28,700
1,400	12	25	47	96	144	277	442	781	1,590	2,880	4,670	9,590	17,400	27,600
1,500	11	24	45	93	139	267	426	752	1,530	2,780	4,500	9,240	16,800	26,600
1,600	11	23	44	89	134	258	411	727	1,480	2,680	4,340	8,920	16,200	25,600
1,700	11	22	42	86	130	250	398	703	1,430	2,590	4,200	8,630	15,700	24,800
1,800	10	22	41	84	126	242	386	682	1,390	2,520	4,070	8,370	15,200	24,100
1,900	10	21	40	81	122	235	375	662	1,350	2,440	3,960	8,130	14,800	23,400
2,000	NA	20	39	79	119	229	364	644	1,310	2,380	3,850	7,910	14,400	22,700

For SI units: 1 inch = 25 mm, 1 foot = 304.8 mm, 1 cubic foot per hour = 0.0283 m^3/h, 1 pound-force per square inch = 0.8947 kPa, 1 inch water column = 0.249 kPa

From the 2021 *Uniform Plumbing Code*

Figure 19-1

Maximum capacity of pipe in cubic feet of natural gas per hour

Commercial Gas Sizing Example

Figure 19-2 shows a typical gas piping arrangement for a restaurant. It's similar to what you might find on the journeyman or master plumber examination. We'll size the gas piping system using the data in Figure 19-1 and the "longest length" method. There is also a "branch length" method for advanced plumbers that can help reduce the size of branches.

Assume the total developed length of gas piping in Figure 19-2 is 147 feet from the meter to outlet A. *The developed length is the only distance you use to calculate the size of any section of the gas piping.* Now find that distance in Figure 19-1. You have to use the next longer distance if column 1 doesn't include the exact length. So you'll use the length of 150 feet. Read across to find the maximum volume that each pipe size will carry.

Now you're ready to size each section of pipe shown in Figure 19-2. Maximum gas demand of outlet A is 365,000 Btu per hour, or 365 cubic feet per hour assuming 1,000 Btu per cubic foot. Looking across the 150-foot line, the first figure that exceeds 365 is in column 6 (482 cfh). Look up to the top of the column — to find the size of pipe you should select for section A. You'd use a $1\frac{1}{2}$-inch pipe.

Use the same procedure to size each remaining section. The maximum gas demand for section B is 26 cfh, so the correct pipe size is $\frac{1}{2}$ inch. The maximum gas demand for section C includes the combined demand of sections A and B, a total of 391 cfh. Again, you'd use a $1\frac{1}{2}$-inch pipe. The maximum gas demand for section D includes the combined demand of five appliances:

30,000 + 30,000 + 25,000 + 230,000 + 90,000 = 405,000 Btu

The conversion to cubic feet yields 405 cfh. Here too, you'd use a $1\frac{1}{2}$-inch pipe. The maximum gas demand for section E includes the combined cfh of sections A, B, C, and D, for a total of 796. You'll have to go to the 2-inch pipe column to find a capacity that exceeds 796.

The maximum gas demand for section F is 289 cfh. Note that the two hot top burners have a *combined* Btu rating of 94,000. The correct pipe size for section F is 1 inch (column 5). The maximum gas demand for section G includes the combined demand of sections A, B, C, D, E and F, a total of 1,085 cfh. We have to use figure 1,480 in column eight. The correct pipe size for section G is $2\frac{1}{2}$ inches.

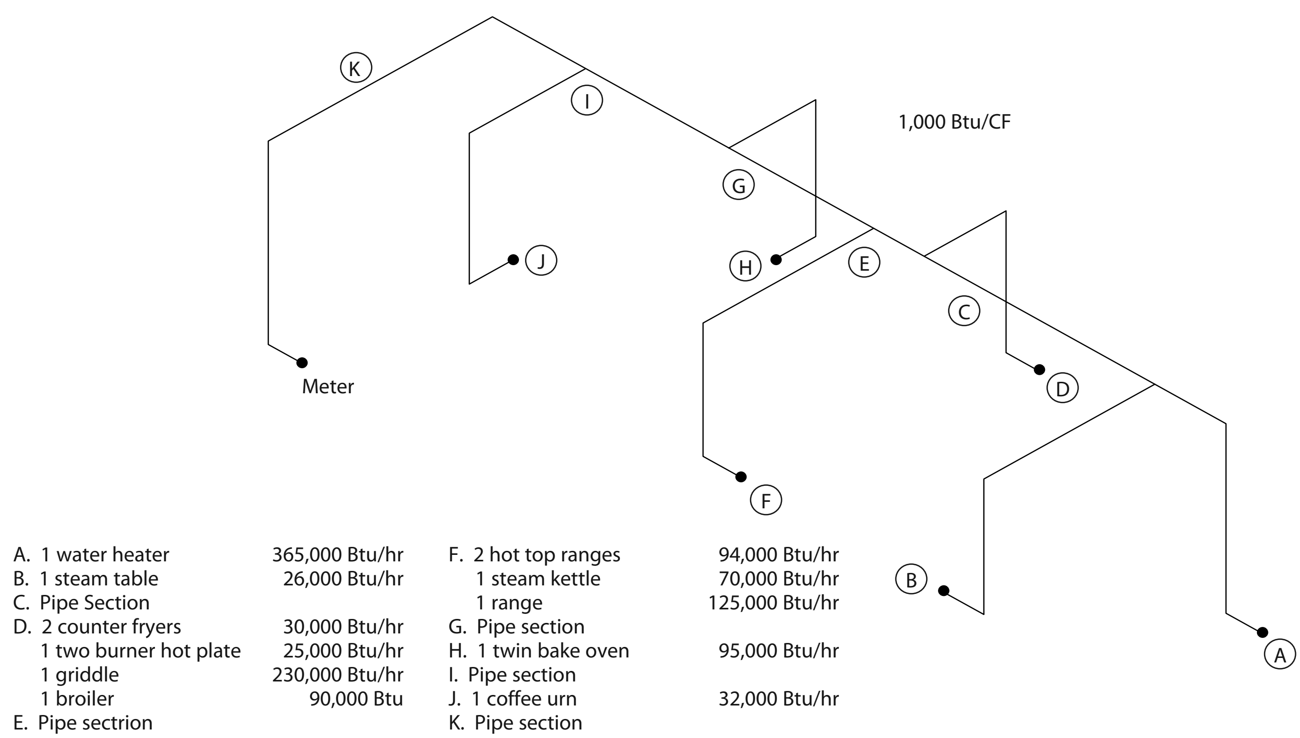


Figure 19-2
Natural gas installation for a commercial kitchen

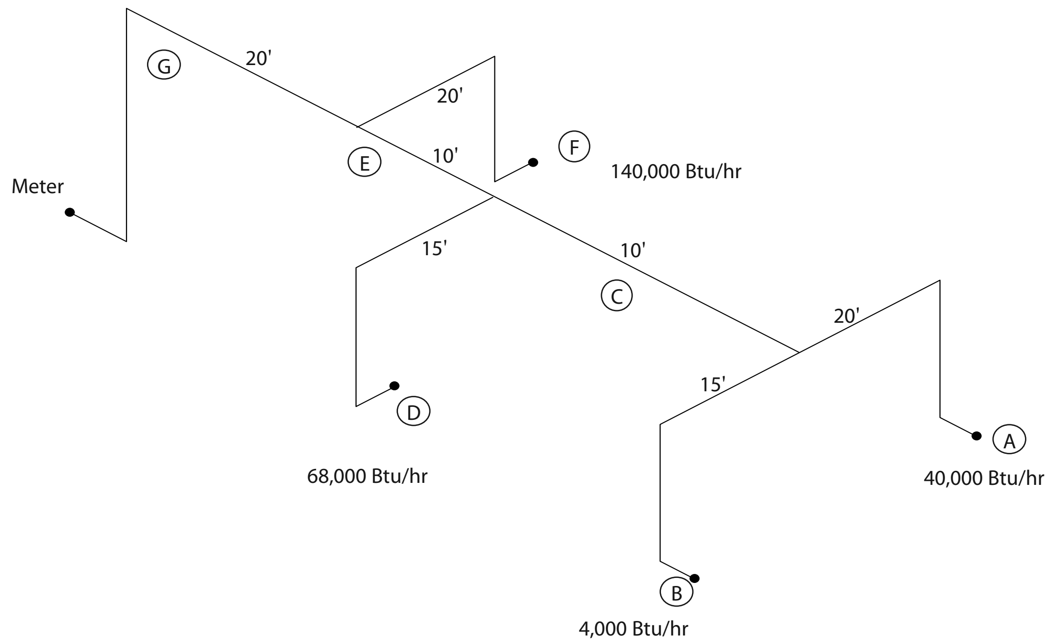


Figure 19-3
Natural gas installation for a residence

The maximum gas demand for section H is 95 cfh and the correct pipe size is 1 inch. The maximum gas demand for section I includes the combined demand of sections A, B, C, D, E, F, G and H, a total of 1,180. Again we'll use column 8 since the combined total doesn't exceed 1,480. The pipe size for section I is $2^1/_2$ inches. The maximum gas demand for section J is 32 cfh and the correct pipe size is $^1/_2$ inch. The maximum demand for section K is the cumulative total for the entire restaurant — 1,212 cfh. The correct pipe size is $2^1/_2$ inches.

We've just sized the entire gas piping system for a commercial building. Review this section until you're sure you understand how to size each section in the system.

Residential Gas Sizing Example

Size the gas piping for a single-family residence just like you sized the restaurant. The total developed length of the gas piping for a residence is usually shorter and the Btu ratings of the appliances are lower. But the sizing procedure is the same.

Figure 19-3 shows a simple gas piping system similar to what you'll find in most single-family residences. Study this illustration and the explanation in the rest of this chapter until you can size each section of pipe correctly. When you master these illustrations, you can size the pipes in any type of low pressure gas system.

The developed length of the gas piping (measured from the meter to the most remote outlet (A in this case) is 60 feet. In Figure 19-1, find the number 60 in column 1. The pipe size at the top of each demand column is the correct pipe size to use for the volume given.

The maximum gas demand of outlet A is 40,000 Btu per hour, or 40 cfh. The correct pipe size is $^1/_2$ inch (column 2). The maximum demand of outlet B is 4,000 Btu, or 4 cfh. Again, use a $^1/_2$-inch pipe. The combined maximum demand for pipe section C is 44 cfh: Use a $^1/_2$-inch pipe. Maximum demand of outlet D is 68,000 Btu per hour, or 68 cfh. The correct pipe size is $^3/_4$ inch. The combined maximum demand for pipe section E is 112 cfh, for a pipe size of $^3/_4$ inch. The maximum demand of outlet F is 140,000 Btu per hour (140 cfh). Use a 1-inch pipe. The combined maximum gas demand for pipe section G is 252 cfh. That's the maximum gas demand for the entire residence. So the correct pipe size is 1 inch.

That's all you need to know to size gas supply systems. In the next chapter you'll learn how to install them.

Review Questions for Chapter 19 (answers begin on page 314)

1. What are the three physical states of matter?
2. What does a gas consist of?
3. At what cooling point do gas particles liquefy?
4. Where was natural gas first discovered in America?
5. About 70 percent of the natural gas produced in the United States is found in which two states?
6. What is added to natural gas as a warning aid to help curb the danger of accidental explosions?
7. What three types of gases are used for fuel today?
8. By what other terms is natural gas (methane) known?
9. Although natural gas itself is not poisonous, how is it lethal?
10. What type of gas is chiefly produced from coal?
11. What poisonous substance is in manufactured gas?
12. What other terms are used for liquefied petroleum gas?
13. Liquefied petroleum gas consists primarily of what substances?
14. What physical change occurs in LP gas under moderate pressure?
15. What happens to liquefied petroleum under normal temperature and atmospheric pressure conditions?
16. Why is LP gas a convenient fuel to use in remote areas?
17. Who's responsible for sizing the gas service pipe to a building?
18. Who governs the sizing and installation methods for interior gas piping?
19. What two factors must you know before sizing any gas building main or branch lines?
20. What is the meaning of the abbreviation "Btu"?
21. How do you define one Btu?
22. How many Btu can you assume to be in each cubic foot of natural gas?
23. If you know the maximum Btu rating for an appliance, how do you convert that into cubic feet?
24. What pipe size should you use when connecting a gas supply pipe to an appliance with a missing Btu rating plate?
25. Regardless of circumstances, what's the minimum size gas supply pipe outlet that you can use?

20

Materials and Installation Methods for Gas Systems

Your local gas code regulates the materials and installation methods you can use for gas systems. Some materials are limited to certain installations, while others are completely prohibited.

When selecting the materials for gas supply pipes, tubing, or fittings, consider the characteristics of your particular gas supply and its effect on the pipes. For example, gases in certain areas are classified as corro-sive. These gases contain an average of 0.3 grains of hydrogen sulfide per 100 cubic feet. If your community gas supply is corrosive, the code won't accept certain types of materials in common use for gas piping.

Materials

A wide variety of materials are acceptable for gas piping. Some are acceptable for underground installations, some for above ground only. Some materials you can use for both. But no matter which material you use, always use fittings of the same material.

Steel and Wrought Iron Pipe

Some piping materials are widely used because of their versatility. The following materials are acceptable for interior use as well as for exterior use underground (except under a concrete slab):

- coated galvanized steel pipe
- coated galvanized wrought iron pipe

These materials are also acceptable for use with corrosive gas. See Figure 20-1. Pipe up to 2 inches is generally threaded. Seal all threaded joints tight with an approved pipe compound. Larger size pipes can be welded or flanged.

Brass and Copper Pipe

Under most codes, you can use yellow brass and copper pipe (75 percent copper) for interior gas piping. Most codes allow you to install both brass and copper pipe outside underground, but not under a concrete slab. All codes agree you can't use brass and copper pipe if the gas is corrosive.

Use brass and copper seamless tubing, Type K or L, for interior gas piping. But first, make sure it's approved by the local code authority or the area gas supplier. Solder joints between fittings and tubing with a hard solder — generally a silver solder. Or you can braze the joints, usually with a filler of brass to join the metals. If the joint isn't concealed, you can also use approved gas flare fittings for joining copper tubing. This type of gas piping generally requires special installation, so you won't see it in most general construction work.

Plastic Pipe

Plastic pipe and fittings, when approved for use by the local authority, must conform with the ASTM (American Society for Testing and Materials) specifi-

Material	Exterior underground	Interior above ground
Coated galvanized steel pipe	X	X
Coated galvanized wrought iron pipe	X	X
Black steel pipe		X
PE plastic pipe	X	
Yellow brass pipe	X	X
Copper pipe (hard)	X	X
Copper tubing (soft)	X	X

Notes

- Metallic piping installed underground must have a minimum 12" of earth cover. Plastic piping must have a minimum 18" of earth cover.
- Other codes may list materials that don't appear in this chart.
- Yellow brass pipe and copper tubing can't be used where gas is corrosive.
- Steel pipes must be coated with an approved material to prevent corrosion.
- Always check local code requirements.

Figure 20-1
Common gas piping materials and where to use them

cations. Corrosive gas doesn't affect plastic pipe and fittings, so you can use PE pipe for exterior underground installations. You can't use PE pipe in interior installations, although some codes allow the use of PVC pipe.

Plastic pipe must meet these requirements:

- Plastic pipe, tubing and fittings can be joined with solvent cement, heat fusion, or compression couplings or flanges.
- If you use solvent cement or heat fusion joints, they have to produce gas-tight joints at least as strong as the tubing being joined.
- Don't make solvent cement or heat fusion joints between different kinds of plastics.
- Use only heat fusion or mechanical joints to join polyethylene (PE) pipe, tubing or fittings. You can't use solvent cement.
- If you make compression mechanical joints, the gasket material in the fitting has to be compatible with the plastic piping, and approved by the gas company.
- Connections between metallic and plastic piping can only be made outside the building, and underground.
- Plastic pipe or tubing can't be threaded.

Corrugated Stainless Steel Piping (CSST)

Several manufacturers produce corrugated stainless-steel piping and fittings for use with natural gas and propane. This pipe requires extra protection since the walls are thin and subject to damage. When properly protected, CSST is allowed in all plumbing codes and is a reliable material. CSST is easy to install and does not require special tools. This product does have a much higher friction rate, so piping is often sized one pipe size larger than traditional steel piping. Manufacturers have training programs for CSST installation and installers are required to have the training prior to performing installations.

Installing Gas Piping

In general, these are the rules you have to follow when installing gas piping:

- Don't install it in any air duct, clothes chute, chimney or vent, ventilating duct, dumbwaiter, or elevator shaft.
- Don't install it underground closer than 8 inches from a water pipe or a sewer line.
- Don't install it in the same ditch with water, sewer or drainage pipe, unless first approved by the local authority.
- You can install it in accessible above-ceiling spaces used as an air plenum, but you can't put the valves there.

Exterior Installations

When you use horizontal metallic gas piping, be sure to place it a minimum of 12 inches underground. If you use plastic gas piping, it has to be 18 inches underground. If you're installing metallic pipe in cor-

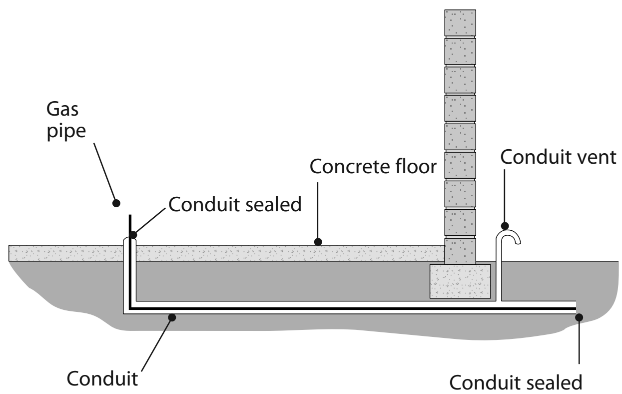


Figure 20-2
Installation beneath concrete floor

rosive soils, protect it with an approved wrapping or one or two coats of asphaltum paint. Insulate the pipe where it enters a building above ground, in crawl spaces, or anywhere it isn't protected from the cold. Many gases contain moisture which can freeze and block the pipe.

Lay underground gas piping in open trenches on a firm bed of earth. In areas where freezing temperatures occur, the trench bottom should be below the frost line to prevent freezing and rupturing of the pipe. Make sure the pipe is securely supported to prevent sagging and excessive stress during backfill. Finally, use only fine materials for backfilling.

Installation Under a Slab

Occasionally you have to install gas piping underground under a building slab. When this is unavoidable, the code permits this type of installation only if the following conditions are met:

1) The entire length of gas piping up and through the floor must be encased in conduit of a material approved for installation beneath buildings, and not less than Schedule 40 pipe.

2) The termination of the conduit above the floor must be sealed to prevent the entrance of any gas into the building in the case of a leak.

3) The termination of the conduit outside the building must be tightly sealed to prevent water from entering the conduit.

4) A vent must be extended above the grade and secured to the conduit. This vent conveys any leaking gas to the outside of the building. See Figure 20-2.

Interior Installations

If you're installing gas equipment or appliances that are subject to vibration or require mobility, connect them with an approved flexible gas hose connector. The gas hose should be no longer than necessary and no longer than 6 feet in any case. Only use approved gas hose connectors to connect the hose to the gas outlet pipe.

Installation in Concrete or Masonry

Gas appliances that aren't placed next to walls make it more difficult to conceal the gas piping. You'll have to install the gas pipe in an open channel in the concrete floor, then conceal it with a removable grill or cover that provides access to the piping. See Figure 20-3.

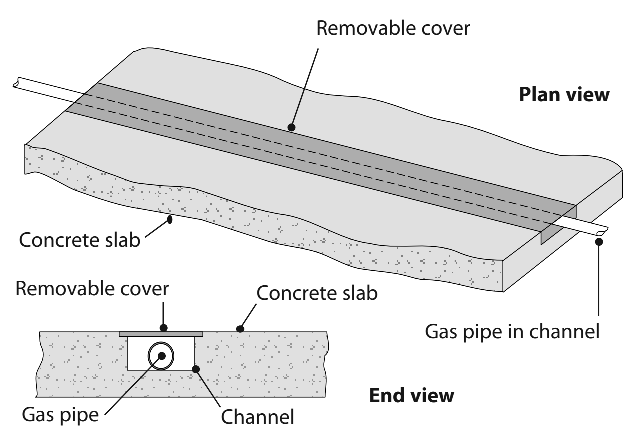


Figure 20-3
Concrete floor open-channel installation

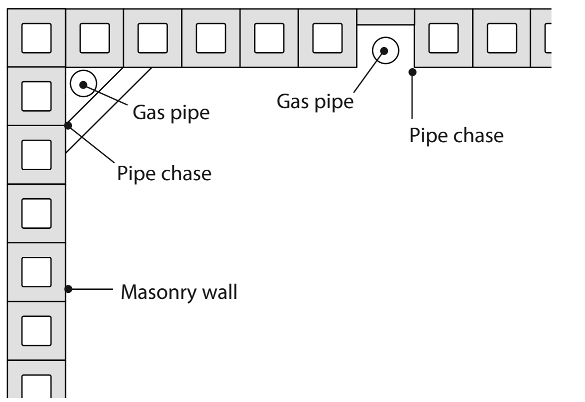


Figure 20-4
Vertical masonry wall chase — plan view

In rare cases where it's unavoidable, you can get approval from your local authority and the gas supplier to embed the pipe in concrete. You can use galvanized steel or wrought iron pipe, but you must meet the following conditions:

1) The concrete can't contain cinder aggregates or additives designed to set concrete more quickly than normal.

2) The pipe must be embedded directly in a portland cement concrete slab with a minimum of $1^1/_2$ inches of concrete on all sides.

3) The piping can't be in contact with any metallic materials.

4) You must protect the pipe from the corrosive effect of the concrete where it enters and exits the slab. Use an approved coating or sleeve.

When gas piping must pass through masonry walls, protect the pipe against corrosion by sleeving or painting. Vertical masonry walls must provide adequate chases to protect the pipe. See Figure 20-4.

The horizontal and vertical supports for gas piping and tubing must meet the same requirements as cold water piping. Look back to Chapter 14.

Installation in Partitions with Wood or Metal Studs

When installing gas piping or tubing horizontally in wood partition walls, take these steps to protect the building structure and the pipe or tubing:

1) Install short runs of horizontal gas piping or tubing that don't require additional joints through a hole drilled in the center of the partition stud. Be sure the hole isn't large enough to weaken the stud.

2) Install longer runs of horizontal gas piping or tubing in notches cut deep enough to conceal the pipe or tubing. Don't cut deeper than one-third of the total width of the stud to avoid weakening the partition.

3) Protect soft tubing in a notched partition with a metal stud guard to avoid penetration by screws or nails.

Metal stud partitions are replacing wood partitions in many new buildings. The metal studs are hollow rather than solid. Simply install the gas pipe or tubing through the manufactured openings in the center of the stud. Wrap the pipe or tubing with an approved material to prevent contact with the metal. Secure the pipe with tie wire.

Ground-joint unions may be used at exposed fixture, appliances, or equipment connections on the discharge side of a building shutoff valve. Where additional unions are needed, right and left nipples and couplings are required. Never use bushings in concealed locations. You can't make new connections on a concealed gas tubing installation, regardless of the tubing material used.

The procedure for cutting, threading and reaming of gas pipe is the same as described for water pipe in Chapter 14. Threads for gas pipe must conform with the standards adopted by the American Standards Association. See Figure 14-6 for the number and length of standard pipe threads. Avoid using pipe with chipped or torn threads.

Installing Drip Pipe and Shutoff Valves

Install gas mains so they can drain dry, with the pitch or grade toward the gas meter. And put in an appropriate drip pipe to catch any condensation that forms in the pipe. The drip pipe, usually assembled from a tee, nipple and cap, must be accessible for emptying. Don't make it smaller than the pipe or pipes it serves, or less than 18 inches long. Protect the drip pipe from freezing in colder climates. See Figure 20-5.

Gas branch pipes must connect to other horizontal pipes at the top or the side of the feeder pipe and never at the bottom. This will keep condensate from filling and obstructing the branch lines. See Figure 20-6.

Buildings with multiple tenants and a master meter must have a gas shutoff valve for each apartment. Locate each shutoff valve on the outside of the building in an accessible location near the meter. Since it is accessible, to avoid accidental or malicious tampering, the shutoff valve usually has a square nut head that requires a special tool.

Each gas appliance inside a building must have an accessible, manually-operated shutoff valve. This interior valve must have a lever handle that doesn't require a tool. Shutoff valves are available in two types for convenient use: a straight pattern or an angle pattern. Locate it as close as possible to the gas outlet pipe, not more than 6 feet from the appliance it serves.

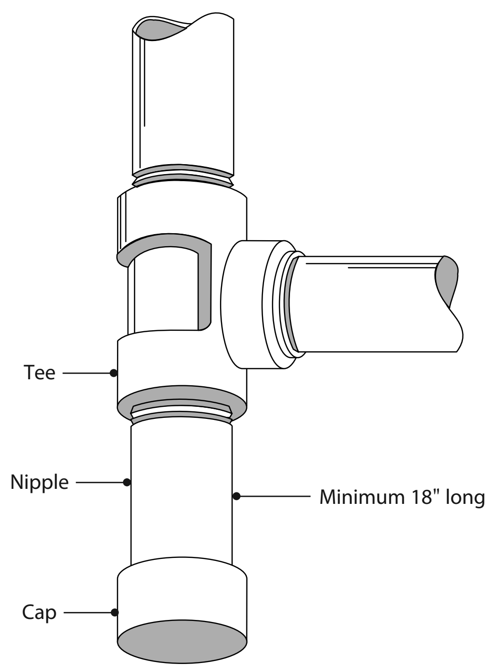


Figure 20-5
Drip pipe

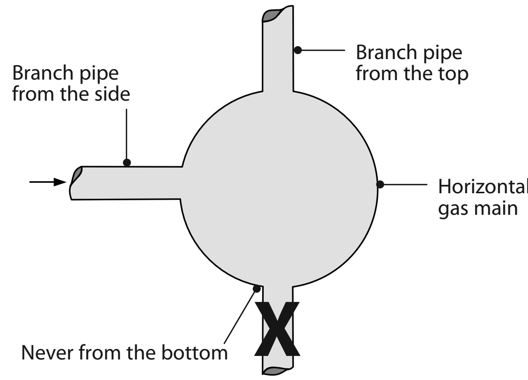


Figure 20-6
Branch pipe connection to horizontal pipe

Don't conceal the completed gas installation until it's been pressure tested. Cap each outlet and install a pressure gauge on one of the outlets. Pressure test at 10 pounds per square inch for at least 15 minutes. The system must remain airtight (no loss of pressure) until after inspection. If a leak should occur, find the leak by running a small brush dipped in liquid soap around each joint. The leaking joint will blow bubbles.

Installing and Venting Gas Appliances

It's the plumber's job to connect the gas from the wall outlet to the appliance, with either a rigid pipe or an approved flexible connector. When the appliances are connected, the gas supplier will purge the lines of air, check for leaks at the joints that connect the appliance to the gas system, light any pilot lights, and finally, adjust each appliance.

Gas appliances such as water heaters and clothes dryers can be installed on the floor of a residential garage under these circumstances:

- The combustion chamber must be a minimum of 18 inches above the floor or adjacent ground
- The appliance is certified as "FVIR" Flammable Vapor Ignition Resistant.

If you install an appliance in a separate room off the garage, the walls, ceiling and door of the room must have a one-hour fire rating if the appliance has

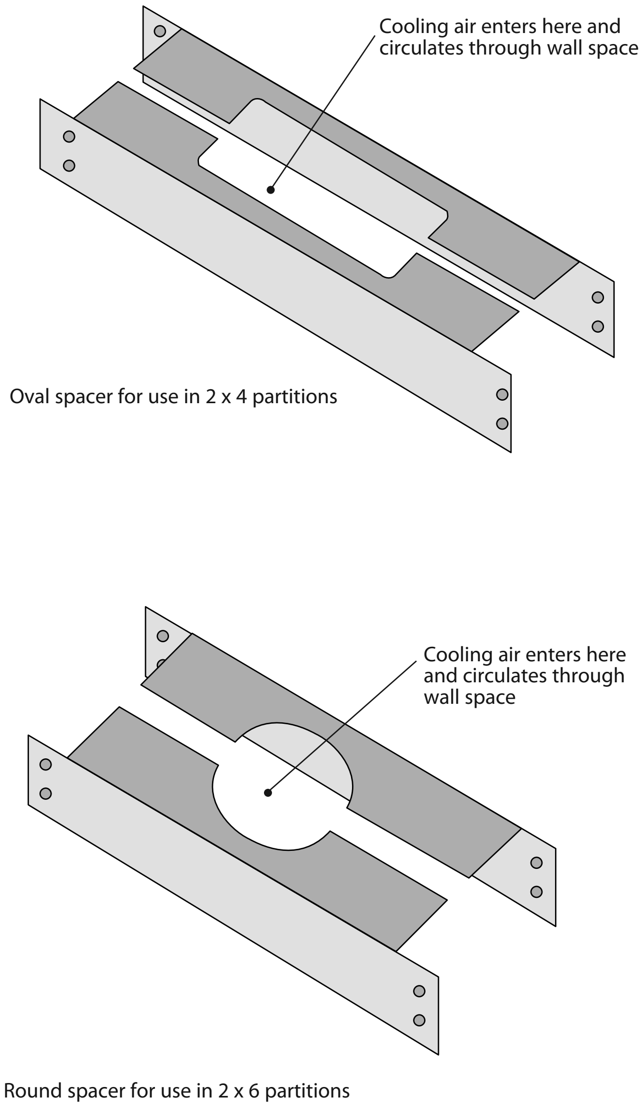


Figure 20-7
Vent pipe spacers

an input of 100,000 Btu or less. It must ventilate through permanent openings with a total free area of 1 square inch for each 1,000 Btu per hour of input rating (with a minimum of two 50-square-inch openings). One vent opening should be a minimum of 12 inches above the floor. The second opening should be a minimum of 12 inches below the ceiling. This provides enough air circulation for the combustion and dilution of the flue gases.

Always install gas appliances so there's access to the appliance for repairs and cleaning as well as the intended use. You can't locate water heaters in any living area that may be closed off, like bedrooms or bathrooms.

Install any appliances that must be vented as close to the vent pipe as possible. If a draft hood is required, the vent pipe can't be smaller than the opening of the draft hood. Provide sufficient clearance between gas appliances and vents and combustible materials to avoid a fire hazard. Place gas water heaters with an insulated jacket at least 2 inches from any combustible material, or 1 inch from one-hour fire-rated materials.

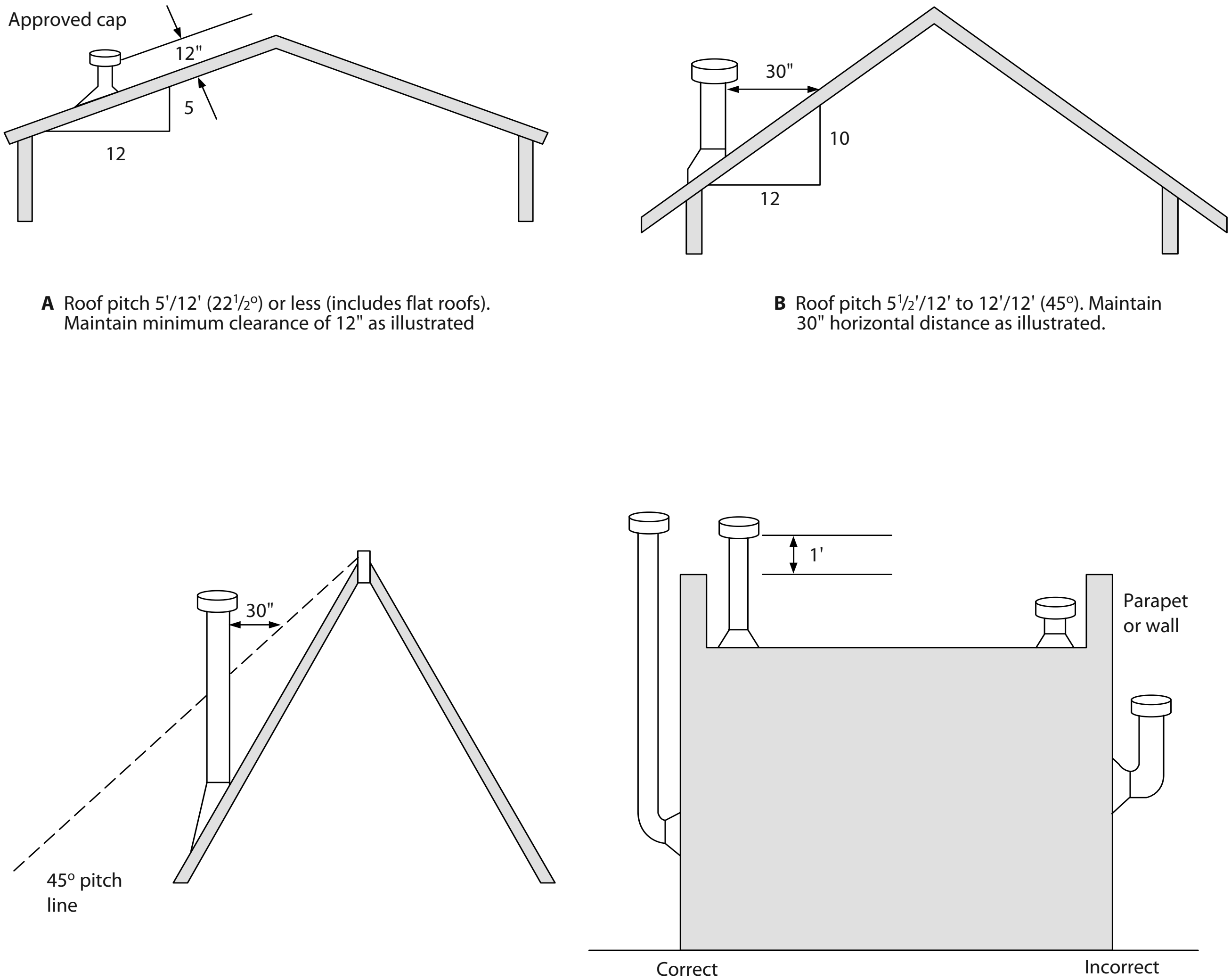
There are two acceptable types of concealed vent pipe material. The most common is the *double-wall metal pipe* and fittings. The clearance distance recommended by the manufacturer is stamped in the metal. It's usually at least 1 inch from any combustible material. The second vent material still found in older homes, is *asbestos cement flue pipe.* It should have a clearance of $1^1/_2$ inches from any combustible material. Vent pipes in partitions built of combustible material must have an approved metal spacer that keeps the surface temperature below 160 degrees F. See Figure 20-7.

You can use *single-wall vent pipe* for exposed vent pipe installed in a room built of noncombustible material. Support all horizontal vent pipes to prevent sagging or misalignment. Use straps or hangers that are at least 20 gauge sheet metal. The horizontal vent section length can't exceed 75 percent of the vertical vent length.

Here are the requirements for locating the exit terminal of a vent pipe:

- Don't put it closer than 4 feet from any opening through which combustion products could enter the building.
- Don't put it closer than 2 feet from an adjacent building.
- Make sure it's at least 4 feet from any property line except a public way.

All vent pipes above the roof of a building must terminate in a UL-approved cap. Figure 20-8 shows several examples of acceptable vent pipe terminations outside a building.



A Roof pitch 5'/12' ($22\frac{1}{2}^\circ$) or less (includes flat roofs). Maintain minimum clearance of 12" as illustrated

B Roof pitch $5\frac{1}{2}$'/12' to 12'/12' (45°). Maintain 30" horizontal distance as illustrated.

C Roof pitch greater than 12'/12' or vertical wall. Maintain 30" horizontal distance from 45° pitch (12'/12') line.

D Vent top should be located 1' above parapet or wall when within 30"

Figure 20-8

Acceptable pipe terminations

Review Questions for Chapter 20 (answers begin on page 315)

1. What must you consider when selecting piping materials for a gas system?
2. What two piping materials are code-accepted for both underground and above ground gas installations where corrosive gas may be present?
3. Name two piping materials that are acceptable for use in a gas system where the gas is corrosive.
4. What percent of yellow brass pipe must be copper if you're using it in a gas installation?
5. Where are you not allowed to install brass and copper pipe in an underground installation?
6. Under what condition should you not use copper piping in a gas system?
7. If approved by your local code or gas supplier, which two weights of copper pipe and tubing can you use for interior gas piping?
8. When joints are necessary in a copper gas piping system, what type of solder must you use?
9. Under what conditions can you use approved gas flare fittings in a copper gas piping system?
10. When plastic pipe and fittings are approved for a gas system, what national organization's specifications must they conform to?
11. In what locations can you make connections between metallic and plastic piping?
12. Name three locations in a building where you should never install gas piping.
13. What's the minimum distance you must maintain between gas piping and a water pipe or a sewer line in an underground installation?
14. What's the minimum depth for placing underground horizontal metallic gas piping?
15. What's the minimum depth for placing underground horizontal plastic gas piping?
16. What's one method of protecting gas piping if you're installing it in corrosive soil?
17. How deep should you install gas piping in areas subject to freezing temperatures?
18. What type of backfill should you use when backfilling a trench containing gas piping?
19. Under what conditions can you install gas piping under a slab?
20. What type of connection do you use for gas equipment or appliances subject to vibration or requiring mobility?
21. How should you install gas piping to serve an appliance located in the center of a room?
22. What must you provide to protect gas piping in vertical masonry walls?
23. For what type of gas pipe installation may you drill a hole in the center of a partition stud?
24. Why shouldn't you notch a partition stud deeper than one-third its total width?
25. How should you protect soft tubing in a notched partition?
26. How should you secure gas piping installed in metal stud partitions?
27. When are bushings permitted in a concealed gas piping system?
28. What must you do to prevent a union in an existing concealed gas line from loosening?
29. When are you allowed to make a new connection on an existing concealed gas piping or tubing installation?
30. The procedure for preparing threads for gas piping is the same as for what other type of piping?
31. To what standards must the threads for gas piping conform?
32. What must you install to catch any condensation that may form in a gas main?
33. Why should gas branch pipes connect only at the top or side of a gas feeder pipe?
34. Why should a shutoff valve be installed near the gas meter?
35. How is accidental or malicious tampering with the outside gas shutoff valve avoided?
36. What type of shutoff valve is required for each gas appliance in a building?
37. What two types of shutoff valves are manufactured for appliances?

38. What's the maximum distance allowed from a shut-off valve to the appliance it serves?

39. What must you do before you can conceal a completed gas installation unit?

40. What's the safest way to check gas piping for leaks?

41. At what minimum height above the garage floor can you set the combustion chamber for a gas water heater?

42. If you install a gas appliance having a 100,000 Btu input or less in a separate room off the garage, exactly what number and size of ventilation opening(s) must you provide, and at what location in the room?

43. Where must you never install a gas water heater?

44. Where must you install gas appliances that require venting?

45. What size vent pipe is required for a 30-gallon gas water heater with a 4-inch draft hood?

46. What's the minimum separation required between a gas water heater with an insulated jacket and any combustible material?

47. What are the two acceptable types of concealed gas vent piping materials?

48. What must you provide for gas vent pipes installed in partitions constructed of combustible material?

49. What gauge metal straps or hangers should you use to support horizontal gas vent piping?

50. How must all gas vent pipes extending above a roof terminate?

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21

Plumbing Fixtures

Over the past 100 years, plumbing organizations have developed well-recognized standards that control the quality and design for all plumbing fixtures in use today. As a plumbing professional, it's your responsibility to install only high-quality fixtures that conform in design to the standards in Figure 21-1. Never allow substandard fixtures that will detract from the quality of the work you do.

Fixtures must be acid resistant and free from defects and concealed fouling surfaces. All fixtures must be set level and in proper alignment with the adjacent walls. And fixtures constructed of pervious materials (such as baths or showers made of tile or marble) must have a waste outlet that can't retain water.

Installing Plumbing Fixtures

Never install fixtures in a room that doesn't have adequate light and ventilation. If there's no window for natural ventilation, you must install a fan and duct. Because inadequate lighting or ventilation promotes unsanitary conditions, most codes prohibit locating fixtures in areas without them.

Water Closets

Grout all water closets, wall-hung or floor-mounted, with white cement or any suitable material to provide a watertight seal at the joint with the wall or floor. This prevents the accumulation of odor-causing materials, avoids other unsanitary conditions and keeps roaches and other insects away from these areas.

Water closets installed for public use (anyplace except a single-family residence or apartment building) must have an elongated bowl equipped with an open front seat. Seats for water closets must be made of smooth nonabsorbent materials and they must fit the water closet bowl. For example, you can't install a round front seat on an elongated bowl.

Wall-hung water closets should be rigidly supported with brass bolts on a concealed metal carrier. Make sure the fixture pipe connection doesn't carry any of the load.

Water closets with tanks designed to use ballcocks must refill after each flushing and then close tight when the tank is full. The flush valve operates manually but the flushing operation must be automatic after it's manually activated. The flushing device and the connection between the tank and the bowl should have enough flow capacity to allow the water to flush all surfaces of the bowl.

The tank has to have a refill tube reaching and turning down into the overflow tube. Water from this tube automatically restores the closet bowl water seal. Make sure there's an antisiphon valve built into the unit to prevent contamination of the potable water supply.

Plumbing fixtures and authorized approvals from *Uniform Plumbing Code* (Table 1701.1)			
	IAPMO	**ISEA**	**ASME**
Plastic bathtub units	Z 124.1-2017		
Plastic lavatories	Z 124.3-2017		
Emergency eyewash and shower equipment		Z 358.1-2014	
Macerating toilet systems and related components			A 112.3.4-2018
Water closet personal hygiene devices			A 112.4.2-2015
Grease interceptors			A 112.14.3-2018
Whirlpool bathtub appliances			A 112.19.7M-2017
Grease removal devices			A 112.14.4-2001
Plastic shower units	IGC 154-2019		
Plumbing Fixture Trim			
Trim for water closet bowls, tanks and urinals			A 112.19.5-2017
Plastic toilet (water closet) seats	Z 124.5-2013		
Plumbing supply fittings			A 112.18.1-2018

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Note: For maximum allowable water usage for plumbing fixtures, see Figure 11-1.

Figure 21-1
Plumbing fixture standards

Each tank also has to have an overflow tube adequate to prevent tank overflow and remove excess water at the rate it enters the tank. Consider what would happen if the flush ball were securely in place on the flush valve seat and the ballcock locked in an open position. The flush valve seat must be a minimum of 1 inch above the rim of the bowl.

A water closet using a flushometer instead of a tank has to have a vacuum breaker located a minimum of 6 inches above the rim of the bowl. It must complete the normal flushing cycle automatically after being manually activated, and deliver enough water to flush all surfaces of the bowl. It should open fully, and close tight under the normal water working pressure. Each flushometer can serve only one water closet, and must be readily accessible for repair. The valve must have some way to regulate the water that flows with each flush.

The *Uniform Plumbing Code* requires all water closets, tank or flushometer, to have a maximum average consumption of 1.6 gallons of water per flush.

Urinals

Wall-hung urinals must be rigidly supported by a concealed metal carrier or other approved backing so no strain is transmitted to the pipe connection. Grout the joint between the urinal and the finished wall surfaces with white cement or other suitable material to provide a watertight seal.

When you install floor-mounted stall urinals, put them slightly below the finished floor to provide drainage. Then put beehive strainers in the waste opening. The trap size is 2 inches.

A urinal with a flushometer must complete the normal flushing cycle automatically after it's manually activated. It must deliver enough water to flush all surfaces of the urinal. The valve must open fully, and close tight at normal water pressure. The urinal must also have some means of regulating water flow. Only one urinal can be served by a single flushometer.

Where a single flushing tank serves several urinals, it must operate automatically once it's manually activated, and have enough capacity to cleanse all urinals simultaneously. For *Uniform Plumbing Code* compliance, urinals must have an average consumption of 1.0 gallons of water per flush.

There are also waterless urinals which use chemical cartridges rather than water.

Lavatories

Wall-hung lavatories for commercial use are supported by a concealed metal carrier. The carrier provides the lavatory with enough support so the fixture pipe connection and the finished wall carry no strain. That makes it unlikely that the lavatory can pull away from the wall. In residential installations, you'll generally support wall-hung lavatories with a metal bracket screwed securely to wood backing fastened to the bathroom partition studs.

The point of lavatory contact to finished wall surfaces must be sealed with white cement or other suitable material.

Cabinet-mounted lavatories are securely fastened to the countertop by special rim clips and are made watertight with a caulking compound or other adhesive. The weight is transferred to the cabinet top and places no strain on the fixture piping.

Other wall-mounted fixtures must be adequately supported and grouted for sanitary purposes. Even shower rods must have a suitable backing so they don't work loose from the wall.

Waste outlets for lavatories must be a minimum of $1^1/_4$ inches outside diameter.

Where circular-type multiple wash sinks are used, each 18 inches of wash sink circumference is considered one lavatory (one fixture unit). Straight-line multiple wash sinks must have a separate set of faucet combinations no closer than 18 inches from center to center. Each faucet set is considered to be one lavatory (one fixture unit).

According to the *International Plumbing Code*, lavatory faucets must have aerators and a maximum water flow rate of 2.2 gallons per minute.

Bathtubs and Showers

The minimum size waste and overflow for bathtubs is $1^1/_2$ inches. There are several approved tub waste and overflows in use today. But some codes prohibit a trip waste because they're difficult to adjust to properly retain and discharge tub water. Any bathtub that's recessed into tile or other finished wall materials must have waterproof joints. The walls must be of smooth, noncorrosive and nonabsorbent waterproof materials to a height of 4 feet above the rim of the tub.

The waste outlet for a shower compartment floor must be at least 2 inches in diameter per *UPC* standards, or $1^1/_2$ inches under the *IPC*; it must be located so water will drain from the shower floor without puddling. The strainer must have a diameter of at least $3^1/_2$ inches, and be removable so the trap can be cleaned. Shower traps can't be smaller than the waste outlet pipe used in the shower compartment.

Shower compartments need a minimum floor area of 1,024 square inches, according to *UPC* standards, whereas the *IPC* only requires 900 square inches; both require a minimum span between walls of 30 inches — adequate for use by adults. The floors must be smooth and sound. Institutional or gang showers used by more than one bather at a time have to be designed so waste water from one bather doesn't pass over areas occupied by other bathers.

Where shower pans are required, use pans of lead, copper or other approved materials. Here are the minimum weights:

- Lead pans — at least 4 pounds per square foot
- Copper pans — at least No. 24 B & S gauge
- Nonmetallic — pan may be constructed (on site) of three layers of 15-pound asphalt impregnated roofing felt

A shower pan of lead or copper must be protected from corrosion where it joins concrete or mortar, with asphaltum paint inside and outside. Place a layer of 30-pound asphalt-saturated felt or a $^1/_2$-inch-thick layer of sand under the pan. This protects the pan against rough surfaces and helps avoid accidental puncturing before it's protected by the finished floor material.

Cut the shower pan large enough to allow a turned-up edge on all sides above the finished curb at least 3 inches, if you're working under *UPC* jurisdictions, or no less than 2 inches under the *IPC*. Shower pans must be securely fastened to the shower strainer base at the invert of the weep holes. Use a clamping ring to make a watertight joint between the shower waste outlet stub and the pan.

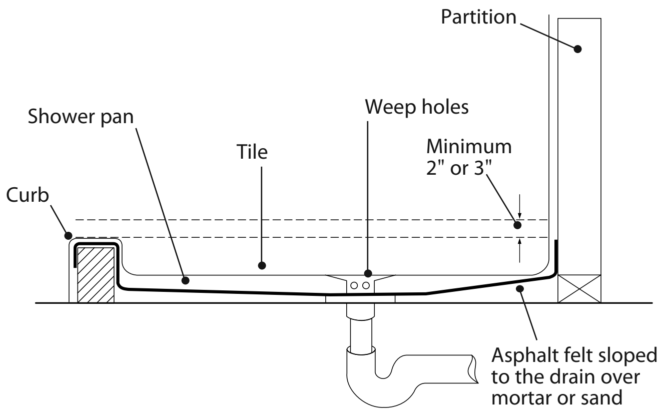

Figure 21-2
Shower pan installation detail

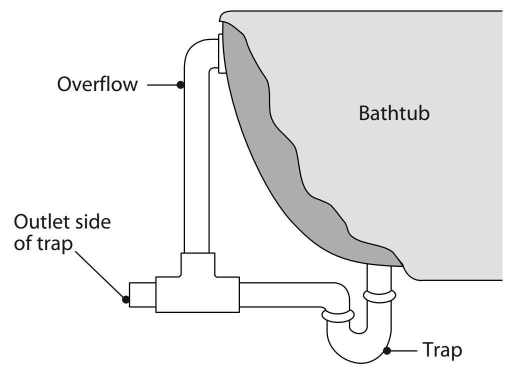

Figure 21-3
Prohibited overflow connection

Support shower pan material with an adequate backing that's secured to the partition studs. This prevents the pan sides from sagging before the interior of the shower compartment is in place to hold the pan rigid. If you have to puncture the shower pan material to secure it in place, make sure the penetration isn't less than 1 inch above the finished curb. Figure 21-2 shows a correctly installed pan.

To test each shower pan, remove the shower strainer plate and plug waste outlet. Fill the pan with water. The pan must be full and ready for the tub and water pipe inspection. Otherwise, the plumbing contractor may have to pay for a reinspection.

Shower pans aren't required in prefabricated shower stalls. But these stalls require individual approval by the plumbing inspector for watertightness. Walls of shower compartments must be waterproof, smooth, noncorrosive and nonabsorbent to 6 feet above the floor. Federal standards state that no shower head can have a flow greater than 2.5 gallons per minute, though some states have even stricter limitations.

Sinks and Laundry Tubs

Waste for sinks and laundry tubs must be at least $1^1/_2$ inches in diameter. Tail pieces and continuous waste pipe must be at least $1^1/_2$ inches outside diameter. Each compartment in a laundry tub needs a waste outlet with a suitable stopper for retaining water.

Domestic sinks need a waste opening at least $3^1/_2$ inches in diameter if there's a waste disposer unit installed.

The *Uniform Plumbing Code* requires that kitchen sink faucets be designed with aerators and have a maximum water flow rate of 2.2 gallons per minute.

Fixture Overflows

Bathtubs and lavatories are two of the more common fixtures provided with overflows. But the code doesn't require overflows on lavatories, so they're often omitted. Integral overflow passageways provide an escape for excess water below the flood-level rim of the fixture, as well as secondary protection against self-siphonage of a fixture trap.

When a plumbing fixture does have an overflow, the waste pipe must serve two purposes. It has to prevent water from rising into the overflow when the stopper is closed, as well as stop water from staying in the overflow when the drain is open for emptying.

Connect the overflow pipe or passageway from a fixture on the inlet side of the fixture trap. This prevents sewer gases and odors from entering the room through the overflow. The code prohibits connecting the overflow of a fixture to any other part of a drainage system. Figure 21-3 shows a prohibited connection.

Fixtures must have durable strainers or stoppers, but they can't prevent rapid drainage of the fixture. There's an exception for fixtures with integral traps, such as water closets, some bidets and some wall-hung urinals. A strainer can't be smaller than the fixture waste outlet it serves and should be easy to remove for cleaning if it's not fixed (manufactured as part of the fixture and not removable).

Food Waste Disposers

You can install a food waste disposer in the two-compartment sink as shown in Figure 21-4 even if there's not a second waste opening available. The waste can flow through a single $1^1/_2$-inch trap if you use a special directional tee or wye, as shown in Figure 21-5.

Commercial food waste grinders must waste directly into the sanitary drainage system, never through a grease interceptor. The waste pipe from a commercial food waste grinder must be equal in size to the discharge opening of the machine, and at least 2 inches. The grinder has to be individually trapped and vented just like any other fixture.

Dishwashers

Dishwasher manufacturers typically have installation instructions that allow the discharge to connect either directly to a waste tee in the tailpiece of a sink, as shown in Figure 21-6, or through an air gap fitting, as shown in Figures 21-7 and 21-8. These are usually deck-mounted to the sink or cabinet top.

Even though the manufacturer may allow installation without an air gap, there are many jurisdictions, including all those following the *Uniform Plumbing Code*, that require drainage through one. An air gap fitting provides the best protection from the dishwasher filling with waste water in the event of a clogged kitchen drain pipe.

A dishwasher may not be placed more than 5 feet from the sink waste connection.

If there's a food disposer unit installed in the sink, the waste from the dishwasher must connect to the tap in the body of food disposer (Figure 21-8).

Floor Flanges

Securely fasten all floor fixtures to an approved floor flange with brass bolts or screws. Flanges for floor fixtures have to be set on top of the finished floor, not recessed flush with it. See Figure 21-9.

Plumbing fixtures with a flanged connection between the fixture and the drainage pipe must be set in setting compound or have an approved gasket or washer. Graphite-impregnated asbestos and felt are approved gasket materials.

The flanges must be of the same material, or compatible with, the materials in a drainage system. Here are the requirements for each kind of system:

- If you use lead stubs to secure the fixture to the drainage system, solder a brass or hard lead flange securely to the stub.
- If you use copper stubs in a copper drainage system, solder a brass flange securely to the copper stub.
- In a cast iron drainage system, cast iron stubs are acceptable under some codes. Then you can use a cast iron flange with a lead and oakum joint to secure the floor flange to the cast iron stub.
- In a plastic drainage system, cement-weld the plastic floor flange to the plastic stub.

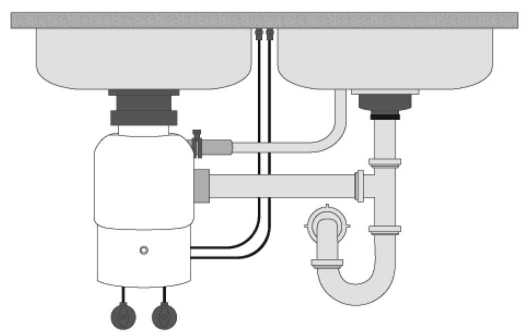

Figure 21-4
Disposer in two-compartment sink

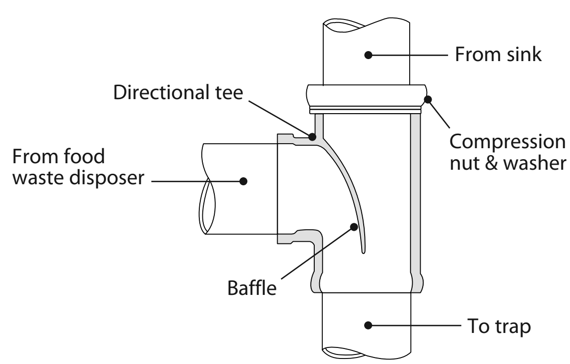

Figure 21-5
Directional tee

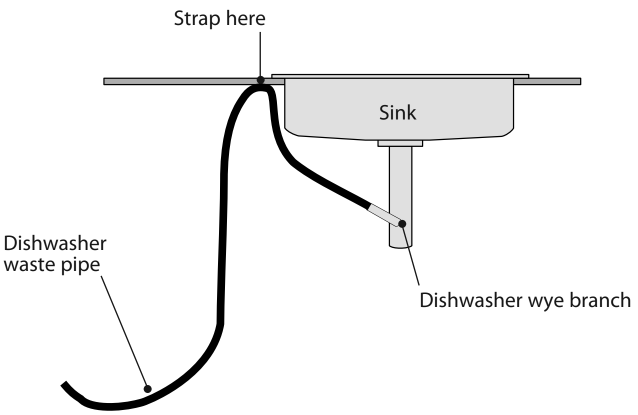

Figure 21-6
Dishwasher connection through wye branch

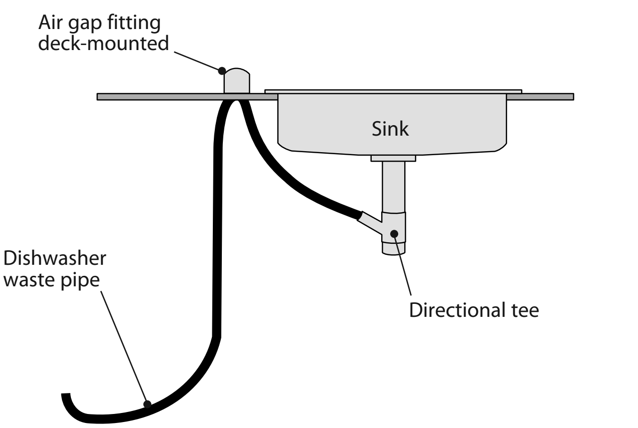

Figure 21-7
Dishwasher connection through directional tee with air gap fitting

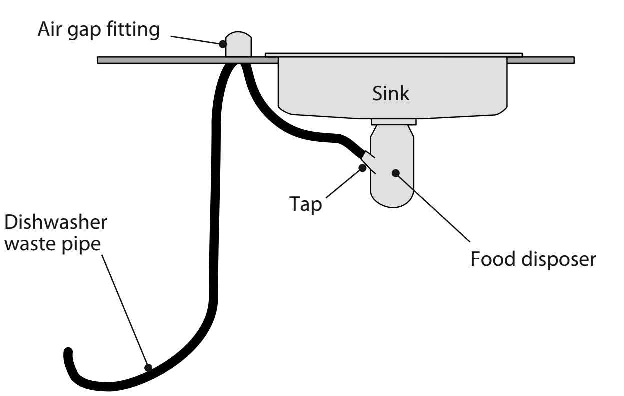

Figure 21-8
Dishwasher connection through food disposer with air gap fitting

Floor Drains

Floor drains are considered fixtures. The traps of floor drains must have a permanent water seal fed from an approved source of water, or an automatic priming device designed and installed for that purpose. This permanent water supply has to retain the trap's seal and prevent evaporation from drying out the trap. A dry trap lets sewer gases enter the building.

You can connect condensate drain waste from air conditioning units to a floor drain, but it's not enough to supply a permanent water seal. A single drinking fountain waste can discharge to a floor drain if it's not in a restroom. This is usually considered an adequate water supply to protect the trap seal.

The discharge from a garbage can washer can't discharge through a trap serving any other device or fixture. Connect the waste pipe directly into the greasy waste line, discharging through a grease interceptor. The receptacle (floor drain) that receives the waste from the garbage can washer must have a basket to collect solids 1/2 inch or larger in size. It's essential that the basket be easily removable for cleaning.

The hot and cold water connection must be properly valved and have an approved vacuum fitting to prevent cross-connection. See Figure 21-10.

Floor drains serving indirect waste pipes from food or drink storage rooms or appliances can't be located in toilet rooms or in any inaccessible or unventilated

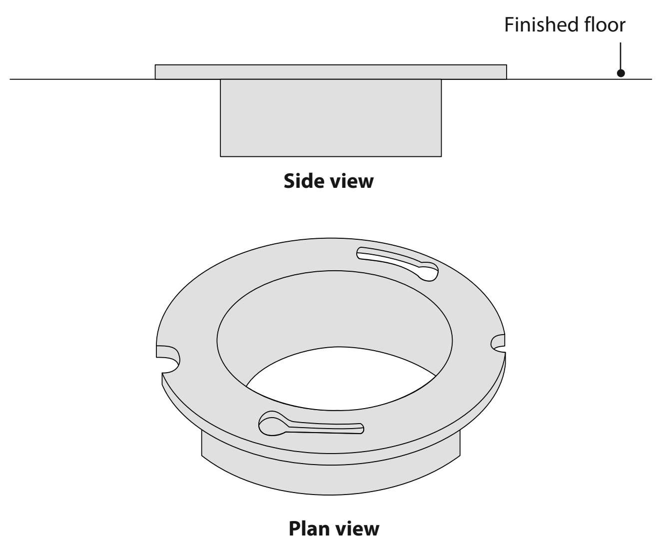

Figure 21-9
Closet floor flange

closet or store room. You can't install any type of plumbing fixture in a room containing air handling machinery.

Special fixtures such as baptisteries, ornamental pools, aquariums, ornamental fountains, developing tanks or sinks and similar fixtures that have a waste and water connection should have the water supply protected from back-siphonage with an approved vacuum breaker.

Plumbing Fixture Clearances

Install all plumbing fixtures with spacing that permits easy access for cleaning and repair, as well as the intended use. Figure 21-11 illustrates the minimum clearances required in most codes. Refer to your local code for your particular requirements.

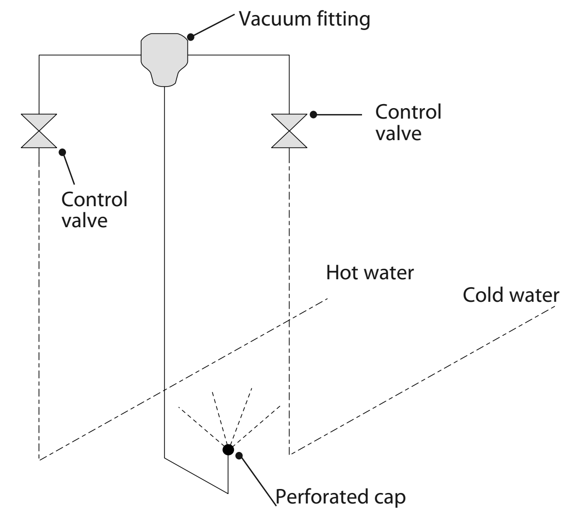

Figure 21-10
Garbage can washer piping diagram

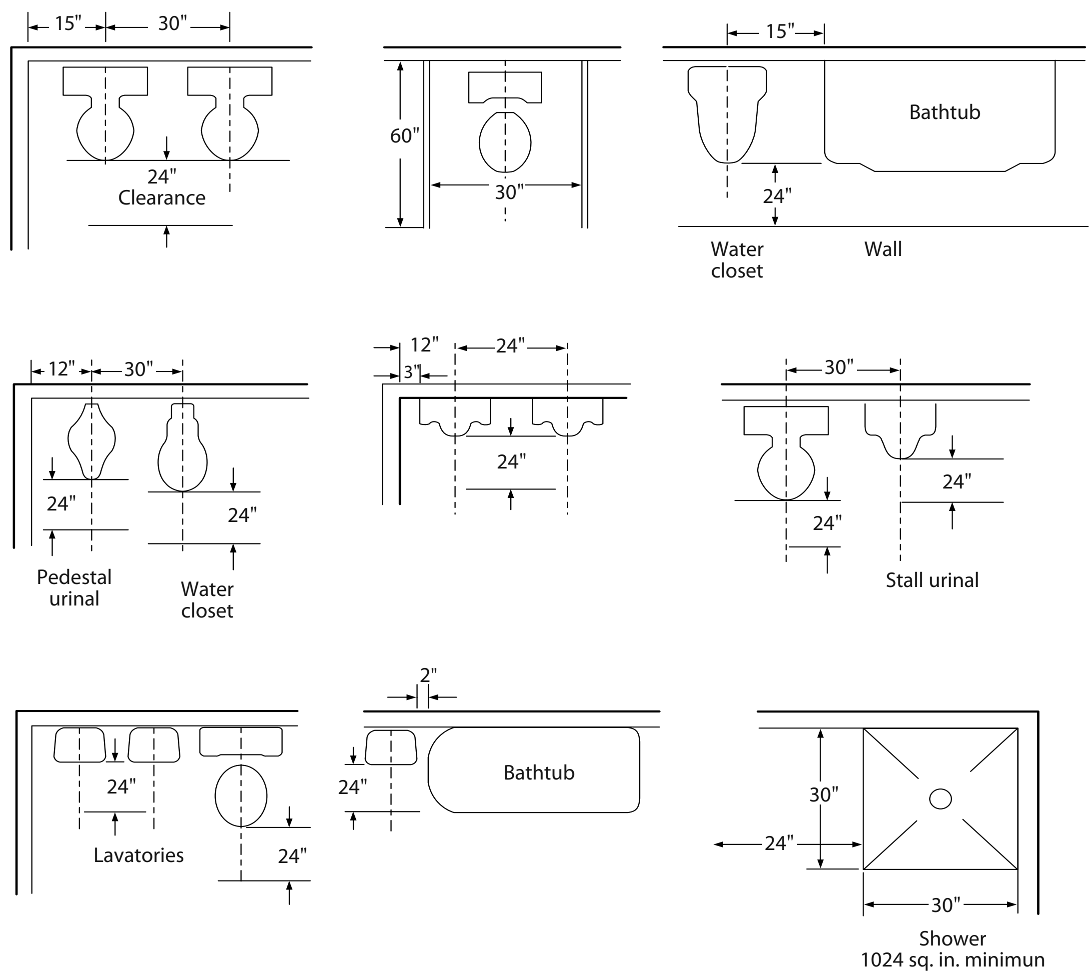

Figure 21-11
Minimum fixture clearances (UPC)

- *Water closets* must have a minimum spacing of 30 inches center-to-center when set in battery installations. They must be set a minimum of 15 inches from the center of the bowl to any finished wall or partition, and a minimum of 15 inches from the center of the bowl to the outside edge of a tub apron. Finally, they must have a minimum clearance of 24 inches from the front of the bowl to any finished wall, door or other plumbing fixture.
- *Urinals*, whether pedestal, stall or wall-hung, require a minimum 24-inch center-to-center spacing when set in a battery installation. They must have a minimum 12-inch clearance from the center of the urinal to any finished wall. Stall and wall-hung urinals must have a minimum clearance of 24 inches from the front of the urinal to any finished wall, door or other plumbing fixture.
- *Lavatories* are manufactured in various designs and widths, so center-to-center measurements don't apply. They must have a clearance of 24 inches from the front of the lavatory to any finished wall, door or other plumbing fixture.
- *Shower* compartment or stalls must have a minimum clearance of 24 inches from the opening to any finished wall, door or other plumbing fixture for easy entry and exit.

Plumbing for Persons with Disabilities

It has become increasingly important to select plumbing fixtures and install them in compliance with the ADA (Americans with Disabilities Act).

If you're selecting a plumbing fixture, make sure it meets ADA requirements. Time and material costs add up quickly, and you don't want to have to remove a fixture you just installed. Look for the wheelchair symbol or other indication on the packaging and in the specifications cut sheet that shows the fixture's design meets the requirements of ADA laws.

Toilets (ADA)

You'll often find a non-compliant toilet already installed by a building owner or his plumber. In non-residential applications the inspector may require the toilet be replaced with one that complies with accessibility codes.

Not all toilets are tall enough to meet ADA law. Toilet seat heights are required to be set at a finished height of 17 to 19 inches from the floor. You can buy a seat that adds a few inches to the height, but the better option is to install an ADA-height toilet.

Whether you install a tank type or flush valve type toilet, the handle for operating the toilet must be on the wide side of the room. Most toilets come with a handle on the left side of the tank. If the wider side of the bathroom wall is on the right side of a toilet, you'll have to order a custom tank that has the handle on the right side of the tank.

Toilets must be set no closer than 16 inches and no more than 18 inches from a finished wall. When you're roughing in the toilet location where the drywall's not in yet, make sure you take into account the thickness of the drywall. If you set the toilet 16 inches from the sill plate, once the drywall's in it's going to be $15^3/_8$ inches from the finished wall. Now you've got a problem.

Commercial toilets have to be the elongated type and have a seat that's open in the front for sanitary purposes.

Urinals must be set no more than 17 inches from the floor to the lip on the fixture, and must extend off the wall a minimum of $13^1/_2$ inches.

Faucets (ADA)

Faucets must be installed within the reach ranges permitted by the ADA so it's easy for a person with a physical disability to operate them. Most people recognize that accessibility laws require fixtures be usable by someone in a wheelchair, but the laws also mandate designs that allow people with other disabilities to use them. Some people have difficulty operating mechanical devices such as faucets. Therefore, ADA law specifies that no more than 5 pounds of force be needed to open and close the faucet.

Faucets also need to be controllable using only one hand, and take into consideration that an operator may have fingers missing. Touchless, lever handles and large push buttons are common choices for ADA compliance.

Touchless electronic metering faucets can be a great choice; however, ADA law requires that the faucet be set to run water for a minimum of 10 seconds.

Sinks (ADA) Sinks and Lavatories

ADA-compliant sinks and lavatories are specially designed with shallow basins in order to fit within the fairly narrow parameters required; that the bottom of the sink be no less than 27 inches off the floor to allow kneeroom for a person in a wheelchair, and the top of the sink, or its flood level, be no higher than 34 inches so such a person can easily use the sink.

Exposed piping under a sink presents a hazard to a person in a wheelchair. They might be burned by contact with the hot water pipe or cut by any sharp edges. You therefore have to wrap insulation around piping under accessible sinks and lavatories to prevent this.

Showers (ADA)

ADA compliant showers are transfer type or have roll-in thresholds. They must have seats and precisely mounted operating parts and shower head heights.

Grab Bars (ADA)

Keep in mind when roughing in the plumbing that items such as grab bars and recessed paper holders will have to go in. You don't want to put a supply pipe right where a recessed paper holder has to go, or the toilet tank where there needs to be a grab bar. Plumbing in walls must be located away from areas that will be used for mounting these items. On small projects, it's often the plumber who has to provide the backing inside the wall for grab bars and installing them during the finishing stage.

Your best guide for compliance is the *ADA Standards for Accessible Design* manual. Chapter 6 of the *Standards* gives the exact required dimensions and clearances for installing all types of plumbing fixtures and has clearly marked diagrams illustrating them. You'll find a copy of Chapter 6 of the *Standards* in the back of this manual, beginning on page 347.

Minimum Fixture Requirements

Whenever the code requires plumbing fixtures, it regulates the minimum number and type of fixtures. This includes all premises intended for human occupancy or use.

The minimum number and type of fixtures set by most plumbing codes is based on the type of occupancy and the anticipated number of people who'll use the facilities. Codes vary considerably in how they arrive at the number of fixtures needed. This book will help you understand and interpret your particular code's method of computing the required toilet facilities. But refer to your local code for the exact requirements.

Residences

The fixtures required vary according to the number of dwelling units in the building.

- *Single-family residences:* Minimum requirements are one kitchen sink, one water closet, one lavatory and one bathtub or shower unit, and provision for a clothes washing machine.
- *Duplex residential units:* One kitchen sink, one water closet, one lavatory, and one bathtub or shower unit are mandatory. There must also be provision for a clothes washing machine for each unit, or for one machine if it's available to all residents.
- *Apartment units:* Each unit must have at least one kitchen sink, one water closet, one lavatory, and one bathtub or shower unit. Provide for a clothes washing machine for each unit unless there's a centrally-located laundry room with the correct ratio of machines according to the particular code. The *Uniform Plumbing Code* requires two

laundry trays or two automatic washer standpipes, or a combination, for each 12 apartment units. For example, an apartment building with 15 units would double the minimum requirements, so you'd need four laundry trays or four automatic washer standpipes, or a combination. It may be that your code requires only one automatic washer standpipe for each 20 apartments. For that 15-unit apartment building, you'd only need one washer standpipe. Never forget to check your local code for their requirements.

When there's a central washing facility for residents in a complex of several buildings, most codes establish a maximum distance to the most remote unit. The distance from the entrance of the most distant apartment building can't exceed 400 feet.

Hot water generating facilities are generally installed in all buildings.

Places of Employment

The number of toilet fixtures in manufacturing plants, heavy industry, warehouses and similar establishments is based on the number of employees. Your local authority can change the percentage ratio and type of fixtures required for males and females. They may alter the requirements in Figure 21-12 if you can provide data which shows that some other fixture ratio is more appropriate.

Let's consider one example. Assume that toilet facilities are needed for a medium-sized manufacturing plant employing 100 persons. Both the *IPC* and *UPC* require a ratio of 50 percent male and 50 percent female facilities. Other codes for the same type occupancy use a percentage ratio of 75 percent male and 25 percent female. Obviously, if these ratios were used rigidly, many installations would have an imbalance of toilet fixtures. The plumbing plans examiner may request a notarized letter from the owner giving the maximum number of probable male and female employees in this particular plant. Then the examiner can determine the correct number and type of plumbing fixtures from the local requirements.

Provide at least one drinking fountain for up to 250 employees if you're under the *UPC*, and 400 if you're under the *IPC*. It must be located within 50 feet of all operational processes. You can't locate the drinking fountain in a restroom or vestibule to a restroom.

You can substitute wash-up sinks for lavatories where the type of employment warrants their use (manufacturing plants, for example).

Businesses that employ up to nine people and that don't cater to the public (such as storage warehouses and light manufacturing buildings) have less rigid requirements. *Some codes* would consider one water closet and one lavatory for both sexes adequate in these applications.

Businesses that are frequented by the public must provide toilet facilities for the number of employees and the public that's reasonably anticipated, unless they have special permission to do otherwise. There are two classifications of public use which determine the number and type of plumbing fixtures required:

1) Establishments that provide countable seating capacity, such as churches, theaters, stadiums and restaurants, are in the first classification.

2) Establishments such as in retail stores, office buildings, and similar establishments that have no countable seating capacity make up the second classification.

In some local codes, the square foot area determines the facilities required for the second classification. Figure 21-13 illustrates parts of Table 1004.5 in the *International Building Code*. Determine your required fixtures using this table or the occupant load based on the egress requirements in your local code.

Public Places with Seating Capacities

For public assembly facilities such as churches, libraries, gymnasiums and similar establishments use the ratios shown in Figure 21-14 to determine the number and type of plumbing fixtures required, and the number of female and male water closets.

Water closets for public use must be separated from the rest of the room and from each other by stalls made of some impervious material.

Data from *Uniform Plumbing Code* Table 422.1: Minimum Plumbing Facilities[1]								
Each building shall be provided with sanitary facilities, including provisions for persons with disabilities as prescribed by the Department Having Jurisdiction. Table 422.1 applies to new buildings, additions to a building, and changes of occupancy or type in an existing building resulting in increased occupant load.								
Type of Occupancy	**Water Closets (Fixtures per Person)**[3]		**Urinals (Fixtures per Person)**[4]	**Lavatories (Fixtures per Person)** [5,6]		**Bathtubs or Showers (Fixtures per Person)**	**Drinking Fountains/ Facilities (Fixtures per Person)**	**Other**
F1, F2 Factory or Industrial occupancy-fabricating or assembly work	Male 1: 1-50 2: 51-75 3: 76-100	Female 1: 1-50 2: 51-75 3: 76-100	—	Male 1: 1-50 2: 51-75 3: 76-100	Female 1: 1-50 2: 51-75 3: 76-100	1 shower for each 15 persons exposed to excessive heat or to skin contamination with poisonous, infectious or irritating material.	1: 1-250 2: 251-500 3: 501-750	1 service sink or laundry tray
	Over 100, add 1 fixture for each additional 40 persons		—	Over 100, add 1 fixture for each additional 40 persons			Over 750, add 1 fixture for each additional 500 persons	

Notes:
1 The figures shown are based upon 1 fixture being the minimum required for the number of persons indicated or any fraction thereof.
3 The total number of required water closets for females shall be not less than the total number of required water closets and urinals for males.
4 For each urinal added in excess of the minimum required, one water closet shall be permitted to be deducted. The number of water closets shall not be reduced to less than two-thirds of the minimum requirement.
5 Group lavatories that are 24 lineal inches (610 mm) of wash sink or 18 inches (457 mm) of a circular basin, where provided with water outlets for such space, shall be considered equivalent to one lavatory.
6 Metering or self-closing faucets shall be installed on lavatories intended to serve the transient public.

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Figure 21-12
Minimum plumbing fixtures for places of employment (employees only): Manufacturng, industrial, warehouses, workshops, foundries or similar establishments

Toilet rooms connected to public rooms or passageways must have a vestibule or must otherwise be screened or arranged to insure decency and privacy.

Both the *IPC* and *UPC* have provisions for single-occupant and family-use restrooms to accommodate non-gender-specific individuals, provide better security for children, and diaper-changing facilities to all parents.

Food and Drink Establishments

Use Figure 21-15 to determine the minimum toilet facilities for establishments where food and drink are served and consumed on the premises. This includes cafeterias, restaurants, private clubs and similar establishments with countable seating capacities. Most codes follow the percentage ratio of 50 percent male to 50 percent female.

Maximum Floor Area Allowances Per Occupant	
Type of occupancy	**Occupancy Load Factor**[a]
Business area	100 gross
Dormitories	50 gross
Educational/Classroom	20 net
Mercantile	60 gross
Residential	200 gross
Storage/Shipping	300 gross
Warehouses	500 gross

a. Floor area in square feet per occupant

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Figure 21-13
Square feet per occupant based on net or gross floor area

Data from *Uniform Plumbing Code* Table 422.1: Minimum Plumbing Facilities

Type of Occupancy	Water Closets (Fixtures per Person)		Urinals (Fixtures per Person)	Lavatories (Fixtures per Person)		Bathtubs or Showers (Fixtures per Person)	Drinking Fountains/ Facilities (Fixtures per Person)	Other
	Male	Female	Male	Male	Female			
A-3 Assembly occupancy (typical without fixed or permanent seating)- arcades, places of worship, museums, libraries, lecture halls, gymnasiums (without spectator seating), indoor pools (without spectator seating)	1: 1-100 2: 101-200 3: 201-400	1: 1-25 2: 26-50 3: 51-100 4: 101-200 6: 201-300 8: 301-400	1: 1-100 2: 101-200 3: 201-400 4: 401-600	1: 1-200 2: 201-400 3: 401-600 4: 601-750	1: 1-100 2: 101-200 4: 201-300 5: 301-500 6: 501-750	—	1: 1-250 2: 251-500 3: 501-750	1 service sink or laundry tray
	Over 400, add 1 fixture for each additional 500 males and 1 fixture for each additional 125 females		Over 600, add 1 fixture for each additional 300 males	Over 750, add 1 fixture for each additional 250 males and 1 fixture for each additional 200 females.			Over 750, add 1 fixture for each additional 500 persons	
A-4 Assembly occupancy (indoor activities or sporting events with spectator seating) - swimming pools, skating rinks, arenas and gymnasiums	1: 1-100 2: 101-200 3: 201-400	1: 1-25 2: 26-50 3: 51-100 4: 101-200 6: 201-300 8: 301-400	1: 1-100 2: 101-200 3: 201-400 4: 401-600	1: 1-200 2: 201-400 3: 401-750	1: 1-100 2: 101-200 4: 201-300 5: 301-500 6: 501-750	—	1: 1-250 2: 251-500 3: 501-750	1 service sink or laundry tray
	Over 400, add 1 fixture for each additional 500 males and 1 fixture for each additional 125 females		Over 600, add 1 fixture for each additional 300 males	Over 750, add 1 fixture for each additional 250 males and 1 fixture for each additional 200 females.			Over 750, add 1 fixture for each additional 500 persons	

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Figure 21-14

Minimum plumbing fixtures for churches, libraries, gymnasiums and similar establishments

Any establishment that caters to drive-in service (like fast food restaurants) must provide adequate toilet facilities. According to the *UPC*, the number of occupants is equal to the number of parking stalls. So 40 parking stalls represent 40 people. Assume that 20 are males and 20 are females. To determine the required toilet facilities, use Figure 21-15. You'd have to provide one water closet, one urinal and one lavatory for males, and two water closets and one lavatory for females.

Public food service establishments that offer only take-out service aren't required to provide guest toilet facilities. They only require toilet facilities for employees and hand-washing facilities in the kitchen.

The floors and walls of public toilet rooms must have tile or other impervious materials to a height of 4 feet.

If the seating capacity is unknown, some codes use the square foot method (see Figure 21-13) to determine the number of people who'll occupy the premises. Other codes base the occupant load on the egress requirements of the building code. Check your local code for its particular requirements.

Toilet rooms must have easy and convenient access for both patrons and employees. The restrooms must be located within 100 feet along a line of travel from the nearest exit to the dining room, bar or food service area. Toilet rooms must be located on the same floor as the area they serve.

In food or drink establishments where dishes, glasses, or cutlery are reused, provide for a dishwashing machine or suitable three-compartment sink. Where food or drink are prepared or served, you must install a hand sink for employees' use. It's not enough to have lavatories in adjoining toilet rooms.

Public Places Without Seating Capacities

In computing restroom facilities for public places like shopping centers, retail stores and office buildings, you need to determine the amount of habitable floor space (area). You can deduct uninhabitable space like corridors, stairways, vertical shafts, and equipment rooms from the gross floor area. Then use the net square footage to find the occupant load factor for the business. Figure 21-13 shows net square footage per expected occupant, according to some codes. Other codes may base the occupant load on the egress requirements instead of the square footage.

Roughing-In

Roughing-in the fixtures is possibly the single most critical point where plumbers display their skill (or lack of skill). Proper roughing-in of the waste and water outlets requires both knowledge and good workmanship. The plumbing fixtures will be an important part of the building throughout the life of the building. They need to be done right.

It's important that you have a thorough knowledge of roughing-in measurements for various types of plumbing fixtures. You must know the height, distance and location for waste and water outlets for wall-hung and floor-mounted fixtures. Memorize these measurements for common fixtures or jot them down in a notebook you can keep in your tool box. For special fixtures, you can get complete roughing-in information from the manufacturer or distributor.

We'll cover roughing-in dimensions for common fixtures — bathtubs, water closets, lavatories, showers, kitchen sinks, service sinks, urinals, bidets and drinking fountains. The roughing-in measurements in Figures 21-16 through 21-20 are for American Standard fixtures, but they're similar to those of other manufacturers.

Note that the standard roughing-in measurement for water closets with tanks is 12 inches from the finished wall. If the water closet outlet is roughed too close or too far from the finished wall, there are special water closets that you can set at 10 or 14 inches from the wall.

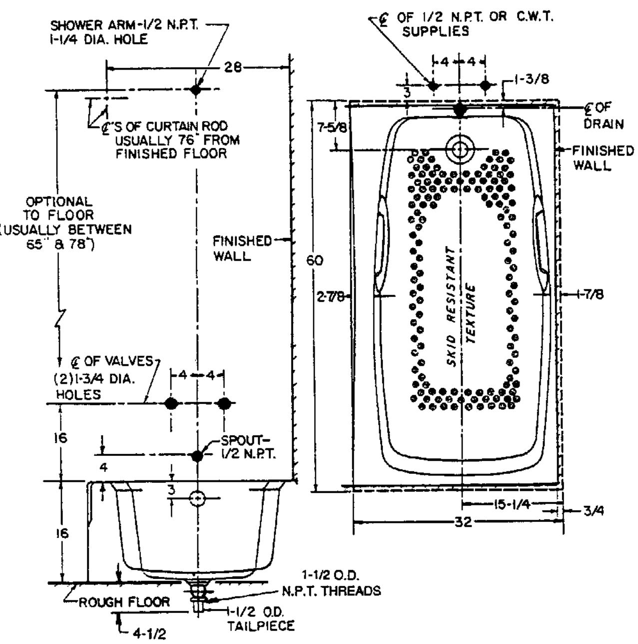
Data from Uniform Plumbing Code Table 422.1: Minimum Plumbing Facilities

Type of Occupancy[2]	Water Closets (Fixtures per Person)		Urinals (Fixtures per Person)	Lavatories (Fixtures per Person)		Bathtubs or Showers (Fixtures per Person)	Drinking Fountains/ Facilities (Fixtures per Person)	Other
A-2 Assembly occupancy - restaurants, pubs, lounges, night clubs and banquet halls.	Male 1: 1-50 2: 51-150 3: 151-300 4: 301-400	Female 1: 1-25 2: 26-50 3: 51-100 4: 101-200 6: 201-300 8: 301-400	Male 1: 1-200 2: 201-300 3: 301-400 4: 401-600	Male 1: 1-150 2: 151-200 3: 201-400	Female 1: 1-150 2: 151-200 3: 201-400	—	1: 1-250 2: 251-500 3: 501-750	1 service sink or laundry tray
	Over 400, add 1 fixture for each additional 250 males and 1 fixture for each 125 females.		Over 600, add 1 fixture for each additional 300 males.	Over 400, add 1 fixture for each additional 250 males and 1 fixture for each 200 females.			Over 750, add 1 fixture for each additional 500 persons.	

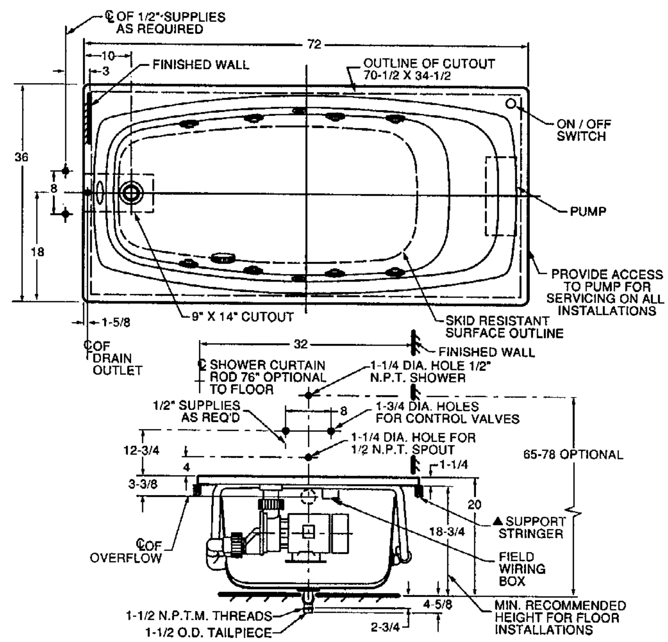
Notes:
[2] A restaurant is defined as a business that sells food to be consumed on the premises.
a. The number off occupants for a drive-in restaurant shall be considered as equal to the number of parking stalls.
b. Hand-washing facilities shall be available in the kitchen for employees.

From the *UPC*™ with permission of the *IAPMO* ©2021

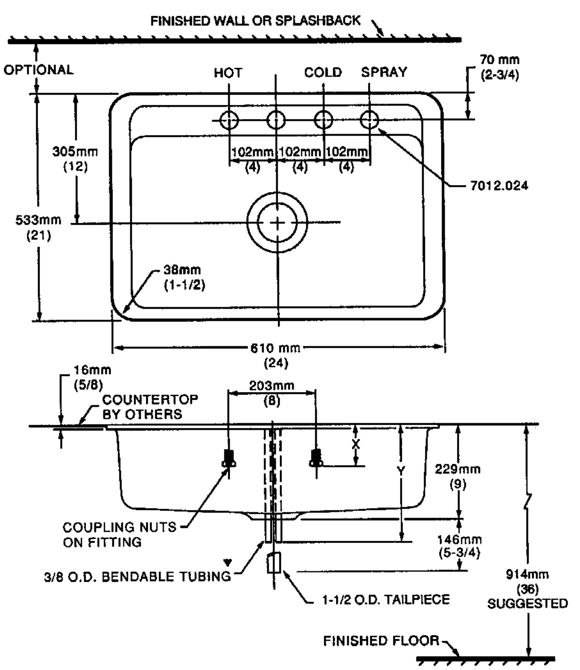
Figure 21-15
Minimum plumbing facilities for drink and/or eat establishments



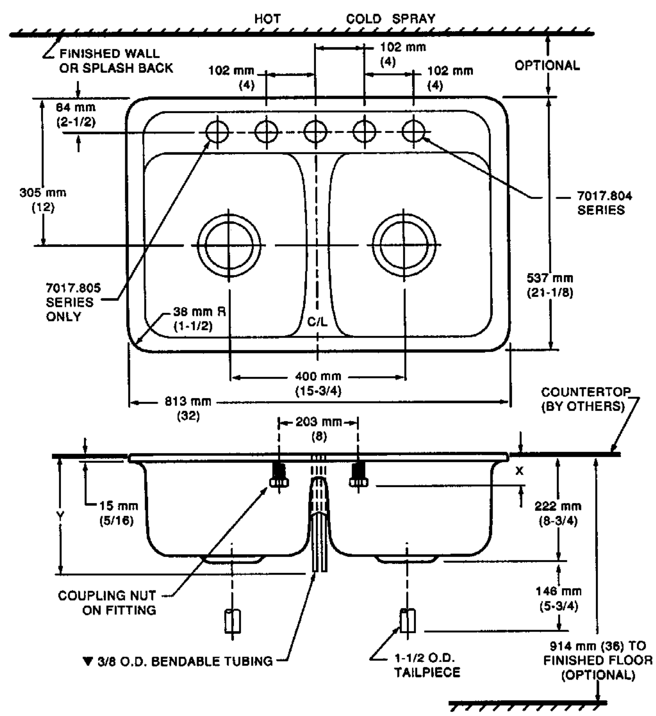
A Spectra™ bath



B Oxford™ whirlpool



C Custom-line™ sink

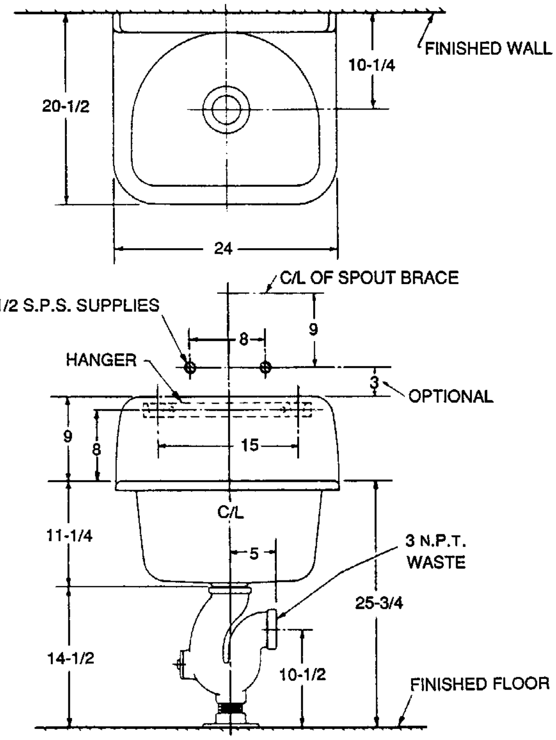


D Custom-line™ sink — double compartment

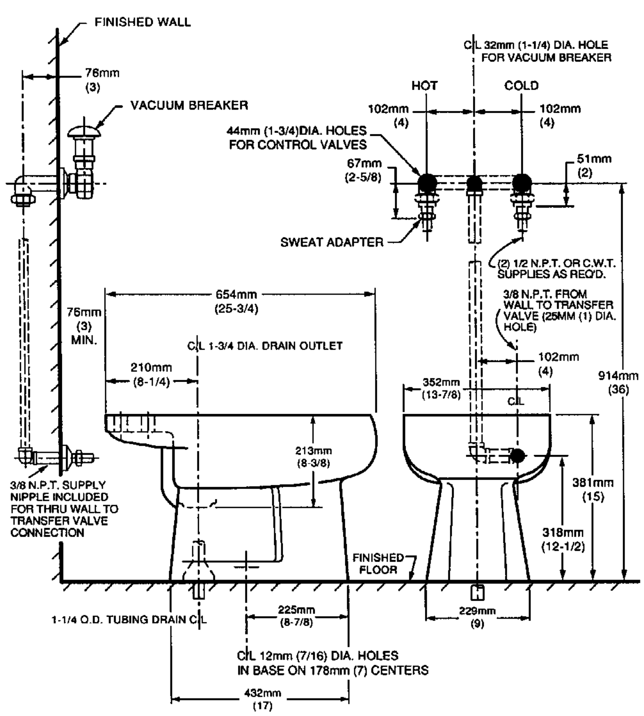
Courtesy: American Standard

Figure 21-16

Roughing-in measurements for tubs and sinks



A Akron™ service sink

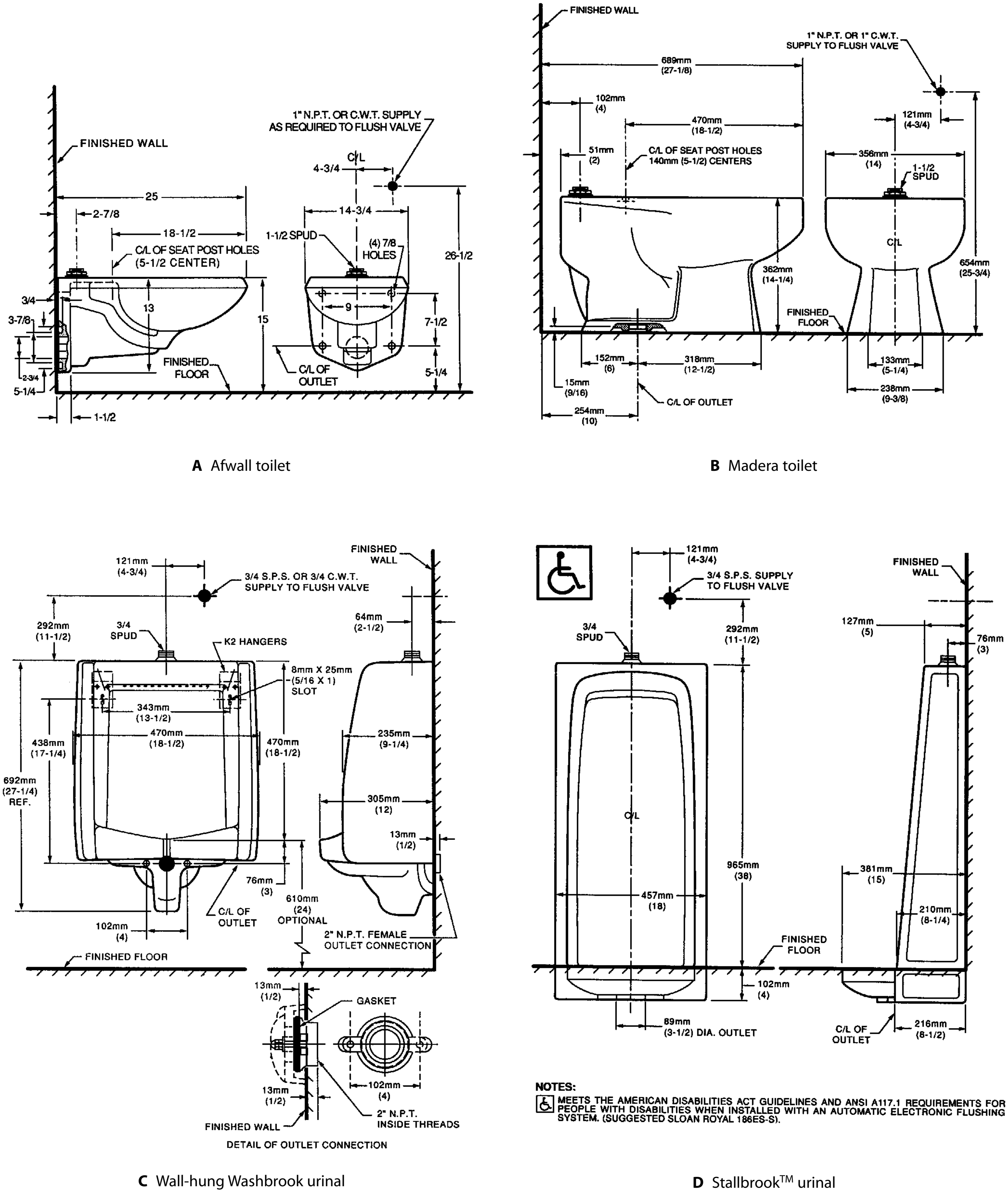


B Lexington™ bidet

Courtesy: American Standard

Figure 21-17

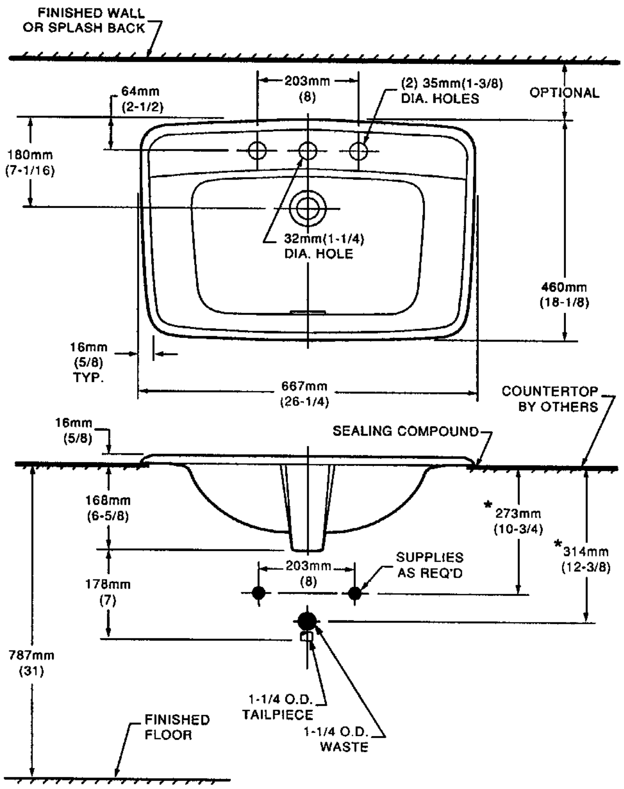
Roughing-in measurements for service sink and bidet



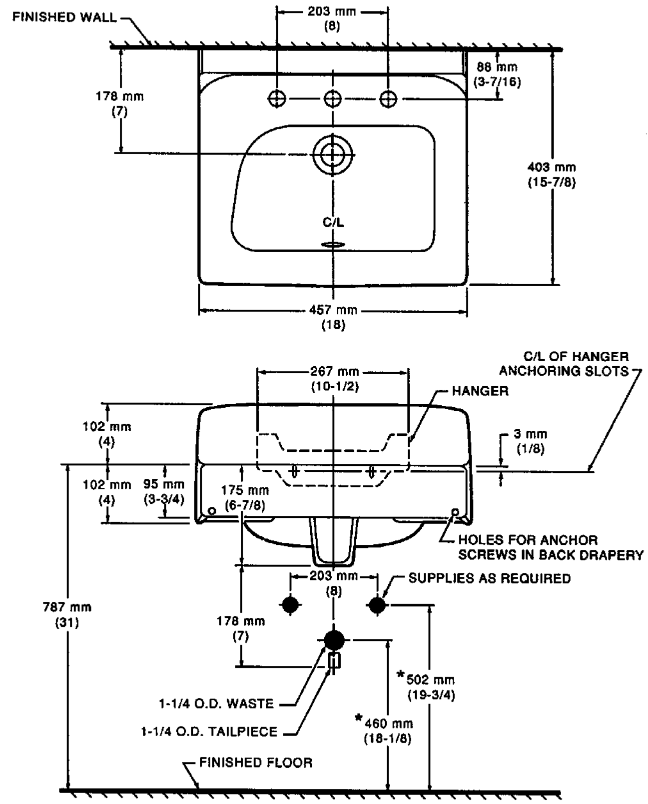
Courtesy: American Standard

Figure 21-18

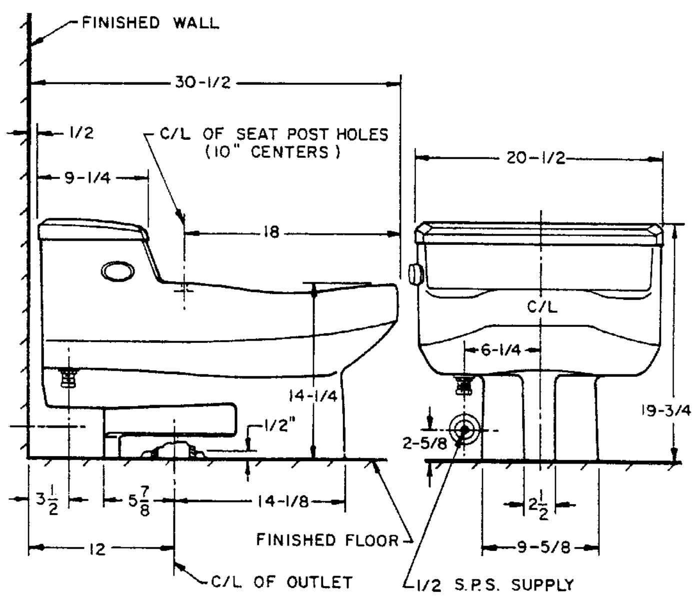
Roughing-in measurements for toilets and urinals



A Plaza Suite™ lavatory



B Wall-hung Penlyn™ lavatory

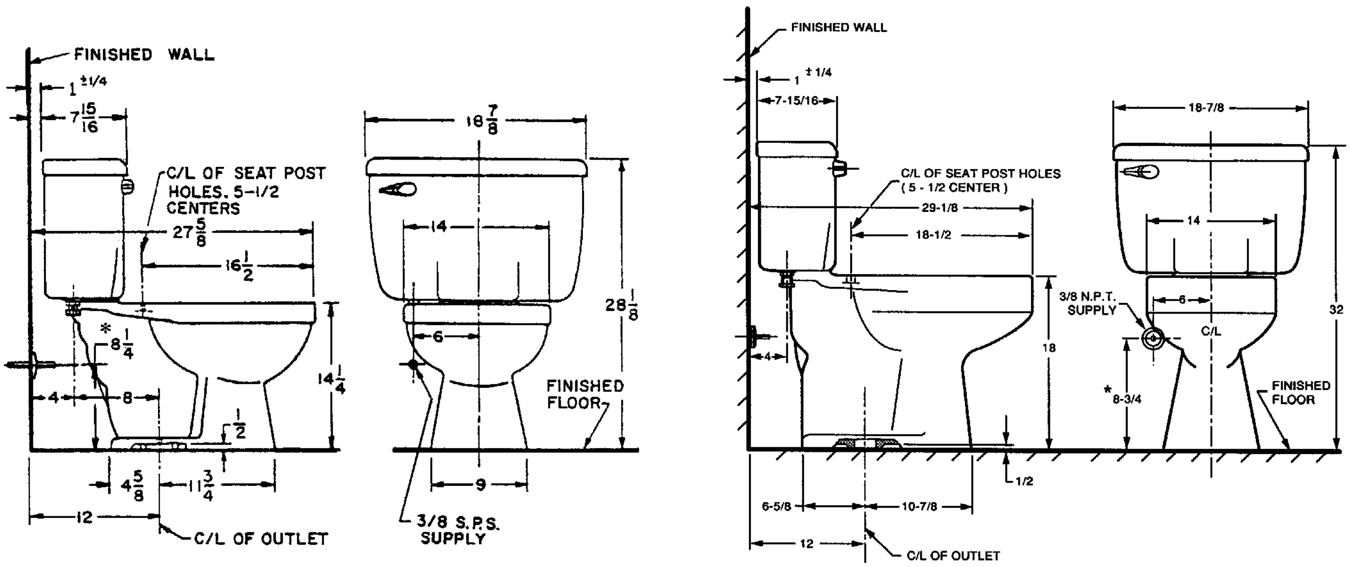


C One-piece Roma toilet

Courtesy: American Standard

Figure 21-19

Roughing-in measurements for lavatories and toilets



A Plebe toilet

B Cadet toilet

Courtesy: American Standard

Figure 21-20
Roughing-in measurements for toilets

Plumbing Fixture Carriers

Toilet rooms are the most susceptible of all rooms to unsanitary conditions. The bases of on-the-floor fixtures are natural areas for accumulated filth that's nearly impossible to remove. Bathroom floors made of wood tend to deteriorate next to and beneath toilet fixtures. Off-the-floor water closets can solve both of these problems. They've been gaining popularity for both commercial and residential use.

Some apprentices and journeymen seldom have an opportunity to work with off-the-floor plumbing fixtures. You can use the illustrations in Figures 21-21 through 21-24 to become familiar with their installation methods.

Figure 21-21 illustrates a flush valve on-the-floor and off-the-floor water closet commonly used in commercial buildings. There are many factors to evaluate when planning an installation, including cost, material, labor required, space available, and handling requirements. With on-the-floor water closets, you have to penetrate and sleeve the slabs at each fixture to accommodate waste piping, which often has to be suspended below the slab. Suspended piping like that needs to be concealed in multistory installations, with drop or furred ceilings in the rooms below.

Figure 21-23 shows tank type on-the-floor and off-the-floor water closets commonly used in residential buildings. You can see some of the advantages of the off-the-floor installation. You don't have to penetrate the slab or floor at each fixture like you do with on-the-floor installations. There's a clear, unobstructed floor for cleaning. And deterioration isn't a problem.

Figure 21-23 is a typical floor plan showing a battery of water closets. This illustration is important because it shows you how to identify left and right hand closet carriers. Figure 21-24 shows three ways to vent a horizontal run of fixtures.

A single-family residence never has battery installations like commercial buildings. Residential carriers have fewer parts so they're easier to assemble. They're designed to receive the waste from a single water closet or at most two water closets (from back-to-back installations). Most residential carriers are compatible with the newer piping materials.

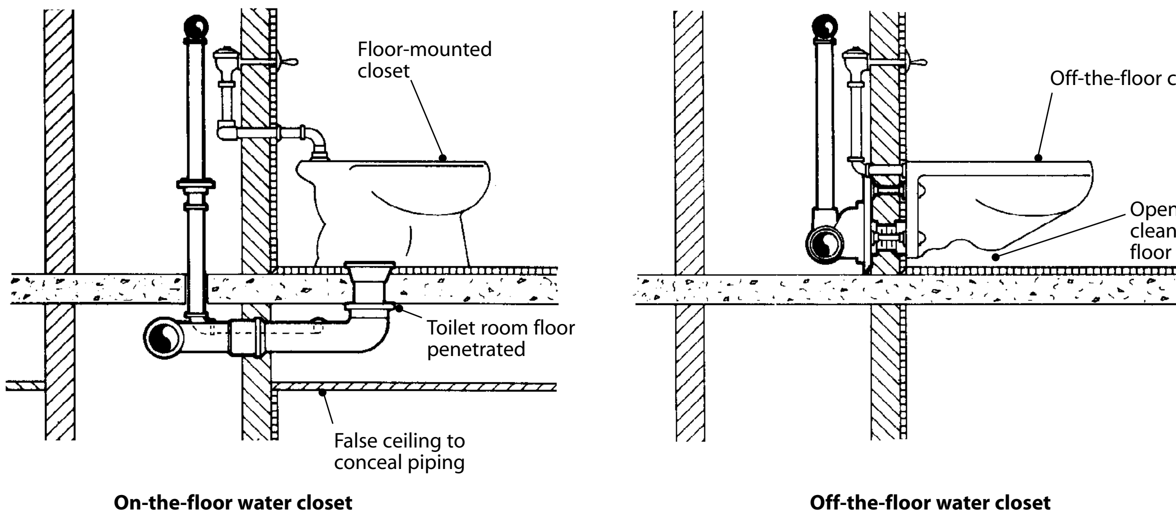


Figure 21-21
Commercial water closet installation

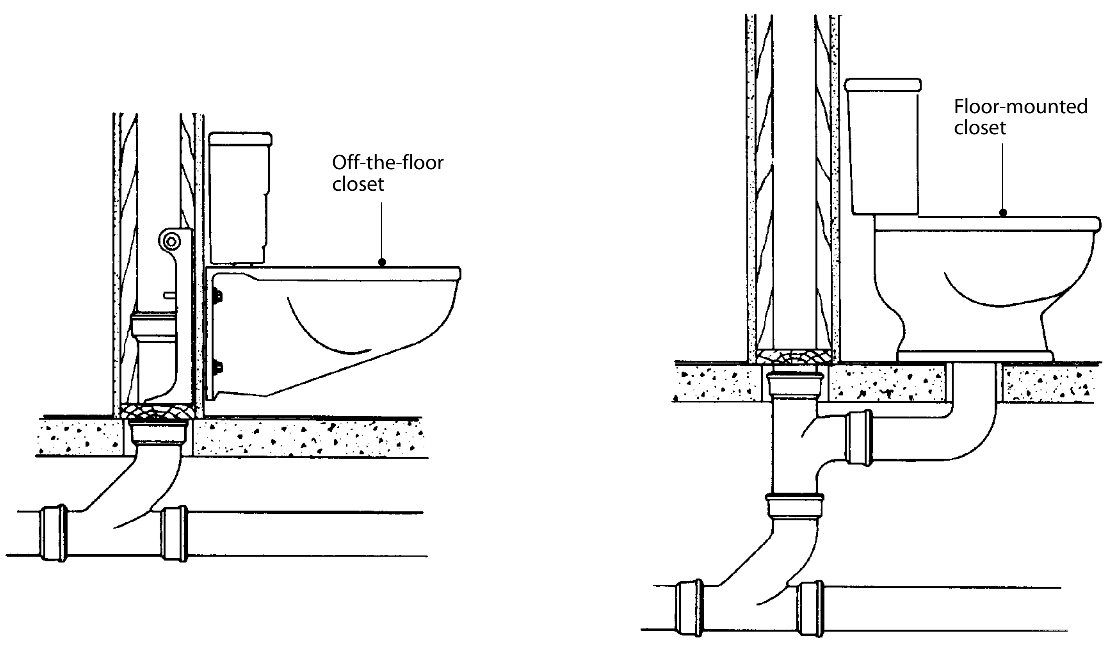
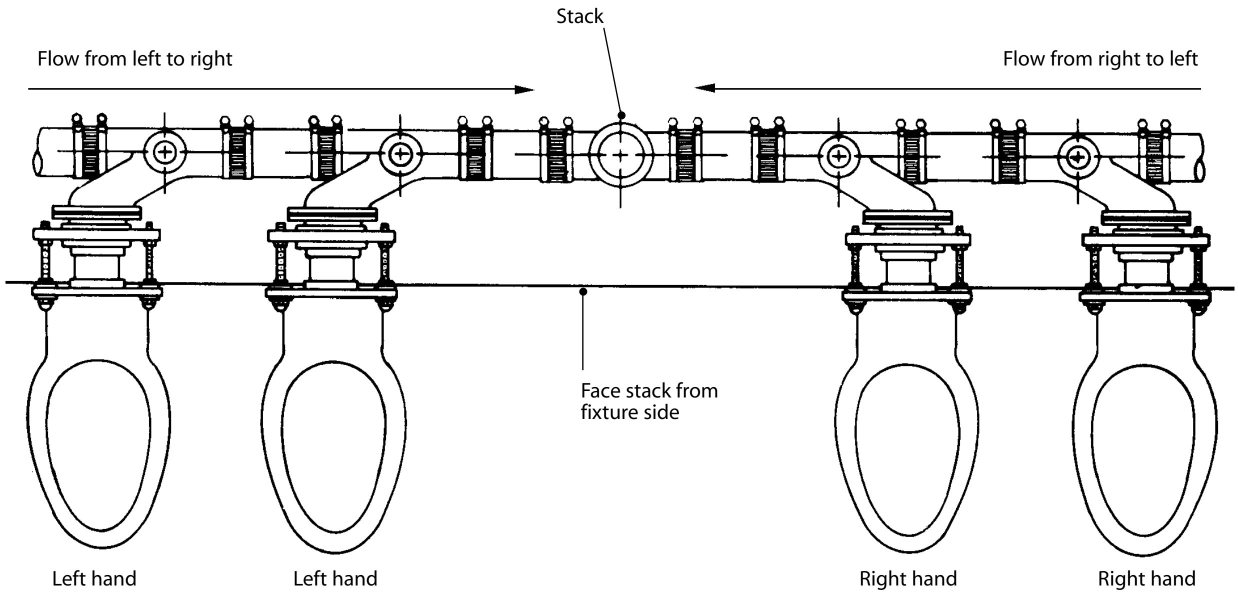


Figure 21-22
Residential water closet installation



Notes
1. If flow in waste line is from the right of the stack, the closet fitting should be a right hand fitting.
2. If flow in waste line is from the left of the stack, the closet fitting should be a left hand fitting.

Figure 21-23
Diagram to determine left or right hand closet fittings

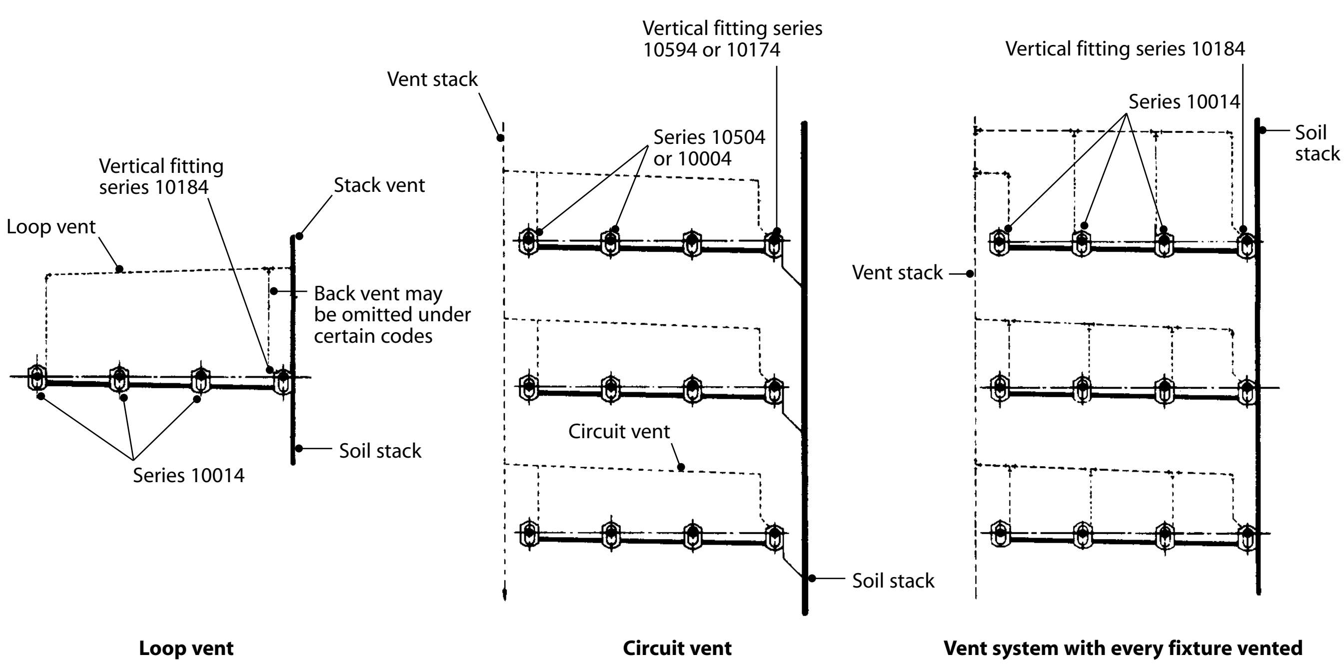


Figure 21-24
Venting a horizontal run of fixtures — Josam carriers

Review Questions for Chapter 21 (answers begin on page 317)

1. What is required of plumbing fixtures constructed of pervious materials such as tile or marble?
2. What must you provide in a bathroom where there's no natural ventilation available?
3. What potential danger exists when a bathroom doesn't have adequate lighting or ventilation?
4. What toilet bowl design must be installed in facilities intended for public use?
5. What seat type is required for public toilet bowls?
6. What purpose does a toilet tank refill tube serve?
7. What purpose does an overflow tube in a toilet tank serve?
8. What must a toilet have if it uses a flushometer rather than a tank?
9. What operation must a toilet flushometer accomplish after being manually activated?
10. How many toilets can a flushometer serve?
11. Why should a toilet flushometer be installed so it's readily accessible?
12. How should a wall-hung urinal be supported?
13. How should a wall-hung lavatory be finished at the wall contact point?
14. What are the two basic designs for urinals?
15. Why must stall urinals be recessed slightly below the finished floor?
16. What type of strainer is required for the waste opening of a floor-mounted stall urinal?
17. How are cabinet-mounted lavatories secured to the countertop?
18. What's the minimum outside diameter for lavatory waste outlets?
19. Where circular-type multiple wash sinks are used, how many inches of wash sink circumference represents one lavatory?
20. What's the minimum bathtub waste and overflow size?
21. Why do some codes today prohibit the use of a trip waste?
22. What's required of the joints for a bathtub that's recessed into the finished wall?
23. What type of wall materials must you use for a recessed bathtub?
24. What's the minimum size waste outlet required for a shower compartment?
25. What are the design requirements for shower strainers?
26. What's the minimum floor area required for any shower compartment?
27. What minimum weight per square foot do most codes require for lead shower pans?
28. How do you protect lead or copper shower pans from corrosion when they're installed on concrete floors?
29. How high should the sides of a shower pan extend above the finished curb?
30. At what point in a building's construction should a shower pan be prepared for inspection?
31. When is a shower pan not required?
32. How high must the walls of a shower compartment extend above the floor?
33. What's the minimum diameter required for a laundry tub waste?
34. How large should the waste opening be on a domestic kitchen sink with a waste disposer unit?
35. Name two common fixtures provided with an overflow.
36. Why must the overflow pipe or passageway from a fixture be connected on the inlet side of the fixture trap?
37. What type of fixtures are not required to have a strainer or stopper?
38. What determines the minimum size of a fixture strainer?
39. Where is the overflow of a fixture never permitted to connect?
40. What restriction is placed on strainers or stoppers?
41. What fitting must you use when you install a waste disposer on an existing two-compartment sink using a single trap?
42. Through what device may a commercial food waste grinder in a restaurant ***not*** discharge?

43. What's the minimum size waste opening required for a commercial sink?
44. How should a commercial food waste grinder be trapped and vented?
45. When an air gap fitting is required for a dishwasher waste pipe, where does the code require you install it?
46. By most code standards, what's the maximum distance allowed between a dishwasher and the sink waste connection?
47. What must the waste pipe from the dishwasher connect to if there's a food disposal unit installed in a sink?
48. Where should the flange for a floor fixture be set?
49. What gasket materials are approved for use with plumbing fixtures having a flanged connection?
50. Into what category does the code place floor drains?
51. Why must floor drain traps have a permanent water seal?
52. In what area can drinking fountain waste not be discharged into a floor drain?
53. What type of equipment installed in a room disallows the installation of any kind of plumbing fixture?
54. How do you protect the water supply from backsiphonage when installing special fixtures with waste and water connections?
55. What must you consider in regard to spacing and clearances when installing any plumbing fixture?
56. What's the minimum center-to-center spacing required for water closets when set in battery installations?
57. What's the minimum required distance from the front of a urinal to any finished wall?
58. Why are center-to-center measurements not applicable to lavatories?
59. What's the minimum clearance required from the opening of a shower compartment or stall to any finished wall?
60. Why are public buildings and privately owned multistory apartment buildings now required to have toilet facilities for persons with disabilities?
61. What are the minimum fixture requirements for a single-family residence?
62. How do you determine the number of toilet fixtures required in a place of employment?
63. What must be provided if toilet rooms are connected to public rooms or passageways?
64. Give two reasons for the fairly recent conversions of many public restrooms to single-occupancy and family-use restrooms.
65. What determines the minimum toilet facilities needed for food establishments catering to drive-in service?
66. If the seating capacity in a restaurant is unknown, what method do some codes use to determine the number of persons who'll occupy the premises at one time?
67. Rather than using the square-foot method, what do some codes use to determine the occupant load for a restaurant when the seating capacity is unknown?
68. How do you compute the restroom facility required for public places such as shopping centers, retail stores or large office buildings?
69. What knowledge is required for proper roughing-in of the waste and water outlets for various types of plumbing fixtures?
70. Where can you get complete roughing-in information for *special* plumbing fixtures?
71. What's the standard roughing-in measurement for all water closets?
72. Of all the rooms in a house, which room is the most susceptible to unsanitary conditions?
73. What type of bathroom plumbing fixtures do some apprentices and journeymen seldom have the opportunity to work with?
74. Name two advantages to off-the-floor water closets.
75. With what materials are most residential carriers designed to be compatible?

Answers to Review Questions

Chapter 2

1. **The two parts of a private sanitary drainage system are:**
   1) all the pipes installed within the wall line of a building on private property for the purpose of receiving liquid waste or other waste substances (whether in suspension or in solution), and 2) the pipes which convey this waste to a public sewer or a private, approved sewage disposal system. *See page 7*

2. **The aim of municipal codes in relation to drainage systems is:**
   to protect the public health. *See page 7*

3. **Most requests for clarification and resolution brought to the Boards of Rules & Appeals center on the code section dealing with:**
   the drain, waste and vent systems. *See page 7*

4. **The section of the code that most questions and isometric drawings for the journeyman and master's examinations are taken from is:**
   the section on sanitary drainage and vent systems. *See page 7*

5. **Isometric drawings serve to provide:**
   a clear means of communication between plumbing professionals. *See page 7*

6. **It's important for a plumbing contractor to know how to make and interpret isometric drawings in order to:**
   1) be able to estimate the cost of a job, and 2) show the job foreman how to rough-in a particular job. *See page 7*

7. **The three basic pipe angles you need to illustrate in an isometric drawing of a plumbing system are:**
   1) the horizontal pipe, 2) the vertical pipe, and 3) the 45-degree angle pipe. *See page 7*

8. **The lines on an isometric drawing represent:**
   pipe and fittings. *See page 9*

9. **The purpose of a horizontal twin tap sanitary tee is:**
   to permit two similar fixtures to connect to the same waste and vent stack at the same level. *See page 9*

10. **Plumbing fixtures are identified in isometric drawings and floor plans by:**
    several common abbreviations, either letters (such as L for lavatory) or shortened words (such as LAV, also used for lavatory). *See pages 9 & 12*

11. **Another term for a public sewer is:**
    municipal sewer. *See page 14*

12. **Two other terms used for a building sewer are:**
    private sewer and sanitary sewer. *See page 14*

13. **A building drain is also known as a main because:**
    it acts as the principal artery to which you can connect other drainage branches of the sanitary system. *See page 14*

14. **Plumbers often refer to a fixture drain by the term:**
    trap arm. *See page 14*

15. The kind of waste a waste pipe carries is:

only liquid waste from plumbing fixtures, excluding water closets and bed pan washers. It does not convey waste that includes fecal matter. *See page 14*

16. A soil stack is:

the vertical section of pipe in the plumbing system that receives the discharge of water closets, with or without the discharge from other fixtures. *See page 14*

17. The function a branch interval serves is:

the same function as a soil stack. It becomes an integral part of a soil stack, except that its vertical height can never be less than 8 feet. *See page 14*

18. A horizontal branch is:

the part of a drainpipe that extends laterally from a soil or waste stack. It receives the discharge from one or more fixture drains.

See page 14

19. The main factor you use to determine pipe size within a drainage system is:

the maximum fixture unit load. *See page 15*

20. Besides maximum fixture unit value, the three additional factors you must take into consideration when sizing drainage piping are:

1) the types of fixtures used, 2) the slope of the drainpipe, and 3) the vertical length of drainpipe. *See page 15*

21. You would use the code book tables that list the various fixture load values to:

compute the total fixture load for any type of plumbing system. *See page 15*

22. Special fixtures are connected to the drainage system by:

indirect means. *See page 15*

23. Among the devices that are considered special fixtures are:

drinking fountains, bottle coolers, ice making machines, milk and soft drink dispensers, and coffee urns. (Any two answers are correct.) *See page 15*

24. Continuous and intermittent flow devices that you can connect to a drainage system include:

sump ejectors, pumps, air conditioning equipment and similar devices. (Any two answers are correct.) *See page 17*

25. For each gallon per minute of flow from continuous flow devices such as sump ejectors, the *Uniform Plumbing Code* allows:

2 fixture units. *See page 17*

26. One major area of difference between the model codes when it comes to designing drainage systems is:

the way they assign fixture units. *See page 17*

27. The generally accepted fall per foot for horizontal drainage pipe is:

$^1/_4$ inch. *See page 18*

28. Restrictions, limitations and exceptions in the code book will always supersede:

the established pipe sizes and fixture units in any code drainage table. *See page 20*

29. Most codes regard fixtures with waste openings larger than the waste pipe to which they need to connect as:

prohibited. *See page 21*

30. The code calls a stack that receives the discharge from a water closet:

a soil stack. *See page 21*

31. The minimum size vent required by the code to serve a water closet is:

2 inches. *See page 22*

32. The code-accepted minimum size for a main vent stack in a building is:

3 inches. *See page 22*

33. When sizing drainage piping in a multistory building, you accumulate the fixture unit load at:

the base of each stack. *See pages 22-23*

34. The procedure you should follow in sizing vertical drainage pipes in a multistory building is:

to start with the top drainage fixture units and work down to the building drain, accumulating the total fixture units at the base of the stack. *See pages 22-23*

35. From one end to the other, the size of a vertical waste/soil stack:

does not vary. It must remain the same size throughout. *See page 23*

36. A soil or waste stack can't be smaller than the largest horizontal branch pipe connected to it, except:

when connecting to a 3- × 4-inch water closet bend, which is not considered by some codes to be a reduction in size. See Figures 2-24, 2-25 and 2-26. *See pages 23 and 25*

37. The main considerations when sizing drain and vent pipes for future fixtures are:

the number and type of fixtures to be used. *See page 25*

38. When sizing a vertical stack with an offset of 45 degrees or less, it's defined as:

straight, and sized as a straight vertical stack. *See page 25*

39. The horizontal portion of a vertical stack with an offset greater than 45 degrees is sized:

as a building drain. *See page 26*

40. In a vertical stack, the minimum distance for an offset above or below the horizontal branch is:

2 feet. *See page 26*

41. The minimum required separation of horizontal branch drains in a multistory building is:

8 feet. *See page 26*

42. Since World War II, synthetic detergents have changed the characteristics of household waste by:

increasing the quantity of suds being discharged. *See pages 26-27*

43. There are several appliances and/or fixtures that are considered suds-producing by codes, including:

kitchen sinks, bathtubs, clothes washing machines, dishwashers, and laundries. (Any two answers are correct.) *See page 27*

44. When suds-producing fixtures and appliances discharge into an improperly-designed drainage and vent system, it can cause:

suds to bubble up into fixtures on the lower floors of the building. *See page 27*

45. When it's impossible for waste to drain by gravity into the building drainage system, it must be discharged:

into an approved sump and then pumped into the building drainage system. *See page 28*

46. Sumps and receiving tanks should be located so they are accessible for:

inspection, repairs and cleaning. *See page 28*

47. Most codes require that sumps for public use be equipped with a duplex pumping system because:

a duplex system allows pumps to discharge waste alternately, and in case of repairs, one pump can remain in service. *See page 28*

48. The two devices required in the discharge line between the pump and the gravity system are:

a check valve and a gate valve. *See page 28*

49. For most codes, the minimum acceptable size for a sump discharge pipe in a commercial or public installation is:

3 inches. *See page 29*

50. Sumps receiving clear water waste from floor drains or air conditioning condensate drains are not required to:

have a cover or be vented. See page 29

Chapter 3

1. The two causes of fixture trap seal loss that vent systems protect against in normal fixture use are:

siphonage and back pressure. *See page 33*

2. Battery venting is:

venting any group of two or more similar adjacent fixtures using a common horizontal drainage line. *See page 33*

3. The function of a branch vent is:

to connect one or more individual vents to a vent stack. *See page 34*

4. A common vent is used in a plumbing system to:

vent two fixture branches that are installed at the same level in a vertical stack. *See page 34*

5. A continuous vent is:

the vertical portion that is a continuation of the drain to which it connects. *See page 34*

6. **Another term used to describe a continuous vent is:**
   a stack vent. *See page 34*

7. **The term used to describe a vent that does not receive any sewage discharge is:**
   a dry vent. *See page 34*

8. **The number of fixture traps an individual vent is installed to serve is:**
   one. *See page 35*

9. **A main vent is defined in the code as:**
   the principal artery (pipe) of a venting system to which vent branches may be connected. *See page 35*

10. **The primary function of a relief vent is:**
    to provide additional air circulation in taller buildings and in circuit-vented drains serving four or more toilets. *See page 35*

11. **The definition of a side vent is:**
    a vent connecting to a horizontal drain pipe through a fitting at an angle not greater than 45 degrees to the vertical. *See page 36*

12. **The definition of a stack vent is:**
    the dry portion of a soil or waste pipe that extends above the highest horizontal drain connected to the stack and terminates above the roof. *See page 36*

13. **The function of a vent header is to:**
    connect two or more vent pipes to the main vent at one point, or extend through the roof separately. *See page 36*

14. **The primary purpose of a vent stack is:**
    to provide circulation of air to and from all parts of a drainage system. *See page 36*

15. **The two purposes a wet vent serves are:**
    as a vent and as a means to convey waste from fixtures other than water closets. *See page 36*

16. **The purpose a yoke vent serves is to:**
    prevent pressure changes in the stack. *See page 36*

17. **Another term used to describe back pressure is:**
    positive pressure. *See page 37*

18. **Negative pressure in a fixture drain can cause:**
    siphonage of the fixture trap seal. *See page 37*

19. **In frost-prone climates, the *International Plumbing Code* requires the vent extension through the roof to be at least:**
    3 inches in diameter. *See page 37*

20. **The *Uniform Plumbing Code* requires that a roof vent in a cold climate terminate at least:**
    10 inches above the roof. *See page 38*

21. **The free flow of air within the sanitary drainage system prevents:**
    back pressure or siphoning action from destroying fixture trap seals. *See page 39*

22. **As the maximum fixture unit load increases, the height of the vent pipe:**
    must decrease. *See page 40*

23. **The vent stack requirement for a building with a single building sewer is:**
    one vent stack (of not less than 3 or 4 inches) extending through and above the roof. *See page 40*

24. **If a water closet is located in an accessory building, the minimum size vent accepted by code is:**
    2 inches. *See page 40*

25. **The minimum size "dry" vent allowed by code when venting a water closet is:**
    2 inches. (This is also true for a wet vent.) *See page 40*

26. **The smallest individual vent stack size permitted by code is:**
    1¼ inches. *See page 40*

27. **The minimum size vent that can be used for a 3-inch drain pipe is:**
    1½ inches. *See page 40*

28. **The factor that determines the maximum length of any vent pipe is:**
    its diameter. *See page 40*

29. **The distance separation required between a horizontal vent pipe and the flood level rim of the fixture served is:**
    6 inches. *See page 40*

30. Kitchen sinks located away from walls or partitions are called:
island sinks. *See page 41*

31. The number of vents needed to vent a horizontal offset in a vertical stack is:
two, a relief vent at the top of the lower section and a vent at the base of the upper section. *See page 42*

32. A wet vent can be used to convey waste only from fixtures:
with low unit ratings. *See page 43*

33. On a 3-inch horizontal wet vent, the number of fixture units the *IPC* will allow is:
up to 12 fixture units. *See page 43*

34. The vertical drain between two fixtures connected to a stack at different levels is called:
a wet vent. *See page 43*

35. The vent required by code for a sump that receives body waste is:
a local vent. *See page 44*

36. A local vent is needed on a sump:
to prevent an air-lock from occurring in the sub-building drainage system. *See page 44*

37. According to code, sumps receiving clear water waste:
do not need to be vented. *See page 44*

38. Some codes permit the use of vertical combination waste and wet vent piping in:
high-rise buildings. *See page 44*

39. The types of establishments that horizontal combination waste and vent systems are usually installed in are:
certain commercial establishments such as supermarkets or large warehouses with floor drainage. *See page 46*

40. Fixtures that may connect to a horizontal combination waste and vent system are:
sinks, floor sinks, indirect waste receptors, floor drains, or similar applications. (Any three are acceptable.) *See page 46*

42. A major requirement before you can install a horizontal combination waste and vent system is:
having your plans and specifications approved by your administrative authority. *See page 47*

43. Codes prohibit the connection of appurtenances that deliver large quantities of water to a horizontal combination waste and vent system because:
adequate venting must be maintained, and appurtenances delivering large quantities of water may cause venting problems. *See page 47*

44. The minimum distance from a door that you may install a terminal for a sanitary vent system is:
10 feet, unless it extends 3 feet (some codes, 2 feet) above the top of the door. *See page 47*

45. A vent terminal must extend above the roof:
at least 10 inches (6 inches in some codes). *See page 48*

46. When a horizontal vent extends through a wall and turns upward, the code requires that:
it must be effectively screened. *See page 48*

47. You should never terminate a vent pipe under:
the overhang of any building. *See page 48*

48. The minimum height above ground level at which a vent pipe installed outdoors must terminate is:
10 feet. *See page 48*

49. The "rule of thumb" for determining the minimum aggregate cross-sectional area for the vents required for venting a building drainage system is:
that it can't be less than that of the largest required building sewer. *See page 48*

50. The formula you use to find the cross-sectional area of a pipe is:
the square of the diameter of a circle (the pipe diameter) multiplied by .7854 equals the area of the circle (or the cross-sectional area of the pipe). *See page 48*

Chapter 4

1. **The purpose of a fixture trap is:**
to prevent obnoxious odors and sewer gases from entering the building. *See page 53*

2. **Building traps are still required today only under the following conditions:**
where sewer gases are extremely corrosive or contain high explosive gas content. *See page 53*

3. **When connected directly to the drainage system, plumbing fixtures must be equipped with:**
a water seal trap. *See page 53*

4. **The protection of a liquid seal must be accomplished without:**
materially affecting the flow of sewage or other waste liquids. *See page 53*

5. **The only kind of trap that doesn't have to be self-cleaning is:**
the interceptor trap. *See page 54*

6. **The rule that governs the size of a trap outlet compared to its connecting fixture drain is:**
A trap outlet can never be larger than the fixture drain to which it connects. *See page 54*

7. **A trap that depends on the action of movable parts to retain its water seal:**
Can never be used. *See page 54*

8. **Traps that most model codes prohibit are:**
bell traps, crown-vented traps, pot traps, running traps, 3/4 S traps, full S traps, drum traps and traps with slip-joint nuts and washers on the discharge side of the trap above the water seal (Any two of these are acceptable answers.) *See page 54*

9. **The minimum depth of fixture trap seals is:**
2 inches. *See page 54*

10. **The maximum depth of fixture trap seals is:**
4 inches. *See page 54*

11. **The trap which is exempted from the normally required depth of a trap water seal is:**
an interceptor trap. It always requires a deeper seal. *See page 54*

12. **Cleanouts installed on fixture traps below concrete floors on fill should not be located:**
Anywhere. Fixture traps below concrete floors on fill are prohibited from having trap cleanouts. *See page 54*

13. **When installing a fixture trap, you determine the correct level in relation to:**
its water level. *See page 54*

14. **A water closet may not have a separate trap because:**
the code states that fixtures with integral traps can't be separately trapped. *See page 55*

15. **Two or three lavatories adjacent to each other may use a single trap:**
when the waste outlets do not exceed 30 inches, center to center. *See page 55*

16. **When three lavatories are connected to the same trap, the trap must be:**
located in the center. *See page 55*

17. **According to code, a fixture can be double trapped:**
never. *See page 55*

18. **A food waste disposal unit in a restaurant may not discharge through a pot sink trap, regardless of size. According to code:**
Commercial food waste disposal units must be separately trapped. *See page 55*

19. **According to some codes, a food waste disposal unit may discharge through a continuous waste of a sink served by a single trap if:**
a directional tee is used. *See page 55*

20. **Some codes may allow a domestic clothes washer to use the same trap that serves a laundry tray when:**
it's adjacent to the laundry tray. *See page 55*

21. **The code-approved materials which may be used for concealed fixture traps are:**
cast brass, cast iron, lead, ABS plastic or PVC plastic. (Any two of these are acceptable answers.) *See page 56*

22. **The code prohibits concealed fixture traps from having:**
cleanouts. *See page 56*

23. When a tubular trap is used, its minimum gauge must be:
17 gauge. *See page 56*

24. The acceptable materials commonly used for accessible fixture traps are:
cast iron, cast brass, lead, 17 gauge tubular brass or copper. For a plastic system you must use ABS or PVC plastic. (Any two of these are acceptable answers.) *See page 56*

25. The code-approved materials that may be used for chemical, acid or corrosive wastes are:
borosilicate glass, high silicon cast iron, and lead pipe with walls at least 1/8 inch thick. (There might be others when approved by local authorities.) *See page 56*

26. The required wall thickness of lead pipe used to convey chemical, acid or corrosive wastes is:
1/8 inch. *See page 56*

27. The maximum vertical drop from a shower outlet to the trap water seal is:
24 inches. *See page 56*

28. The minimum height of a vertical standpipe inlet from the finished floor is:
18 inches. *See page 56*

29. The maximum vertical drop of a floor drain (considered a fixture) to the trap water seal is:
24-inch tailpiece (pipe) limit. *See page 56*

30. One of the main reasons for code-established fixture trap sizes is:
to drain the fixture rapidly. *See page 56*

31. Using the *UPC* Table in Figure 4-15, the maximum length of a 3" trap arm is:
6 feet. *See page 58*

32. Every fixture trap must be protected against:
siphonage and back pressure. *See page 58*

33. The developed length of a fixture drain includes the measurement from the crown weir to the vent pipe and the:
offsets and turns. *See page 58*

34. When, because of the fixture location, the fixture drain exceeds the limits set by code, what do the code allow you to do:
slightly increase the pipe size. *See page 58*

35. Two adverse reactions to a fixture trap when a plumbing system is improperly installed are:
the fixture trap may lose its seal by siphonage or back pressure. *See page 59*

Chapter 5

1. Before cleanouts became an essential part of the drainage system, plumbers had to:
cut a hole in blocked drainage pipe to insert a cleaning cable (and then patch it with a cement, or cement-like, mixture). *See page 63*

2. Three important cleanout requirements for today's model codes are:
location, distance between cleanouts, and size. *See page 63*

3. The most common plumbing maintenance problem is:
clogged drains. *See page 63*

4. The most common cause of clogged drains is:
a foreign object or other substances not designed for a drainage pipe to handle.
See page 63

5. Some things you'll commonly find in a kitchen that can cause a clogged drain are:
grease, cooking oil, butter, gravy and coffee grounds (any two are acceptable). *See page 63*

6. The dual purpose of a cleanout (or a cleanout tee) installed where a building sewer connects to the public sewer lateral is:
1) to water test the building sewer, 2) to insert a sewer cable for rodding. *See page 63*

7. The name of the fitting that permits upstream as well as downstream rodding is:
a two-way cleanout. *See page 64*

8. When a cleanout is extended to grade in an area subject to frequent traffic, the type cleanout head that should be used is:
countersunk. *See page 64*

9. According to the *Uniform Plumbing Code,* the maximum separation distance between 4-inch cleanouts is:
100 feet. *See page 64*

10. Near the base of each vertical waste or soil stack, you must install:
a cleanout. *See page 65*

11. If it's not possible to extend a cleanout to an accessible outside location, the alternative allowed by code is:
a cleanout tee in a vertical stack. *See page 65*

12. When a dead end is created by a cleanout, the maximum distance it can extend outside the building wall is:
5 feet. *See page 66*

13. The plumbing fixture that used to be considered a substitute for a cleanout, but is no longer allowed, is:
a water closet. *See page 66*

14. P traps into which floor drains with removable strainers discharge need not have a:
cleanout. *See page 66*

15. The only time a roof stack terminal in a one-story building can be used as a cleanout is:
when it's on a main drain, not on branch lines. *See page 66*

16. According to code, when rain leaders connect to a horizontal storm drain, they must be equipped with:
a cleanout. *See page 66*

17. The clearance required by code for a 2-inch cleanout is:
18 inches. *See page 67*

18. Cleanouts should be installed:
in the direction of flow. *See page 67*

19. Two prohibitions for the use of cleanout openings are:
1) the installation of another fixture, 2) floor drainage. *See page 67*

20. Cleanout plugs must be equipped with:
a raised nut or a recessed socket for removal. *See page 67*

21. Most codes will permit a building sewer be installed without manholes when:
the sewer is less than 8 inches. *See page 67*

22. The *International Plumbing Code* gives as the minimum size for a cleanout installed in a 4-inch pipe at the junction of a building drain and a building sewer as:
4 inches. Refer to Figure 5-16. *See page 68*

23. The smallest size cleanout accepted by the *Uniform Plumbing Code* for a 6-inch building drain is:
3½ inches. Refer to Figure 5-16. *See page 68*

24. According to the *International Plumbing Code*, the maximum distance between manholes on a straight run is:
400 feet. *See page 68*

25. When a standard-type cleanout terminates in an area where there's vehicular traffic, the code requires:
installation of an approved cleanout box. *See page 68*

Chapter 6

1. The types of waste that the code considers objectionable and harmful to the building drainage system are:
grease, oil, sand, plaster, lint, hair, glass, acids, flammable waste. (Any three of these are acceptable.) *See page 71*

2. Before it's allowed to enter the drainage system, one of the following three processes must be performed on objectionable and harmful waste:
interception, separation or neutralization. *See page 71*

3. The primary purpose of an interceptor or separator trap is:
to prevent objectionable waste from entering the drainage system. *See page 71*

4. When an interceptor is used, the working blueprints must show:
an approved detailed drawing, specifications and location of the interceptor. *See page 71*

5. The waste that must not go through an interceptor is:
any waste not requiring treatment. *See page 71*

6. The following types of commercial buildings require the installation of a grease interceptor:

restaurants, supermarkets, meat processing plants, hotel kitchens, bars, cafeterias and clubs. (Any three are acceptable.) *See page 71*

7. Grease interceptors are not generally required in these buildings:

Single-family residences or private living quarters, apartment buildings and establishments that sell only packaged food. (Any two are acceptable.) *See page 71*

8. The two types of grease interceptor installations usually approved by code are:

inside and outside installations. *See page 71*

9. An inside grease interceptor is usually used in:

a small restaurant that generates a small amount of grease. *See page 71*

10. The mandated grease retention capacity of a grease interceptor is:

2 pounds for each GPM of flow. *See page 71*

11. The maximum grease capacity permitted for an inside grease interceptor is:

100 pounds. *See page 71*

12. The two typical installation methods for inside grease interceptors are:

floor-mounted or below the floor. *See page 71*

13. An approved flow control fitting must be installed on small inside grease interceptors:

so the flow won't exceed the rated capacity of the interceptor. *See page 72*

14. In order to omit the fixture trap for a pot sink the *IPC* requires:

the horizontal distance between the sink outlet and the grease interceptor must be no more than 5 feet. *See page 72*

15. The *IPC* gives maximum vertical fixture tailpiece drop for a fixture connected to an inside grease interceptor at:

30 inches. *See page 72*

16. Grease interceptors must be easily accessible for:

inspection, cleaning and removal of the intercepted grease. *See page 72*

17. The installation of an inside grease interceptor is prohibited in the part of a building:

where food is handled. *See page 72*

18. Most codes prohibit the installation of a water-cooled grease interceptor because:

the jacket could fracture or corrode creating the potential for cross-connection with the potable water supply. *See pages 72*

19. Most codes prohibit a food waste disposal from discharging through a:

grease interceptor. *See page 73*

20. The two major considerations when sizing a grease interceptor for a fully-equipped commercial restaurant are:

the seating capacity and number of hours of operation. *See page 73*

21. The grease interceptor retention time required for a fully-equipped commercial restaurant is:

2.5 hours. *See page 73*

22. The minimum retention time for a grease interceptor in a small single-service kitchen is:

1.5 hours. *See pages 73-74*

23. Most codes don't spell out sizing methods for commercial grease interceptors. Instead, they defer the sizing to:

the local health department or local plumbing officials. *See page 74*

24. Identical restaurants in different geographical areas may require grease interceptors of different sizes because:

local codes in each location may have different formulas for sizing. *See page 74*

25. How does the *Uniform Plumbing Code* size gravity grease interceptors?

the *Uniform Plumbing Code*'s sizing criterion for gravity grease interceptors is based on the total number of fixture units. *See page 74*

26. The most commonly accepted construction material for outside grease interceptors is:

concrete. *See page 74*

27. Most codes require the inlet invert in an outside grease interceptor to discharge a minimum of:
$2^1/_2$ inches above the liquid level line.
See page 74

28. The minimum size cleanout manhole for an outside grease interceptor is:
20 inches in diameter. *See page 74*

29. An outside grease interceptor that is 21 feet long would require:
three manholes. *See page 75*

30. Outside grease interceptors must be designed and installed to avoid becoming:
air bound. *See page 75*

31. Most codes require that outside grease interceptors have:
at least two compartments. *See page 75*

32. The greasy waste line system is designed and installed to function as a:
separate drainage system. *See page 75*

33. A greasy waste line can connect to the building sewer if:
it passes through a grease interceptor first.
See page 75

34. The two code-approved greasy waste systems are:
the conventional greasy waste system and the combination waste and vent system.
See page 76

35. The greasy waste system that you'll most often be working on is:
the conventional greasy waste system. *See page 76*

36. The guidelines for sizing pipes for a conventional greasy waste system are:
the same as those outlined by your local code for DWV systems. *See page 76*

37. The difference between a conventional greasy waste system and a combination waste and vent system is:
the combination waste and vent system provides a horizontal wet venting system using a common waste and vent pipe. *See page 76*

38. Some codes might permit the use of a combination waste and vent system in areas:
where conventional venting isn't practical, such as for extensive floor drainage areas, group showers, supermarkets, demonstration or work tables in school buildings, or in similar applications where fixtures are not located adjacent to walls or partitions. (Any three are acceptable.)
See page 76

39. Some codes don't recommend connecting grease-producing restaurant kitchen equipment to a combination waste and vent system because:
it's not self-scouring. *See page 76*

40. Pipes in a combination waste and vent system are sized two pipe sizes larger than a conventional greasy waste system because:
the larger pipes provide adequate air movement within the system to maintain a flow balance.
See page 76

41. A fixture tailpiece should be as short as possible, never exceeding:
2 feet. *See page 76*

42. You can't allow an appurtenance that delivers large quantities of waste to discharge into a combination waste and vent system because:
it might inhibit adequate venting. *See page 76*

43. If a branch line in a combination waste and vent system exceeds 15 feet, you must provide:
separate venting. *See page 78*

44. In a greasy combination waste and vent system, the minimum area of any vent must be:
one-half the size of the waste pipe it serves.
See page 78

45. The code requires that each vent stack in a combination waste and vent system have:
an accessible cleanout. *See page 78*

46. Lint interceptors are not required by code in:
single-family houses or in apartment buildings where there's a washer in each unit. *See page 78*

47. Businesses that require lint interceptors in their drainage system are:
commercial or self-service laundries.
See page 78

48. The type of strainer usually required on a commercial or self-service lint interceptor is:

a removable $^{1}/_{2}$-inch mesh screen basket or screen. *See page 78*

49. In some codes, the horizontal drainage pipes serving commercial or self-service clothes washing machines are called:

indirect waste pipes. *See page 78*

50. The advantage of an indirect waste system for a commercial or self-service laundry is that:

an indirect system doesn't require trapping or venting. *See page 78*

51. In a self-service laundry, a 3-inch standpipe can accommodate:

two clothes washers. *See page 78*

52. When a commercial or self-service lint interceptor connects to a building drainage system, the vent on the horizontal discharge pipe should be located:

as close as possible to the lint interceptor. *See page 79*

53. Most codes don't provide established sizing methods for self-service laundries, but leave it to:

the local plumbing officials. *See page 79*

54. The design criteria for commercial laundries are set by:

the manufacturers. *See page 79*

55. The size of a lint interceptor in a self-service laundry is determined by:

the number of washing machines installed, the number of cycles, waste flow rate, retention time and storage factor. *See page 79*

56. The usual code-required retention period for a lint interceptor is:

2.0 hours. *See page 79*

57. Using the local code formula in our example, the lint interceptor size for a self-service laundry with eight clothes washing machines is:

360-gallon liquid capacity. (Formula: $8 \times 2 \times 3 \times 7.5 = 360$ gallons). *See page 80*

58. The general definition of areas where gasoline, oil and sand interceptors are required is:

anyplace where sand, oil, gasoline or other volatile liquids can enter the drainage system. *See page 80*

59. The types of establishments where the code would require a gasoline, oil and sand interceptor include:

repair garages where motor vehicles are serviced and repaired and where floor drainage is provided; commercial motor vehicle washing facilities; gasoline stations with grease racks, grease pits or wash racks; factories that have oily and/or flammable wastes from manufacturing, storage, maintenance, repair or testing; public storage garages where floor drainage is provided; or any other place where sand, oil, gasoline or other volatile liquids can be discharged into the drainage system. (Any three answers will do.) *See page 80*

60. The sizing and design of gasoline and oil interceptors that handle volatile liquids are determined by:

the amount of volatile liquids generated in the system. *See page 81*

61. Examples of establishments that, according to the code, generate small amounts of volatile liquids and sand are:

commercial garages servicing or storing fewer than ten vehicles, or service stations and repair shops that service, but don't store vehicles. *See page 81*

62. The type of floor drain usually required for an automobile repair shop is:

a bucket-type floor drain. (No separate sand interceptor is required.) *See page 81*

63. The minimum liquid capacity for an oil interceptor in the floor drainage system for a service station is:

18 cubic feet per 20 gallons of design flow. *See page 81*

64. In a commercial garage that services or stores fewer than ten vehicles, the inlet drain pipe should enter the oil interceptor:

above the liquid level line. *See page 81*

65. If the inlet pipe to an oil interceptor is 4 inches, the minimum size for the discharge pipe is:
4 inches. (The discharge pipe should never be smaller than the inlet pipe.) *See page 81*

66. You can omit the vent for the discharge pipe in an oil interceptor if:
a) it discharges into a catch basin,
b) it discharges into a vented building sewer or building drain and the discharge pipe doesn't exceed a 15-foot developed length, or
c) the interceptor is located outside the building. (Any of the three is acceptable.) *See page 81*

67. An oil interceptor for a service station must be located:
outside the building. *See page 81*

68. In addition to an oil interceptor, businesses that generate large amounts of volatile liquids must have:
a waste oil storage tank. *See page 81*

69. The minimum size vent required by most codes for a waste oil storage tank for a business that generates large amounts of volatile liquids is:
$1^{1}/_{2}$ inches. *See page 82*

70. Codes require that waste oil storage tanks be UL approved. The abbreviation UL stands for:
Underwriters Laboratories, Inc. *See page 82*

71. The minimum height above grade for a vent serving a waste oil storage tank is:
12 feet. *See page 82*

72. Before it enters an oil interceptor, floor drainage for a commercial garage building must first discharge through a:
sand interceptor. *See page 82*

73. Before the liquid wastes can discharge into the building drainage system, bottling plants must first discharge their processed wastes into:
an interceptor. *See page 82*

74. The drainage line of a commercial fixture used for bathing animals must contain:
a hair interceptor. *See page 82*

75. The code requires interceptors or separators for all drain lines in slaughtering rooms and meat dressing rooms. The blueprints with the type, size and location of these interceptors or separators must be approved by:
local authorities. *See pages 82-83*

76. Before discharging to a legal point of disposal, most codes require that drainage pipe wastes from animal boarding businesses pass through:
an interceptor tank. *See page 83*

77. The floor drainage from transformer vault rooms must discharge into:
an oil spill holding tank. *See page 83*

78. The authority to size a transformer oil spill holding tank belongs to:
the local power company. *See page 83*

79. Dental and orthopedic sinks must be equipped with an interceptor trap:
to prevent wax, plaster and other objectionable substances from discharging into the drainage system. *See page 83*

80. The purpose of a neutralizing tank is:
to dilute corrosive liquids, spent acids and other chemicals that might otherwise damage a drainage system. *See page 84*

Chapter 7

1. Wastes from fixtures, appliances and devices not regularly classed as plumbing fixtures may be drained by:
indirect means if they have a drip or drainage outlet. *See page 89*

2. The purpose of the indirect drainage method for special fixtures is:
to prevent sewage from backing up into these fixtures in case of a stoppage. *See page 89*

3. Plumbing fixtures and appliances that may be drained by indirect means are:
bar sinks, hand sinks, refrigerators, ice boxes, cooling or refrigerating coils, extractors, steam tables, egg boilers, coffee urns, stills, sterilizers, commercial dishwashers, water stations, water lifts, expansion tanks, cooling jackets, drip or overflow pans, air conditioning condensate drains, drains from overflows, relief vents from the water supply system, and similar applications. (Any three answers are acceptable.) *See page 89*

4. Devices that may be drained by indirect means are:

overflow and relief pipes on the water supply system, relief pipes on expansion tanks, sprinkler systems and cooling jackets. (Any two answers are acceptable.) *See page 89*

5. Overflow pipes on the water supply system must always be indirectly connected to the sanitary drainage system:

to avoid the possibility of contaminating the potable water supply through cross connection. *See page 89*

6. When there's the possibility of a potable water supply system becoming contaminated through an unsafe source, it's called:

a cross connection. *See page 89*

7. Any indirect waste piping exceeding 5 feet but less than 15 feet, in *UPC* jurisdictions; or that exceeds 2 feet but is less than 4, in *IPC* jurisdictions, must be:

directly trapped. *See page 89*

8. When a vent is required in indirect waste piping, it must be installed:

to extend separately to the outside air. *See page 89*

9. The minimum size for indirect waste pipes is:

1/2 inch. *See page 89*

10. The two types of indirect waste piping are:

air break and air gap. *See page 89*

11. An *air break* installation requires the type of indirect waste piping arrangement in which:

a drain pipe from a fixture, appliance or device discharges indirectly into a fixture or receptor at a point below the flood level rim of the receptor. Refer to Figure 7-3. *See page 90*

12. An *air gap* installation requires the type of indirect waste piping arrangement in which:

there's an unobstructed vertical distance through the free atmosphere between the drain pipe outlet from a fixture, appliance or device and the flood level rim of the receptor into which it discharges. Refer to Figures 7-2 and 7-4. *See page 90*

13. For an *air gap* installation, the minimum separation between the fixture outlet and the rim of the receptor is:

2 inches or twice the drain pipe size. *See page 90*

14. The main requirement for indirect waste receptor installations to allow for inspecting and cleaning is:

accessibility. *See page 91*

15. The factor that determines the type of receptor to use for *air gap* indirect waste pipe is:

whether or not the area will have pedestrian traffic. *See page 91*

16. The kind of strainer that the code requires for a floor sink is:

a beehive strainer that's at least 4 inches high. *See page 91*

17. The type of receptor most commonly used where *air break* indirect waste pipe is installed is:

a floor drain. Refer to Figure 7-3. *See page 91*

18. Most codes categorize automatic clothes washer standpipes as:

indirect waste receptors. *See page 91*

19. The installation of a standpipe receptor for an automatic clothes washer must include:

proper traps and vents. *See page 91*

20. The code prohibits the installation of an indirect waste receptor in:

a toilet room, closet, cupboard or storeroom. (Any one answer is acceptable.) *See page 92*

21. In places where gravity drainage isn't possible, indirect waste pipe may require the use of a:

sump. *See page 92*

22. The equipment used to lift liquids from a sump to a place of disposal is:

a sump pump. Refer to Figure 7-7. *See page 92*

23. Clear water wastes must empty into the building drainage system by means of:

an indirect waste pipe with an air gap. Refer to Figure 7-1. *See page 92*

24. In cases where air conditioning waste is connected to the building storm system, the type connection you should use is:

either air gap or air break. *See page 93*

25. The generally accepted methods of disposing of air conditioning wastes are:

an approved receptor or other suitable fixture, a sump, a building storm or sanitary drain, the building inside rain leader, or a waste and overflow or lavatory tailpiece (not all codes accept this last method of disposing of air conditioning waste). (Any two answers are acceptable.) *See page 93*

26. The maximum water temperature that can be discharged directly into a drainage system is:

140 degrees F. *See page 93*

27. Wastes from swimming pools, wading pools and spas must be connected to the building sanitary system by:

indirect means. *See page 93*

28. The type of waste disposal system that can never receive waste from a swimming pool is:

a septic tank. *See page 94*

29. If rainwater is not properly collected and disposed of:

it can become a nuisance and a health hazard. *See page 94*

30. In previous years, the type of drainage system commonly used in older cities located near lakes, rivers or the ocean was:

a combined sewer system. *See page 94*

31. To connect new construction into an existing combined sewer system, you need:

advance approval. *See page 94*

32. Roof drains must be equipped with:

strainers. *See page 94*

33. Most codes require installation of deck drains in the following locations:

sun decks and parking decks. *See page 94*

34. Two features that are unique to deck drain designs are:

Deck drains are unusual in that they are flat, and that they are sized two times larger than the inlet of the pipe they are connected to. *See page 94*

35. The maximum area most codes permit an area drain to handle is:

100 square feet. *See page 94*

36. The type drain you must use where there's a flat surface between a window and an outside wall is:

a sill drain. *See page 95*

37. When a planter drain is used, your local authority may require:

a sand interceptor. *See page 95*

38. The purpose of subsoil drains is:

to intercept surface water before it reaches the building's foundation wall or footings. *See page 95*

39. The sizing of storm water drainage pipes is usually determined by:

a mechanical engineer. *See page 96*

40. The two determining factors in sizing storm water drainage pipes are:

the square footage of impervious areas, and the maximum anticipated rainfall rate in any one hour. *See page 96*

41. As a plumber you should learn all you can about sizing commercial storm drainage and disposal systems because:

you may be doing the installing, and because it's likely to be on your journeyman and/or master plumber's examination. *See page 96*

42. Storm drainage tables differ in local codes because:

there's a great variation in maximum anticipated rainfall in different areas. *See page 96*

43. Why is it better to install a larger quantity of small roof drains and leader pipes than a smaller quantity of large roof drains and leader:

It's better to install a larger quantity of small roof drains and leader pipes than a smaller quantity of large roof drains and leader pipes because, even though you'll need more, it's less expensive. In addition, the more drains there are on a roof, the less the likelihood of ponding *See page 96*.

44. Once you know the maximum anticipated rainfall where you work, and the square feet to be drained, you can determine the sizing of storm drainage pipes by simply using:

the tables in your local code. *See page 96*

45. When the slope is increased, it affects the sizing of horizontal storm drainage pipes as follows:

the steeper the slope, the greater the area that can be drained by each pipe size; as a result, each pipe size can be smaller. *See page 98*

Chapter 8

1. The purpose of a written plumbing code is:

to protect the public health, welfare and safety. *See page 103*

2. In general, the plumbing code covers:

the proper design, installation and maintenance of plumbing systems. *See page 103*

3. The potable water supply system ends and the sewage system begins at:

the plumbing fixtures. *See page 103*

4. It's important to design a proper drainage system:

to prevent the fowling or the depositing of solids along the walls of drainage pipes. *See page 103*

5. A drainage system must be properly vented in order to:

provide a free circulation of air. *See page 103*

6. A properly vented drainage system prevents:

the possibility of siphonage or the forcing of trap seals. *See page 103*

7. You must provide adequate cleanouts on a drainage system:

so that all portions of the system are accessible to cleaning equipment. *See page 103*

8. There are a number of fittings that are acceptable for making a change in direction in drainage pipes, including:

a short sweep, a quarter bend, an eighth bend, a 45 degree wye, a long sweep, a sixth bend, a sixteenth bend, or combination of these. (Any three answers are acceptable.) *See page 103*

9. The five fittings not acceptable for use in a drainage system are:

fittings having a hub in the direction opposite to flow, fittings having running threads, a tee branch, fittings with bands or fittings with saddles. (Any two of these answers are acceptable.) *See page 103*

10. The trenches must remain open after the installation of drainage pipes until:

the piping has been tested, inspected and accepted by the plumbing inspector. *See page 103*

11. The minimum standards for plumbing system materials are set by:

the plumbing code. *See page 103*

12. If listed or labeled materials aren't available, you may use a substitute material:

only with the approval of the building department. *See page 105*

13. There are certain organizations that approve various plumbing materials. If you see the abbreviation ASTM stamped on a cast iron soil pipe and fitting, it would indicate that the material meets the standards set by:

the American Society for Testing Materials. Refer to Figure 8-1. *See page 104*

14. It's important for you to familiarize yourself with the abbreviations of organizations that approve plumbing materials because:

some of these abbreviations may appear on your journeyman or masters examination. *See page 105*

15. The organization that approves most standards for drainage materials is:

the American Society for Testing Materials (ASTM). Refer to Figure 8-2 and/or your code book. *See page 106*

16. It's important to keep your copy of the code updated because:

the code is always changing and you need to keep up with all the latest materials and installation requirements. You also need to buy the updated code supplement sheets and keep them in your code book. *See page 105*

17. If you're using extra-heavy cast iron pipe underground within a building, most codes will require the cast iron sewer pipe be:

extra heavy as well. *See page 105*

18. Some codes require Schedule 80-strength plastic sewer pipe:

for installations under heavy traffic areas. *See page 105*

19. Concrete pipe isn't generally recommended for ordinary building sewers because:

it's highly susceptible to corrosion from acids and sewer gases. *See page 105*

20. Where permitted, the use of asbestos-cement pipe in a building drainage system is limited to:

outside drainage systems. *See page 105*

21. Bituminous fiber pipe can be used as a building sewer in:

government housing projects (HUD). *See page 105*

22. Other than in building sewers, you can use extra strength vitrified clay pipe:

underground within a building. *See page 105*

23. Some local codes limit the use of plastic DWV pipe in multistory buildings to:

buildings not over three stories high. *See page 105*

24. Where the fill is known to be deleterious, you should not use piping material:

that's subject to corrosion. *See page 105*

25. According to the code, fittings used in a drainage system must conform to:

the material and type of piping used in the drainage system. *See page 108*

26. All the joints in a drainage system must be:

gastight, watertight and root-proof. *See page 108*

27. The minimum size required for subsoil drains is:

4 inches. *See page 108*

28. There are a number of approved materials commonly used for a building subsoil drain, including:

clay drain tile, perforated concrete pipe, corrugated polyethylene tube, concrete drain tile, horizontally split concrete pipe, perforated or horizontally split SR plastic drain pipe, PVC sewer pipe, and vitrified clay pipe. (Any three answers are correct.) *See page 108*

29. In addition to being compatible with the pipe used, fittings in a drainage system must:

not have ledges, shoulders or reductions that could restrict or obstruct flow. *See page 108*

30. The only type of threaded fitting acceptable for use in a drainage system is:

the recessed type. *See page 108*

31. Where threaded pipe is used in a vent system, the fittings may be either:

the drainage type or pressure type, either galvanized or black. *See page 108*

32. The code prohibits the mixing or combining of:

different types of plastic materials (ABS and PVC) in the same plumbing system. *See page 108*

33. When adding to an existing DWV system, you must use materials:

of like grade and quality. *See page 108*

34. When joining different piping materials together in new work, the fitting you must use is:

a transition fitting. Refer to Figure 8-4. *See page 108*

35. Galvanized steel pipe can't be used underground in a DWV system. The code states it must be kept aboveground at least:

6 inches. *See page 108*

36. The minimum depth below grade that vitrified clay pipe must be kept is:

12 inches. *See page 108*

37. The materials that are usually acceptable for use in a chemical or acid system are:

corrosion-resistant materials such as borosilicate glass pipe, high silicon content cast iron pipe, vitrified clay pipe, ABS and PVC Schedule 40 plastic pipe, plastic-lined pipe and lead pipe. (Any two answers are acceptable.) *See page 109*

38. The same materials are approved for use in indirect waste piping as are approved for:

potable water, sanitary drainage or storm drainage systems. *See page 109*

39. When a rain leader discharges directly into a soakage pit, you must install:

an overflow fitting. *See page 109*

40. The conventional means of protecting all exposed rainwater leaders located in areas where they may be subject to damage is:

to place a 3-inch galvanized steel pipe supported in a concrete base in front of the leader. *See page 109*

41. Joints and connections in DWV systems are pressure tested to:

ensure that they are gas and watertight. *See page 110*

42. Every lead-caulked joint in cast iron bell-and-spigot soil pipe must be firmly packed with:

oakum or hemp. *See page 110*

43. When pouring a lead joint, you must do it:

in one pour. *See page 110*

44. An alternate to lead and oakum for sealing bell-and-spigot cast iron soil pipe joints is:

a neoprene rubber gasket. Refer to Figure 8-7. *See page 110*

45. The clamp assembly used in joining hubless cast iron soil pipe and fittings for DWV systems must comply with the standards set by:

the Cast Iron Soil Pipe Institute (CISPI). Refer to Figures 8-1 and 8-8. *See page 110*

46. Joints between asbestos-cement pipe and plastic pipe should always be made with:

an approved adapter coupling with an approved rubber ring. Refer to Figure 8-9. *See page 111*

47. When it's necessary to cut asbestos-cement pipe for a new installation, the tool that you must use to ensure that the fittings will be watertight is:

a tapering tool. Refer to Figure 8-10. *See page 111*

48. The two types of joints used most often to connect plastic pipe and plastic fittings are:

solvent-cemented joints or heat-joined connections. *See page 111*

49. The type sealant that should never be used to seal plastic threaded joints is:

regular pipe dope. *See page 111*

50. The fitting that you must use to join bituminous fiber pipe with other types of materials is:

a transition fitting. *See page 112*

51. The type of fitting that you use to join the plain ends of vitrified clay sewer pipe is known as:

a flexible coupling. *See page 112*

52. The only type of construction in which you can use cement mortar joints and connections for concrete sewer pipe and fittings is:

for repairs and/or connections to existing lines constructed with cement mortar joints. *See page 112*

53. The part of a regular fixture trap on which some codes prohibit the use of slip joint connectors (nuts and washers) is:

on the outlet side of the trap above water seal. *See page 112*

54. Joints between lead pipe and cast iron pipe may be made with the following fittings:

a caulking ferrule, soldering nipple or bushing. *See page 113*

55. Caulked glass joints are made the same manner as caulked cast iron joints except that:

you must use an acid-proof cement, and the oakum or hemp rope must be acid-resistant. *See page 113*

56. To make a burned (welded) lead joint, you should use materials:

of the same composition as the material being joined. *See page 113*

57. Plain end ductile-iron gravity sewer pipe may be joined in the same manner as:

no-hub cast iron pipe. Refer to Figure 8-8. *See page 113*

58. In a threaded DWV system, you should always use:

recessed drainage fittings. *See page 113*

59. The types of fittings approved for copper DWV systems are:

cast brass or wrought copper fittings. *See page 113*

60. Expansion joints may be used in vent piping or drainage stacks for:

the expansion and contraction of pipes. *See page 113*

61. When piping materials have different outside diameters they may be joined together:

with an approved elastomeric sealing sleeve and clamping device. *See page 114*

62. You can connect pipes and fittings of different sizes in a plumbing system using:

the proper size increaser, reducer or reducing fitting. *See page 114*

63. When you need to make changes of direction in horizontal systems or in horizontal-to-vertical drainage systems, the acceptable fittings you can use to accomplish these changes are:

a sweep, a one-eighth bend, a 45-degree wye, a long sweep, a quarter bend, a sixth bend, a sixteenth bend, or a combination of these. (Any two answers are acceptable.) Refer also to Figure 8-14. *See page 114*

64. Where the direction of flow is from the horizontal to the vertical, the three fittings that are acceptable to use are:

a sanitary tee, a quarter bend and a one-fifth bend. Refer to Figure 8-14. *See page 114*

65. You may use materials not covered by the standards cited in your code:

if you get approval from your local authority. *See page 114*

66. The three types of cast iron soil pipe and fittings approved for building sewers are:

lead caulked joints, compression gasket joints for hub and spigot pipe and stainless steel shield with elastomeric gasket joints for no-hub pipe. (Any two answers are acceptable.) *See page 114*

67. The two grades of cast iron soil pipe used today are:

centrifugally-spun service weight and extra heavy cast iron. *See page 114*

68. The characteristics that make cast iron soil pipe superior for building sewers are:

its strength, durability and resistance to trench loads. *See page 114*

69. When you lay pipe with hubs or couplings, you must protect it from damage in the trench by:

excavating for the hubs or couplings to ensure that the pipe barrel sets firmly on the soil. *See page 114*

70. The minimum code-required depth for installing plastic pipe or one of the other fragile pipes approved for building sewers is:

12 inches. *See page 116*

71. Underground or horizontal drainage, waste and vent pipe must be adequately supported in order to:

keep the pipe in alignment and prevent it from sagging. *See page 116*

72. The bases of stacks must be supported by:

masonry or concrete. *See page 116*

73. Drainage pipe passing through cast-in-place concrete should be protected by:

sleeving. *See page 116*

74. The required clearance from the top of a drainage pipe to the bottom of the footing is:

2 inches. *See page 116*

75. When drainage piping is installed in corrosive materials it must be protected with:

sleeves, coating, wrapping or other approved methods. *See page 117*

76. Before installing used drainage piping in any plumbing system, you must ensure that it conforms to:

the standards in your code. *See page 117*

77. The code will permit you to drill or tap a waste or vent pipe for the purpose of rodding:

under no circumstances. *See page 117*

78. The code might permit a lavatory waste to connect to a water closet stub:

under no circumstances. The code prohibits any such connection. *See page 117*

79. The maximum number of stories in which a plastic DWV system may be installed per some local codes is:

three stories. *See page 117*

80. The two types of supporting methods you must consider in drainage, waste and vent systems are:

aboveground **horizontal** piping and aboveground **vertical** piping. *See page 117*

81. The two requirements that must be met when placing hangers for the support of horizontal and vertical piping are:

the hangers must maintain pipe alignment and prevent sagging. *See page 117*

82. When pipe lengths exceed 5 feet, the maximum distance you should allow between hangers for horizontal cast iron soil pipe with lead and oakum joints is:

10 feet (10-foot intervals). *See page 118*

83. The maximum distance you should allow between hangers for horizontal copper pipe 1½ inches and smaller is:

6 feet (6-foot intervals). *See page 118*

84. The maximum allowed distance between supports for horizontal Schedule 40 PVC and ABS solvent-cemented pipe is:

4 feet, for any size pipe. *See page 118*

85. The maximum allowable distance between supports for vertical copper piping is:

every story, but intervals must never exceed 10 feet. *See page 119*

86. Horizontal vent piping should be installed and sloped:

to drain back to the soil or waste pipe by means of gravity. *See page 119*

87. It's important not to allow moist air to be trapped in a horizontal vent pipe because:

entrapped moist air will accelerate corrosion and reduce the life of the pipe. *See pages 119-120*

88. When you size and install indirect waste piping you must always accommodate:

the outlet drainage of the fixture or appliance. *See page 120*

89. When practical, indirect waste pipe should be installed:

below the floor. *See page 120*

90. The indirect waste pipe installation that is made below the floor and connects through the receiving fixture above the water seal of the trap is called:

an air break installation. Refer to Figure 8-24. *See pages 120-121*

91. The outlet for above-the-floor indirect waste pipe should terminate in:

an air gap installation. Refer to Figure 8-25. *See pages 120-121*

92. The minimum size indirect waste pipe you should use for an above-floor installation is:

3/4 inch diameter. *See page 120*

93. The minimum indirect waste pipe size most codes require for a below-floor installation is:

1 1/4 inch diameter. *See page 120*

94. Receiving fixtures for indirect waste piping should be located:

where they are accessible. *See page 121*

95. According to the *UPC*, commercial dishwashing machines must be connected to the building greasy waste drain line by:

direct means. *See page 121*

96. A drinking fountain may be indirectly connected to a floor drain for the purpose of:

resealing the trap. *See page 122*

97. Indirect waste piping for A/C units must be installed below the bottom of the floor slab:

at least 2 inches. Refer to Figure 8-17.
See pages 116 and 122

98. When the waste or condensate from an A/C unit connects to the plumbing drainage system, the A/C unit is classified as:

a plumbing fixture. *See page 123*

99. An air conditioning unit that's over 5 tons but less than 10 tons may discharge its waste into:
a buried pipe, filled with 3/4-inch rock, that's 10 inches in diameter and 24 inches long. *See page 123*

100. The five acceptable areas where air conditioning units 10 tons and larger may discharge their waste are:
a drainage well, the sanitary drainage system, the storm water system, an adequate-size soakage pit and an adequate-size drainfield. (Any three answers are acceptable.) *See page 123*

Chapter 9

1. Under present code standards, the two disposal methods no longer acceptable as a permanent means of dealing with human waste are:
cesspools and outhouses. *See page 127*

2. Even today, drinking water can be contaminated by untreated sewage. This can spread diseases such as:
cholera and typhoid. *See page 127*

3. When public sewers aren't available, the most acceptable method for sewage disposal is:
the septic tank system. *See page 127*

4. The governmental department that has established guidelines for septic tank safety is:
the Department of Environmental Resource Management (DERM). *See page 127*

5. Although septic tank and drainfield installations are important areas of plumbing work, the installation and maintenance work for these systems is usually done by:
a licensed septic tank contractor. *See page 127*

6. Although you probably won't do the work, it's important for you to be informed about the basic principles of septic tank and drainfield installation because:
it's very likely that there will be questions concerning these installations on your journeyman and master's examinations. *See page 127*

7. Septic tanks are designed to:
separate solids from liquid wastes. *See page 127*

8. The approximate amount of waste solids for each 100 gallons of water in a septic tank is:
3/4 of a pound. *See page 127*

9. A septic tank is sized to have a capacity equal to approximately:
24 hours of anticipated flow. *See page 127*

10. The solids in a septic tank are digested through:
a biological process involving bacterial action in which sewage wastes are transformed into gases and harmless liquids. *See page 127*

11. When the effluent enters the drainfield:
it oxidizes and evaporates. *See page 127*

12. After the bacterial process is completed within the septic tank, what remains are:
small amounts of solids that settle on the bottom of the tank as sludge. *See page 127*

13. The lighter, undigested particles that rise to the top of the liquid after the bacterial process in the septic tank is complete are called:
scum. *See page 127*

14. When undigested materials need to be cleaned out of a septic tank, the job must be done by:
a certified professional with the proper equipment to perform this type of work. *See page 127*

15. The materials not code-approved for septic tank construction are:
blocks, bricks and wood. (Any two answers are acceptable.) *See page 128*

16. The two most common types of septic tanks are:
precast concrete tanks and cast-in-place tanks. *See page 128*

17. Concrete septic tanks are protected from corrosion by:
coating them with an approved bituminous coating. *See page 128*

18. In order to prevent contamination by leaking sewage, the code requires that all septic tanks be:
watertight. *See page 128*

19. When sizing a septic tank, you must make sure that the tank will be able to accommodate:
sludge and scum accumulations. *See page 128*

20. Most codes require that septic tanks have:
two compartments. *See page 128*

21. The liquid capacity of the smallest approved septic tank is:
750 gallons. *See page 128*

22. The secondary compartment (outlet compartment) of the tank should have a minimum liquid capacity of:
250 gallons. *See page 128*

23. On a *residential* septic tank, the type of cover slab acceptable for cleaning purposes is:
one that has removable sections. Refer to Figure 9-1. *See page 128*

24. On a 500-gallon capacity commercial septic tank, the number of manholes required is:
two, one over the inlet tee and one over the outlet tee. *See page 128*

25. When the first compartment of a *commercial* septic tank exceeds 12 feet in length, the number of manholes required is:
three, one over the inlet tee, one over the outlet tee and one over the baffle wall. *See page 128*

26. The minimum size requirement for the vertical legs of the inlet and outlet tees of a septic tank is:
4 inches in diameter. *See page 128*

27. A septic tank inlet pipe should be higher than the outlet pipe by at least:
2 inches. *See page 128*

28. The air space above the liquid level in a septic tank must be:
a minimum of 9 inches (8 inches for some codes). *See page 128*

29. When a septic tank is located in a parking lot, the building department requires it to have:
an acceptable traffic cover. *See page 128*

30. When sizing septic tanks for single-family or *multiple* residential units, the capacity is determined by:
the number of bedrooms. *See page 130*

31. The capacity requirements for septic tanks for *commercial* buildings are determined by:
the maximum fixture units for public use. Refer to Figure 9-4. *See page 130*

32. You determine the capacity requirement for a septic tank for a single-family residence that has more bedrooms than there are listed in your code table by:
adding 150 gallons to the sizing requirement for each additional bedroom. *See page 130*

33. You determine the capacity requirement of a septic tank for multiple residential units with more units than there are listed in your code table by:
adding 250 gallons to the size requirement for each extra unit. Refer to Figure 9-3. *See page 131*

34. A septic tank can't be located closer to any water supply line than:
5 feet. *See page 132*

35. A septic tank can't be located closer to the shoreline of an open body of water than:
50 feet. *See page 132*

36. Drainfield materials commonly used to distribute the effluent from septic tanks include:
open-jointed drain tile, perforated drain tile, block or cradle-type drain units, or corrugated plastic perforated tubing. (Any two are acceptable.) *See page 132*

37. The minimum inside diameter of drainfield tile is:
4 inches. *See page 132*

38. The minimum slope for drainfield tile per 100 feet is:
3 inches. *See page 132*

39. The minimum width for each drainfield trench is:
18 inches. *See page 132*

40. The maximum length of a single tile drainfield trench is:
100 feet. *See page 132*

41. The required depth of washed rock under the drain units of a reservoir-type drainfield is:
12 inches. *See pages 132-13*3

42. The maximum distance between centers of the distribution lines of a reservoir type drainfield is:
4 feet. Refer to Figure 9-9. *See page 133*

43. The best soils for absorbing drainfield effluent are:
soils made up of coarse sand or gravel. *See page 134*

44. A percolation test determines:
how long it takes water to be absorbed into the soil. *See pages 134-135*

45. Other than the type of soil, the sizing of a residential drainfield is determined by the:
septic tank capacity in gallons. *See page 135*

Chapter 10

1. The plumbing standards and installation methods for mobile home and RV parks are regulated by:
local agencies. *See page 141*

2. Recreational vehicles are defined in the code as:
dependent trailers. *See page 141*

3. Recreational vehicles have limited plumbing facilities, usually not including:
a toilet. *See page 141*

4. A mobile home is defined by code as:
an independent trailer coach. *See page 141*

5. The code does not require dependent trailer parks to provide:
individual water and sewer connections. *See page 142*

6. A dependent trailer park must provide a separate building with:
toilet facilities and a waste disposal station (service building). *See page 142*

7. A dependent trailer park service building must have an individual:
sewer connection. *See page 142*

8. A dependent trailer park service building must provide a minimum number of:
toilet fixtures for each sex. *See page 142*

9. The *Uniform Plumbing Code* requires one toilet for each sex in a dependent trailer park:
for the first 25 trailer sites in the park. *See page 142*

10. Each toilet room in the service building of a dependent trailer park must have:
a floor drain. *See page 142*

11. In a dependent trailer park service building, the number of lavatories that must be provided for each toilet is:
one lavatory per toilet for the first six toilets. *See page 142*

12. In the men's toilet room of a dependent trailer park service building, the portion of required toilets that may be replaced with urinals is:
one-third of the toilets. *See page 142*

13. The toilet design that must be used in the toilet rooms of a dependent trailer park is:
the elongated type with open front seat. *See page 142*

14. Each toilet installed in a dependent trailer park must have:
a separate stall with a door and latch. *See page 142*

15. A shower installed in a dependent trailer park must have a floor area of:
36 by 36 inches. *See page 142*

16. The location in a dependent trailer park's shower room that must be protected from water overflow is:
the dressing area. *See page 142*

17. According to some local codes, the minimum fixtures required in the women's area of an independent trailer park are:
one toilet, one lavatory and one shower or bathtub. *See page 142*

18. In a trailer park, the fixture units are assigned as:
a set number of fixture units for each site drainage inlet. *See page 142*

19. The criterion used to size a park drainage system is:
the number of trailer sites. *See page 142*

20. The number of fixture units permitted on a 3-inch pipe in a trailer park drainage system is:
35 (refer to Figure 10-1). *See page 143*

21. In a trailer park, the minimum slope for a 4-inch pipe per 100 feet is:
15 inches (refer to Figure 10-2). *See page 143*

22. The installation and backfill for a trailer park drainage system is the same as:
a conventional building sewer. *See page 143*

23. In a trailer park drainage system, the first vent should be located:
no more than 5 feet downstream from the first sewer lateral. *See page 143*

24. When a park lateral terminates with a 4-inch P-trap and a sanitary tee, a cleanout should be installed:
in the top of the sanitary tee. *See page 144*

25. The minimum pressure required at each trailer site for a park's water distribution system is:
20 psi. *See page 144*

Chapter 11

1. By far the most water we obtain for public use originates from:
lakes, rivers and deep wells. *See page 147*

2. Many large cities, when faced with a shortage of available water for human consumption, have had to resort to:
water conservation and moratoriums on new construction to extend their available water resources. *See page 147*

3. To protect our present water sources and search for additional fresh water sources, there must be:
long range planning. *See page 147*

4. The primary source of water for single-family and multifamily residential buildings is:
the municipal water treatment plant. *See page 147*

5. Is water conservation a local issue or a national issue?:
it is a National issue. *See page 147*

6. Until recently, local codes have only considered water conservation methods that involve:
regulating the maximum allowable water usage for plumbing fixtures. Refer to Figure 11-1. *See pages 147-148*

7 If the average drop of water takes only $2^1/_2$ seconds to form, one leaky faucet wastes:
365 gallons of water per year. *See pages 147-148*

8. One new method of water conservation being tried in many areas is:
graywater recycling. *See page 148*

9. Gray water is typically routed to a disposal field or used for what purpose?:
Underground/Subsurface irrigation of plants other than root crops. *See page 148*

10. Graywater is:
untreated household wastewater that has not come in contact with waste from toilets, dishwashers or kitchen sinks. Refer to Figure 11-2. *See pages 148-149*

11. A graywater recycling system cannot be connected to:
any potable water piping system. *See page 148*

12. The fixtures that can connect to a graywater system are:
bathtubs, showers, lavatories, laundry trays and clothes washing machines. (Any three answers are acceptable.) *See page 148*

13. The three things that determine the type of graywater recycling system that may be used are:
the location, the soil type, and the groundwater table. *See page 148*

14. A graywater recycling system for a residential building must discharge the waste:
into underground irrigation piping or disposal fields. *See page 149*

15. When a holding tank is installed above ground, its base must be supported by:
a suitably-sized 3-inch-thick concrete slab. Refer to Figure 11-4. *See pages 149-150*

16. After you install the holding tank and piping, the code requires that you test a graywater system with:
a flow test by filling the tank with water to the overflow line and inspecting all the components for watertightness to the point of disposal. *See page 149*

17. You base your estimate of the amount of graywater discharge from a single-family residence on:
the number of occupants and bedrooms in the home. *See page 149*

18. In estimating graywater discharge for a single-family residence, the number of occupants considered for the first bedroom is:
two. *See page 149*

19. In estimating graywater discharge for a single-family residence, the number of occupants considered for each bedroom, after bedroom number one, is:
one. *See page 149*

20. To estimate the total number of gallons of graywater flow from a single-family residence, the allowance per occupant that you use is:
25 gpd/occupant (excluding laundry).
See page 151

21. To estimate the total number of gallons of graywater flow from a single-family residence, the allowance per occupant, including laundry facilities, that you use is:
25 gpd + 15 gpd for laundry = 40 gpd/occupant.
See page 151

22. A graywater holding tank is protected from overfilling by:
Graywater holding tanks are required to have an overflow drain pipe connected to the sewer.
*See page 15*1

23. When you excavate for a graywater subsurface irrigation/disposal field, you must not allow your excavation to extend within:
5 vertical feet of the highest known seasonal groundwater. *See page 151*

24. Each graywater holding tank must have a locking gasketed access opening in order to:
permit inspection and cleaning. *See page 152*

25. Each graywater holding tank must be permanently marked with:
its rated capacity and a sign that reads, "Graywater irrigation system, danger — unsafe water." *See page 152*

26. The minimum capacity for a graywater holding tank is:
50 gallons. *See page 152*

27. The size of a holding tank vent is determined by:
the total number of fixture units. *See page 152*

28. For replacement purposes, all connecting pipes to holding tanks must be fitted with:
unions or other approved effective fittings. Refer to Figures 11-3 and 11-4. *See page 152*

29. A holding tank must be designed to withstand an earth load in the amount of:
300 pounds psf. *See page 152*

30. To protect against sewer backups, an underground holding tank requires:
a backwater valve. *See page 152*

31. All holding tanks must be constructed of:
steel, with an internal and external corrosion-resistant coating. *See page 152*

32. The minimum pipe size for use in graywater system irrigation/disposal fields is:
3 inches in diameter. *See page 152*

33. Piping materials that are acceptable for graywater/disposal fields are:
perforated ABS, PVC pipe and perforated high-density polyethylene pipe. (Any two answers are acceptable.) *See page 152*

34. The code requires that graywater irrigation/disposal field piping have:
sufficient openings for the proper distribution of the waste water into the trench area.
See page 152

35. The minimum size filter material for a graywater irrigation/disposal field is:
$^3/_4$ inch. *See page 152*

36. The minimum depth of filter material required beneath the pipe in a graywater irrigation/disposal field is:
3 inches. Refer to Figure 11-7. *See pages 152-153*

37. The filter material in a graywater irrigation/disposal field must extend above the pipe:
2 inches. Refer to Figure 11-7. *See page 153*

38. Graywater piping must be laid with a slope of:
3 inches per 100 feet. *See page 153*

39. In a graywater disposal system, the maximum length of each individual line is:

100 feet. Refer to Figure 11-8. *See page 153*

40. When graywater irrigation/disposal lines are installed in areas having steep grades, the code requires that:

the lines be stepped. Refer to Figure 11-9. *See pages 153-154*

41. The minimum distance required from a private property line to a graywater system holding tank is:

5 feet. Refer to Figure 11-10. *See page 154*

42. The minimum distance required from a graywater irrigation/disposal field to streams and lakes is:

50 feet. Refer to Figure 11-10. *See page 154*

43. If it's necessary to install a graywater irrigation/disposal field parallel to a public water main, the work must be approved by:

the local authority. Refer to Figure 11-10, footnote 7. *See page 154*

44. The difference in the design criteria regarding typical soils for graywater irrigation/disposal fields and septic tank drainfields is that:

graywater systems use six typical soils, while septic tanks use five typical soils. Refer to Figure 11-6. *See pages 152 and 155*

45. A graywater system is designed to:

safely manage wastewater by filtering it through the soil and returning it to the underground water table. *See page 155*

Chapter 12

1. The first American city to build a gravity water supply system was:

Boston, Massachusetts. *See page 159*

2. The installation of a pressurized water system made possible:

a safe, abundant supply of water at the turn of a handle. *See page 159*

3. In order to make raw water safe and pleasant for drinking, it's treated for the removal of:

unpleasant tastes, odors and impurities. (Any two answers are acceptable.) *See page 159*

4. Potable water is:

water that meets the health requirements for drinking, culinary and domestic purposes. *See page 159*

5. The agency that's generally responsible for monitoring our public water supply systems is:

the local health department. *See page 159*

6. The purpose of a public water main is:

to carry water for community use. *See page 159*

7. A private service connection to a public water main must have:

a curb stop and a connection to a water meter at the property line. Refer to Figure 12-1. *See pages 159-160*

8. A building water service pipe begins at:

the outlet side of the water meter, at the property line. *See page 161*

9. The pipes that carry water from the water service pipe to the plumbing fixtures and other outlets are called:

the water distributing pipes. *See page 161*

10. The components of a water supply system are:

the water service pipe, the water distributing pipe, the necessary connecting pipes, the standpipe system, fittings, control valves and all appurtenances on private property. (Any three answers are acceptable.) *See page 161*

11. In a water distributing system, the code defines a discharge opening for water as:

a water outlet. *See page 161*

12. In sizing a water system, you won't ever be able to exactly predict:

the maximum rate of flow or the demand in a building's water supply system. *See page 161*

13. When you size water supply piping, it's important to be economical, but you must be sure to avoid:

undersizing the water supply. *See page 161*

14. Physical properties that can affect water in supply pipes are:

density, viscosity, compressibility, boiling point, minimum available pressure, velocity flow and friction loss. (Any two answers are acceptable.) *See page 161*

15. **The type of water supply system that plumbers aren't expected to size is:**
    a complex system (a system requiring pipe sizes larger than those given in Figures 12-4 and 12-5, or the tables in your local code). *See page 161*

16. **The psi pressure at which an ordinary faucet at ground level operates properly is:**
    8 psi. *See page 164*

17. **The minimum required pressure in psi for a floor-mounted ball-cock type water closet is:**
    8 psi. *See page 164*

18. **When there's a need for designing a water supply system using pipes larger than those in your plumbing code, you should:**
    leave the job to a professional engineer. *See page 164*

19. **A water service pipe continues within the building to become:**
    the building water main. *See page 164*

20. **As the building water main progresses through the building, the demand on the line:**
    is likely to decrease. *See page 164*

21. **According to code, the number of fixtures that can connect to a $^1/_2$-inch water supply branch is:**
    two. *See page 164*

22. **When a building exceeds four stories, or where a system's residual pressure is below what's required at the highest water outlet, you must provide:**
    an automatic control pressure pump or an adequate gravity tank. *See page 164*

23. **If a building requires a gravity tank, the design work should be done by:**
    a professional engineer. *See page 164*

24. **If each piping system is the same size, the type system on which you can install the most fixtures is:**
    a copper system. *See page 164*

25. **In most cases, as the size of the water service pipe increases:**
    the pressure loss is reduced or remains stable. *See page 164*

Chapter 13

1. **The water system that most buildings have is:**
   a hot water system. *See page 169*

2. **When a hot water system is installed, the code very specifically requires:**
   the installation of safety devices. *See page 169*

3. **It's important to install safety equipment on hot water systems in order to:**
   protect property from damage and persons from injury due to the hazards of excessive pressure and temperature. *See page 169*

4. **Since requirements for hot water distribution systems aren't specified in the code, the design and sizing of the systems is the responsibility of:**
   professional engineers and plumbers. *See page 169*

5. **The hot water supply systems for large commercial buildings are usually designed by:**
   professional engineers. *See page 169*

6. **The hot water systems for small commercial and residential buildings are usually designed by:**
   the installing plumber. *See page 169*

7. **The two principal objectives in designing a good hot water system are:**
   (1) the system must satisfy the hot water demand for a particular type of occupancy; and,
   (2) it must include safety features that guard against the hazards of excessive pressure and temperature. *See page 169*

8. **The normal design range for hot water temperatures in most plumbing fixtures is:**
   between 110 and 140 degrees Fahrenheit. *See page 169*

9. **Devices now required pertaining to the temperature of water serving certain fixtures are:**
   certified temperature-limiting or pressure-balancing devices to prevent scalding on fixtures such as showers, soaking tubs, public lavatories and bidets. *See page 169*

10. **The three fuels used in most direct water-heating units are:**
    gas, oil and electricity. *See page 169*

11. **Electric water heaters are the most common types used in homes today because:**
    they are clean and attractive and can be installed nearly anywhere within a building. *See page 169*

12. **Gas- or oil-fueled water heaters must be located:**
    in an area where there is adequate ventilation. *See page 169*

13. **Water heaters designed to burn gas or oil must be installed with:**
    flues to carry away combustion gases. *See page 169*

14. **The type of buildings in which circulating hot water is most efficient are:**
    large buildings, such as apartment buildings, with central hot water systems. *See page 170*

15. **When installing hot water pipes in large buildings with circulating lines, an advisable conservation measure is to:**
    insulate the hot water feed lines to prevent heat loss and save energy. (This also provides substantial cost saving.) *See page 170*

16. **Though not required in a cold water system, a hot water system design must allow for:**
    the expansion and contraction of hot water lines. *See page 170*

17. **For each 100 feet of piping, you should allow an expansion variance of:**
    $1^1/_2$ inches. *See page 170*

18. **In the average home, the peak draw period for hot water is assumed to be:**
    1 hour. *See page 170*

19. **When sizing hot water storage tank capacity, the percentage of the tank's hot water supply that's assumed available during the one-hour period of peak draw is:**
    75 percent. *See page 170*

20. **For a peak draw period of one hour, a 40-gallon water heater should provide:**
    30 gallons of hot water. *See page 170*

21. **For a peak draw period of three hours, a 40-gallon water heater must provide:**
    10 gallons of hot water per hour. *See page 171*

22. **For a storage tank heater, the amount of hot water that's available during the peak demand periods is determined by:**
    the heating capacity per hour. *See page 17*1

23. **The recommended storage capacity for a gas water heater installed in a two-bedroom house is:**
    30 gallons. Refer to Figure 13-3. *See page 171*

24. **The recommended storage capacity for an oil-burning water heater installed in a three-bedroom house is:**
    30 gallons. Refer to Figure 13-3. *See page 171*

25. **The recommended storage capacity for an electric water heater installed in a four-bedroom house is:**
    66 gallons. Refer to Figure 13-3. *See page 171*

26. **The determining factor in choosing the storage capacity for any water heater, regardless of fuel type, is:**
    the number of bedrooms in the house. *See page 171*

27. **It might be wise to split the hot water system and install two water heaters when:**
    the layout requires long pipe runs. *See page 171*

28. **The capacity size for a packaged high recovery rate heater that would generally be adequate for up to 12 living units is:**
    a 75-gallon storage tank. *See page 171*

29. **The code requires that all equipment used for the heating or storage of hot water be equipped with:**
    a pressure relief valve. *See page 171*

30. **The pressure relief valve on a hot water heater serves to:**
    safely relieve excess storage tank pressure. *See page 171*

31. **When you install a water heater, the following should remain visible:**
    the plates with the maximum working water pressure and other data. *See page 171*

32. **In locating a water heater, you must ensure that it's accessible for servicing or replacement without:**
    having to remove any permanent part of the building. *See page 171*

33. The temperature relief valve that's required on all domestic hot water heaters is:

the reseating type, rated by its Btu capacity. *See pages 171-172*

34. The type of relief valve commonly used today is:

a combination pressure and temperature relief valve. *See page 172*

35. On a hot water heater pipe, a shut-off or check valve must never be installed:

between the relief valve and the hot water heater tank. *See page 172*

36. Because of possible contamination, the code prohibits the hot water relief valve drip pipe from connecting to:

any plumbing drainage or vent system. *See page 172*

37. A water heater relief valve drip pipe can never terminate above any of the following fixtures:

a water closet, urinal, bidet, bathtub or shower stall. (Any three answers are acceptable.) *See page 172*

38. A water heater relief valve drip pipe should terminate:

to an observable point outside the building. *See page 172*

39. The end of a water heater relief valve drip pipe may *not* be:

the threaded type. *See page 172*

40. If hot water storage tanks are placed above the roof of a building, the relief valve pipe may discharge:

on the surface of the roof. *See page 172*

41. The size of the relief valve discharge piping is governed by:

the size of the opening of the relief device. *See page 172*

42. A water heater drain pan is required when:

a water heater is located above the ground floor level of a building. *See page 172*

43. The required depth of a water heater drain pan is:

$1^1/_2$ inches (2 inches, in some codes). *See page 173*

44. The minimum size drain pan outlet is:

$^3/_4$ inch (1 inch, in some codes). *See page 173*

45. The clearance between the drain pan sides and the water heater must be:

a minimum of 2 inches. *See page 173*

46. In a vertical installation, the maximum number of water heater drain pans that you can connect to a 1-inch riser is:

three. *See page 173*

47. On a water heater, the required location for a heat trap is:

on the hot water line leading away from the water heater. *See page 173*

48. The purpose of a heat trap on a water heater is:

to prevent hot water from rising into the hot water line. (This also saves approximately 2 percent of the hot water generating cost.)

See page 173

49. The energy-saving device, aside from insulation, that's required on all water heaters is:

a shutoff that will prevent the water from being heated to above 210 degrees F. *See page 173*

50. The three conventional hot water circulating systems are:

the inverted upfeed system, the looped system and the downfeed system. (Any two answers are acceptable.) *See page 174*

Chapter 14

1. The three things the plumbing code regulates for water piping are:

the materials, the sizing and the installation methods. *See page 179*

2. The plumbing code requires that there be an adequate supply of potable water to all fixtures so they:

will flush properly and remain clean and sanitary. *See page 179*

3. Code-established safeguards protect our water supply because:

they prevent pollution of the water supply. *See page 179*

4. Two reasons why you should consider the kind of water and soil in your area before you select and size the material for water supply pipes are:

(1) some water corrodes the interior wall of some pipes; and, (2) some types of soil can corrode the exterior of some pipes. *See page 179*

5. The pipes that are specifically prohibited in a potable water supply system are:

pipes that can leave toxic substances in the water supply or were once used for other than a potable water supply system. *See page 179*

6. All plastic pipe and fittings must display identification/acceptance from:

the ASTM or other recognized national standard of acceptance. *See page 179*

7. The minimum working pressure required by code for plastic water service piping is:

160 psi. *See page 179*

8. The plastic pipe and fittings first approved for a building water distribution system was:

CPVC. *See page 181*

9. The highest water temperature that CPVC plastic pipe can withstand is:

180 degrees F. *See page 181*

10. The type of copper water tube not permitted underground within a building is:

Type M. Refer to Figure 14-2. *See page 181*

11. Three distinct advantages plastic pipe and fittings have over metallic pipe and fittings are:

they resist corrosion, scale, sediment buildup and aren't affected by soil conditions or electrolysis. (Any three answers are correct.)

See page 181

12. When installing water service pipe in the same trench as the building sewer, you must place it:

on a solid shelf excavated at one side of the common trench and at least 12 inches (10 inches, some codes) above the sanitary sewer line. You must also keep the joints in the water service pipe to a minimum. Refer to Figure 14-3.
See pages 181-182

13. When you install metallic water service pipe on filled corrosive soil, you must protect it with:

one or two coats of asphaltum paint or other approved coating. *See page 182*

14. Water service supply piping must be securely supported in order to:

prevent sagging, misalignment and breaking.
See page 182

15. Materials considered superior for outside water service supply piping include:

cast iron water pipe, cast iron threaded water pipe, wrought iron pipe and galvanized steel pipe. (Any two answers are acceptable.)

See page 182

16. Large boulders, rocks or cinder fill shouldn't be used to backfill a metallic water service supply trench because:

they might physically damage or encourage corrosion of the pipe. *See page 182*

17. PVC, PE and PEX plastic pipe must be treated with special care because:

they are considered fragile. Refer also to Figure 8-16. *See page 182*

18. The minimum separation distance required between a water service supply pipe and a sewer line when they are installed in separate open trenches is:

5 feet, unless of a material approved for use within a building. *See page 182*

19. In climates where pipe is subject to freezing, water service supply pipe should be buried deep enough to be:

12 inches below the frost line. *See page 182*

20. Between the bottom of a building foundation or footing and the top of the water service supply pipe, you must have a clearance of:

2 inches. *See page 183*

21. When connecting a lawn sprinkler system to a potable water service supply pipe, on the discharge side of each valve you must install:

an approved backflow preventer. *See page 183*

22. In each building's water service supply pipe, independent of the water meter valve, you must install:
a separate, accessible, control valve (some codes require two). *See page 183*

23. Water service supply piping must be electrically isolated from:
other pipes, conduits, soil pipe, building steel and steel reinforcing. *See page 183*

24. The code prohibits a public water supply from interconnecting with:
a private water supply, such as a well. *See page 183*

25. When you connect a swimming pool water supply to the potable water service pipe, in order to prevent cross connection you must provide:
a positive air gap. *See page 183*

26. When mineral deposits in the water solidify in the distribution pipes over a period of time, it can cause:
a reduced flow of water and/or premature failure of the system. *See page 183*

27. When a pipe passes through cast-in-place concrete, you should provide a clearance around its circumference of:
1/2 inch. *See page 184*

28. In climates subject to freezing temperatures, you shouldn't install water pipe in any unheated areas unless you protect it with:
adequate insulation. *See page 184*

29. You should not allow hot and cold water pipes to come into contact with each other in underground or partition installations because:
the heat from the hot water pipe will be transferred to the cold water pipe. *See page 184*

30. In most jurisdictions, each water closet supply pipe is required to have:
an independent control valve installed above the floor. *See page 184*

31. The number of residential plumbing fixtures that you can connect to a 1/2-inch cold water supply pipe is:
two. *See page 184*

32. You can protect water pipe installations from water hammer by providing:
an ASSE 1010-certified water hammer device. *See page 184*

33. When water pressure within a building is more than 80 psi, you must install:
an approved water pressure regulator with a strainer. *See page 184*

34. You must support horizontal screwed water pipe at intervals of:
approximately 12 feet. *See page 185*

35. The maximum distance allowed between supports for horizontal CPVC plastic pipe is:
3 feet for pipe 1 inch and smaller, 4 feet for pipe sizes larger than 1 inch. *See page 185*

36. What are the support requirements for vertical 1 1/4-inch copper tubing carrying cold water?
supported at each floor level. *See page 185*

37. The code requires that potable water supply outlets terminate above the overflow rim of a fixture because:
this provides an air gap. *See page 185*

38. On all water outlets equipped for hose connections (except for clothes washers) you must install:
a backflow preventer. *See page 185*

39. In the water supply system, unions must have:
metal-to-metal joints and ground seats. *See page 185*

40. The standards that all pipe and fitting threads must meet are:
those adopted by the American Standards Association. Refer to Figure 14-6. *See pages 185-186*

41. When you use a wrench that's too large for a fitting, the result can be:
a bad joint or a cracked fitting. *See page 186*

42. The wrench size recommended to tighten a fitting on a 2-inch pipe is:
a 24-inch pipe wrench. Refer to Figure 14-7. *See page 186*

43. The most common type of heavy-duty steel pipe cutter is:
the single wheel cutter. *See page 186*

44. When a pipe cutter wheel leaves a bur on the inside of a pipe up to 2 inches, the tool you should remove it with is:

a pipe reamer. Refer to Figure 14-8.
See page 186

45. The only person that knows for certain whether an installed pipe has good threads is:

the plumber who installed it. *See page 187*

46. When you're laying out and dimensioning piping arrangements, the only offsets that aren't difficult to calculate are the:

90-degree elbows. *See page 187*

47. The two tools usually used to cut copper tubing are:

a tubing cutter and a hacksaw. *See page 187*

48. The most common joint for copper pipe is:

the sweat joint. *See page 188*

49. In a potable water supply system, the maximum allowable lead content for solders and fluxes is:

two-tenths (0.20) of 1 percent. *See page 188*

50. Properly cleaning and heating a copper joint helps make a sound solder joint by:

allowing surface tension to spread the solder to all parts of the joined surfaces. *See page 188*

51. When cutting plastic pipe, you can be sure of getting a square end by:

using a pipe cutter or a miter box and hacksaw.
See page 188

52. The common term for a cemented plastic pipe joint is:

a "welded" joint. *See page 189*

53. To remove impurities and gloss from the surfaces of plastic pipe and fittings, use:

a liquid cleaner or fine sandpaper. *See page 189*

54. You can make only one joint at a time in a plastic water system because:

the plastic cement sets very quickly.
See page 189

55. After you cement the last joint, you shouldn't test a plastic water system for at least:

half an hour. *See page 189*

Chapter 15

1. The percentage of homes in the U.S. that depend on private wells as their source of water is approximately:

10 percent (one in 10). *See page 193*

2. The agencies with authority to approve and inspect domestic wells are:

the local health department and the Department of Environmental Protection (DEP). (Either answer is acceptable.) *See page 193*

3. Before you can drill or drive a well, you must:

obtain a permit. *See page 193*

4. When you drive or drill a well, the bottom of the well casing must extend:

into the dry weather water table. Refer to Figure 15-1. *See pages 193-194*

5. Well water is generally classified as:

hard water. *See page 193*

6. Well water is considered hard water because:

it has a high mineral content. *See page 193*

7. Well water has a distinctly different taste from "city water" because:

it doesn't contain chlorine or other chemicals.
See page 193

8. The minerals in untreated well water may cause:

stains in the plumbing fixtures and scale build-up in the plumbing system. *See page 193*

9. You can improve the taste and smell of well water by:

installing a water softener. Refer to Figure 15-2.
See pages 193-194

10. The tradesmen most likely to install wells, suction lines, pumps and water pressure pumps are:

professional well drillers (Although plumbing contractors are also qualified to do this type of work, they usually subcontract it out.)
See page 194

11. Professional well drillers are certified and licensed as:

specialty contractors. *See page 194*

12. Even though plumbing contractors seldom install domestic wells, two reasons you should learn about well systems are:
many of the people you deal with will assume you know something about wells, and plumber's examinations often include questions on well systems. *See page 194*

13. The minimum depth that local authorities usually require for a potable water supply wells is:
30 feet. *See page 194*

14. Wells that are dug or driven are classified as:
shallow wells. *See page 194*

15. The two types of driven wells are:
those with an open end casing and those with a casing equipped with a well point. *See page 194*

16. Open end well casings are commonly used:
where the ground water table is close to the ground surface and in a good rock formation. *See page 194*

17. When you're sure that you've installed a good well, before it's ready for use you must:
hook up a pump and pump water out of the well until the water is free of rocks and sand. *See page 195*

18. You would use well casings equipped with a well point:
where the water table is in loose shale or sand. *See page 195*

19. You would use a well point with a screen or fine perforations where there is:
sand. *See page 195*

20. You would use a well point with large openings where there is:
gravel or loose rock formations. *See page 195*

21. Wells that are drilled are classified as:
deep wells. *See page 195*

22. Water from deep wells is more desirable than water from shallow wells because:
there's less chance of contamination. *See page 195*

23. Without specific approval from your local authority, you may never locate a well:
within a building or under the roof or projection of any building. *See page 195*

24. The well casing in a drilled well must terminate:
in a suitable aquifer. *See page 195*

25. The reason a 36-inch-wide sloping concrete collar is required around the top of the well casing is:
to prevent surface water from carrying pollutants down the well casing to the water reservoir. *See page 195*

26. To provide access for inspections, measure well depth, test the static water level and allow disinfecting agents to be added to the well, you must install:
a tee. *See page 195*

27. The minimum size for a suction line from the well to the pump is:
1 inch. *See page 195*

28. You should install the check valve on a well suction pipe:
as close as practical to the well. *See page 197*

29. The two types of check valves commonly used on suction lines are:
the spring-loaded type and the flapper-type. (Either answer is acceptable.) *See page 197*

30. On the well suction line, just before the pump, you must install:
a union or a slip coupling. (Either answer is acceptable.) *See page 197*

31. The two types of pressure tanks in common use are:
the hydropneumatic pressure tank and the diaphragm pressure tank. *See page 197*

32. Of the two commonly used pressure tanks, the one that's been the dominant well water supply system since the 1920s is:
the hydropneumatic tank. *See page 197*

33. The psi operating range for a hydropneumatic tank is:
between 20 and 40 psi of water pressure. *See page 197*

34. When there's not enough air to pressurize the tank in a hydropneumatic system:
the pump cycles on and off too often. *See page 197*

35. The minimum size hydropneumatic tank needed for a single-family residence is:

42 gallons. *See page 199*

36. The diaphragm tank has been approved for use in domestic well water systems since:

the 1950s, over 60 years. *See page 199*

37. By adding a little extra capacity to a diaphragm tank, you can usually prevent:

excessive cycling (too-frequent pump starts). *See page 199*

38. The purpose of installing a gate valve on the discharge side of the tank is:

to act as the house valve to control water in the building. *See page 199*

39. The minimum size gate valve required is:

$^3/_4$ inch. *See page 199*

40. When you locate the tank and equipment, you should take care that they are:

set level and placed so that they're accessible for repair or replacement. *See page 199*

Chapter 16

1. The minimum size public water main that you can use to supply a fire standpipe system is:

4 inches. *See page 201*

2. When a public water main can't provide the required quantity and pressure for a fire standpipe system, the alternative methods you can use include:

a fire pressure pump or a gravity tank. *See page 201*

3. A fire standpipe system is required in buildings that are higher than:

50 feet. *See page 201*

4. The special requirement that ensures a constant water supply is available for a fire standpipe system is:

a pressurized (wet) system. *See page 201*

5. For buildings under construction that require standpipes, you must locate fire department connections:

at street level on the outside of the building and at each floor level up to the highest constructed floor. *See page 201*

6. Fire standpipe locations must be arranged so that the standpipes are protected from:

mechanical and fire damage. *See page 201*

7. The maximum distance from the nozzle end of a 100-foot fire hose that any part of a building floor can be is:

30 feet. *See page 201*

8. If the stairways are enclosed, the fire standpipes should be located:

in the enclosed stairways. *See page 201*

9. If the stairways aren't enclosed, the fire standpipes must be located:

within 10 feet of the floor landing of a stairway. *See page 201*

10. When stairways aren't available, additional fire standpipes may be located:

in hallways or other accessible locations approved by the authority. *See page 201*

11. The special fire-protection provisions required by some codes for buildings designed for theatrical performances are:

that there's a $2^1/_2$-inch standpipe on each side of the stage, with a hose not over 75 feet long at each standpipe hose station. The Uniform Fire Code requires automatic sprinklers.

See page 202

12. When a fire standpipe system is required and there's no adequate public water supply, the alternate water system that the code will accept is:

an on-site well system. *See page 202*

13. The maximum drawdown for an on-site fire well system when pumping at 150 percent pump capacity is:

4 feet. *See page 202*

14. An on-site fire well system must be sized for a flow of:
500 gallons per minute at 20 psi. *See page 203*

15. The requirement for fire department hose connections is that they must have:
national standard threads. *See page 203*

16. Before the fire department having jurisdiction over an on-site well system will give you final approval, you must:
test the system. *See page 203*

17. You may not have a direct connection between an on-site fire well system and:
the potable water supply system. *See page 203*

18. The difference between an on-site standard fire well installation and a regular on-site well system is:
for an on-site fire well you don't have to install a pump, and the hose connection can be a single $4^1/_2$-inch American Standard Hose connection. (Either answer is correct.) *See page 203*

19. For fire protection in commercial, industrial and residential areas, the code usually requires:
fire hydrants. *See page 203*

20. The location of all fire hydrants must be approved by:
the fire department. *See page 204*

21. Underground fire line and fitting materials must be approved by:
the local authority having jurisdiction. *See page 204*

22. Aboveground fire lines and fittings must be able to withstand a pressure of:
175 psi. *See page 204*

23. At each change of direction in underground fire lines, you must provide:
concrete thrust blocks resting on undisturbed soil. *See page 204*

24. Underground fire lines are tested to ensure that they can withstand:
200 psi of pressure. *See page 204*

25. The minimum size requirement for fire standpipes in buildings up to 100 feet high is:
4 inches. *See page 204*

26. The minimum size requirement for fire standpipes in buildings over 100 feet high is:
6 inches. *See page 204*

27. The maximum length allowed for a building standpipe is:
275 feet. *See page 204*

28. On buildings that are 50 feet or higher, fire standpipes are required to extend above the roof:
30 inches. *See page 205*

29. The fire department connection that you're required to install on each standpipe extension above the roof is:
a roof manifold. Refer to Figure 16-6.
See pages 205-206

30. Standpipes located in stairway enclosures require valves for fire department hose connections that are:
$2^1/_2$ inches. Refer to Figure 16-6.
See pages 205-206

31. The maximum distance allowed from the standpipe or hose station to a hose outlet is:
10 feet. *See page 205*

32. The pipe size generally used to connect a hose station to the fire standpipe is:
$2^1/_2$ inches. Refer to Figure 16-6.
See pages 205-206

33. A fire hose cabinet must be located:
within 10 feet of the standpipe and where it's accessible at all times. Refer to Figure 16-6.
See pages 205-206

34. Each fire hose must be able to withstand a working pressure of:
100 psi. *See page 206*

35. If the pressure exceeds 100 psi at the fire hose outlet, you must install:
a pressure regulating device. *See page 206*

36. A fire pump required to supply a 500 gpm flow rate must be certified by:
Underwriters Laboratory (UL listed).
See page 207

37. The electric service required for fire pumps with a 500 gpm flow rate must be:

a separate electric service or a connection through a separate automatic transfer switch to a standby generator. *See page 207*

38. The equipment that you can use to maintain the 15 psi minimum pressure required on the roof in a fire standpipe system is:

either a jockey pump actuated by a pressure switch or a connection to a suitable domestic system through two 170 psi check valves (one with a soft seat and one with a hard seat). *See page 207*

39. Those qualified to install fire protection systems consisting of standpipes and fire hoses are:

plumbing contractors with local or state certification. *See page 207*

40. Some states require that plumbing contractors be certified by the state fire marshall before they can install fire protection systems with:

automatic sprinklers. *See page 207*

41. The minimum size for risers in a combined fire system is:

6 inches in diameter. *See page 207*

42. The water supply need for a combined fire system is determined by:

the occupancy class of the building. *See page 207*

43. The combustibility level of a Class I building is considered:

moderate. *See page 207*

44. The combustibility level of a Class II building is considered:

low. *See page 207*

45. The combustibility level of a Class III building is considered:

high. *See page 207*

46. In an installation where more than one fire standpipe riser is required, you must:

loop the risers at the lowest floor. *See page 207*

47. Each fire standpipe riser branch line must be taken off:

at the floor it serves. *See page 208*

48. The two fittings that you should install on the water supply line for automatic sprinkler systems are:

a post-indicator valve and a check valve. *See page 208*

49. If you use two or more fire pumps in an automatic sprinkler installation, each pump must operate:

independently. *See page 209*

50. You can use an engine-driven fire pump only under the condition that:

it's approved in advance by local jurisdictional authorities. *See page 209*

Chapter 17

1. In order to specialize in the installation of piping and equipment for swimming pools and spas, a contractor must earn:

a certificate of competency. *See page 213*

2. Even though specialists generally do swimming pool and spa work, in most parts of the country you must still be knowledgeable about it because:

you'll have questions about swimming pool and spa work on your journeyman and master plumber examinations. *See page 213*

3. Most local codes define a swimming pool as:

any structure suitable for swimming or recreational bathing that's over 24 inches deep. *See page 213*

4. Most local codes define a private swimming pool as:

one that's located at a single-family residence and is available only to the family and their guests. *See page 213*

5. Most local codes define a public swimming pool as:

one that's used collectively by a number of persons for swimming or bathing, whether a fee is charged or not. *See page 213*

6. The most common mechanical system plumbed into swimming pools today is:

a recirculating system. *See page 213*

7. The basic equipment required for a recirculating-type swimming pool is:

a pump and a filter system. *See page 213*

8. Other terms that you can use to identify recirculating piping are:
return piping and pool inlet piping. *See page 213*

9. The chemicals you use to maintain the quality of swimming pool water are:
chlorine or fluorine. *See page 213*

10. Water is lost from a swimming pool by:
evaporation, splashing and backwashing. (Any two answers are acceptable.) *See page 213*

11. The purpose of having a good swimming pool filtration system is:
to assure that the water is clean, clear of organic matter and safe from harmful bacteria. *See page 213*

12. In order to prevent cross-connection, a homeowner who uses a garden hose to fill his swimming pool or spa must install:
a vacuum breaker on the hose bibb. Refer to Figure 17-1. *See pages 213-214*

13. To prevent cross-connection, swimming pools with a direct connection to the public water supply are required to have:
a fill spout with an air gap above the overflow rim of pool. *See page 213*

14. There are several approved methods for disposing of swimming pool water, including:
emptying into (a) an adequately sized drainfield, (b) a sewage system (if approved by local authority), (c) a disposal well, (d) an adequately sized soakage pit or (e) an open waterway, bay or ocean (where permitted). It may also be (f) piped to a sprinkler system used for irrigation or (g) puddled on the property. In both (f) and (g), the swimming pool water must be confined to the pool owner's private property. (Any two answers are acceptable.) *See page 214*

15. The minimum number of inlets required for a swimming pool is:
two. *See page 216*

16. When the main swimming pool drain is used for a return, it is considered to be:
an inlet. *See page 216*

17. When the main swimming pool drain is used for a return you must size it:
as a suction line. *See page 216*

18. The minimum diameter size for a swimming pool vacuum fitting is:
$1^1/_2$ inches. *See page 216*

19. You connect a vacuum fitting to the swimming pool pump on:
the suction side of the pump. Refer to Figures 17-3 and 17-4. *See pages 215-216*

20. The filtration rate for pressure sand filters is:
not over 5 gpm per square foot of filter area. *See page 216*

21. The inflow and effluent lines for a swimming pool sand filter must have:
pressure gauges. Refer to Figure 17-3. *See pages 215-216*

22. A swimming pool backwash line must have:
a sight glass. Refer to Figure 17-3. *See pages 215 and 217*

23. The two types of diatomite filters used for filtering swimming pool water are:
the vacuum type and the pressure type. *See page 217*

24. The filtration rate for a diatomite swimming pool filter is:
2 gpm per square foot of effective filter area. *See page 217*

25. Provisions must be made for removing caked diatomite from the swimming pool filter by:
backwashing or disassembling the filter. *See page 217*

26. The design and installation of a diatomite filter must permit:
the filter elements to be removed easily. *See page 217*

27. At the high point on each swimming pool pressure filter tank you must install:
an air relief device. Refer to Figure 17-3. *See page 217*

28. One surface skimming device can accommodate:
1,000 square feet of swimming pool surface. *See page 217*

29. The required rate of flow through a swimming pool skimming device is:
at least 25 gpm per skimmer. *See page 217*

30. Copper, Type K or L pipe can be used in a pool installation for:

all lines. Refer to Figure 17-5. *See page 217*

31. Cast iron, service weight pipe can be used in a swimming pool installation for:

gutter lines only. Refer to Figure 17-5. *See page 217*

32. The weight required for all fittings used with ABS or PVC plastic pipe in swimming pool installations is:

Schedule 40. *See page 217*

33. The type fittings that you must use in a swimming pool gutter line are:

the drainage type. *See page 217*

34. You may not install short radius 90-degree elbow fittings on swimming pool or spa piping:

below grade on suction piping. *See page 217*

35. The minimum size suction piping required for swimming pools and spas is:

2 inches in diameter. *See page 217*

36. If you're installing dissimilar metals in swimming pool filter piping, the kinds of fittings required are:

dielectric fittings. *See page 218*

37. The pressure required to water-test a swimming pool pressure piping system, including the main drain, is:

40 psi. *See page 218*

38. The main drain for a swimming pool should be located:

at the lowest point in the pool. Refer to Figure 17-6. *See page 218*

39. The older, flat-type main drains for swimming pools are no longer acceptable by most codes today because:

their strong suction can hold children beneath the water and cause drowning. *See page 218*

40. The two code-accepted main drain covers used for swimming pools and spas today are:

the antivortex type and an 85-square-inch open grate type. *See page 218*

41. Gas-fired swimming pool heaters and swimming pool boilers must comply with the standards set by:

the AGA and ASME. *See page 218*

42. A national testing agency that can approve oil-burning equipment for swimming pools is:

Underwriters Laboratory. *See page 218*

43. The maximum temperature acceptable for heated swimming pool water is:

105 degrees Fahrenheit. *See page 218*

44. For a spa to be considered a spa and not a pool, the maximum gallon capacity cannot exceed:

3,250 gallons of water. *See page 218*

45. The maximum temperature of a spa heater is:

105 degrees Fahrenheit. *See page 219*

Chapter 18

1. Today, solar energy is used in homes for:

heating water for all domestic purposes, including swimming pools. *See page 223*

2. The professional plumber should know about installing solar energy units because:

they are becoming more and more common, the codes are changing to cover solar energy, and they require a plumbing permit for installation. Chances are you, as a plumber, will be working with solar energy installations. *See page 223*

3. The first requirement for installing, repairing or altering any solar energy system is:

to get a plumbing permit. *See page 223*

4. In most cases, the plans for a solar water heating system are prepared by:

a registered professional engineer. *See page 223*

5. The plumbing drawings for a solar water heating system must show:

the entire solar system, including structural calculations, mounting frames and anchorage detail. *See page 223*

6. When tested, a solar energy system must be able to withstand a pressure of:

125 psi for at least 15 minutes without leaking. *See page 223*

7. **Using solar energy for heating domestic water isn't considered new because:**
   sun-rich areas such as Florida and California have been successfully using solar-heated water since the beginning of the century. *See page 223*

8. **A solar water heater could lower the average household's water-heating costs by approximately:**
   50 percent. *See page 223*

9. **The three major components of a solar water heating system are:**
   (1) the solar heat collector, (2) the circulation system and (3) the solar storage tank.
   See pages 223-224

10. **If you're dealing with a pumped solar system, the fourth component you'll need is:**
    the control center. *See page 224*

11. **The type of solar heat collector that's most practical for residential use is:**
    the flat plate solar heat collector. *See page 224*

12. **The water temperatures produced by solar water heating systems can reach:**
    approximately 200 degrees Fahrenheit.
    See page 224

13. **The three materials acceptable for the heat deck of a solar heat collector are:**
    copper, aluminum and steel. *See page 224*

14. **The thermal difference between using copper, aluminum or steel for heat deck materials is:**
    none. Thermally, there's no difference between copper, aluminum or steel when used as heat deck materials. *See page 224*

15. **The tubing and collector plate must be of the same metal because:**
    they need to expand and contract at the same rate. *See page 224*

16. **The two purposes accomplished by ensuring that the solar heat collector box is well insulated are:**
    you shield the heat deck plate from the weather, and you reduce the heat loss. *See page 225*

17. **The reason you should use glass with a low iron content in a solar heat collector is because:**
    it's transparent and admits solar radiation, but it's opaque to the long-wave energy trapped inside the collector box. This trapped heat is then transferred to the fluid in the tubing. *See page 225*

18. **In order to prevent heat loss in a solar collector in a cold climate, you should:**
    install a solar collector box with a double layer of glass. *See page 225*

19. **The quality of materials you should use for frames and braces for securing solar heat collectors to roof structures is:**
    exterior-quality. *See page 225*

20. **Solar collector panels that aren't an integral part of the roof must be mounted above the roof surface:**
    a minimum of 3 inches. *See page 225*

21. **At its lowest point, a solar collector panel box must have:**
    drainage holes. *See page 225*

22. **According to U.S. government figures, each of the first two people in a family will use:**
    20 gallons of hot water per day (40 gallons total for two people). *See page 225*

23. **According to U.S. government figures, each additional family member after the first two will require:**
    15 gallons of hot water per person per day.
    See page 225

24. **Each day, a 4- by 12-foot solar heat collector will provide:**
    approximately 80 gallons of hot water.
    See page 225

25. **The minimum size solar storage tank recommended for a family of four is:**
    80 gallons. *See page 225*

26. **The percentage of solar energy that strikes the glass surface of a collector and actually heats the water circulating through the tubing is:**
    only about 30 to 65 percent. *See page 226*

27. To be the most efficient, a flat solar heat collector should face:
in the general direction of the sun's path across the sky, preferably south. *See page 226*

28. The reason you should mount a solar heat collector as close as possible to the storage tank is:
to reduce heat losses and friction in the pipes. *See page 227*

29. Before you install a solar heat collector as an awning or as a fixed overhang on a residence, you must have:
approval from your local authority. *See page 227*

30. A natural thermosiphon solar water heating system works in the following manner:
the hot water (which is lighter) rises naturally to the storage tank and replaces the heavier cold water, which is then drawn into the collector. The bottom of the storage tank must be located at least 2 feet higher than the top of the collector in order for the thermosiphon to work and the water to circulate through the system on its own. *See pages 227-228*

31. When a solar storage tank is attic-mounted, most codes require you to install:
an adequate-sized drain pan with a drain pipe extending to the exterior of the building.
See page 228

32. The minimum size piping that you can use in a thermosiphon circulation system is:
$^{3}/_{4}$ inch. *See page 228*

33. In a pumped solar system, you can locate the hot water storage:
in any convenient place. *See page 228*

34. In a pumped circulation system, the size copper tubing that's permissible to use is:
$^{1}/_{2}$ inch. *See page 228*

35. In a closed solar energy collection system, the fluid you can use is:
antifreeze. *See page 228*

36. In a closed solar energy collection system, the heat is transferred to the water in the storage tank by means of:
a heat exchanger. *See page 228*

37. The *2006 Uniform Solar Energy Code* requires that pipe and fittings used within a solar system meet the standards:
set by code for a potable water system.
Exception: Aluminum tubing may be used *if first approved by the local authority. See page 230*

38. The two most common materials used for pipe and fittings in a solar circulation system are:
galvanized steel pipe and fittings and copper pipe and fittings (Type K or Type L copper pipe). *See page 230*

39. You can't use plastic pipe in a solar circulation system because:
plumbing standards forbid the use of plastic pipe where temperatures could exceed 180 degrees Fahrenheit. *See page 230*

40. You should insulate all piping that carries heated water, fluids or gases from the solar collector to storage tank in order to:
minimize heat loss in the system. *See page 230*

41. Valves up to 2 inches in diameter installed in a solar piping system must be constructed of:
brass, or other approved materials. *See page 230*

42. You must install control valves in a solar system:
where they can isolate the solar system from the potable water supply, and where they are all readily accessibly. *See page 230*

43. The required location for a combination temperature and pressure relief valve in a solar hot water storage tank is:
in the hottest water — in the top one-eighth of the tank. *See page 230*

44. If authorities require a second relief valve, besides the mandated relief valve on the storage tank, you should place it:
at the highest point of the piping system.
See page 231

45. Automatic air discharge valves must be installed:
at the highest point of a solar piping system.
See page 231

46. If the water usage in a household is reduced, you can prevent the water stored in the solar storage tank from becoming dangerously hot by:
installing a tempering valve in the hot water pipe leading from the tank. *See page 232*

47. The minimum working pressure for a solar storage tank is:
300 psi. *See page 232*

48. If a solar controller is malfunctioning and you've ruled out any shorts or breaks in the sensor wires, the likely cause of the malfunction is:
corrosion at the sensors' connections. *See page 232*

49. When a solar system circulating pump is running but the water in the tank isn't hot, the problem is most likely caused by:
air trapped in the collector. Refer to Figure 18-10. *See page 233*

50. The probable cause for a solar collector freezing is:
the pitch of the flat, horizontally-mounted collector doesn't permit the pipes to drain dry. Refer to Figure 18-10. *See page 233*

Chapter 19

1. The three physical states of matter are:
solid, liquid and gas. *See page 237*

2. A gas consists of:
constantly moving atoms, with neither fixed space nor volume. *See page 237*

3. Gas particles liquefy when cooled:
below their boiling point. *See page 237*

4. The first discovery of natural gas in America was in:
West Virginia in 1775. *See page 237*

5. About 70 percent of the natural gas produced in the United States is found in the states of:
Texas and Louisiana. *See page 237*

6. The warning aid added to natural gas to help curb the danger of accidental explosions is:
a chemical scent. *See page 237*

7. The three types of gases used for fuel today are:
natural gas, manufactured gas and liquefied petroleum gas. *See pages 237-238*

8. Natural gas (methane) is also known as:
dry, or sweet gas. *See page 237*

9. Although natural gas itself is not poisonous, it can cause death:
by suffocation in a closed space, or as a result of injuries in an explosion. *See page 237*

10. The type of gas chiefly produced from coal is:
manufactured gas. *See page 237*

11. The poisonous substance in manufactured gas is:
carbon monoxide. *See page 237*

12. Other names used for liquefied petroleum gas are:
LP or bottled gas. *See page 238*

13. Liquefied petroleum gas consists primarily of:
butane or propane, or a mixture of both. *See page 238*

14. The physical change that occurs in LP gas under moderate pressure is:
that it turns into a liquid state. *See page 238*

15. Under normal temperature and atmospheric pressure conditions, liquefied petroleum:
returns to its original gaseous state. *See page 238*

16. LP gas is a convenient fuel to use in remote areas because:
it's easily containerized and transported. *See page 238*

17. The responsibility for sizing the gas service pipe to a building belongs to:
the gas supplier. *See page 238*

18. The sizing and installation methods for interior gas piping are governed by:
the local gas code. *See page 238*

19. Two factors you must know before sizing any gas building main or branch lines are:
(1) the maximum gas demand at each appliance outlet, and (2) the length of piping required to reach the most remote outlet. *See page 238*

20. The abbreviation "Btu" stands for:
British thermal unit. *See page 238*

21. One Btu is defined as:
the quantity of heat required to raise the temperature of 1 pound of water 1 degree Fahrenheit. *See page 238*

22. The number of Btu that you can assume to be in each cubic foot of natural gas is:
1,000 cfh (cubic feet per hour). *See page 238*

23. If you know the maximum Btu rating for an appliance, you convert it into cubic feet by:
dividing the value in Btu by 1,000. *See page 238*

24. When you connect a gas supply pipe to an appliance that's missing its Btu rating plate, the required pipe size is:
the same size as, or larger than, the size of the appliance inlet pipe. *See page 238*

25. Regardless of circumstances, the minimum size gas supply pipe outlet that you can use is:
1/2 inch. *See page 238*

Chapter 20

1. When selecting piping materials for a gas system, you must consider:
the characteristics of your particular gas supply and its effect on pipe, especially if the gas is corrosive. *See page 243*

2. Two piping materials that are code-accepted for both underground and above ground gas installations where corrosive gas may be present are:
coated galvanized steel pipe and coated galvanized wrought iron pipe. *See page 243*

3. Piping materials that are acceptable for use in a gas system where the gas is corrosive are:
galvanized steel pipe, black steel pipe and galvanized wrought iron pipe. (Any two answers are acceptable.) *See page 243*

4. The percent of yellow brass pipe that must be copper if you're using it in a gas installation is:
75 percent. *See page 243*

5. In an underground installation, you're not allowed to install brass and copper pipe:
under a concrete slab. *See page 243*

6. You should not use copper piping in a gas system if:
the gas is corrosive. *See page 243*

7. If approved by your local code or gas supplier, the two weights of copper pipe and tubing that you can use for interior gas piping are:
Type K or Type L. *See page 243*

8. When joints are necessary in a copper gas piping system, the type of solder you must use is:
hard solder, usually a silver solder. *See page 243*

9. You can use approved gas flare fittings in a copper gas piping system only if:
the joints are not concealed. *See page 243*

10. When plastic pipe and fittings are approved for a gas system, they must conform to the specifications of:
the American Society for Testing and Materials (ASTM). *See page 243*

11. You can only make connections between metallic and plastic piping:
outside the building and underground.
See page 244

12. The building locations where you should never install gas piping are:
air ducts, clothes chutes, elevator shafts, chimneys, vents, ventilating ducts and dumbwaiters. (Any three answers are acceptable). *See page 244*

13. The minimum distance you must maintain between gas piping and a water pipe or a sewer line in an underground installation is:
8 inches. *See page 244*

14. The minimum depth for placing underground horizontal metallic gas piping is:
12 inches. *See page 244*

15. The minimum depth for placing underground horizontal plastic gas piping is:
18 inches. *See page 244*

16. Ways of protecting gas piping if you're installing it in corrosive soil are:
with an approved wrapping, or, with one or two coats of asphaltum paint. (Either answer is correct.) *See page 244*

17. In areas subject to freezing temperatures, the depth at which you should install gas piping is:
below the frost line. *See page 244*

18. When backfilling a trench containing gas piping, the type of backfill you should use is:
fine material. *See page 244*

19. You can install gas piping under a slab only if the following installation conditions are met:

(1) encase the pipe completely in conduit; (2) seal the termination of the conduit above the floor to prevent any gas entry; (3) seal the termination of the conduit outside the building to prevent any water entry; and (4) extend a vent above grade and secure it to the conduit to convey any leaking gas outside the building. Refer to Figure 20-2. *See page 245*

20. The connection you use for gas equipment or appliances subject to vibration or requiring mobility is:

an approved flexible gas hose connector. *See page 245*

21. You should install gas piping to serve an appliance located in the center of a room by:

laying the pipe in an open channel cut into the concrete floor. Refer to Figure 20-3. *See page 245*

22. To protect gas piping in vertical masonry walls you must provide:

adequate chases. Refer to Figure 20-4. *See page 246*

23. You may drill a hole in the center of a partition stud when installing:

a short run of horizontal gas piping that does not require additional joints. *See page 246*

24. You shouldn't notch a partition stud deeper than one-third its total width because:

you'll weaken the stud. *See page 246*

25. You should protect soft tubing in a notched partition with:

a metal stud guard to prevent penetration by lath nails. *See page 246*

26. You should secure gas piping installed in metal stud partitions with:

tie wire. *See page 246*

27. Bushings are permitted in a concealed gas piping system:

never. *See page 246*

28. In order to prevent the loosening of a union in an existing concealed gas line:

you need to punch the center nut on the joint. *See page 246*

29. You are allowed to make a new connection on an existing concealed gas piping or tubing installation:

at no time. *See page 246*

30. The procedure for preparing threads for gas piping is the same as preparing threads for:

water piping. *See page 246*

31. The threads for gas piping must conform to the standards of the:

American Standards Association (ASA). *See page 246*

32. To catch any condensation that may form in a gas main, you must install:

a drip pipe. *See page 246*

33. Gas branch pipes should connect only at the top or side of a gas feeder pipe in order to:

prevent condensation from entering the lines and obstructing the flow of gas. *See page 246*

34. A shutoff valve should be installed near the gas meter in order to:

allow for the gas to the building to be shut off from an easily-accessible location. *See page 246*

35. To avoid accidental or malicious tampering with the outside gas shutoff valve:

it's installed with a square nut head that can only be turned with a special tool. *See page 246*

36. Each gas appliance in a building is required to have a shutoff valve that is:

manually-operated and accessible. *See page 246*

37. The two types of shutoff valves manufactured for appliances are:

the straight pattern and the angle pattern. *See pages 246-247*

38. The maximum distance allowed from a shutoff valve to the appliance it serves is:

6 feet. *See page 247*

39. Before you can conceal a completed gas installation unit, it must be:

pressure tested and inspected. *See page 247*

40. The safest way to check gas piping for leaks is:

to brush liquid soap around each joint to see if bubbles appear. *See page 247*

41. **The minimum height above the garage floor that you can set the combustion chamber for a gas water heater is:**
    18 inches. *See page 247*

42. **When you install a gas appliance having 100,000 Btu input or less in a separate room off the garage, you must provide:**
    two 50-square-inch ventilation openings, one 12 inches above the floor and one 12 inches below the ceiling. *See page 247*

43. **Gas water heaters should never be installed in:**
    living areas that may be closed, such as bedrooms or bathrooms. *See page 247*

44. **Gas appliances that require venting must be installed:**
    as close as possible to the vent. *See page 247*

45. **A 30-gallon gas water heater with a 4-inch draft hood requires a vent pipe:**
    no smaller than the opening of the draft hood, 4 inches in this case. *See page 247*

46. **The minimum separation required between a gas water heater with an insulated jacket and any combustible material is:**
    2 inches. *See page 248*

47. **The two acceptable types of concealed gas vent piping materials are:**
    double-wall metal pipe and fittings, and asbestos cement flue pipe. *See page 248*

48. **For gas vent pipes installed in partitions constructed of combustible material, you must provide:**
    an approved metal spacing device. *See page 248*

49. **Horizontal gas vent piping must be supported with metal straps or hangers that are:**
    at least 20 gauge sheet metal. *See page 248*

50. **All gas vent pipes extending above a roof must terminate in:**
    UL approved caps. *See page 248*

Chapter 21

1. **Fixtures constructed of pervious materials such as tile or marble must have:**
   waste outlets that can't retain water.
   See page 253

2. **In a bathroom where there's no natural ventilation available, you must provide:**
   a fan and duct. *See page 253*

3. **In a bathroom without adequate lighting or ventilation there is the potential danger of:**
   unsanitary conditions. *See page 253*

4. **The toilet bowl design that you're required to install in facilities intended for public use is:**
   the elongated type. *See page 253*

5. **The seats for public toilet bowls are required to be:**
   the elongated type with an open front, made of smooth nonabsorbent materials. *See page 253*

6. **A toilet tank refill tube serves the purpose of:**
   automatically restoring the toilet bowl water seal. *See page 253*

7. **An overflow tube in a toilet tank serves to:**
   prevent the tank from overflowing by removing excess water at the same rate that it enters the tank. *See page 254*

8. **A toilet that uses a flushometer rather than a tank must have:**
   a vacuum breaker. *See page 254*

9. **After being manually activated, a toilet flushometer must:**
   complete the normal flushing cycle automatically and deliver enough water to flush all surfaces of the bowl. *See page 254*

10. **The number of toilets a flushometer can serve is:**
    one. *See page 254*

11. **A toilet flushometer should be installed so it's readily accessible for:**
    repairs. *See page 254*

12. **A wall-hung urinal should be supported by:**
    a concealed metal carrier or other approved backing so that no strain is transmitted to the pipe connection. *See page 254*

13. **At the wall contact point, finish a wall-hung lavatory by:**
    sealing it with white cement or other suitable material. *See page 254*

14. The two basic urinal designs are:
the wall-hung type and the floor-mounted stall type. *See page 254*

15. Stall urinals must be recessed slightly below the finished floor in order to:
provide proper drainage. *See page 254*

16. The waste opening of a floor-mounted stall urinal is required to have:
a beehive-type strainer. *See page 254*

17. Cabinet-mounted lavatories are secured to the countertop by:
special rim clips. *See page 255*

18. The minimum outside diameter for lavatory waste outlets is:
$1^1/_4$ inches. *See page 255*

19. Where circular-type multiple wash sinks are used, one lavatory or fixture unit is represented by:
each 18 inches of wash sink circumference. *See page 255*

20. The minimum size for a bathtub waste and overflow is:
$1^1/_2$ inches. *See page 255*

21. Some codes today prohibit the use of a trip waste because:
they are difficult to adjust to properly retain and discharge tub water. *See page 255*

22. Bathtubs recessed into the finished wall are required to have joints that are:
waterproof. *See page 255*

23. The wall materials you use for a recessed bathtub must be:
smooth, noncorrosive, nonabsorbent and waterproof to a height of 4 feet above the rim of the tub. *See page 255*

24. The *UPC* minimum size waste outlet required for a shower compartment is:
2 inches. *See page 255*

25. Shower strainers must be designed:
with a minimum diameter of $3^1/_2$ inches and they must be removable so the trap can be cleaned. *See page 255*

26. The minimum floor area required for any shower compartment is:
1,024 square inches. *See page 255*

27. The minimum weight that most codes require for lead shower pans is:
4 pounds per square foot. *See page 255*

28. To protect lead or copper shower pans from corrosion when they're installed on concrete floors:
you must paint them with asphaltum paint inside and outside. *See page 255*

29. The sides of a shower pan should extend above the finished curb:
at least 2 inches under the *UPC* or 3 inches under the *IPC*. *See page 255*

30. A shower pan should be prepared for inspection at the same point in the building's construction as:
the inspection for the tub and water pipe. *See page 256*

31. A shower pan is not required:
in prefabricated shower stalls provided each is approved for watertightness by the plumbing inspector. *See page 256*

32. Walls of shower compartments must extend above the floor:
6 feet. *See page 256*

33. The minimum diameter required for a laundry tub waste is:
$1^1/_2$ inches. *See page 256*

34. The waste opening on a domestic kitchen sink with a waste disposer unit should be:
at least $3^1/_2$ inches. *See page 256*

35. Two common fixtures provided with overflows are:
bathtubs and lavatories. *See page 256*

36. The overflow pipe or passageway from a fixture must be connected on the inlet side of the fixture trap in order to:
prevent sewer gases and odors from entering the room through the overflow. *See page 256*

37. The type of fixtures that are not required to have a strainer or stopper are:

fixtures with an integral trap, such as toilets and most urinals. *See page 256*

38. The minimum size of a fixture strainer is determined by:

the fixture waste outlet it serves. *See page 256*

39. The overflow of a fixture is never permitted to connect to:

any other part of a drainage system. *See page 256*

40. The restriction placed on strainers or stoppers is:

they can't prevent rapid drainage of the fixture. *See page 256*

41. When you install a waste disposer on an existing two-compartment sink using a single trap, you must use:

a special directional tee or wye fitting to flush garbage away from the other sink compartment. Refer to Figure 21-5. *See page 257*

42. A commercial food waste grinder in a restaurant may not discharge through:

a grease interceptor. *See page 257*

43. The minimum size waste opening required for a commercial sink is:

2 inches. *See page 257*

44. A commercial food waste grinder should be trapped and vented:

individually, like any other fixture. *See page 257*

45. When an air gap fitting is required on a dishwasher waste pipe, you should install it:

deck-mounted on the sink or cabinet top. Refer to Figures 21-7 and 21-8. *See page 258*

46. By most code standards, the maximum distance allowed between a dishwasher and the sink waste connection is:

5 feet. *See page 257*

47. If there's a food disposal unit installed in a sink, the waste pipe from the dishwasher must connect to:

the tap in the body of the food disposer. Refer to Figure 21-8. *See page 258*

48. The flange for a floor fixture should be set:

on top of the finished floor. Refer to Figure 21-9. *See pages 257 and 258*

49. The gasket materials approved for use with plumbing fixtures having a flanged connection are:

graphite-impregnated asbestos and felt. *See page 258*

50. The code places floor drains in the category of:

fixtures. *See page 257*

51. Floor drain traps must have a permanent water seal:

to prevent evaporation from drying out the trap and allowing sewer gases into the building. *See page 258*

52. Drinking fountain waste cannot discharge into a floor drain if the drain is:

in a restroom. *See page 258*

53. No plumbing fixtures of any kind can be installed in a room containing:

air handling machinery. *See page 259*

54. When installing special fixtures with waste and water connections, you protect the water supply from back-siphonage by:

installing an approved vacuum breaker. *See page 259*

55. When installing any plumbing fixture, you must provide spacing and clearances:

that permit the fixture to be used in the manner intended, and that allow easy access for cleaning and repairs. *See page 259*

56. The minimum center-to-center spacing required for water closets when set in battery installations is:

30 inches. Refer to Figure 21-11. *See page 259*

57. The minimum required distance from the front of a urinal to any finished wall is:

24 inches. Refer to Figure 21-11. *See page 260*

58. Center-to-center measurements are not applicable to lavatories because:

lavatories are manufactured in a variety of designs and widths. *See page 260*

59. The minimum clearance required from the opening of a shower compartment or stall to any finished wall is:

24 inches. Refer to Figure 21-11. *See page 260*

60. Both public buildings and privately owned multistory apartment buildings must have toilet facilities for persons with disabilities because:

it's the right thing to do and federal and state laws have mandated them.
See pages 260-261

61. The minimum fixture requirements for a single-family residence are:

one kitchen sink, one water closet, one lavatory, one bathtub or shower unit and a provision for a clothes washing machine. *See page 261*

62. The number of toilet fixtures required in a place of employment is determined by:

the number of employees and a ratio set by the local authority. *See page 262*

63. If toilet rooms are connected to public rooms or passageways, there must be:

a vestibule or a screen to ensure decency and privacy. *See page 263*

64. The purpose behind the conversion of many public restrooms to single-occupancy and family-use restrooms is:

to accommodate non-gender-specific individuals, provide better security for children, and to provide diaper-changing facilities to all parents. (Any two answers are acceptable.) *See page 263*

65. The minimum toilet facilities needed for food establishments catering to drive-in service is determined by:

the number of parking stalls in the parking lot; one parking stall equals one customer.
See page 264

66. If the seating capacity in a restaurant is unknown, the method used by some codes to determine the number of persons who'll occupy the premises at one time is:

the square foot method. Refer to Figure 21-13. *See pages 263 and 264*

67. Rather than using the square-foot method, some codes determine the occupant load for a restaurant where the seating capacity is unknown by:

the egress requirement of the building code.
See page 264

68. You compute the restroom facility required for public places such as shopping centers, retail stores or large office buildings by:

deducting the uninhabitable spaces from the gross floor area and then using the net square footage of the remaining space to find the occupant load factor. *See page 265*

69. Proper roughing-in of the waste and water outlets for various types of plumbing fixtures requires:

a thorough knowledge of roughing-in measurements. Refer to Figures 21-18 through 21-22. *See pages 265-271*

70. You can get complete roughing-in information for *special* plumbing fixtures from:

the manufacturer or distributor. *See page 265*

71. The standard roughing-in measurement for water closets with tanks is:

12 inches from the finished wall. *See page 265*

72. Of all rooms in a house, the one most susceptible to unsanitary conditions is:

the toilet room (bathroom). *See page 270*

73. The type of bathroom plumbing fixtures that some apprentices and journeymen seldom have the opportunity to work with is:

off-the-floor plumbing fixtures. *See page 270*

74. Advantages to off-the-floor water closets are:

you don't have to penetrate the floor at each fixture, there's a clear unobstructed floor for cleaning, and there's no risk of deterioration of the floor next to and beneath the fixture, as there is with on-the-floor fixtures. (Any two answers are acceptable. *See page 270*

75. Most residential carriers have been designed to be compatible with:

the newer piping materials. *See page 270*

Examination Day

This chapter is a 200-question test which will help you evaluate your understanding of the plumbing code, and better prepare you for the journeyman's or master's examination. The multiple choice questions here are the same type, but not the same questions, that you'll find on the examination. This chapter should help you locate areas where you need additional study. Answers to the questions are at the end of the chapter.

The topics covered in this test include drainage, waste, and vent piping and fittings, private disposal systems, trailer park requirements, public and private water systems, swimming pools, fire standpipe systems, solar energy systems, gas systems, fixture requirements and mathematical problems.

You'll get the greatest benefit by putting your answers on a separate sheet of paper and completing the test before you check the answer page. When you know which answers you missed, review the section of the book covering that topic. Then review all the questions you missed until you can answer every question correctly.

If you find this type of study helpful, the author has another book, *Plumber's Exam Preparation Guide*, that is devoted entirely to preparing you for the exam. It's comprised of hundreds of multiple choice questions, with explanations included and with the wording from the plumbing code provided. And like this book, it includes a 200-question sample Plumber's Exam so you can practice, grade yourself and judge when you're ready to take the real exam.

Multiple Choice Questions

1. The primary function of a relief vent is to
   (A) prevent back siphonage.
   (B) supply fresh air to a bathroom.
   (C) vent the water heater to prevent its explosion.
   (D) provide circulation of air between drainage and vent systems.

2. All piping passing under the footings of a building must have a clearance of at least ____ inches between the top of the pipe and the bottom of the footing.
   (A) 2
   (B) 3
   (C) 4
   (D) 5

3. Except when deeper seals are required for interceptors, a fixture trap must have a water seal of between
   (A) 1 and 3 inches.
   (B) 1 and 4 inches.
   (C) 2 and 4 inches.
   (D) 3 and 5 inches.

4. A waste pipe may receive the discharge from a
   (A) lavatory and urinal.
   (B) bedpan washer and lavatory.
   (C) urinal and bedpan washer.
   (D) bathtub and water closet.

5. Fixture trap inlets measured vertically from the bottom of the fixture to the top of the trap seal shall not exceed
   (A) 12 inches.
   (B) 15 inches.
   (C) 18 inches.
   (D) 24 inches.

6. What is the name of the vent that doesn't receive any sewer discharge?
   (A) a dry vent.
   (B) a wet vent.
   (C) a circuit vent.
   (D) a relief vent.

7. One non-metallic code-approved pipe that can't be used for building sewers is
   (A) ABS.
   (B) Schedule 160 PVC .
   (C) vitrified clay.
   (D) Schedule 40 PVC .

8. The pipe that's *not* suitable for use as underground vent piping is
   (A) cast iron soil pipe.
   (B) lead pipe.
   (C) galvanized steel pipe.
   (D) brass pipe.

9. Cleanouts 3 inches and larger must be accessible, and have a clearance of
   (A) 6 inches.
   (B) 12 inches.
   (C) 18 inches.
   (D) 24 inches.

10. In a sanitary drainage system, the smallest pipe size allowed for a soil stack is
    (A) 2 inches.
    (B) 2½ inches.
    (C) 3 inches.
    (D) 4 inches.

11. One thing that may *not* be used in drainage pipes is
    (A) 45 degree wyes.
    (B) traps.
    (C) supports.
    (D) running threads.

12. Materials approved by the code for residential fire sprinklers include
    (A) Aluminum pipe.
    (B) cast iron pipe.
    (C) CPVC, PEX and black steel.
    (D) Schedule 40 PVC.

13. Hydropneumatic water supply tanks must have an air volume control valve to
    (A) remove excessive air in the tank.
    (B) control water pressure.
    (C) prevent rapid on-off operation of the pump.
    (D) prevent air from getting into the pipes of the plumbing system.

14. The maximum area most codes will permit an area drain to handle is
    (A) 50 square feet.
    (B) 75 square feet.
    (C) 100 square feet.
    (D) 125 square feet.

15. The suction line from the water supply well to the pump (if less than 40 feet) must be at least
    (A) 1 inch.
    (B) 1¼ inches.
    (C) 1½ inches.
    (D) 2 inches.

16. Roof drain strainers must extend at least ____ inches above the roof surface.
    (A) 2
    (B) 3
    (C) 4
    (D) 5

17. The maximum temperature at which waste water can be discharged into a building drainage system is
    (A) 90 degrees.
    (B) 125 degrees.
    (C) 140 degrees.
    (D) 180 degrees.

18. The required minimum cover over vitrified clay sewer pipe is
    (A) 6 inches.
    (B) 12 inches.
    (C) 18 inches.
    (D) 24 inches.

19. The water service pipe is the pipe from
   (A) the outlet side of the water meter to the building served.
   (B) the water main to the house valve.
   (C) the outlet side of the water meter to the first water distributing pipe.
   (D) the water meter to the building foundation.

20. A sump is a tank or pit located below the normal grade of the gravity system which must be emptied by mechanical means. Its primary function is to receive
   (A) waste from floor drains only.
   (B) clear water waste only.
   (C) waste containing chemicals in solution.
   (D) waste that requires lifting.

21. Horizontal branch drains in multistory buildings require a minimum separation of
   (A) 6 feet.
   (B) 8 feet.
   (C) 10 feet.
   (D) 12 feet.

22. For plumbing fixtures to operate properly, they need water piping to supply sufficient.
   (A) velocity
   (B) volume
   (C) pressure
   (D) both B and C

23. To protect water pipe installations from water hammer, you must
   (A) provide for expansion.
   (B) install an approved water hammer seal trap on the inflow pipe.
   (C) install the system to drain dry.
   (D) install a water hammer arrestor.

24. In an air gap installation, what is the minimum separation permitted by the *IPC* between the indirect waste outlet and the rim of the receptor?
   (A) 3 inches.
   (B) twice the drain pipe size.
   (C) no less than the outlet size.
   (D) the greater of the outlet size and 2½ inches

25. When a house water system is connected to both a well supply and a public water supply, the condition should be corrected by
   (A) using a by-pass line.
   (B) installing a backflow preventer on the well side.
   (C) placing a check valve on the house side.
   (D) disconnecting the well supply and capping it off.

26. A dishwasher installed to the *UPC* is required to drain through a
   (A) high loop
   (B) check valve
   (C) air gap
   (D) wet vent

27. Water conservation is considered a
   (A) personal issue
   (B) city issue
   (C) state issue
   (D) national issue

28. The maximum height of an ADA compliant toilet is
   (A) 15 inches.
   (B) 16 inches.
   (C) 18 inches.
   (D) 19 inches.

29. Grease interceptors must be designed and installed so that they
   (A) won't become air bound.
   (B) will work without any maintenance.
   (C) separate grease and sewage.
   (D) are oversized to reduce maintenance.

30. Battery venting requires a ____ to vent two or more similar adjacent fixtures which discharge into a common horizontal waste or soil branch.
   (A) branch vent
   (B) vent stack
   (C) continuous vent
   (D) loop vent

31. A vent that connects one or more individual vents with a vent stack is defined as a
(A) relief vent.
(B) branch vent.
(C) wet vent.
(D) common vent.

32. A building drainage system which cannot drain by gravity into the building sewer must discharge into
(A) a sump.
(B) perforated piping.
(C) open joint piping.
(D) a branch drain.

33. A building sewer that receives storm water is known as
(A) an all-purpose sewer.
(B) a special sewer.
(C) a dual system sewer.
(D) a combined sewer.

34. A common vent is installed to vent
(A) 2 or more water closets.
(B) a service sink with a 3-inch trap only.
(C) 2 fixture drains installed at the same level in a vertical stack.
(D) the last 2 fixtures on a horizontal drainage system.

35. According to the *UPC*, 1 fixture unit flow rate for special fixtures is considered up to
(A) 7½ gallons per minute.
(B) 9½ gallons per minute.
(C) 10 gallons per minute.
(D) 12 gallons per minute.

36. A horizontal waste line may be connected to the vertical section of a waste stack by using
(A) a saddle tee.
(B) a test tee.
(C) a single sanitary tee.
(D) a combination.

37. Piping passing through cast-in-place concrete shall be protected by
(A) painting the pipe with asphaltum paint.
(B) wrapping the pipe with air conditioning tape.
(C) sleeving to give ½-inch annular space around the entire pipe.
(D) wrapping the pipe with felt.

38. A 10-ton air conditioning unit centrally located below a building roof may discharge indirectly into
(A) rain water leaders which discharge to the curb gutter.
(B) a vent stack having a minimum size of 3 inches.
(C) the building sanitary drainage system.
(D) a 10-inch diameter buried pipe.

39. You may use plastic pipe and fittings for wall-hung plumbing fixtures if
(A) the fixture doesn't weigh more than twelve pounds.
(B) the building is a single family residence.
(C) prior approval is obtained from the plumbing inspector.
(D) the fixture pipe connection doesn't carry any of the load.

40. All underground soil, waste and vent piping and fittings inside a building located over deleterious fill must be
(A) lead pipe.
(B) centrifugally-spun service-weight cast iron pipe.
(C) brass pipe.
(D) Schedule 40 PVC.

41. Soil, waste and vent piping above ground inside buildings over deleterious fill may *never* be
(A) galvanized pipe.
(B) plastic pipe.
(C) copper type K, L, or DWV.
(D) asbestos cement.

42. When showers are provided in a trailer park, the minimum floor area of each shower is
(A) 24 x 24, or 576 square inches.
(B) 28 x 28, or 784 square inches.
(C) 30 x 30, or 900 square inches.
(D) 36 x 36, or 1,296 square inches.

43. A neutralizing tank is required for corrosive waste which
(A) contains spent acids.
(B) has a pH factor of 5.0.
(C) has waste that needs separation.
(D) is generated in a repair garage.

44. Fixture unit value as a load factor for special fixtures is determined by the
    (A) size of the fixture trap.
    (B) type of fixture.
    (C) manufacturer's suggested load factor.
    (D) location of fixture.

45. A building sewer, when connected to a septic tank, may be considered and sized as a building drain if the developed length does not exceed
    (A) 5 feet.
    (B) 8 feet.
    (C) 10 feet.
    (D) 12 feet.

46. A domestic kitchen sink may be installed on a waste stack that
    (A) is less than 2 inches in diameter.
    (B) is 2 inches in diameter.
    (C) vents lower fixtures.
    (D) has a diameter at least the same size as its trap.

47. Sumps and receiving tanks for liquid waste
    (A) must be constructed of pervious materials.
    (B) must be accessibly located.
    (C) need not be vented.
    (D) are for public use only.

48. Ejector pumps shall be provided with a
    (A) check valve on the discharge side of the gate valve.
    (B) gate valve only.
    (C) check valve only.
    (D) check valve located on the pump side of the gate valve.

49. According to the *Uniform Plumbing Code*, not more than ____ water closet(s) may discharge into a 3- inch stack at the same point.
    (A) 2
    (B) 3
    (C) 4
    (D) 5

50. According to the *Uniform Plumbing Code*, not more than — water closet(s) may discharge into a 3-inch stack.
    (A) 3
    (B) 4
    (C) 5
    (D) 6

51. What is the minimum size vent allowed to serve a water closet?
    (A) 3 inches.
    (B) 2½ inches.
    (C) 2 inches.
    (D) no smaller than the size of the drain outlet.

52. What factor determines the maximum length of a vent pipe?
    (A) the size of the vent opening.
    (B) the number of DFUs it serves.
    (C) the Jurisdiction Having Authority.
    (D) the diameter of the vent pipe.

53. Sump vents may
    (A) never be connected to the common venting system.
    (B) be vented independently through the roof.
    (C) be connected to the nearest roof leader.
    (D) be vented indirectly to the drainage system.

54. According to the *IPC*, the minimum size pipe used for subsoil drains is
    (A) 2½ inches.
    (B) 3 inches.
    (C) 4 inches.
    (D) 6 inches.

55. Air conditioning condensate drains may connect
    (A) directly to a rain water leader pipe.
    (B) by indirect means to the building drainage system.
    (C) to a properly-sized water heater drain pan pipe.
    (D) to any waste piping installed under a slab.

56. Drip pipes from walk-in refrigerator floors or store-room floors where food is stored must be installed
    (A) to drain into a 1½-inch pipe.
    (B) to drain into a sump.
    (C) as a direct waste.
    (D) as an indirect waste.

57. Walk-in refrigerator floors or store-room floors where food is stored must be ____ above the overflow point of receiving fixtures.
    (A) 1 inch
    (B) 2 inches
    (C) 3 inches
    (D) 4 inches

58. Air conditioning condensate drains for units with not more than 5 tons capacity may discharge
    (A) onto a pervious area.
    (B) onto an impervious area.
    (C) directly into a building drainage system.
    (D) indirectly into a building storm drain.

59. Air conditioning drains of PVC shall be a minimum of ____ below the bottom of the slab.
    (A) 2 inches
    (B) 4 inches
    (C) 6 inches
    (D) 12 inches

60. For concrete sewer pipe, approximately ____ percent of the joint at the base of the socket shall be filled with jute or hemp.
    (A) 10
    (B) 15
    (C) 25
    (D) 30

61. Mortar for cement joints shall be composed of
    (A) 2 parts cement, 1 part sand.
    (B) 1 part cement, 2 parts sand.
    (C) 2 parts cement, 2 parts sand.
    (D) 3 parts cement, 1 part sand.

62. A trap depending on movable parts to retain its seal may be used
    (A) for fixtures with clear water waste only.
    (B) for fixtures having integral traps only.
    (C) for swimming pool installations.
    (D) never.

63. The waste from a commercial dishwasher must discharge
    (A) indirectly into the building greasy waste drain.
    (B) into a floor drain.
    (C) directly into the building drainage system.
    (D) into a special sump.

64. Accessible cleanouts must be located so that all building drains are within reach of a ___ -foot cable.
    (A) 25
    (B) 50
    (C) 75
    (D) 100

65. According to the *International Plumbing Code*, cleanouts must be the same nominal size as the pipe in which they're installed, up to inches.
    (A) 4
    (B) 6
    (C) 8
    (D) 10

66. Vertical Schedule 40 plastic pipe must be supported at intervals of
    (A) 4 feet.
    (B) 6 feet.
    (C) each story.
    (D) every 2 stories.

67. Suspended horizontal lead joint soil pipe, in 10 foot lengths, must be supported at ____ intervals.
    (A) 4-foot
    (B) 6-foot
    (C) 8-foot
    (D) 10-foot

68. All extensions of soil, waste and vent stacks must terminate at least ____ inches above the roof.
    (A) 4
    (B) 6
    (C) 8
    (D) 12

69. Most codes state that where roofs are used as sun decks, all vents must extend at least ____ above the deck.
    (A) 24 inches
    (B) 36 inches
    (C) 60 inches
    (D) 84 inches

70. Vent pipes are graded to
    (A) prevent air lock.
    (B) help circulate the air.
    (C) drain to the soil or waste pipe.
    (D) prevent backflow.

71. The fixture which may *not* discharge into a horizontal 3-inch wet vent is
    (A) a bidet.
    (B) a water closet.
    (C) a shower.
    (D) a bathtub.

72. The type of vent that's prohibited is a
    (A) yoke vent.
    (B) crown vent.
    (C) common vent.
    (D) back vent.

73. From what types of fixtures may a wet vent be used to convey waste?
    (A) any permitted plumbing fixture.
    (B) only those not conveying human waste.
    (C) only fixtures that have alternate venting.
    (D) only fixtures with low unit ratings.

74. A continuous vent is also known as a
    (A) stack vent.
    (B) vent stack.
    (C) main stack.
    (D) relief vent.

75. The diameter of an individual vent can't be less than ____ inch(es).
    (A) 1
    (B) 1¼
    (C) 1½
    (D) 2

76. What is the name of the drainage fitting that permits upstream as well as downstream rodding?
    (A) combination cleanout.
    (B) two-way cleanout.
    (C) sanitary cleanout.
    (D) sewer tee.

77. According to the *IPC*, a 2-inch combination waste and vent stack that's shorter than 30 feet may *not* receive the discharge from
    (A) 4 lavatories.
    (B) 2 bathtubs.
    (C) 1 urinal.
    (D) 2 showers.

78. The minimum size vent stack allowable when a water closet is installed in an accessory building is
    (A) 2 inches.
    (B) 2½ inches.
    (C) 3 inches.
    (D) 4 inches.

79. The vent terminal of a sanitary plumbing system can't be less than ____ feet from the point of any mechanical air intake opening.
    (A) 6
    (B) 8
    (C) 10
    (D) 12

80. If a vent terminal is within ten feet of any door, window, or ventilating opening, it must extend at least ____ foot/feet above such opening.
    (A) 1
    (B) 3
    (C) 4
    (D) 5

81. Establishments that don't require a grease interceptor are
    (A) bars.
    (B) clubs.
    (C) supermarkets.
    (D) packaged food establishments.

82. Fixture trap cleanouts are prohibited on
    (A) lavatory traps.
    (B) barber shop sinks.
    (C) concealed traps.
    (D) kitchen sinks.

83. Equip all sundeck drains with a
    (A) plastic strainer to prevent corrosion.
    (B) flat surface strainer.
    (C) minimum 2-inch waste outlet.
    (D) brass strainer only.

84. The more roof drains you install,
    (A) the fewer leader pipes required.
    (B) the more expensive it will be.
    (C) the fewer puddles you'll have.
    (D) the larger the leader pipe will have to be.

85. When a planter drain is used, your local authority may require that
    (A) the waste water discharge through the storm water system.
    (B) the excess waste water pass through a sand interceptor.
    (C) a flapper valve be installed within 2 feet of the drain.
    (D) a backwater valve be installed on the waste line.

86. When you have a vertical wall that drains onto a flat roof area that you're sizing, be sure to add up to ____ of the vertical wall area to your horizontal projection.
    (A) 25 percent
    (B) $33^1/_3$ percent
    (C) 50 percent
    (D) 75 percent

87. The maximum distance between hangers for 1½- inch horizontal copper pipe is
    (A) 4 feet.
    (B) 6 feet.
    (C) 8 feet.
    (D) 10 feet.

88. The material that shall *not* be used for above-ground storm drainage within a building is
    (A) concrete pipe.
    (B) galvanized steel pipe.
    (C) plastic pipe.
    (D) lead pipe.

89. When a rainwater leader discharges directly into a soakage pit, it requires
    (A) a backwater valve.
    (B) a cleanout at its base.
    (C) protection from vehicle traffic.
    (D) an overflow fitting at its base.

90. Where asbestos-cement pipe is permitted, you can use it only for
    (A) storm sewers.
    (B) acid waste.
    (C) rain leaders.
    (D) greasy waste substances.

91. Small grease interceptors require a
    (A) water-cooled jacket to speed coagulation.
    (B) vent on the discharge side.
    (C) flow control fitting.
    (D) grease retention capacity of 50 pounds.

92. The minimum capacity for graywater holding tanks is ____ gallons.
    (A) 30
    (B) 40
    (C) 50
    (D) 60

93. An excavation for graywater disposal fields must never come within
    (A) 5 vertical feet of the highest known seasonal groundwater.
    (B) 5 feet of the building structure.
    (C) 40 feet of any stream.
    (D) 8 feet of a public water main.

94. What is the temperature range fixtures supplying hot water in a residence are normally set for?
    (A) between 110 and 140 F.
    (B) between 115 and 130 F.
    (C) between 120 and 140 F.
    (D) between 140 and 150 F.

95. Interceptors for a commercial laundry must be maintained in efficient operating condition by periodic
    (A) removal of accumulated contents.
    (B) replacement of "limited use" parts.
    (C) flushing with chemical mixtures.
    (D) checking the outlet pipe.

96. The overflow from a fixture must be connected to
    (A) the crown vent.
    (B) the fixture branch.
    (C) a drip pan.
    (D) the inlet side of the fixture trap.

97. A lavatory must have a clearance of ____ inches from the front of the lavatory to any finished wall, door or other plumbing fixture.
    (A) 40
    (B) 38
    (C) 26
    (D) 24

98. Where bucket type floor drains are required, most codes mandate the minimum diameter of its outlets to be
    (A) 2 inches.
    (B) 4 inches.
    (C) 6 inches.
    (D) 8 inches.

99. When a water closet is installed next to a bath tub, the minimum distance from the center of the bowl to the edge of a tub is
(A) 10 inches.
(B) 15 inches.
(C) 24 inches.
(D) 30 inches.

100. What is assumed to be the peak draw period for hot water in the average home?
(A) 2 hours.
(B) 1½ hours.
(C) 1 hour.
(D) 1 hour plus an additional 30 minutes for each bedroom over three.

101. Water closets installed for public use must have a
(A) regular closed-front seat with or without a cover.
(B) regular open-front seat with or without a cover.
(C) elongated closed-front seat with or without a cover.
(D) elongated open-front seat with or without a cover.

102. When sheet lead is used for a shower pan, it must weigh at least ____ pounds per square foot.
(A) 2
(B) 4
(C) 6
(D) 8

103. When sheet copper is used for a shower pan, it must weigh at least ____ ounces per square foot.
(A) 4
(B) 6
(C) 8
(D) 12

104. Lead and copper shower pans must be protected against the corrosive effects of concrete by
(A) coating the inside with asphaltum paint.
(B) coating the outside with asphaltum paint.
(C) coating the inside and outside with asphaltum paint.
(D) coating the inside and outside with a water seal paint.

105. Built-in tubs with overhead showers must have
(A) an 8-inch shower arm.
(B) a waterproof joint between the tub and wall.
(C) a minimum of 5-foot tile walls.
(D) either a shower door or curtain.

106. No floor drain or other plumbing fixture shall be installed in a room
(A) containing air handling machinery.
(B) used for sleeping.
(C) used for the storage of food.
(D) used for recreation purposes.

107. Floor drains serving indirect waste pipes from food or drink storage rooms shall *not* be installed in any
(A) toilet room.
(B) unventilated room.
(C) storeroom.
(D) kitchen.

108. According to the *UPC*, the maximum length of a 4" trap arm is.
(A) 10
(B) 12
(C) 15
(D) 20

109. The code defines graywater as
(A) partially treated household waste water, excluding toilet waste.
(B) untreated household waste water, excluding toilet and kitchen sink waste.
(C) clothes washing machine waste water only.
(D) kitchen sink waste water only.

110. The sizing and design of gasoline and oil interceptors which handle volatile liquids is governed by
(A) the amount of volatile liquids in a system.
(B) the number of floor drains for public storage garages.
(C) the number of floor drains for an automotive repair shop.
(D) the number of washing facilities which cater to commercial motor vehicles.

111. Unless the plumbing inspector rules otherwise, every floor drain trap directly connected to the drainage system must have a permanent water seal which can be fed from
(A) a drinking fountain.
(B) an ice maker.
(C) an automatic priming device.
(D) an A.C. condensate drain.

112. Previously-used piping material may be reused in a potable water supply system when
(A) it's been galvanized inside and outside.
(B) its previous use was for a potable water supply system.
(C) it's approved by a plumbing inspector.
(D) the water is not too hard.

113. Pressure-rated plastic service piping must have a minimum working pressure of
(A) street level pressure.
(B) 75 pounds per square inch.
(C) 100 pounds per square inch.
(D) 160 pounds per square inch.

114. Codes require that lawn sprinkler systems using potable water have an approved
(A) gate valve.
(B) backflow preventer.
(C) check valve.
(D) ground joint union.

115. The hose-connected faucet that's not required to have a backflow preventer installed is
(A) a three-compartment commercial sink.
(B) a service sink.
(C) an automatic clothes washing machine.
(D) an outside hose faucet.

116. Plastic water service piping requires a minimum cover of
(A) 6 inches.
(B) 8 inches.
(C) 10 inches.
(D) 12 inches.

117. The minimum liquid capacity of a septic tank serving a three-bedroom, three-bath residence is
(A) 750 gallons.
(B) 1,000 gallons.
(C) 1,200 gallons.
(D) 1,500 gallons.

118. Cast-in-place septic tanks must be designed to support an earth load, of not less than ___ psf.
(A) 250
(B) 300
(C) 350
(D) 500

119. The minimum distance from a drainfield to a basement wall is
(A) 5 feet.
(B) 8 feet.
(C) 10 feet.
(D) 12 feet.

120. When a seepage pit is installed in the vicinity of a septic tank drainfield, the minimum separation distance is
(A) not important.
(B) 5 feet.
(C) 8 feet.
(D) 10 feet.

121. Where reservoir-type drainfields are used, the maximum distance between centers of distribution lines is
(A) 1 foot.
(B) 2 feet.
(C) 3 feet.
(D) 4 feet.

122. The suction line from a potable water-supply well serving a single family residence shall have a union installed before
(A) the pump.
(B) the hair strainer.
(C) the check valve.
(D) the well casing.

123. Even when the underground water table is quite shallow, your local authority may require a well depth of
(A) 25 feet.
(B) 30 feet.
(C) 35 feet.
(D) 40 feet.

124. The minimum sized hydropneumatic tank for a single family residence shall be
(A) 20 gallons.
(B) 30 gallons.
(C) 42 gallons.
(D) 50 gallons.

125. Waste from an air conditioning unit connected to the building sanitary drainage system must allow ____ fixture unit(s) per gallon per minute.
(A) 1
(B) 2
(C) 3
(D) 4

126. A 4-inch concrete pad must be poured around the well casing and extend ____ inches on all sides.
(A) 10
(B) 18
(C) 20
(D) 36

127. The maximum length of a single tile drainfield lateral is ____ feet.
(A) 40
(B) 60
(C) 80
(D) 100

128. Horizontal screwed gas piping 1¼ inches and larger shall be supported every ____ feet.
(A) 4
(B) 6
(C) 10
(D) 12

129. The location that's *not* acceptable for installation of gas piping within a building is
(A) under a concrete floor.
(B) a solid partition.
(C) a hollow partition.
(D) an elevator shaft.

130. Branch outlet pipes for a gas distribution system must never be taken from the ____ of horizontal lines.
(A) top
(B) side
(C) bottom
(D) end

131. Plastic pipe, tubing and fittings used for the installation of gas piping shall not be joined by
(A) heat-fusion method.
(B) solvent cement method.
(C) adhesive method.
(D) compression couplings or flanges.

132. Equipment that requires mobility during operation inside a building may use indoor gas hose connectors, providing the length doesn't exceed ____ feet.
(A) 6
(B) 8
(C) 10
(D) 12

133. For most fixtures, excluding direct flush valves, the *IPC* gives the minimum service pressure at the point of discharge at ____ psi.
(A) 4
(B) 6
(C) 8
(D) 10

134. Combination pressure and temperature valves must be installed so that the temperature sensing element is within ____ of the top of the tank.
(A) 2 inches
(B) 4 inches
(C) 6 inches
(D) 8 inches

135. When the pool pressure piping system is ready for inspection, it must be water-tested at
(A) 10 psi.
(B) 20 psi.
(C) 30 psi.
(D) 40 psi.

136. When sizing a septic tank for a single-family or multiple residential unit, what factor is used to calculate the capacity of the tank?
(A) the number of fixture units in the building.
(B) the number of bedrooms.
(C) the absorbency rating of the drainfield.
(D) the hours of anticipated flow.

137. The minimum size for a domestic water heater relief valve discharge is
    (A) never smaller than the opening on the device.
    (B) one-half size larger than the opening on the device.
    (C) 1 inch.
    (D) ¾ inch.

138. If it's not possible to extend a cleanout to an accessible outside location, the alternative allowed by code is
    (A) a cleanout tee in a vertical stack.
    (B) increase the pipe by one size so a longer pipe length will be allowed.
    (C) install an exposed P trap at the base of the stack at a point no greater than 4 feet above the finished floor.
    (D) install a two-way fitting that permits both upstream and downstream rodding at the closest inside location.

139. The *UPC* allows oversizing a trap and trap arm
    (A) oversizing is never allowed
    (B) by one pipe size only
    (C) by two pipe sizes only
    (D) without limitation

140. Material approved by the *UPC* for use for distributing water under a floor slab includes
    (A) copper type M
    (B) copper type K
    (C) PVC
    (D) copper type dwv

141. Liquid waste, as defined by code, does *not* include the discharge from
    (A) urinals.
    (B) rain leaders.
    (C) dental chairs.
    (D) kitchen sinks.

142. The term "sewage" as defined by the code would not include
    (A) liquid waste containing animal matter in suspension.
    (B) liquid waste containing minerals in solution.
    (C) rain water.
    (D) liquids containing chemicals in solution.

143. Standpipes and fittings above ground within exterior building walls must be strong enough to withstand ____ pounds per square inch water pressure at the topmost outlet.
    (A) 55
    (B) 65
    (C) 100
    (D) 150

144. Outside rain leaders, when exposed to contact with vehicles, must have a cast iron pipe which extends ____ feet above grade.
    (A) 2
    (B) 3
    (C) 4
    (D) 5

145. Any indirect waste pipe installation must have a ____ -inch minimum clearance above the floor.
    (A) 1
    (B) 2
    (C) 3
    (D) 4

146. Any cleanout plug made of heavy brass or plastic must be ____ inch thick.
    (A) $^1/_{16}$
    (B) $^1/_8$
    (C) $^3/_{16}$
    (D) $^1/_4$

147. Horizontal copper tubing 2 inches and larger must be supported at approximately ____ intervals.
    (A) 4 foot
    (B) 6 foot
    (C) 8 foot
    (D) 10 foot

148. Residential septic tanks
    (A) must have a minimum capacity of 500 gallons.
    (B) may not receive storm water.
    (C) may be constructed of masonry block with a coat of ½-inch portland cement grout.
    (D) shall be rectangular in shape.

149. A vapor vent for a small oil interceptor must extend at least ____ feet above grade.
   (A) 6
   (B) 8
   (C) 10
   (D) 12

150. According to the *UPC*, the minimum size water building supply pipe from the meter to the house is
   (A) ½ inch.
   (B) ¾ inch.
   (C) 1 inch.
   (D) determined by meter size.

Using Illustration 1, identify each section of piping as specified in questions 151 through 154.

151. Section "A" is an
   (A) island vent.
   (B) loop vent.
   (C) relief vent.
   (D) circuit vent.

152. Section "B" is a
   (A) waste pipe.
   (B) fixture drain.
   (C) building drain.
   (D) fixture branch.

153. Section "C" is a
   (A) fixture branch.
   (B) wet vent.
   (C) combination waste and vent pipe.
   (D) dirty waste pipe.

154. Section "D" is a
   (A) soil pipe.
   (B) waste pipe.
   (C) building sewer.
   (D) building drain.

Using the information from the *UPC*, give the fixture units and size of pipes shown in Illustration 2 for questions 155 through 157.

155. The minimum size of urinal trap "A" is
   (A) 1½ inches.
   (B) 2 inches.
   (C) 2½ inches.
   (D) 3 inches.

156. Fitting "B" is known in the trade as a
   (A) double combination wye and $^1/_8$ bend.
   (B) double combination wye and $^1/_5$ bend.
   (C) double combination wye
   (D) double drainage wye.

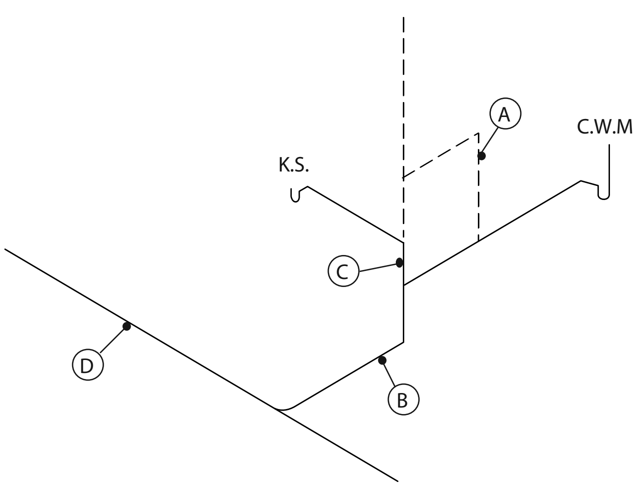


Illustration 1

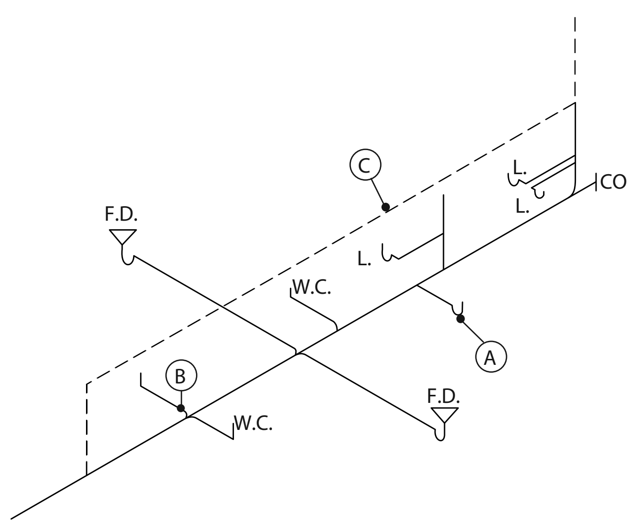


Illustration 2

157. The minimum size of horizontal vent pipe "C" is
    (A) 2 inches.
    (B) 2½ inches.
    (C) 3 inches.
    (D) 4 inches.

158. According to the *UPC*, a 3-inch building drain installed at a maximum fall (pitch) of $^1/_8$ inch per foot may receive the discharge from fixtures having a total fixture unit load of
    (A) 18 F.U.
    (B) 22 F.U.
    (C) 25 F.U.
    (D) 28 F.U.

159. Using the *UPC*, a 2-inch vent pipe, 20 feet long, is adequate to serve
    (A) 14 bathtubs.
    (B) 7 automatic clothes washers.
    (C) 26 lavatories.
    (D) 13 showers.

160. When sizing a septic drain field, ____ soils will require a larger drain field area than ____ soils.
    (A) sandy, clay
    (B) clay, sandy
    (C) course sand, fine sand
    (D) course sand, gravel

161. According to the *UPC*, a clothes washing machine standpipe must have a minimum length of
    (A) 10 inches.
    (B) 14 inches.
    (C) 18 inches.
    (D) 28 inches.

Use Illustration 3 to answer questions 162 through 164.

162. The pipe section "A" between the two lavatories and the sink serves as a
    (A) waste pipe for the kitchen sink.
    (B) waste pipe for the lavatories.
    (C) vent pipe for the kitchen sink.
    (D) common vent for both fixtures.

163. The combined fixture units at pipe section "B" is
    (A) 1 unit.
    (B) 2 units.
    (C) 3 units.
    (D) 4 units.

164. The combined number of fixture units at pipe section "C" is
    (A) 1 unit.
    (B) 2 units.
    (C) 3 units.
    (D) 4 units.

165. Using Illustration 4, the maximum length required by the *UPC* for the 4-inch pipe "A", which serves a floor drain from a vented building drain, is
    (A) 3 feet.
    (B) 10 feet.
    (C) 15 feet.
    (D) 20 feet.

166. A drain field must have a maximum cover of ____ inches?
    (A) 12
    (B) 18
    (C) 24
    (D) 36

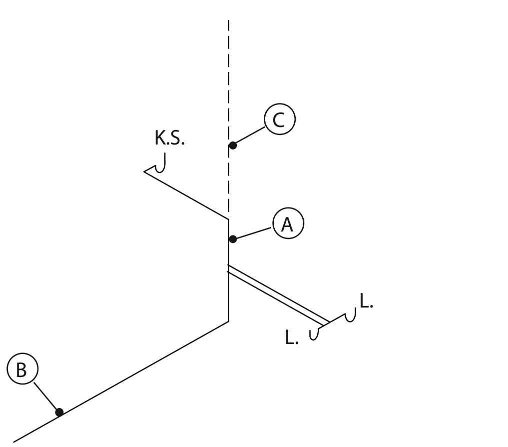


Illustration 3

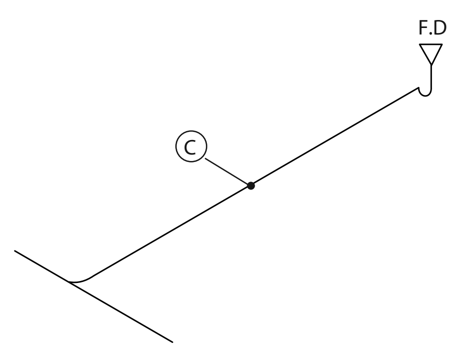


Illustration 4

167. A flaring tool is used to make flare joints in
   (A) Type K copper pipe.
   (B) Type L copper pipe.
   (C) Flexible copper tubing.
   (D) Type DWV copper tubing.

168. According to the *UPC*, a material that is not approved as a water distribution pipe underground within a building is
   (A) CPVC plastic water pipe.
   (B) copper water tube, Type K and L.
   (C) brass pipe.
   (D) PE plastic pipe.

169. The piping which may be used to convey corrosive gases is
   (A) brass.
   (B) galvanized steel.
   (C) Type K copper pipe.
   (D) stainless steel extra heavy.

170. Vent piping serving a gas water heater that penetrates the roof near a 2-foot parapet wall should be a minimum of
   (A) 1 foot high.
   (B) 2 feet high.
   (C) 3 feet high.
   (D) 4 feet high.

171. A water closet using a flushometer valve must have a vacuum breaker located at least ____ inch(es) above the rim of the bowl.
   (A) 1
   (B) 3
   (C) 6
   (D) 8

172. A single flushometer valve may be used to serve
   (A) 1 water closet.
   (B) 2 water closets.
   (C) 1 water closet and 1 urinal.
   (D) 1 water closet and 2 urinals.

173. In a water piping system, the code prohibits the use of
   (A) CPVC plastic.
   (B) brass.
   (C) type M copper pipe.
   (D) aluminum pipe.

174. Steel fittings used within a building in a water piping system must
   (A) be beaded.
   (B) have standard pipe threads.
   (C) be plain.
   (D) be galvanized.

175. Metal water piping installed in a building is required to be
   (A) supported every 3 feet
   (B) supported every 4 feet
   (C) designed for minimum flow conditions
   (D) electrically bonded to the service panel

176. The size of a gas supply piping outlet serving any gas appliance must not be less than
   (A) $^3/_8$ inch.
   (B) $^1/_4$ inch.
   (C) $^3/_4$ inch.
   (D) the appliance inlet pipe.

177. The combustion chamber of a gas-fired water heater installed in a private garage must be at least ____ above the floor level.
   (A) 12 inches
   (B) 18 inches
   (C) 24 inches
   (D) 28 inches

178. The *UPC* requires that new or replacement selfclosing faucets for a train station comply with water conservation requirements by having a maximum flow rate of
   (A) 1.2 gpm.
   (B) 1.8 gpm.
   (C) 0.25 gpm.
   (D) 0.75 gpm.

179. A sanitary tee may
   (A) not be used to change direction in drainage pipes.
   (B) be used to change direction from vertical to horizontal.
   (C) be used to change direction from horizontal to vertical.
   (D) both B and C are permitted uses.

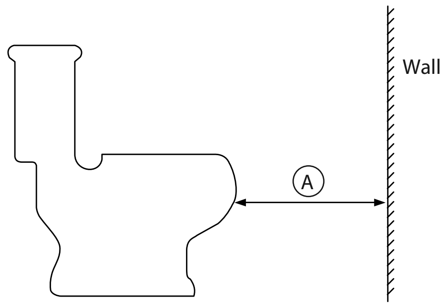


Illustration 5

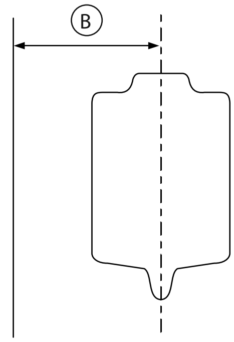


Illustration 6

180. Most codes require a minimum air space of ____ inches above the liquid level in a septic tank.
(A) 4
(B) 9
(C) 10
(D) 12

181. Each drain unit for a reservoir-type drainfield serving a 900 gallon septic tank should equal
(A) 2 square feet.
(B) 2 linear feet.
(C) 4 square feet.
(D) 4 linear feet.

182. For each trailer park site drainage inlet, the *UPC* assigns ____ fixture units.
(A) 10
(B) 12
(C) 14
(D) 16

183. According to the *UPC*, a 4-inch sewer installed at a slope at 15 inches per 100 feet may serve ____ trailers.
(A) 21
(B) 23
(C) 25
(D) 28

184. When installing an ADA-compliant sink, what is the minimum clearance from the bottom of the sink to the finished floor?
(A) 24 inches.
(B) 27 inches.
(C) 30 inches.
(D) 32 inches.

185. The fittings for galvanized drainage, waste and vent pipes must be
(A) galvanized inside only.
(B) galvanized outside only.
(C) the straight type.
(D) the recessed type.

186. In Illustration 5, distance "A" between a water closet and a partition must be at least
(A) 12 inches.
(B) 15 inches.
(C) 21 inches.
(D) 30 inches.

187. In Illustration 6, distance "B" for a wall-hung urinal must be at least
(A) 10 inches.
(B) 12 inches.
(C) 15 inches.
(D) 16 inches.

188. Using Illustration 6 once again, distance "B" for a stall urinal must be at least
(A) 10 inches.
(B) 12 inches.
(C) 15 inches.
(D) 16 inches.

189. An insulated gas-fired water heater must be at least ____ inch(es) from any door or wall constructed of combustible materials.
(A) 1
(B) 2
(C) 3
(D) 4

190. A thermosiphon solar system requires
   (A) a circulating pump.
   (B) a thermostat sensor.
   (C) a minimum ½-inch pipe in the collector and circulation system.
   (D) a minimum ¾-inch pipe in the collector and circulation system.

191. The material not recommended for a solar heat collector deck is
   (A) plastic pipe.
   (B) aluminum pipe.
   (C) copper pipe.
   (D) steel pipe.

192. When applying a conversion factor of 1000 BTU per CFH, a gas appliance rated at 220,000 Btu per hour is equal to
   (A) 22 cubic feet per hour.
   (B) 220 cubic feet per hour.
   (C) 2,200 cubic feet per hour.
   (D) 22,000 cubic feet per hour.

193. The material used in a gas system that's *not* permitted outside a building, underground, is
   (A) plastic pipe.
   (B) aluminum pipe.
   (C) copper pipe.
   (D) brass pipe.

194. A commercial food waste disposer unit must be connected directly into
   (A) the sanitary drainage system.
   (B) the greasy waste system.
   (C) a bucket type trap.
   (D) a grease trap.

195. A water heater relief valve drip pipe must terminate
   (A) at an observable point outside the bulding.
   (B) onto a pervious surface such as a planter bed.
   (C) at the main building drain.
   (D) into a permitted wye connection with the building sewer.

196. A sump check valve must be located
   (A) in the basement drain.
   (B) on the sump side of the gate valve.
   (C) on the building drain side of the gate valve.
   (D) 2 feet from the building drain.

197. Fixtures connected directly to the sanitary drainage system must be equipped with
   (A) a water seal trap.
   (B) a vent.
   (C) a backwater valve.
   (D) a waste pipe.

198. A 2-inch pipe has an aggregate cross-sectional area of
   (A) 1.7671.
   (B) 3.1416.
   (C) 4.9087.
   (D) 7.0686.

199. According to the *UPC*, the minimum floor area of a shower stall must be ____ square inches.
   (A) 950
   (B) 1,024
   (C) 1,110
   (D) 1,200

200. What is the plumber's best source for finding the exact required dimensions and clearances for plumbing installations for ADA compliance?
   (A) the *Uniform Federal Accessibility Standards for Barrier-Free Design*.
   (B) *Guide to the ADA Standards*, Chapter 12.
   (C) the *International Plumbing Code*, Chapter 11, *Accessibility*.
   (D) the *ADA Standards for Accessible Design*, Chapter 6.

Multiple Choice Answers

1. D (p. 35)
2. A (p. 116, Fig. 8-17)
3. C (p. 54)
4. A (p. 14)
5. D (p. 56, Fig. 4-11)
6. A (p. 34)
7. B (p. 105, Fig. 14-2)
8. C (p. 108)
9. D (p. 67)
10. C (p. 21)
11. D (p. 103)
12. C (p. 202)
13. B (p. 197)
14. C (p. 94)
15. A (p. 195)
16. C (p. 94)
17. C (p. 93)
18. B (p. 116, Fig. 8-16)
19. C (p. 161)
20. D (p. 28)
21. B (p. 26)
22. C (p. 162)
23. D (p. 184)
24. B (p. 90)
25. D (p. 183)
26. C (p. 121)
27. D (p. 147)
28. D (p. 260)
29. A (p. 75)
30. A (p. 34)
31. B (p. 33)
32. A (p. 28)
33. D (p. 94)
34. C (p. 34, Fig. 3-3)
35. A (p. 17, Fig 2-13)
36. C (pp. 114-115)
37. C (p. 116)
38. C (p. 123)
39. D (pp. 253-255)
40. D (p. 105)
41. D (p. 108)
42. D (p. 142)
43. A (p. 84
44. D (p. 15, Fig, 2-12)
45. C (p. 21)
46. B (p. 21)
47. B (p. 28)
48. D (p. 29, Fig. 2-35)
49. C (p. 18)
50. C (p. 18)
51. B (p. 22)
52. D (p. 40)
53. B (p. 44)
54. C (p. 108)
55. B (p. 93)
56. D (p. 122, Fig. 8-28)
57. B (p. 122, Fig. 8-28)
58. A (p. 123)
59. A (p. 122)
60. C (p. 112)
61. B (p. 112)
62. D (p. 54)
63. C (p. 121)
64. D (p. 64)
65. A (pp. 67-68, Fig. 5-16)
66. C (p. 119)
67. D (pp. 118-119, Fig. 8-22)
68. B (p. 48)
69. D (p. 48)
70. C (p. 119)
71. B (p. 43)
72. B (p. 54, Fig. 4-2)
73. D (p. 43)
74. A (p. 34)
75. B (p. 39, Fig. 3-21)
76. B (p. 67)
77. C (p. 45, Fig. 3-29)
78. A (p. 40)
79. C (p. 48)
80. B (p. 47)
81. D (p. 71)
82. C (p. 54)
83. B (p. 94)
84. C (p. 96)
85. B (p. 95)
86. C (p. 97)
87. B (p. 118, Fig. 8-22)
88. A (p. 107)
89. D (p. 109, Fig. 8-5)
90. A (p. 109)
91. C (p. 21)
92. C (p. 21)
93. A (p. 151, Fig. 11-10)
94. A (p. 169)
95. A (p. 78)
96. D (p. 256)
97. D (p. 260)
98. B (p. 81)
99. B (p. 260, Fig. 21-11)
100. C (p. 170)
101. D (p. 253)
102. B (p. 255)
103. D (p. 255)
104. C (p. 255)
105. B (p. 255)
106. A (p. 123)
107. A (p. 92, Fig. 8-30)
108. A (p. 58)
109. B (p. 148)
110. A (p. 81)
111. C (p. 258)
112. B (p. 179)
113. D (p. 179)
114. B (p. 183)
115. C (p. 185)
116. D (p. 116, Fig. 8-16)
117. B (p. 130, Fig. 9-2)
118. D (p. 128)
119. B (p. 137)
120. B (p. 137)
121. D (p. 133, Fig. 9-8)
122. A (p. 197)
123. B (p. 194)
124. C (p. 199, Fig. 15-5)
125. B (p. 123)
126. B (p. 195, Fig. 15-4)
127. D (p. 132)
128. B (p. 185, Fig. 8-22)
129. D (p. 244)
130. C (p. 247, Fig. 20-6)
131. C (p. 244)
132. A (p. 24)
133. C (p. 164, Fig. 12-3)
134. C (p. 172, Fig. 13-5)
135. D (p. 218)
136. B (p. 130)
137. A (p. 172, Fig. 13-16)
138. A (p. 65)
139. B (p. 58)
140. B (p. 181)
141. B (p. 14)
142. C (p. 14)
143. B (pp. 204 &206)
144. D (p. 108)
145. C (p. 120)
146. B (p. 67)
147. D (p. 118)
148. B (p. 127)
149. D (p. 82)
150. B (p. 163)
151. C (p. 58, Fig. 4-17)
152. A (p. 14)
153. B (p. 14)
154. D (p. 14)
155. B (p. 254)
156. A (p. 10, Fig. 2-3)
157. C (p. 41)
158. D (p. 18, Fig. 2-16)
159. B (p. 18, Fig. 2-16)
160. B (p. 135)
161. C (p. 91)
162. A (p. 14)
163. B (pp. 15 & 16, Figs. 2-9, & 2-11)
164. D (pp. 15 & 16, Figs. 2-9 & 2-11)
165. B (p. 59, Fig. 4-18)
166. C (p. 137)
167. C (p. 188)
168. D (p. 181)
169. B (p. 243)
170. C (p. 249, Fig. 20-8 (D))
171. C (p. 254)
172. A (p. 254)
173. D (p. 224)
174. D (p. 179)
175. B (p. 204)
176. D (p. 238)
177. B (p. 247)
178. C (p. 148, Fig. 11-1)
179. C (p. 115, Fig. 8-14)
180. B (p. 128)
181. C (p. 133)
182. B (p. 244)
183. A (p. 142, Fig. 10-1)
184. D (p. 184)
185. D (p. 113)
186. C (pp. 259-260, Fig. 21-12)
187. B (p. 260, Fig. 21-12)
188. B (p. 260, Fig. 21-11)
189. B (p. 248)
190. D (p. 228)
191. A (p. 230)
192. B (p. 238)
193. B (p. 244, Fig. 20-1)
194. A (p. 257)
195. A (p. 172)
196. B (p. 29, Fig. 2-35)
197. A (p. 53)
198. B (p. 48, Fig. 3-33)
199. B (p. 255)
200. D (p. 261)

Appendix: Definitions and Abbreviations

The terms included here are found in most plumbing codes. Some words in the code have become so descriptive and specialized that their meaning is different from what a dictionary might give.

Two words that appear repeatedly in every code are *shall* and *may*. To be able to comply with the code, you must clearly understand the specialized meanings of these words.

- *Shall* is mandatory. It requires compliance without deviation. For example, part of the requirements for waste disposal is that "sewage and liquid waste shall be treated and disposed of as hereinafter provided."
- *May* is a permissive term. When used in the code, it means allowable or optional, but not required. For example, "Drinking fountains may be installed with indirect waste only for the purpose of resealing required traps of floor drains."

"Building drain" and "building sewer" are two terms often used improperly. Many professionals assume that both terms apply to the same part of the drainage system. However, note the code definition for each term:

- A *building drain* is the main, horizontal collection system within the walls of a building that extends to 2 feet beyond the building line. (This distance may vary in some codes.)
- A *building sewer* is defined as that part of the horizontal drainage system outside the building line that connects to the building drain and conveys the liquid waste to a legal point of disposal.

Effective and constructive code interpretation is possible only when the words and terms used in the code are understood. Many definitions can be illustrated through isometric drawings. It's possible to have some variation and still remain within the intent of the code definitions. The alert professional will discover that most isometric drawings fit into these definitions. Isometric illustrations provide a better understanding of code definitions.

Definitions

Absorption The process of being absorbed in a drainfield absorption area.

Air gap (in a water supply system) The unobstructed vertical distance through the free atmosphere between the lowest opening from any pipe or faucet supplying water to a tank, plumbing fixture, or other device, and the flood level rim of the receptacle.

Air lock A stoppage or slowing of the passage of water or liquid waste through a piping system caused by air that has become trapped in the pipe or pipe connection. For example, air trapped in the flexible hose connection from a mobile home or trailer to the park sewer connection, caused by a sag in the hose, can slow or stop the flow of waste or sewage.

Anaerobic Living without free oxygen. For example, anaerobic bacteria function in septic tanks to digest organic matter.

Approved Having the approval of the plumbing official or other authority given jurisdiction by the code.

Area drain A receptacle designed to collect surface or rain water from an open area.

Back siphonage The flow of water or other liquids, mixtures or substances into the distributing pipe of a potable supply of water, or into any other fixture, device, or appliance from any source other than its intended course, due to a negative pressure in such pipe.

Backfill That portion of the trench excavation up to the original earth line that is required to be refilled after sewer or other piping has been laid.

Backflow The flow of water or other liquids, mixtures, or substances into the distributing pipe of a potable supply of water, or into any other fixture or appliance from any source other than its intended course.

Backflow connection Any arrangement under which backflow can occur. Also known as *backflow condition*.

Backflow preventer A device or means to prevent the flow of water or other liquids, mixtures, or substances into the distributing pipe of a potable supply of water, or into any other fixture or appliance from any source other than its intended course.

Backwash piping Piping, including the piping connected to the backwash outlet of the filter, that conveys waste water to an approved point of disposal.

Base The lowest point of any vertical pipe.

Battery of fixtures Any group of two or more similar adjacent plumbing fixtures that discharge into a common horizontal waste or soil branch.

Boiler blow-off An outlet on a boiler that permits the emptying or discharging of water or sediment from the boiler.

Branch Any part of the piping system other than a main, a riser or a stack.

Branch drainage pipe That portion of the drainage system extending from a trailer park sanitary drainage system to the trailer site, including the terminal end that connects to the trailer drain hose.

Branch interval A length of soil or waste stack (vertical pipe), generally one story in height (approximately 9 feet, but not less than 8 feet), which connects the horizontal branches from one floor or story of a building to the stack.

Branch vent A vent that connects one or more individual vents with a vent stack or a stack vent.

Branch water pipe That portion of the water distribution system extending from a trailer park service main to a trailer site, including the terminal end which connects to the trailer water supply pipe.

Building drain The main horizontal sanitary collection system, inside the wall line of the building, that conveys sewage to the building sewer which begins 2 feet (more in some codes) outside the building wall. The building drain excludes the waste and vent stacks that receive the discharge from soil, waste and other drainage pipes, including storm water.

Building sewer That part of the horizontal piping of a drainage system that connects to the end of the building drain and conveys the contents to a public sewer, private sewer, or individual sewage disposal system.

Building storm drain A drain used to receive and convey rain water, surface water, ground water, subsurface water and other clear water waste, and discharge these waste products into a building storm sewer or a combined building sewer beginning 2 feet outside the building wall.

Building storm sewer The pipe that connects to the end of the building storm drain to receive and convey its contents to a public storm sewer, combined sewer, or other approved disposal point.

Building subdrain Any portion of a drainage system which cannot drain by gravity into the building sewer.

Caulking Any approved method for rendering a joint water and gas tight. For cast iron pipe and fittings with hub joints, the term refers to caulking the joint with lead and oakum.

Circuit vent A vent that serves two or more fixture traps. It connects to a horizontal branch drain from the downstream side of the highest (last) fixture connection and then to the vent stack.

Code Regulations and their subsequent amendments, or any emergency rule or regulation, lawfully adopted by the administrative authority having jurisdiction to control plumbing work.

Combined building sewer A building sewer which receives storm water, sewage and other liquid waste.

Common vent The vertical vent portion which serves to vent two fixture drains that are installed at the same level in a vertical stack.

Conductor See *Leader*.

Continuous waste A drain connecting two or more fixtures or a single fixture with more than one compartment to a common trap.

Cross connection Any physical connection or arrangement between two separate piping systems, one containing potable water and the other containing water of unknown or questionable safety. The code prohibits cross connections.

Dead end A branch leading from a soil, waste or vent pipe, building drain or building sewer that is terminated by a plug or other closed fitting at a developed distance of 2 feet or more. A dead end is also classified as an extension for future connection, or as an extension of a cleanout for accessibility.

Dependent travel trailer Any motorized vehicle used as a temporary dwelling unit for travel, vacation and recreation. Usually has limited built-in sanitary facilities but not a plumbing system suitable for connection to a park sewage and water supply system.

Dependent travel trailer sanitary service station A trailer park location equipped for emptying intermediate waste holding tanks.

Developed length The length of a pipe measured along the center line of the pipe and fittings.

Diameter The nominal diameter (distance straight through the middle) of a pipe or fitting as designated commercially, unless specifically stated otherwise.

Downspout See *Leader*.

Drain Any pipe which carries liquid, waste water or other water-borne wastes in a building drainage system to an approved point of disposal.

Drain hose connection An approved flexible hose that is easily detachable and is used to connect a trailer drain to a park's sewer inlet connection.

Drainage system All of the piping within public or private premises that conveys sewage, rain water, or other liquid wastes to a legal point of disposal.

Drainage well Any drilled, driven or natural cavity which taps the underground water table and into which surface waters or treated waste water, industrial waste or sewage is disposed. Always requires approval from local authority.

Dry vent That portion of a vent system that receives no sewage or waste discharge.

Durham system An all-threaded pipe system of rigid construction, using recessed drainage fittings to correspond to the types of piping being used in drain, waste and vent systems.

Effective opening The minimum cross-sectional area of the diameter of a pipe at the point of water supply discharge.

Effluent The liquid waste discharged from a septic tank into the drainfield.

Filter piping All the piping, fittings, and valves necessary to connect the filter system of a swimming pool together as a unit.

Fire lines The complete wet standpipe system of a building, including the water service, standpipe, roof manifold, Siamese connections and pumps.

Fixture branch The drain from the trap of a fixture to the junction of that drain with a vent. Some codes refer to a fixture branch as a *fixture drain*.

Fixture drain The drain from the fixture branch to the junction of any other drain pipe. Some codes refer to a fixture drain as a *fixture branch*.

Fixture unit A design factor used to determine the load-producing effects of different types of plumbing fixtures on the plumbing system. For instance, most codes accept that 1 fixture unit equals up to 7.5 gallons per minute of flow.

Flood level rim The top edge of a plumbing fixture or other receptacle from which water or other liquids can overflow, such as in the rim of a bathtub.

Floor drain An opening or receptacle located at approximately floor level which is connected to a trap, designed to receive the discharge from indirect waste and floor drainage.

Floor sink An opening or receptacle, usually made of enameled cast iron, located at approximately floor level which is connected to a trap, designed to receive the discharge from indirect waste and floor drainage. A floor sink is more sanitary and easier to clean than a regular floor drain, and is usually used for restaurant and hospital installations.

Flushometer valve A device actuated by direct water pressure which discharges a predetermined quantity of water to fixtures for flushing purposes.

Grade The slope or pitch of drainage piping, known as the *fall*, usually expressed as a fraction of an inch per foot.

Horizontal branch A drain pipe extending laterally from a soil or waste stack or building drain. It may or may not have vertical sections or branches.

Horizontal pipe Any pipe or fitting that makes an angle of more than 45 degrees with the vertical.

Independent trailer coach Any trailer coach designed for permanent occupancy, equipped with kitchen and bathroom facilities and a plumbing system suitable for connection to a sewage, water and gas supply system in a trailer park.

Indirect waste A waste pipe that conveys liquid wastes (other than body wastes) by discharging them into an open plumbing fixture or receptacle such as a floor drain or floor sink. The overflow point of such a fixture or receptacle is at a lower elevation than the item drained.

Inground pool Any pool where the sides rest partially on, or have full contact with, the surrounding earth.

Inlet coupling The terminal end of a trailer park's water system at each trailer site. The water service connection from the trailer coach is made by a swivel fitting or threaded pipe end.

Insanitary Contrary to sanitary principles; unclean enough to endanger health.

Interceptor A device designed and installed to separate and retain deleterious, hazardous, or undesirable matter from normal wastes, and permit normal sewage or liquid wastes to discharge by gravity into the disposal terminal or sewer.

Intermediate waste holding tank An enclosed tank mounted on a travel trailer for temporary retention of waterborne waste.

Leader The vertical water conductor from the roof to the building storm drain, combined building sewer, or other approved means of disposal. Also called a *downspout.*

Liquid waste The liquid discharge from any fixture, appliance or appurtenance that connects to a plumbing system that does not receive body waste.

Load factor The percentage of the total connected fixture unit flow rate that is likely to occur at any point with the probability factor of simultaneous use. It varies with the type of occupancy, which, in turn, determines the total flow unit.

Loop or circuit waste and vent A combination of plumbing fixtures on the same floor level, in the same or in adjacent rooms, that are connected to a common horizontal branch soil or waste pipe.

Main The principal artery of any system of continuous piping, to which branches may be connected.

Main vent The principal artery of the venting system, to which vent branches may be connected.

May A permissive term used in the code which means allowable or optional, but not required.

Mezzanine An intermediate floor placed on any story or in a room. When the total area of a mezzanine floor exceeds $33\frac{1}{3}$ percent of the total floor area in that room or on that story, it is then considered an additional story rather than a mezzanine.

Mobile home, left side The side farthest from the curb when a mobile home is being towed or is in transit.

Mobile home lot A space in a mobile home park designed for the accommodation of one mobile home.

Mobile home or travel trailer park A parcel of land designated and improved to accommodate one or more trailers. Such trailers may be used for temporary or permanent living quarters.

Mobile park sanitary drainage system The entire drainage piping system in the mobile park used to convey waterborne waste to a legal point of disposal.

Mobile park water service main That portion of the park's water-distributing system that extends from park's water supply source to each branch service line.

Non-permanent pool Any pool constructed to be disassembled and re-assembled to its original integrity.

Non-swimming area Any portion of a pool which is too shallow or which has underwater ledges or walls that prevent normal swimming activity.

Onground pool Any pool where the bottom and sides rest fully above the surrounding earth.

Park sanitary drainage system The entire drainage piping system used to convey sewage or other liquid waste from all the trailer drain connections to a public sewer or private sewage disposal system.

Park water main The portion of the water supply piping that extends from the public water supply or other source of supply to the branch service lines.

Permanent pool Any pool constructed in the ground, on the ground, or in a building, that cannot be disassembled for storage.

Pitch Grade or slope of the piping. See also *Grade*.

Plumbing (includes any or all of the following) (1) The materials, including pipe, fittings, valves, fixtures and appliances, which are attached to and are a part of a system for the purpose of creating and maintaining sanitary conditions in a building, camp or swimming pool on private property where people live, work, play, assemble or travel. (2) That part of a water supply and sewage and drainage system extending from either the public water supply mains or private water supply to the public sanitary, storm or combined sanitary and storm sewers, or to a private sewage disposal plant, septic tank, disposal field, pit, box filter bed or any other receptacle, or into any natural or artificial body of water or water course upon public or private property. (3) The design, installation or contracting for installation, removal and replacement, repair or remodeling, of all or any part of the materials, appurtenances or devices attached to and forming a part of a plumbing system, including the installation of any fixture, appurtenance or devices used for cooking, washing, drinking, cleaning, fire fighting, mechanical or manufacturing purposes.

Plumbing fixtures Receptacles, devices, or appliances that are supplied with water or that receive or discharge liquids or liquid borne waste, with or without discharge, into the drainage system to which they may be directly or indirectly connected.

Plumbing official inspector The chief administrative officer charged with the administration, enforcement and application of the plumbing code and all amendments thereto.

Plumbing system The drainage system, water supply, water supply distribution pipes, plumbing fixtures, traps, soil pipes, waste pipes, vent pipes, building drains, building sewers, building storm drain, building storm sewer, liquid waste piping, water treating equipment, water using equipment, sewerage treatment, sewerage treatment equipment, fire standpipes, fire sprinklers, and relative appliances and appurtenances, including their respective connections and devices, within the private property lines of a premise.

Potable water Water which is satisfactory for drinking, culinary and domestic purposes and that meets the requirements of the health authority having jurisdiction. Potable water is considered *purified*, having been treated by one or several processes as required by its original untreated condition.

Private property For the purposes of the code, private property includes all property except streets or roads dedicated to the public, and public easements (excluding easements between private parties).

Private or private use fixtures The plumbing fixtures in residences and apartments, and in private bathrooms of hotels and similar installations, where the fixtures are intended for the use of a family or an individual.

Private sewer A sewer privately owned and not directly controlled by a public authority.

Private swimming pool A swimming pool located at a single-family residence and available for use only by the family of the household and their guests.

Public or public use fixtures Plumbing fixtures in commercial and industrial establishments, restaurants, bars, public buildings, comfort stations, schools, gymnasiums, railroad stations or places to which the public is invited or which are frequented by the public without special permission or special invitation, and other installations (whether paid or free) where a number of fixtures are installed so that their unrestricted use is available to the public.

Public sewer A common sewer directly controlled by public authority.

Public swimming pool A pool, together with its buildings and appurtenances, where the public is allowed to bathe or which is open to the public for bathing purposes by consent of the owner. It may be operated by an owner, lessee, operator, licensee, or concessionaire whether a fee is charged or not. A public pool may be one of four types:

1) *Competition pool* — a pool used for competitive swimming events.
2) *Public pool* — a pool intended for public recreational use.
3) *Semi-public pool* — a pool operated in conjunction with buildings such as hotels, motels and apartments.
4) *Special purpose pool* — a pool operated for water therapy treatments rather than for recreational purposes.

Recirculating piping (also called *return piping* or *pool inlet piping*) The piping connected to the discharge side of the pool pump. It returns water to the pool after filtering.

Refuse All solid wastes, including garbage, rubbish and ashes, but excluding body waste.

Relief vent A vent, the primary function of which is to provide air circulation between drainage and vent systems.

Rim An unobstructed open edge at the overflow point of a fixture.

Rock drainfield Washed rock from 3/4 to 2 1/2 inches used in septic tank drainfield absorption areas.

Roof drain An outlet installed to receive water that collects on the surface of a roof and that discharges that water into a leader or downspout.

Roughing-in The installation of all the parts of a plumbing system that can be completed prior to the installation of the plumbing fixtures; includes drainage, water supply, and vent piping, and the necessary fixture supports.

Sanitary sewer A pipe which carries sewage, excluding storm, surface and ground water.

Second hand A term applied to material or plumbing equipment which has been installed and used, or removed after use.

Septic tank A watertight receptacle which receives the discharge of a drainage system or part thereof, so designed and constructed as to separate solids from liquid, digest organic matter through a period of detention, and allow the liquids to discharge into the soil outside the tank through a subsurface system of open-joint or perforated piping, or other approved methods.

Service building A building in a trailer park with laundry facilities as well as toilet and bathing facilities for men and women.

Service connection The portion of the water distribution system that extends from the mobile home park branch service line to the inlet fitting at the trailer.

Sewage Any liquid waste containing animal, mineral or vegetable matter in suspension or solution. May also include liquids containing chemicals in solution.

Shall A mandatory term. When used in the code, it requires compliance without deviation.

Side vent A vent which connects to a horizontal drain pipe through a fitting at an angle no greater than 45 degrees to the vertical.

Slope See *Grade*.

Soil pipe Any pipe which conveys the discharge of water closets or fixtures having similar functions, with or without the discharge from other fixtures, to the building drain or building sewer.

Stack The vertical pipe of a soil, water or vent piping system.

Stack vent The extension of a soil or waste stack above the highest horizontal drain connected to the stack. Also called a *waste vent* or *soil vent*.

Stack venting A method of venting fixtures through the soil or waste stack.

Standpipe system A system of piping installed for fire protection purposes which has a primary water supply constantly or automatically available at each hose outlet.

Storm sewer A sewer used for conveying rainwater and/or surface water.

Subsurface drain A drain that receives only subsurface or seepage water and conveys it to a place of disposal.

Sump A tank or pit, located below the normal grade of the gravity system, which receives sewage or liquid waste and which must be emptied by mechanical means, such as a pump.

Supply well Any artificial opening in the ground designed to conduct water from a source bed through the surface when water from such well is used for public, semi-public or private use.

Supports Devices for supporting and securing pipe and fixtures to walls, ceilings, floors or structural members. Also known as *hangers* or *anchors*.

Swimming pool Any structure suitable for swimming or recreational bathing that's over 24 inches deep.

Trailer A mobile home, truck coach, travel trailer or recreation vehicle that can be used as a dwelling.

Trailer coach Any vehicle which can be licensed for use on public streets but is designed for permanent occupancy as a dwelling for one or more persons.

Trailer coach space A site or lot within a trailer park designated for use by one trailer coach.

Trap A fitting or device designed and constructed to provide a liquid seal that prevents the back passage of air and sewer gases without materially affecting the flow of sewage or water.

Trap seal The maximum vertical depth of liquid that a trap will retain, measured between the crown weir and the top of the dip of the trap.

Vacuum fitting A device which connects the pool sweeper hose to the side of the pool for cleaning purposes. Every pool must have a vacuum fitting, located a maximum of 10 inches below the water surface inside the pool, in an accessible location.

Vent stack A vertical vent pipe installed primarily for the purpose of providing circulation of air to and from any part of the drainage system.

Vent system A pipe or pipes installed to provide a flow of air to or from a drainage system, or to provide a circulation of air within such system which prevents back pressure and siphonage from breaking water trap seals serving the fixtures on the system.

Vertical pipe Any pipe or fitting installed in a vertical position or that makes an angle of not more than 45 degrees with the vertical.

Waste pipe Any pipe which receives the discharge of any fixture, except water closets or fixtures having similar functions, and conveys it to the building drain or to the soil or waste stack.

Water-distributing pipe A pipe within a building which conveys water from the water service pipe to the plumbing fixtures, appliances and other water outlets.

Water main A water supply pipe for public or community use. The public water distribution system is located in the street, alley or a dedicated easement adjacent to individual parcels of land.

Water service pipe The pipe from the water main or other source of water supply to the building served.

Water supply system A piping system consisting of the water service pipe, the water-distributing pipes, the standpipe system and the necessary connecting pipes, fittings, control valves and all appurtenances related to the water supply in or on private property.

Wet vent A waste pipe designed to vent and convey waste from fixtures other than water closets.

Yoke vent A pipe connecting upward from a soil or waste stack for the purpose of preventing pressure changes in the stacks.

Abbreviations

The abbreviations here are often found on blueprints (building plans) and in plumbing reference books (including the code) to identify plumbing fixtures, pipes, valves and nationally-recognized associations.

A	area
A.D.	area drain
AGA	American Gas Association
AISI	American Iron and Steel Institute
ASA	American Standard Association
ASCE	American Society of Civil Engineering
ASHRAE	American Society of Heating, Refrigeration and Air Conditioning Engineers
ASME	American Society of Mechanical Engineers
ASSE	American Society of Sanitary Engineering
ASTM	American Society for Testing and Materials

AWWA	American Water Works Association
B.S.	bar sink
B.	bidet
B.T.	bathtub
Btu	British thermal unit
C to C	center to center
CI	cast iron
CISPI	Cast Iron Soil Pipe Institute
C	condensate line
CO	cleanout
C.W.	cold water
cu. ft.	cubic feet
cu. in.	cubic inches
C.W.M.	clothes washing machine
C.V.	check valve
D.F.	drinking fountain
D.W.	dish washer
E to C	end to center
E.W.C.	electric water cooler
°F	degrees Fahrenheit
F	Fahrenheit
F.B.	foot bath
F.F.	finish floor
F.CO	floor cleanout
F.D.	floor drain
F.D.C.	fire department connection
F.E.C.	fire extinguisher cabinet
F.G.	finish grade
F.H.C.	fire hose cabinet
F.L.	fire line
F.P.	fire plug
F.S.P.	fire standpipe
F.U.	fixture unit
gal.	gallons
gpd	gallons per day
gpm	gallons per minute
Galv.	galvanized
G.S.	glass sink
G.V.	gate valve
H.B.	hose bibb
Hd or H.D.	head
H.W.	hot water
H.W.R.	hot water return
H.W.T.	hot water tank
in.	inch
I.D.	inside diameter

I.W.	indirect waste
I.P.S.	iron pipe size
K.S.	kitchen sink
L. or LAV.	lavatory
L.T.	laundry tray
L	length
lb.	pound
Max.	maximum
Mfr.	manufacturer
Min.	minimum
M.H.	manhole
NAPHCC	National Association of Plumbing Heating and Cooling Contractors
NBFU	National Board of Fire Underwriters
NBS	National Board of Standards
NFPA	National Fire Protection Association
NPS	nominal pipe size
O	oxygen
O.D.	outside diameter
oz.	ounce
P.D.	planter drain
P.P.	pool piping
psi	pounds per square inch
Rad.	radius
R.D.	roof drain
red.	reducer
R.L.	roof leader
San.	sanitary
Sh.	shower
Spec.	specification
sq.	square
S.B.	sitz bath
sq. ft.	square feet
S.P.	swimming pool
S.S.	service sink
Std.	standard
SV	service
SW	service weight
S & W	soil and waste
T	temperature
U or Ur.	urinal
V	volume
VTR	vent through roof
W	waste
W.C.	water closet
W.H.	water heater
XH	extra heavy

CHAPTER 6: PLUMBING ELEMENTS AND FACILITIES

601 General

601.1 Scope. The provisions of Chapter 6 shall apply where required by Chapter 2 or where referenced by a requirement in this document.

602 Drinking Fountains

602.1 General. Drinking fountains shall comply with 307 and 602.

602.2 Clear Floor Space. Units shall have a clear floor or ground *space* complying with 305 positioned for a forward approach and centered on the unit. Knee and toe clearance complying with 306 shall be provided.

> **EXCEPTION:** A parallel approach complying with 305 shall be permitted at units for *children's use* where the spout is 30 inches (760 mm) maximum above the finish floor or ground and is 3 ½ inches (90 mm) maximum from the front edge of the unit, including bumpers.

602.3 Operable Parts. *Operable parts* shall comply with 309.

602.4 Spout Height. Spout outlets shall be 36 inches (915 mm) maximum above the finish floor or ground.

602.5 Spout Location. The spout shall be located 15 inches (380 mm) minimum from the vertical support and 5 inches (125 mm) maximum from the front edge of the unit, including bumpers.

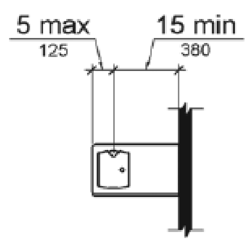


Figure 602.5
Drinking Fountain Spout Location

602.6 Water Flow. The spout shall provide a flow of water 4 inches (100 mm) high minimum and shall be located 5 inches (125 mm) maximum from the front of the unit. The angle of the water stream shall be measured horizontally relative to the front face of the unit. Where spouts are located less than 3 inches (75 mm) of the front of the unit, the angle of the water stream shall be 30 degrees maximum. Where spouts are located between 3 inches (75 mm) and 5 inches (125 mm) maximum from the front of the unit, the angle of the water stream shall be 15 degrees maximum.

Advisory 602.6 Water Flow. The purpose of requiring the drinking fountain spout to produce a flow of water 4 inches (100 mm) high minimum is so that a cup can be inserted under the flow of water to provide a drink of water for an individual who, because of a disability, would otherwise be incapable of using the drinking fountain.

602.7 Drinking Fountains for Standing Persons. Spout outlets of drinking fountains for standing persons shall be 38 inches (965 mm) minimum and 43 inches (1090 mm) maximum above the finish floor or ground.

603 Toilet and Bathing Rooms

603.1 General. Toilet and bathing rooms shall comply with 603.

603.2 Clearances. Clearances shall comply with 603.2.

603.2.1 Turning Space. Turning *space* complying with 304 shall be provided within the room.

603.2.2 Overlap. Required clear floor *spaces*, clearance at fixtures, and turning *space* shall be permitted to overlap.

603.2.3 Door Swing. Doors shall not swing into the clear floor space or clearance required for any fixture. Doors shall be permitted to swing into the required turning space.

EXCEPTIONS: 1. Doors to a toilet room or bathing room for a single occupant accessed only through a private office and not for *common use* or *public use* shall be permitted to swing into the clear floor *space* or clearance provided the swing of the door can be reversed to comply with 603.2.3.

2. Where the toilet room or bathing room is for individual use and a clear floor *space* complying with 305.3 is provided within the room beyond the arc of the door swing, doors shall be permitted to swing into the clear floor *space* or clearance required for any fixture.

Advisory 603.2.3 Door Swing Exception 1. At the time the door is installed, and if the door swing is reversed in the future, the door must meet all the requirements specified in 404. Additionally, the door swing cannot reduce the required width of an accessible route. Also, avoid violating other building or life safety codes when the door swing is reversed.

603.3 Mirrors. Mirrors located above lavatories or countertops shall be installed with the bottom edge of the reflecting surface 40 inches (1015 mm) maximum above the finish floor or ground. Mirrors not located above lavatories or countertops shall be installed with the bottom edge of the reflecting surface 35 inches (890 mm) maximum above the finish floor or ground.

Advisory 603.3 Mirrors. A single full-length mirror can accommodate a greater number of people, including children. In order for mirrors to be usable by people who are ambulatory and people who use wheelchairs, the top edge of mirrors should be 74 inches (1880 mm) minimum from the floor or ground.

603.4 Coat Hooks and Shelves. Coat hooks shall be located within one of the reach ranges specified in 308. Shelves shall be located 40 inches (1015 mm) minimum and 48 inches (1220 mm) maximum above the finish floor.

604 Water Closets and Toilet Compartments

604.1 General. Water closets and toilet compartments shall comply with 604.2 through 604.8.

EXCEPTION: Water closets and toilet compartments for *children's use* shall be permitted to comply with 604.9.

604.2 Location. The water closet shall be positioned with a wall or partition to the rear and to one side. The centerline of the water closet shall be 16 inches (405 mm) minimum to 18 inches (455 mm) maximum from the side wall or partition, except that the water closet shall be 17 inches (430 mm) minimum and 19 inches (485 mm) maximum from the side wall or partition in the ambulatory *accessible* toilet compartment specified in 604.8.2. Water closets shall be arranged for a left-hand or right-hand approach.

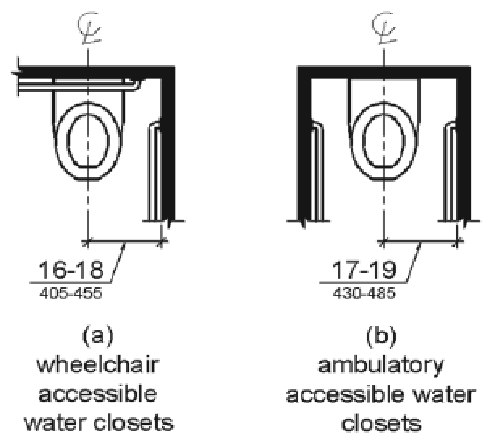


Figure 604.2
Water Closet Location

604.3 Clearance. Clearances around water closets and in toilet compartments shall comply with 604.3.

604.3.1 Size. Clearance around a water closet shall be 60 inches (1525 mm) minimum measured perpendicular from the side wall and 56 inches (1420 mm) minimum measured perpendicular from the rear wall.

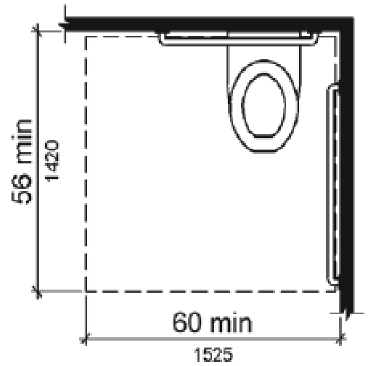


Figure 604.3.1
Size of Clearance at Water Closets

604.3.2 Overlap. The required clearance around the water closet shall be permitted to overlap the water closet, associated grab bars, dispensers, sanitary napkin disposal units, coat hooks, shelves, *accessible* routes, clear floor *space* and clearances required at other fixtures, and the turning *space*. No other fixtures or obstructions shall be located within the required water closet clearance.
EXCEPTION: In *residential dwelling units*, a lavatory complying with 606 shall be permitted on the rear wall 18 inches (455 mm) minimum from the water closet centerline where the clearance at the water closet is 66 inches (1675 mm) minimum measured perpendicular from the rear wall.

> **Advisory 604.3.2 Overlap.** When the door to the toilet room is placed directly in front of the water closet, the water closet cannot overlap the required maneuvering clearance for the door inside the room.

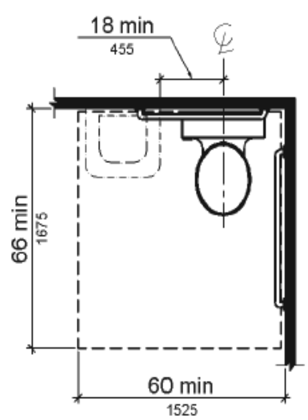


Figure 604.3.2 (Exception)
Overlap of Water Closet Clearance in Residential Dwelling Units

604.4 Seats. The seat height of a water closet above the finish floor shall be 17 inches (430 mm) minimum and 19 inches (485 mm) maximum measured to the top of the seat. Seats shall not be sprung to return to a lifted position.

EXCEPTIONS: 1. A water closet in a toilet room for a single occupant accessed only through a private office and not for *common use* or *public use* shall not be required to comply with 604.4.

2. In *residential dwelling units*, the height of water closets shall be permitted to be 15 inches (380 mm) minimum and 19 inches (485 mm) maximum above the finish floor measured to the top of the seat.

604.5 Grab Bars. Grab bars for water closets shall comply with 609. Grab bars shall be provided on the side wall closest to the water closet and on the rear wall.

EXCEPTIONS: 1. Grab bars shall not be required to be installed in a toilet room for a single occupant accessed only through a private office and not for *common use* or *public use* provided that reinforcement has been installed in walls and located so as to permit the installation of grab bars complying with 604.5.

2. In *residential dwelling units*, grab bars shall not be required to be installed in toilet or bathrooms provided that reinforcement has been installed in walls and located so as to permit the installation of grab bars complying with 604.5.

3. In detention or correction *facilities*, grab bars shall not be required to be installed in housing or holding cells that are specially designed without protrusions for purposes of suicide prevention.

> **Advisory 604.5 Grab Bars Exception 2.** Reinforcement must be sufficient to permit the installation of rear and side wall grab bars that fully meet all accessibility requirements including, but not limited to, required length, installation height, and structural strength.

604.5.1 Side Wall. The side wall grab bar shall be 42 inches (1065 mm) long minimum, located 12 inches (305 mm) maximum from the rear wall and extending 54 inches (1370 mm) minimum from the rear wall.

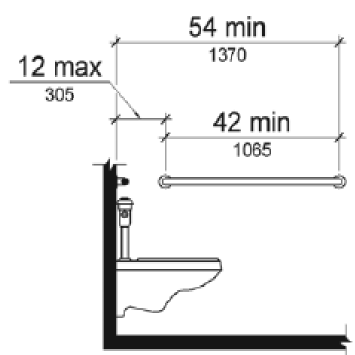


Figure 604.5.1
Side Wall Grab Bar at Water Closets

604.5.2 Rear Wall. The rear wall grab bar shall be 36 inches (915 mm) long minimum and extend from the centerline of the water closet 12 inches (305 mm) minimum on one side and 24 inches (610 mm) minimum on the other side.

EXCEPTIONS: 1. The rear grab bar shall be permitted to be 24 inches (610 mm) long minimum, centered on the water closet, where wall space does not permit a length of 36 inches (915 mm) minimum due to the location of a recessed fixture adjacent to the water closet.

2. Where an *administrative authority* requires flush controls for flush valves to be located in a position that conflicts with the location of the rear grab bar, then the rear grab bar shall be permitted to be split or shifted to the open side of the toilet area.

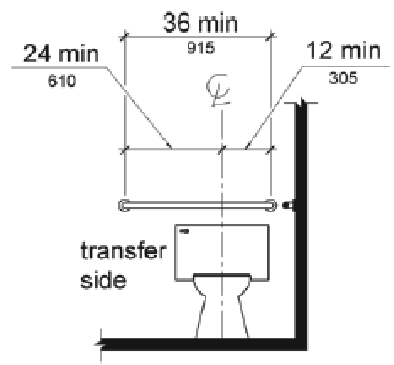


Figure 604.5.2
Rear Wall Grab Bar at Water Closets

604.6 Flush Controls. Flush controls shall be hand operated or automatic. Hand operated flush controls shall comply with 309. Flush controls shall be located on the open side of the water closet except in ambulatory *accessible* compartments complying with 604.8.2.

> **Advisory 604.6 Flush Controls.** If plumbing valves are located directly behind the toilet seat, flush valves and related plumbing can cause injury or imbalance when a person leans back against them. To prevent causing injury or imbalance, the plumbing can be located behind walls or to the side of the toilet; or if approved by the local authority having jurisdiction, provide a toilet seat lid.

604.7 Dispensers. Toilet paper dispensers shall comply with 309.4 and shall be 7 inches (180 mm) minimum and 9 inches (230 mm) maximum in front of the water closet measured to the centerline of the dispenser. The outlet of the dispenser shall be 15 inches (380 mm) minimum and 48 inches (1220 mm) maximum above the finish floor and shall not be located behind grab bars. Dispensers shall not be of a type that controls delivery or that does not allow continuous paper flow.

> **Advisory 604.7 Dispensers.** If toilet paper dispensers are installed above the side wall grab bar, the outlet of the toilet paper dispenser must be 48 inches (1220 mm) maximum above the finish floor and the top of the gripping surface of the grab bar must be 33 inches (840 mm) minimum and 36 inches (915 mm) maximum above the finish floor.

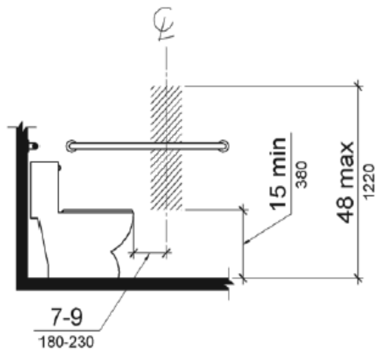


Figure 604.7
Dispenser Outlet Location

604.8 Toilet Compartments. Wheelchair *accessible* toilet compartments shall meet the requirements of 604.8.1 and 604.8.3. Compartments containing more than one plumbing fixture shall comply with 603. Ambulatory *accessible* compartments shall comply with 604.8.2 and 604.8.3.

604.8.1 Wheelchair Accessible Compartments. Wheelchair *accessible* compartments shall comply with 604.8.1.

604.8.1.1 Size. Wheelchair *accessible* compartments shall be 60 inches (1525 mm) wide minimum measured perpendicular to the side wall, and 56 inches (1420 mm) deep minimum for wall hung water closets and 59 inches (1500 mm) deep minimum for floor mounted water closets measured perpendicular to the rear wall. Wheelchair *accessible* compartments for *children's use* shall be 60 inches (1525 mm) wide minimum measured perpendicular to the side wall, and 59 inches (1500 mm) deep minimum for wall hung and floor mounted water closets measured perpendicular to the rear wall.

Advisory 604.8.1.1 Size. The minimum space required in toilet compartments is provided so that a person using a wheelchair can maneuver into position at the water closet. This space cannot be obstructed by baby changing tables or other fixtures or conveniences, except as specified at 604.3.2 (Overlap). If toilet compartments are to be used to house fixtures other than those associated with the water closet, they must be designed to exceed the minimum space requirements. Convenience fixtures such as baby changing tables must also be accessible to people with disabilities as well as to other users. Toilet compartments that are designed to meet, and not exceed, the minimum space requirements may not provide adequate space for maneuvering into position at a baby changing table.

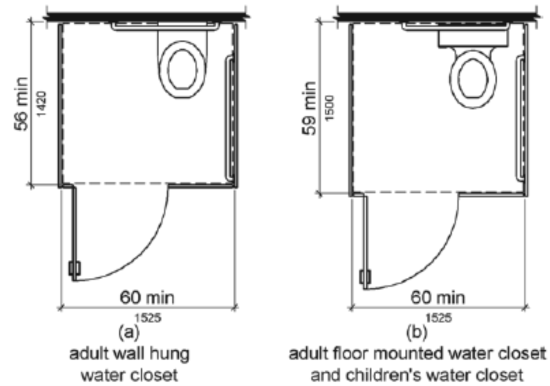


Figure 604.8.1.1
Size of Wheelchair Accessible Toilet Compartment

604.8.1.2 Doors. Toilet compartment doors, including door hardware, shall comply with 404 except that if the approach is to the latch side of the compartment door, clearance between the door side of the compartment and any obstruction shall be 42 inches (1065 mm) minimum. Doors shall be located in the front partition or in the side wall or partition farthest from the water closet. Where located in the front partition, the door opening shall be 4 inches (100 mm) maximum from the side wall or partition farthest from the water closet. Where located in the side wall or partition, the door opening shall be 4 inches (100 mm) maximum from the front partition. The door shall be self-closing. A door pull complying with 404.2.7 shall be placed on both sides of the door near the latch. Toilet compartment doors shall not swing into the minimum required compartment area.

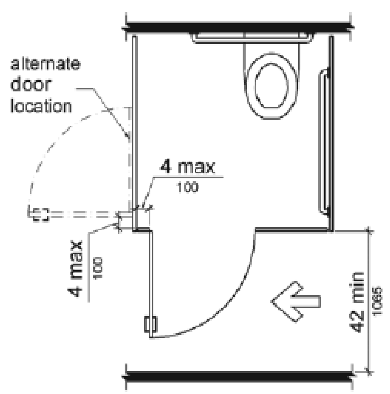


Figure 604.8.1.2
Wheelchair Accessible Toilet Compartment Doors

604.8.1.3 Approach. Compartments shall be arranged for left-hand or right-hand approach to the water closet.

604.8.1.4 Toe Clearance. The front partition and at least one side partition shall provide a toe clearance of 9 inches (230 mm) minimum above the finish floor and 6 inches (150 mm) deep minimum beyond the compartment-side face of the partition, exclusive of partition support members. Compartments for *children's use* shall provide a toe clearance of 12 inches (305 mm) minimum above the finish floor.

EXCEPTION: Toe clearance at the front partition is not required in a compartment greater than 62 inches (1575 mm) deep with a wall-hung water closet or 65 inches (1650 mm) deep with a floor-mounted water closet. Toe clearance at the side partition is not required in a compartment greater than 66 inches (1675 mm) wide. Toe clearance at the front partition is not required in a compartment for *children's use* that is greater than 65 inches (1650 mm) deep.

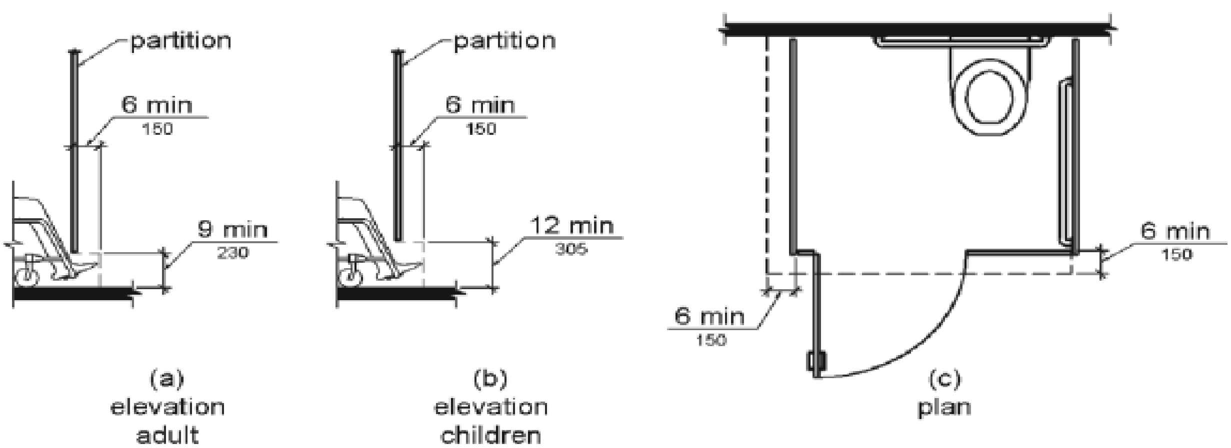


Figure 604.8.1.4
Wheelchair Accessible Toilet Compartment Toe Clearance

604.8.1.5 Grab Bars. Grab bars shall comply with 609. A side-wall grab bar complying with 604.5.1 shall be provided and shall be located on the wall closest to the water closet. In addition, a rear-wall grab bar complying with 604.5.2 shall be provided.

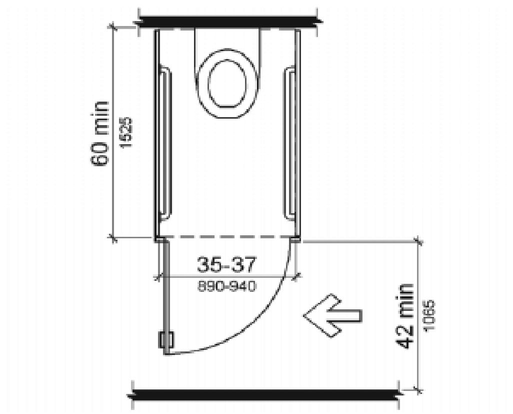
604.8.2 Ambulatory Accessible Compartments. Ambulatory *accessible* compartments shall comply with 604.8.2.

604.8.2.1 Size. Ambulatory *accessible* compartments shall have a depth of 60 inches (1525 mm) minimum and a width of 35 inches (890 mm) minimum and 37 inches (940 mm) maximum.

604.8.2.2 Doors. Toilet compartment doors, including door hardware, shall comply with 404, except that if the approach is to the latch side of the compartment door, clearance between the door side of the compartment and any obstruction shall be 42 inches (1065 mm) minimum. The door shall be self-closing. A door pull complying with 404.2.7 shall be placed on both sides of the door near the latch. Toilet compartment doors shall not swing into the minimum required compartment area.

604.8.2.3 Grab Bars. Grab bars shall comply with 609. A side-wall grab bar complying with 604.5.1 shall be provided on both sides of the compartment.

Figure 604.8.2



Ambulatory Accessible Toilet Compartment

604.8.3 Coat Hooks and Shelves. Coat hooks shall be located within one of the reach ranges specified in 308. Shelves shall be located 40 inches (1015 mm) minimum and 48 inches (1220 mm) maximum above the finish floor.

604.9 Water Closets and Toilet Compartments for Children's Use. Water closets and toilet compartments for children's use shall comply with 604.9.

Advisory 604.9 Water Closets and Toilet Compartments for Children's Use. The requirements in 604.9 are to be followed where the exception for children's water closets in 604.1 is used. The following table provides additional guidance in applying the specifications for water closets for children according to the age group served and reflects the differences in the size, stature, and reach ranges of children ages 3 through 12. The specifications chosen should correspond to the age of the primary user group. The specifications of one age group should be applied consistently in the installation of a water closet and related elements.

Advisory Specifications for Water Closets Serving Children Ages 3 through 12			
	Ages 3 and 4	**Ages 5 through 8**	**Ages 9 through 12**
Water Closet Centerline	12 inches (305 mm)	12 to 15 inches (305 to 380 mm)	15 to 18 inches (380 to 455 mm)
Toilet Seat Height	11 to 12 inches (280 to 305 mm)	12 to 15 inches (305 to 380 mm)	15 to 17 inches (380 to 430 mm)
Grab Bar Height	18 to 20 inches (455 to 510 mm)	20 to 25 inches (510 to 635 mm)	25 to 27 inches (635 to 685 mm)
Dispenser Height	14 inches (355 mm)	14 to 17 inches (355 to 430 mm)	17 to 19 inches (430 to 485 mm)

604.9.1 Location. The water closet shall be located with a wall or partition to the rear and to one side. The centerline of the water closet shall be 12 inches (305 mm) minimum and 18 inches (455 mm) maximum from the side wall or partition, except that the water closet shall be 17 inches (430 mm) minimum and 19 inches (485 mm) maximum from the side wall or partition in the ambulatory *accessible* toilet compartment specified in 604.8.2. Compartments shall be arranged for left-hand or right-hand approach to the water closet.

604.9.2 Clearance. Clearance around a water closet shall comply with 604.3.

604.9.3 Height. The height of water closets shall be 11 inches (280 mm) minimum and 17 inches (430 mm) maximum measured to the top of the seat. Seats shall not be sprung to return to a lifted position.

604.9.4 Grab Bars. Grab bars for water closets shall comply with 604.5.

604.9.5 Flush Controls. Flush controls shall be hand operated or automatic. Hand operated flush controls shall comply with 309.2 and 309.4 and shall be installed 36 inches (915 mm) maximum above the finish floor. Flush controls shall be located on the open side of the water closet except in ambulatory *accessible* compartments complying with 604.8.2.

604.9.6 Dispensers. Toilet paper dispensers shall comply with 309.4 and shall be 7 inches (180 mm) minimum and 9 inches (230 mm) maximum in front of the water closet measured to the centerline of the dispenser. The outlet of the dispenser shall be 14 inches (355 mm) minimum and 19 inches (485 mm) maximum above the finish floor. There shall be a clearance of 1 1/2 inches (38 mm) minimum below the grab bar. Dispensers shall not be of a type that controls delivery or that does not allow continuous paper flow.

604.9.7 Toilet Compartments. Toilet compartments shall comply with 604.8.

605 Urinals

605.1 General. Urinals shall comply with 605.

> **Advisory 605.1 General.** Stall-type urinals provide greater accessibility for a broader range of persons, including people of short stature.

605.2 Height and Depth. Urinals shall be the stall-type or the wall-hung type with the rim 17 inches (430 mm) maximum above the finish floor or ground. Urinals shall be 13 ½ inches (345 mm) deep minimum measured from the outer face of the urinal rim to the back of the fixture.

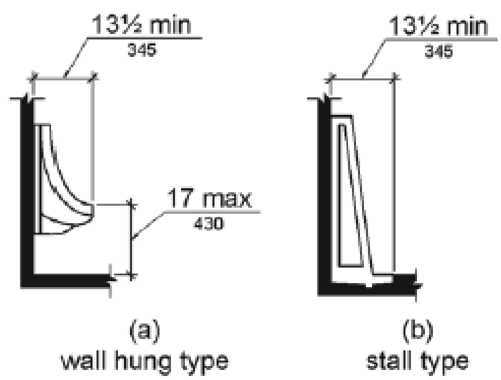


Figure 605.2
Height and Depth of Urinals

605.3 Clear Floor Space. A clear floor or ground *space* complying with 305 positioned for forward approach shall be provided.

605.4 Flush Controls. Flush controls shall be hand operated or automatic. Hand operated flush controls shall comply with 309.

606 Lavatories and Sinks

606.1 General. Lavatories and sinks shall comply with 606.

> **Advisory 606.1 General.** If soap and towel dispensers are provided, they must be located within the reach ranges specified in 308. Locate soap and towel dispensers so that they are conveniently usable by a person at the accessible lavatory.

606.2 Clear Floor Space. A clear floor *space* complying with 305, positioned for a forward approach, and knee and toe clearance complying with 306 shall be provided.

EXCEPTIONS: 1. A parallel approach complying with 305 shall be permitted to a kitchen sink in a space where a cook top or conventional range is not provided and to wet bars.

2. A lavatory in a toilet room or bathing *facility* for a single occupant accessed only through a private office and not for *common use* or *public use* shall not be required to provide knee and toe clearance complying with 306.

3. In *residential dwelling units*, cabinetry shall be permitted under lavatories and kitchen sinks provided that all of the following conditions are met:

(a) the cabinetry can be removed without removal or replacement of the fixture;

(b) the finish floor extends under the cabinetry; and

(c) the walls behind and surrounding the cabinetry are finished.

4. A knee clearance of 24 inches (610 mm) minimum above the finish floor or ground shall be permitted at lavatories and sinks used primarily by children 6 through 12 years where the rim or counter surface is 31 inches (785 mm) maximum above the finish floor or ground.

5. A parallel approach complying with 305 shall be permitted to lavatories and sinks used primarily by children 5 years and younger.

6. The dip of the overflow shall not be considered in determining knee and toe clearances.

7. No more than one bowl of a multi-bowl sink shall be required to provide knee and toe clearance complying with 306.

606.3 Height. Lavatories and sinks shall be installed with the front of the higher of the rim or counter surface 34 inches (865 mm) maximum above the finish floor or ground.

EXCEPTIONS: 1. A lavatory in a toilet or bathing *facility* for a single occupant accessed only through a private office and not for *common use* or *public use* shall not be required to comply with 606.3.

2. In r*esidential dwelling unit* kitchens, sinks that are adjustable to variable heights, 29 inches (735 mm) minimum and 36 inches (915 mm) maximum, shall be permitted where rough-in plumbing permits connections of supply and drain pipes for sinks mounted at the height of 29 inches (735 mm).

606.4 Faucets. Controls for faucets shall comply with 309. Hand-operated metering faucets shall remain open for 10 seconds minimum.

606.5 Exposed Pipes and Surfaces. Water supply and drain pipes under lavatories and sinks shall be insulated or otherwise configured to protect against contact. There shall be no sharp or abrasive surfaces under lavatories and sinks.

607 Bathtubs

607.1 General. Bathtubs shall comply with 607.

607.2 Clearance. Clearance in front of bathtubs shall extend the length of the bathtub and shall be 30 inches (760 mm) wide minimum. A lavatory complying with 606 shall be permitted at the control end of the clearance. Where a permanent seat is provided at the head end of the bathtub, the clearance shall extend 12 inches (305 mm) minimum beyond the wall at the head end of the bathtub.

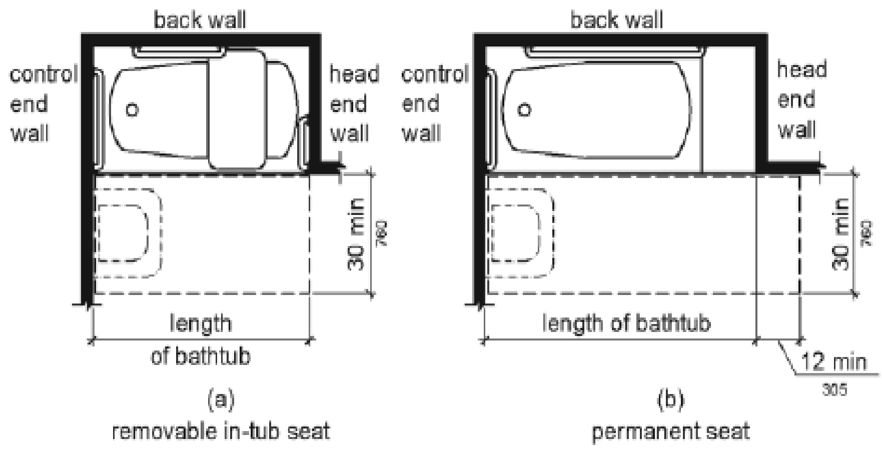


Figure 607.2
Clearance for Bathtubs

607.3 Seat. A permanent seat at the head end of the bathtub or a removable in-tub seat shall be provided. Seats shall comply with 610.

607.4 Grab Bars. Grab bars for bathtubs shall comply with 609 and shall be provided in accordance with 607.4.1 or 607.4.2.

EXCEPTIONS: 1. Grab bars shall not be required to be installed in a bathtub located in a bathing *facility* for a single occupant accessed only through a private office and not for *common use* or *public use* provided that reinforcement has been installed in walls and located so as to permit the installation of grab bars complying with 607.4.

2. In *residential dwelling units*, grab bars shall not be required to be installed in bathtubs located in bathing *facilities* provided that reinforcement has been installed in walls and located so as to permit the installation of grab bars complying with 607.4.

607.4.1 Bathtubs With Permanent Seats. For bathtubs with permanent seats, grab bars shall be provided in accordance with 607.4.1.

607.4.1.1 Back Wall. Two grab bars shall be installed on the back wall, one located in accordance with 609.4 and the other located 8 inches (205 mm) minimum and 10 inches (255 mm) maximum above the rim of the bathtub. Each grab bar shall be installed 15 inches (380 mm) maximum from the head end wall and 12 inches (305 mm) maximum from the control end wall.

607.4.1.2 Control End Wall. A grab bar 24 inches (610 mm) long minimum shall be installed on the control end wall at the front edge of the bathtub.

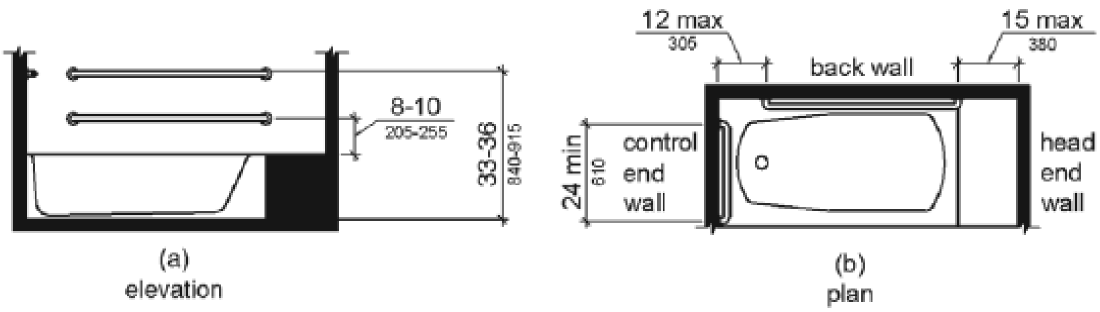


Figure 607.4.1
Grab Bars for Bathtubs with Permanent Seats

607.4.2 Bathtubs Without Permanent Seats. For bathtubs without permanent seats, grab bars shall comply with 607.4.2.

607.4.2.1 Back Wall. Two grab bars shall be installed on the back wall, one located in accordance with 609.4 and other located 8 inches (205 mm) minimum and 10 inches (255 mm) maximum above the rim of the bathtub. Each grab bar shall be 24 inches (610 mm) long minimum and shall be installed 24 inches (610 mm) maximum from the head end wall and 12 inches (305 mm) maximum from the control end wall.

607.4.2.2 Control End Wall. A grab bar 24 inches (610 mm) long minimum shall be installed on the control end wall at the front edge of the bathtub.

607.4.2.3 Head End Wall. A grab bar 12 inches (305 mm) long minimum shall be installed on the head end wall at the front edge of the bathtub.

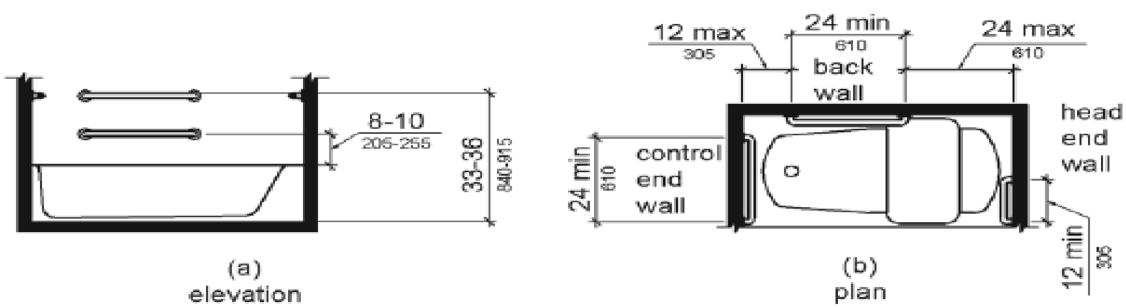


Figure 607.4.2
Grab Bars for Bathtubs with Removable In-Tub Seats

607.5 Controls. Controls, other than drain stoppers, shall be located on an end wall. Controls shall be between the bathtub rim and grab bar, and between the open side of the bathtub and the centerline of the width of the bathtub. Controls shall comply with 309.4.

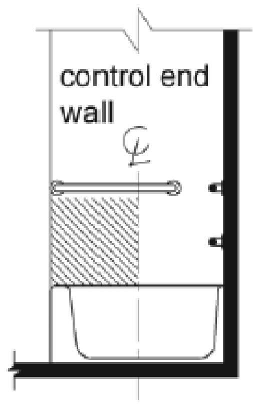


Figure 607.5
Bathtub Control Location

607.6 Shower Spray Unit and Water. A shower spray unit with a hose 59 inches (1500 mm) long minimum that can be used both as a fixed-position shower head and as a hand-held shower shall be provided. The shower spray unit shall have an on/off control with a non-positive shut-off. If an adjustable-height shower head on a vertical bar is used, the bar shall be installed so as not to obstruct the use of grab bars. Bathtub shower spray units shall deliver water that is 120°F (49°C) maximum.

Advisory 607.6 Shower Spray Unit and Water. Ensure that hand-held shower spray units are capable of delivering water pressure substantially equivalent to fixed shower heads.

607.7 Bathtub Enclosures. Enclosures for bathtubs shall not obstruct controls, faucets, shower and spray units or obstruct transfer from wheelchairs onto bathtub seats or into bathtubs. Enclosures on bathtubs shall not have tracks installed on the rim of the open face of the bathtub.

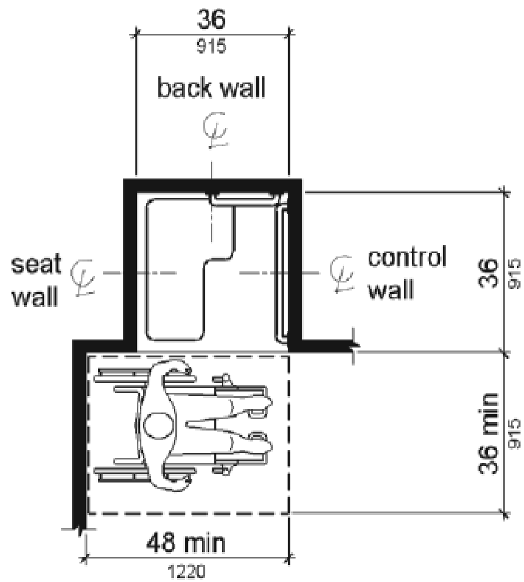
608 Shower Compartments

608.1 General. Shower compartments shall comply with 608.

Advisory 608.1 General. Shower stalls that are 60 inches (1525 mm) wide and have no curb may increase the usability of a bathroom because the shower area provides additional maneuvering space.

608.2 Size and Clearances for Shower Compartments. Shower compartments shall have sizes and clearances complying with 608.2.

608.2.1 Transfer Type Shower Compartments. Transfer type shower compartments shall be 36 inches (915 mm) by 36 inches (915 mm) clear inside dimensions measured at the center points of opposing sides and shall have a 36 inch (915 mm) wide minimum entry on the face of the shower compartment. Clearance of 36 inches (915 mm) wide minimum by 48 inches (1220 mm) long minimum measured from the control wall shall be provided.



Note: inside finished dimensions measured at the center points of opposing sides

Figure 608.2.1
Transfer Type Shower Compartment Size and Clearance

608.2.2 Standard Roll-In Type Shower Compartments. Standard roll-in type shower compartments shall be 30 inches (760 mm) wide minimum by 60 inches (1525 mm) deep minimum clear inside dimensions measured at center points of opposing sides and shall have a 60 inches (1525 mm) wide minimum entry on the face of the shower compartment.

608.2.2.1 Clearance. A 30 inch (760 mm) wide minimum by 60 inch (1525 mm) long minimum clearance shall be provided adjacent to the open face of the shower compartment.

EXCEPTION: A lavatory complying with 606 shall be permitted on one 30 inch (760 mm) wide minimum side of the clearance provided that it is not on the side of the clearance adjacent to the controls or, where provided, not on the side of the clearance adjacent to the shower seat.

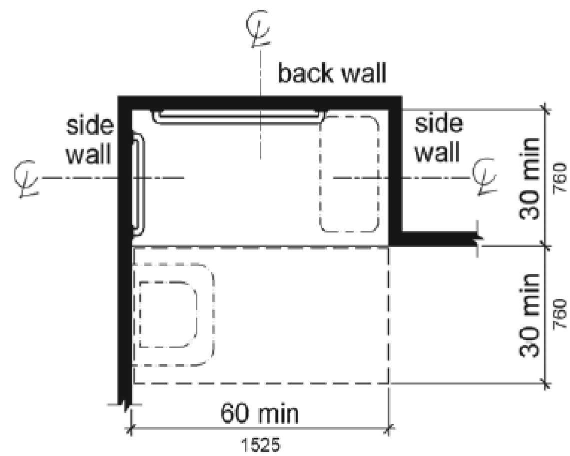


Figure 608.2.2
Standard Roll-In Type Shower Compartment Size and Clearance

608.2.3 Alternate Roll-In Type Shower Compartments. Alternate roll-in type shower compartments shall be 36 inches (915 mm) wide and 60 inches (1525 mm) deep minimum clear inside dimensions measured at center points of opposing sides. A 36 inch (915 mm) wide minimum entry shall be provided at one end of the long side of the compartment.

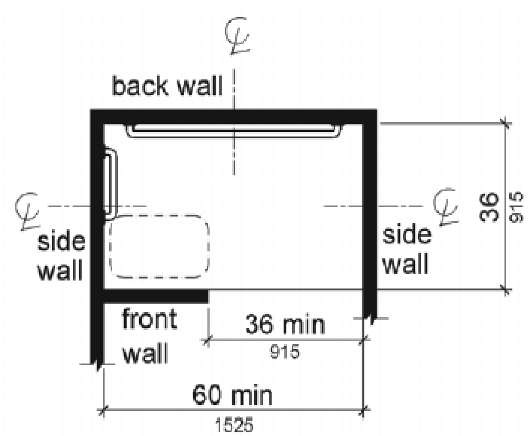


Figure 608.2.3
Alternate Roll-In Type Shower Compartment Size and Clearance

608.3 Grab Bars. Grab bars shall comply with 609 and shall be provided in accordance with 608.3. Where multiple grab bars are used, required horizontal grab bars shall be installed at the same height above the finish floor.

EXCEPTIONS: 1. Grab bars shall not be required to be installed in a shower located in a bathing *facility* for a single occupant accessed only through a private office, and not for *common use* or *public use* provided that reinforcement has been installed in walls and located so as to permit the installation of grab bars complying with 608.3.

2. In *residential dwelling units*, grab bars shall not be required to be installed in showers located in bathing facilities provided that reinforcement has been installed in walls and located so as to permit the installation of grab bars complying with 608.3.

608.3.1 Transfer Type Shower Compartments. In transfer type compartments, grab bars shall be provided across the control wall and back wall to a point 18 inches (455 mm) from the control wall.

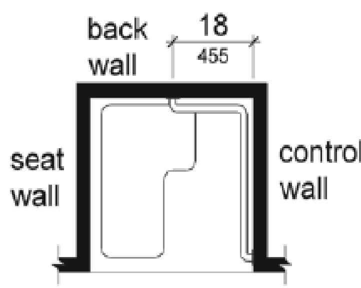


Figure 608.3.1
Grab Bars for Transfer Type Showers

608.3.2 Standard Roll-In Type Shower Compartments. Where a seat is provided in standard roll-in type shower compartments, grab bars shall be provided on the back wall and the side wall opposite the seat. Grab bars shall not be provided above the seat. Where a seat is not provided in standard roll-in type shower compartments, grab bars shall be provided on three walls. Grab bars shall be installed 6 inches (150 mm) maximum from adjacent walls.

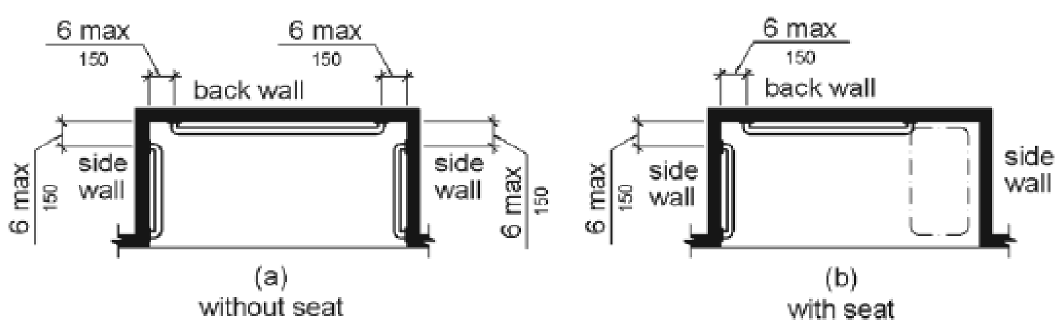


Figure 608.3.2
Grab Bars for Standard Roll-In Type Showers

608.3.3 Alternate Roll-In Type Shower Compartments. In alternate roll-in type shower compartments, grab bars shall be provided on the back wall and the side wall farthest from the compartment entry. Grab bars shall not be provided above the seat. Grab bars shall be installed 6 inches (150 mm) maximum from adjacent walls.

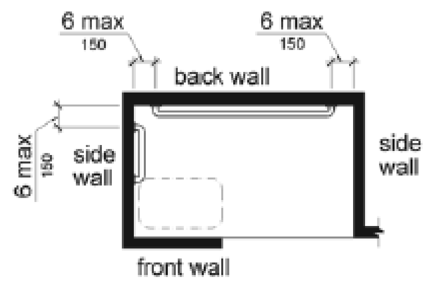


Figure 608.3.3
Grab Bars for Alternate Roll-In Type Showers

608.4 Seats. A folding or non-folding seat shall be provided in transfer type shower compartments. A folding seat shall be provided in roll-in type showers required in *transient lodging* guest rooms with mobility features complying with 806.2. Seats shall comply with 610.

EXCEPTION: In *residential dwelling units*, seats shall not be required in transfer type shower compartments provided that reinforcement has been installed in walls so as to permit the installation of seats complying with 608.4.

608.5 Controls. Controls, faucets, and shower spray units shall comply with 309.4.

608.5.1 Transfer Type Shower Compartments. In transfer type shower compartments, the controls, faucets, and shower spray unit shall be installed on the side wall opposite the seat 38 inches (965 mm) minimum and 48 inches (1220 mm) maximum above the shower floor and shall be located on the control wall 15 inches (380 mm) maximum from the centerline of the seat toward the shower opening.

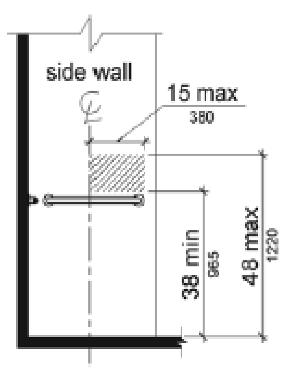


Figure 608.5.1
Transfer Type Shower Compartment Control Location

608.5.2 Standard Roll-In Type Shower Compartments. In standard roll-in type shower compartments, the controls, faucets, and shower spray unit shall be located above the grab bar, but no higher than 48 inches (1220 mm) above the shower floor. Where a seat is provided, the controls, faucets, and shower spray unit shall be installed on the back wall adjacent to the seat wall and shall be located 27 inches (685 mm) maximum from the seat wall.

Advisory 608.5.2 Standard Roll-in Type Shower Compartments. In standard roll-in type showers without seats, the shower head and operable parts can be located on any of the three walls of the shower without adversely affecting accessibility.

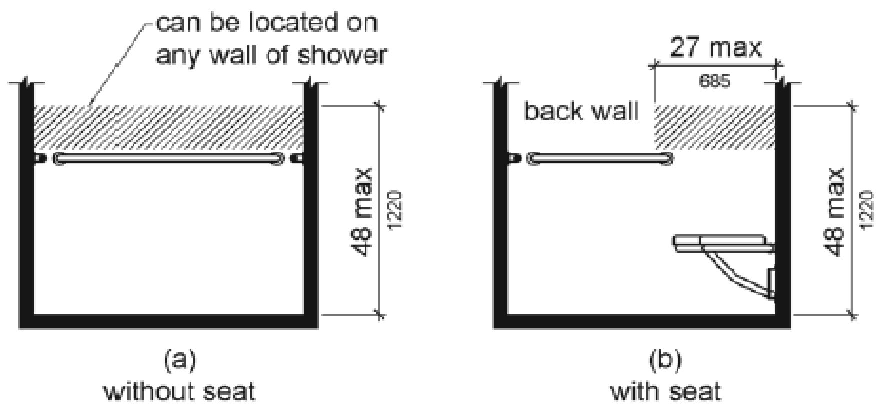


Figure 608.5.2
Standard Roll-In Type Shower Compartment Control Location

608.5.3 Alternate Roll-In Type Shower Compartments. In alternate roll-in type shower compartments, the controls, faucets, and shower spray unit shall be located above the grab bar, but no higher than 48 inches (1220 mm) above the shower floor. Where a seat is provided, the controls, faucets, and shower spray unit shall be located on the side wall adjacent to the seat 27 inches (685 mm) maximum from the side wall behind the seat or shall be located on the back wall opposite the seat 15 inches (380 mm) maximum, left or right, of the centerline of the seat. Where a seat is not provided, the controls, faucets, and shower spray unit shall be installed on the side wall farthest from the compartment entry.

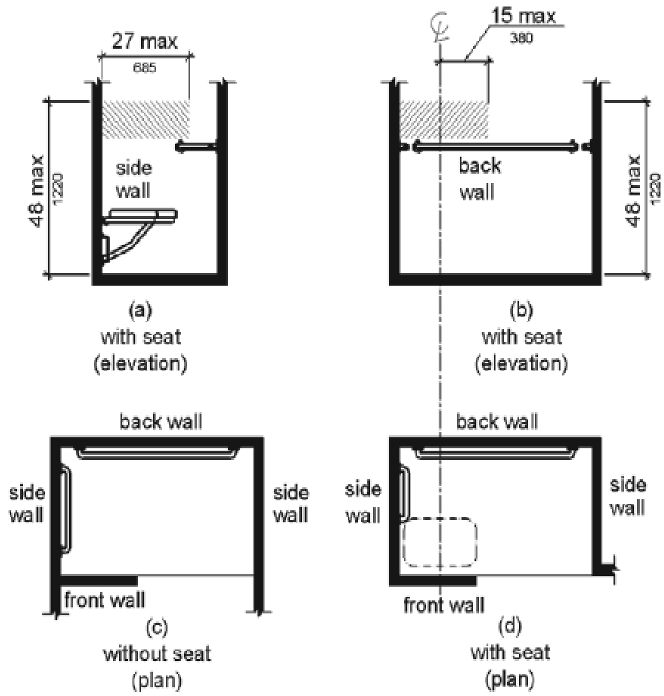


Figure 608.5.3
Alternate Roll-In Type Shower Compartment Control Location

608.6 Shower Spray Unit and Water. A shower spray unit with a hose 59 inches (1500 mm) long minimum that can be used both as a fixed-position shower head and as a hand-held shower shall be provided. The shower spray unit shall have an on/off control with a non-positive shut-off. If an adjustable-height shower head on a vertical bar is used, the bar shall be installed so as not to obstruct the use of grab bars. Shower spray units shall deliver water that is 120°F (49°C) maximum.

EXCEPTION: A fixed shower head located at 48 inches (1220 mm) maximum above the shower finish floor shall be permitted instead of a hand-held spray unit in facilities that are not medical care *facilities*, long-term care *facilities*, *transient lodging* guest rooms, or *residential dwelling units*.

Advisory 608.6 Shower Spray Unit and Water. Ensure that hand-held shower spray units are capable of delivering water pressure substantially equivalent to fixed shower heads.

608.7 Thresholds. Thresholds in roll-in type shower compartments shall be ½ inch (13 mm) high maximum in accordance with 303. In transfer type shower compartments, thresholds ½ inch (13 mm) high maximum shall be beveled, rounded, or vertical.

EXCEPTION: A threshold 2 inches (51 mm) high maximum shall be permitted in transfer type shower compartments in existing *facilities* where provision of a ½inch (13 mm) high threshold would disturb the structural reinforcement of the floor slab.

608.8 Shower Enclosures. Enclosures for shower compartments shall not obstruct controls, faucets, and shower spray units or obstruct transfer from wheelchairs onto shower seats.

609 Grab Bars

609.1 General. Grab bars in toilet *facilities* and bathing *facilities* shall comply with 609.

609.2 Cross Section. Grab bars shall have a cross section complying with 609.2.1 or 609.2.2.

609.2.1 Circular Cross Section. Grab bars with circular cross sections shall have an outside diameter of 1 ¼/ inches (32 mm) minimum and 2 inches (51 mm) maximum.

609.2.2 Non-Circular Cross Section. Grab bars with non-circular cross sections shall have a cross-section dimension of 2 inches (51 mm) maximum and a perimeter dimension of 4 inches (100 mm) minimum and 4.8 inches (120 mm) maximum.

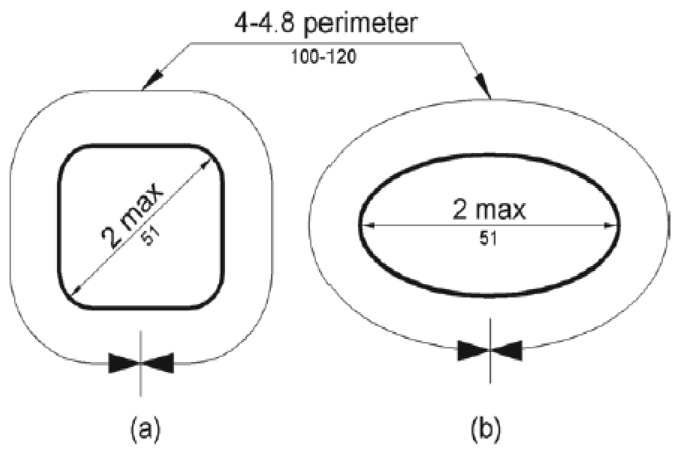


Figure 609.2.2
Grab Bar Non-Circular Cross Section

609.3 Spacing. The space between the wall and the grab bar shall be 1 ½ inches (38 mm). The *space* between the grab bar and projecting objects below and at the ends shall be 1 ½ inches (38 mm) minimum. The *space* between the grab bar and projecting objects above shall be 12 inches (305 mm) minimum.

EXCEPTION: The *space* between the grab bars and shower controls, shower fittings, and other grab bars above shall be permitted to be 1 ½ inches (38 mm) minimum.

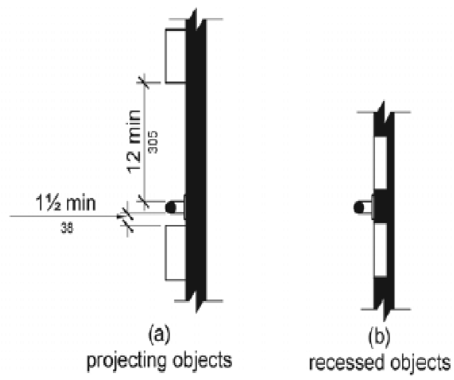


Figure 609.3
Spacing of Grab Bars

609.4 Position of Grab Bars. Grab bars shall be installed in a horizontal position, 33 inches (840 mm) minimum and 36 inches (915 mm) maximum above the finish floor measured to the top of the gripping surface, except that at water closets for *children's use* complying with 604.9, grab bars shall be installed in a horizontal position 18 inches (455 mm) minimum and 27 inches (685 mm) maximum above the finish floor measured to the top of the gripping surface. The height of the lower grab bar on the back wall of a bathtub shall comply with 607.4.1.1 or 607.4.2.1.

609.5 Surface Hazards. Grab bars and any wall or other surfaces adjacent to grab bars shall be free of sharp or abrasive elements and shall have rounded edges.

609.6 Fittings. Grab bars shall not rotate within their fittings.

609.7 Installation. Grab bars shall be installed in any manner that provides a gripping surface at the specified locations and that does not obstruct the required clear floor *space*.

609.8 Structural Strength. Allowable stresses shall not be exceeded for materials used when a vertical or horizontal force of 250 pounds (1112 N) is applied at any point on the grab bar, fastener, mounting device, or supporting structure.

610 Seats

610.1 General. Seats in bathtubs and shower compartments shall comply with 610.

610.2 Bathtub Seats. The top of bathtub seats shall be 17 inches (430 mm) minimum and 19 inches (485 mm) maximum above the bathroom finish floor. The depth of a removable in-tub seat shall be 15 inches (380 mm) minimum and 16 inches (405 mm) maximum. The seat shall be capable of secure placement. Permanent seats at the head end of the bathtub shall be 15 inches (380 mm) deep minimum and shall extend from the back wall to or beyond the outer edge of the bathtub.

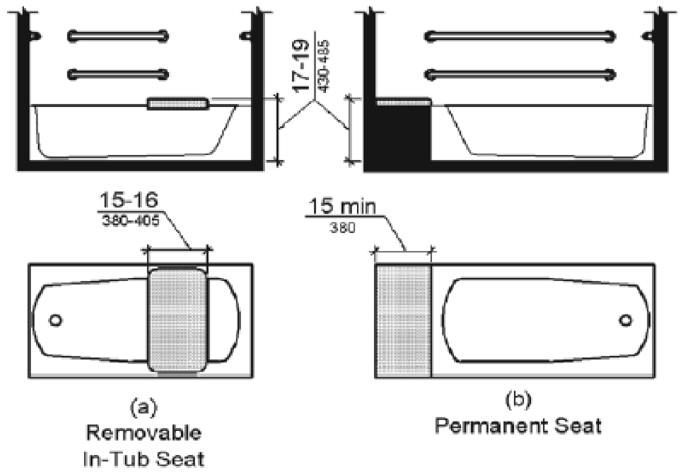


Figure 610.2
Bathtub Seats

610.3 Shower Compartment Seats. Where a seat is provided in a standard roll-in shower compartment, it shall be a folding type, shall be installed on the side wall adjacent to the controls, and shall extend from the back wall to a point within 3 inches (75 mm) of the compartment entry. Where a seat is provided in an alternate roll-in type shower compartment, it shall be a folding type, shall be installed on the front wall opposite the back wall, and shall extend from the adjacent side wall to a point within 3 inches (75 mm) of the compartment entry. In transfer-type showers, the seat shall extend from the back wall to a point within 3 inches (75 mm) of the compartment entry. The top of the seat shall be 17 inches (430 mm) minimum and 19 inches (485 mm) maximum above the bathroom finish floor. Seats shall comply with 610.3.1 or 610.3.2.

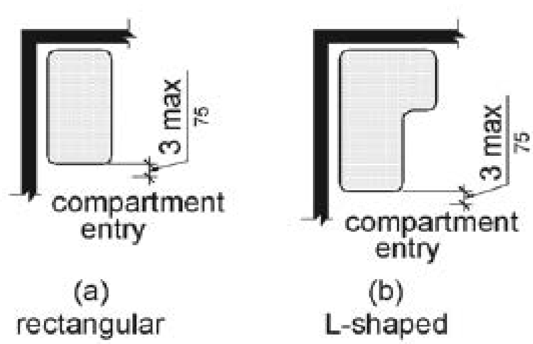


Figure 610.3
Extent of Seat

610.3.1 Rectangular Seats. The rear edge of a rectangular seat shall be 2 ½ inches (64 mm) maximum and the front edge 15 inches (380 mm) minimum and 16 inches (405 mm) maximum from the seat wall. The side edge of the seat shall be 1 ½ inches (38 mm) maximum from the adjacent wall.

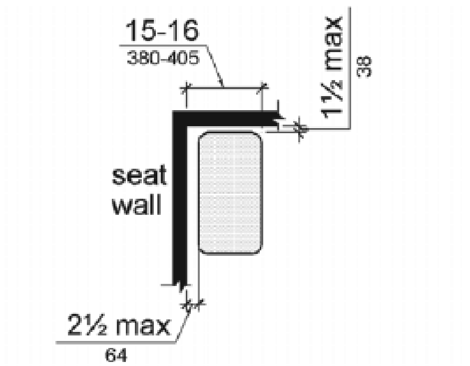


Figure 610.3.1
Rectangular Shower Seat

610.3.2 L-Shaped Seats. The rear edge of an L-shaped seat shall be 2 ½ inches (64 mm) maximum and the front edge 15 inches (380 mm) minimum and 16 inches (405 mm) maximum from the seat wall. The rear edge of the "L" portion of the seat shall be 1 ½ inches (38 mm) maximum from the wall and the front edge shall be 14 inches (355 mm) minimum and 15 inches (380 mm) maximum from the wall. The end of the "L" shall be 22 inches (560 mm) minimum and 23 inches maximum (585 mm) from the main seat wall.

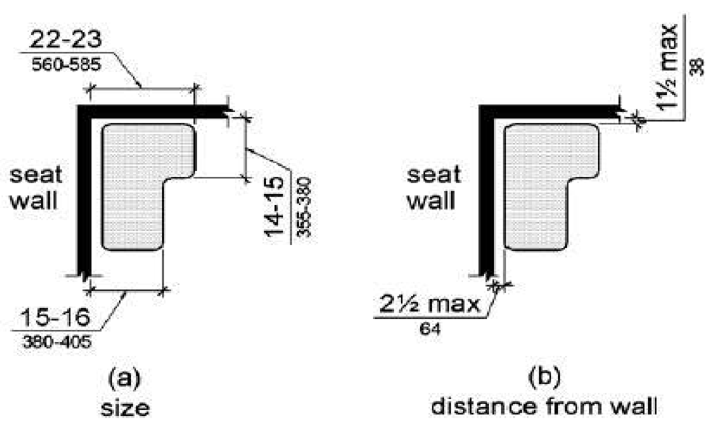


Figure 610.3.2
L-Shaped Shower Seat

610.4 Structural Strength. Allowable stresses shall not be exceeded for materials used when a vertical or horizontal force of 250 pounds (1112 N) is applied at any point on the seat, fastener, mounting device, or supporting structure.

611 Washing Machines and Clothes Dryers

611.1 General. Washing machines and clothes dryers shall comply with 611.

611.2 Clear Floor Space. A clear floor or ground *space* complying with 305 positioned for parallel approach shall be provided. The clear floor or ground space shall be centered on the appliance.

611.3 Operable Parts. *Operable parts*, including doors, lint screens, and detergent and bleach compartments shall comply with 309.

611.4 Height. Top loading machines shall have the door to the laundry compartment located 36 inches (915 mm) maximum above the finish floor. Front loading machines shall have the bottom of the opening to the laundry compartment located 15 inches (380 mm) minimum and 36 inches (915 mm) maximum above the finish floor.

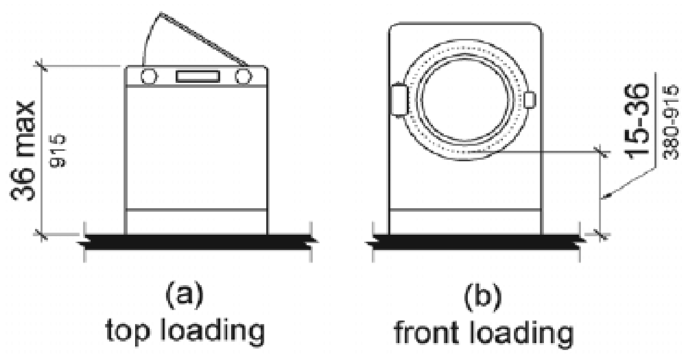


Figure 611.4
Height of Laundry Compartment Opening

612 Saunas and Steam Rooms

612.1 General. Saunas and steam rooms shall comply with 612.

612.2 Bench. Where seating is provided in saunas and steam rooms, at least one bench shall comply with 903. Doors shall not swing into the clear floor *space* required by 903.2.

EXCEPTION: A readily removable bench shall be permitted to obstruct the turning space required by 612.3 and the clear floor or ground *space* required by 903.2.

612.3 Turning Space. A turning space complying with 304 shall be provided within saunas and steam rooms.

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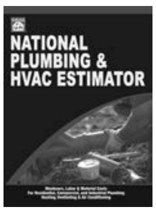

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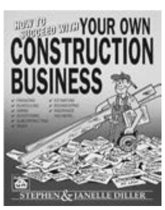

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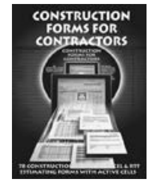

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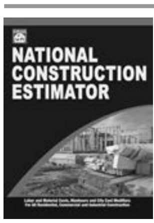

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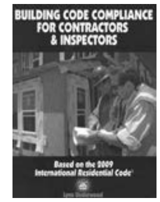

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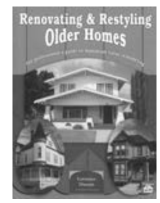

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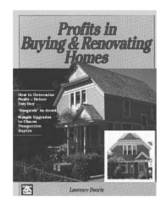

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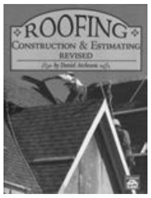

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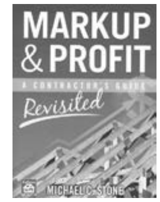

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