The American Society of Plumbing Engineers defines plumbing systems as all potable water supply and distribution pipes, plumbing fixtures and traps, drainage and vent pipes, and building (house) drains, including their respective joints and connections, devices, receptacles, and appurtenances within the property lines of the premises and including potable water piping, potable water treating or using equipment, fuel gas piping, water heaters, and vents for same.

A model code defines plumbing systems as “all potable water building supply and distribution pipes, all plumbing fixtures and traps, all drainage and vent pipe(s), and all building drains and building sewers, including their respective joints and connection devices, receptors, and appurtenances within the property lines of the premises and shall include potable water piping, potable water treating or using equipment, medical gas and medical vacuum systems, fuel gas piping, water heaters and vents for same.”

Plumbing engineers are responsible for systems that serve all types of buildings, including commercial, residential, and institutional buildings, such as hospitals, laboratories, industrial plants, jails, schools, shopping centers, housing developments, power plants, research centers, and sports complexes.

The plumbing engineer is now responsible for design of the following systems:
1. Sanitary drainage
2. Sanitary sewage disposal
3. Storm water drainage
4. Site drainage
5. Storm water disposal
6. Venting
7. Domestic water
   A. Cold water
   B. Hot water
   C. Hot water circulation
   D. Tempered water
   E. Tepid water for emergency eyewash and showers
8. Fire protection
   A. Standpipe
   B. Sprinkler
   C. CO2
   D. Clean agent
9. Acid and industrial waste
10. Chilled drinking water
11. Gas
    A. Natural and manufactured
    B. Liquefied petroleum (LP)
12. Compressed air
13. Vacuum
    A. Clinical and surgical
    B. Laboratory
    C. Cleaning
14. Argon
15. Oxygen
16. Carbon dioxide
17. Nitrogen
18. Nitrous oxide
19. Helium
20. Deionized water
21. Distilled water Systems and Fixtures
22. Water treatment
23. Liquid soap dispensing
24. Disinfectant
25. Food waste disposal and solid waste handling
26. Radioactive waste
27. Pools and decorative fountains
28. Lawn sprinkler and irrigation.

Although this list may seem extensive, there are many additional specialized and exotic systems for which the plumbing engineer is called upon to furnish his or her professional expertise.

**FIXTURE SELECTION**

The type, quantity, and arrangement of plumbing fixtures is usually the prerogative of the architect, but the engineer must evaluate and advise the architect as to type and arrangement and, particularly, space requirements. The type and quantity of fixtures to be installed in a building is predicated upon the number of people served and the type of building occupancy. These requirements are clearly delineated in every building code. Separate facilities must be provided for male and female personnel and these facilities must be within easy access from any floor of the building. "Easy access" has been interpreted to mean within one floor distance so that a person never has to walk more than one floor up or down.

**QUALITY OF FIXTURES**

Manufacturers have accepted certain standards for the manufacture of plumbing fixtures. Most manufacturers adhere to these standards so that, at the present time, fixture quality is a minor problem. A list of standards affecting plumbing fixtures, plumbing design, and engineering is included in Table 1-1. These standards include some that apply to important recent trends: The limitation of water consumption in water closets to 1.6 gallons per flush (gpf) is required in most jurisdictions and it is required that fixtures and designs ensure accessibility for the handicapped in public and private buildings. Engineers should be familiar with these standards and must consult applicable codes for the jurisdiction in which the design is being done.

When evaluating fixtures, the following characteristics should be carefully checked:
1. Strength
2. Durability
3. Corrosion resistance (acid resisting)
4. Abrasion resistance
5. Absence of defects
6. Adequate performance for the service intended
7. Concealed fouling surfaces.

Materials most commonly used in the manufacture of fixtures are enameled cast iron, enameled pressed steel, vitreous china, vitrified earthenware, and stainless steel. Additionally, plastics, aluminum, and stone compositions have been used.

Fixture Classification Fixtures may be divided into the following classes:
1. Water closets

2. Urinals
3. Lavatories
4. Sinks
5. Service sinks
6. Bathtubs
7. Showers
8. Drinking fountains

**Water Closets**

Water closets are manufactured in a number of styles and with various features that make them distinct from each other. These include siphon jet reverse trap, wash down, blowout, siphon vortex, siphon wash, flush valve (flushometer valve), gravity tank, flushometer tank, dual flush, wallhung tank, corner tank, prison, handicapped design, pneumatic assist flush, wall mounted, floor mounted, back outlet, one-piece tank type, two-piece tank type, round front bowl, and elongated bowl. Traditionally water closets have been made of vitreous china; however, water closets are now also made of plastics, cultured marble, or—for institutional installations—of stainless steel or aluminum.

Certain types of water closets are unacceptable. They are those that have:

1. An invisible water seal
2. Unventilated spaces
3. Surfaces that are not thoroughly cleansed with each flushing action

Quiet operation and economical use of water are important qualities of a water closet. Water closets must be emptied of waste after each use without using any moving parts within the trapway, and the flushing action must cleanse the walls of the bowl and then refill the bowl and trap.

Water closets may be floor-outlet mounted on special closet flange connections in the floor or wall-hung closets mounted on a combination chair carrier and fitting that supports the water closet without placing any stress on the wall. The wall-hung water closet permits greater ease in cleaning the floor around and below the closet. Manufacturers supply bowls for a variety of flushing actions.

Passage of the Energy Policy Act of 1992 by the US government changed the design of a water closet. It imposed a maximum flushing rate of 1.6 gallons per flush (gpf) (6 L per flush). This was a significant drop in the quantity of water used, previously 3.5 gal per flush, and was considered to be a water savings. Prior to the first enactment of water conservation in the late 1970s, water closets typically flushed between 5 and 7 gal of water. The greatest water use, 7 gal per flush, was by blowout water closets.

With the modification in water flush volume, the style of each manufacturer’s water closet changed. The former terminology for identifying water closets no longer fit. Water closets were previously categorized as blowout, siphon jet, washout, reverse trap, and wash down. (See Figure 1-1.) The new style of 1.6 gpf water closets fit between the cracks of these old categories. The
A floor-mounted water closet is supported by the floor and connected directly to the piping through the floor. (See Figure 1-2.)

A wall hung water closet is supported by a wall hanger and never comes in contact with the floor. Wall hung water closets are considered superior for maintaining a clean floor in the toilet room since the water closet doesn’t interfere with the cleaning of the floor. (See Figure 1-3 and 1-4.)

Floor-mounted, back outlet water closets are supported by the floor yet connect to the piping through the wall. The advantage of the floor-mounted, back outlet water closet is that the penetrations of the floor are reduced for the plumbing. It should be noted that with the change to 1.6 gal per flush it is more difficult for manufacturers to produce a floor-mounted, back outlet water closet that meets all of the flushing performance requirements in the standard. (See Figure 1-5.)

SHAPE AND SIZE
A water closet bowl is classified as either a round front or elongated. An elongated bowl has an opening that extends 2 in. farther to the front of the bowl. Most plumbing codes require elongated bowls for public and employee use. The additional 2 in. provides a larger opening, often called a "target area." With the larger opening, there is a greater likelihood of maintaining a cleaner water closet for each user.

For floor-mounted water closets, the outlet is identified based on the rough-in dimension. The rough-in is the distance from the back wall to the center of the outlet when the water closet is installed. A standard rough-in bowl outlet is 12 in. Most manufacturers also make water closets with a 10-in. or 14-in. rough-in. (See Figure 1-6.)

The size of the bowl is also based on the height of the bowl rim measured from the floor:

- A **standard water closet** has a rim height of 14 to 15 in. This is the most common water closet to install.
- A **child’s water closet** has a rim height of 10 in. above the floor. Many plumbing codes require child’s water closets in day-care centers and kindergarten toilet rooms for use by small children.
- A **water closet for juvenile use** has a rim height of 13 in.
- A **water closet for the physically challenged** has a rim height of 18 in. With the addition of the water closet seat, the fixture is designed to conform to the accessibility requirements.

WATER CLOSET SEAT
A water closet seat must be designed for the shape of the bowl to which it connects. There are two styles of water closet seat: solid and split

![Figure 1-1](image1.png)

![Figure 1-2](image2.png)
rim. Plumbing codes typically require a split rim seat for public and employee use water closets. The split rim seat is designed to facilitate easy wiping by females, and to prevent contact between the seat and the penis with males. This is to maintain a high level of hygiene in public facilities.

A new style of water closet seat has a plastic wrap around the seat. The intent of this seat is to allow a clean surface for each use. The seat is intended to replace the split rim seat in public and employee locations.

**FLUSHING PERFORMANCE**

The flushing performance requirements for a water closet are found in a separate standard, ANSI/American Society of Mechanical Engineers (ASME) A112.19.6. This standard identifies the test protocol that must be followed to certify a water closet. The tests include a ball removal test, granule test, ink test, dye test, water consumption test, trap seal restorat ion test, water rise test, back pressure test, rim top and seat fouling test, and a drain line carry test, and a bulk media test.

The ball removal test utilizes 100 polypropylene balls that are \( \frac{3}{4} \) in. in diameter. The water closet must flush at least an average of 75 balls on the initial flush of three different flushes. The polypropylene balls are intended to replicate the density of human feces.

The granule test utilizes approximately 2500 disc shaped granules of polyethylene. The initial flush of three different flushes must result in no more than 125 granules on average remaining in the bowl. The granule test is intended to simulate a flush of watery feces (diarrhea).

The ink test is performed on the inside wall of the water closet bowl. A felt tip marker is used to draw a line around the inside of the bowl. After flushing, no individual segment of line can exceed \( \frac{1}{2} \) in. The total length of the remaining ink line must not exceed 2 in. This test determines that the water flushes all interior surfaces of the bowl.

The dye test uses a color dye to add to the water closet trap seal. The concentration of the dye is determined both before and after flushing the water closet. The dilution ratio of 100:1 must be obtained for each flush. This test determines the evacuation of urine in the trap seal.

The water consumption test determines that the water closet meets the federal mandate of 1.6 gal per flush.

The trap seal restoration test determines that the water closet refills the trap of the bowl after each flush. The remaining trap seal must be a minimum of 2 in. in depth.

The water rise test evaluates the rise of water in the bowl when the water closet is flushed. The water cannot rise above a point 3 in. below the top of the bowl.

The back pressure test is used to determine that the water seal remains in place when exposed to a back pressure (from the outlet side of the bowl) of 2½ in. of water column (wc). This test determines that no sewer gas will escape through the fixture when high pressure occurs in the drainage system piping.

The rim top and seat fouling test determines if the water splashes onto the top of the rim or seat of the water closet. This test ensures that the user will not encounter a wet seat when using the water closet.

The drain line carry test determines the performance of the water closet flush. The water closet is connected to a 4-in. drain 60 ft in length pitched \( \frac{1}{4} \) in./ft. The same 100 polypropylene balls used in the flush test are used in the drain line carry test. The average carry distance of all the polypropylene balls must be 40 ft in length. This test determines the ability of the water closet to flush the contents in such a manner that they properly flow down the drainage piping.
The bulk media test is a test of a large quantity of items placed in the bowl. The bowl cannot be stopped up by the bulk media during the flush, and a certain flushing performance of the bulk media is required. The debate over this test is the repeatability of the test. In Canada, water closets must conform to Canadian Standards Association (CSA) B45.1, CSA B45.4, or CSA B45.5. While Canada does not have a federal mandate requiring 1.6-gal-per-flush water closets, many areas require these water closets. It should also be noted that Canada requires a bulk media test for water closet flush performance.

**INSTALLATION REQUIREMENTS**

The water closet must be properly connected to the drainage piping system. For floor-mounted water closets, a water closet flange is attached to the piping and permanently secured to the building. For wood framed buildings, the flange is screwed to the floor. For concrete floors, the flange sits on the floor.

Noncorrosive closet bolts connect the water closet to the floor flange. The seal between the floor flange and the water closet is made with either wax rings or an elastomeric sealing connection. The connection formed between the water closet and the floor must be sealed with caulking or tile grout.

For wall hung water closets, the fixture must connect to a wall carrier. The carrier must transfer the loading of the water closet to the floor. A load can be transferred to the piping system. Water closet carriers must conform to ANSI/ASME A112.6.1.

The minimum spacing required for a water closet is 15 in. from the centerline of the bowl to the side wall, and 21 in. from the front of the water closet to any obstruction in front of the water closet. The standard dimension for a water closet compartment is 30 in. wide by 60 in. in length. The water closet must be installed in the center of the standard compartment. The minimum distance required between water closets is 30 in.

The change in the flushing performance of the 1.6-gal-per-flush water closet has affected the piping connection for back-to-back water closet installations. With a 3.5-gal-per-flush water closet, the common fitting used to connect back-to-back water closets was either a 3-in. double sanitary tee or a 3-in. double fixture fitting. With the superior flushing of the 1.6-gpf water closet, the plumbing codes have prohibited the installation of a double sanitary tee or double fixture fitting for back-to-back water closets. The only acceptable fitting is the double combination wye and eighth bend. The fitting, however, increases the spacing required between the floor and the ceiling.

The minimum spacing required to use a double sanitary tee fitting is 30 in. from the centerline of the water closet outlet to the entrance of the fitting. This spacing rules out a back-to-back water closet connection.

One of the problems associated with the short pattern fittings is the siphon action created in the initial flush of the water closets. This siphon action can draw the water out of the trap of the water closet connected to the other side of the fitting. Another potential problem is the interruption of flow when flushing a water closet. The flow from one water closet can propel water across the fitting, interfering with the other water closet.

**FLUSHING SYSTEMS**

**Gravity flush** The most common means of flushing a water closet is a gravity flush. This is the flush with a tank type water closet, described above, wherein the water is not pressurized in the tank. The tank stores a quantity of water to establish the initial flush of the bowl. A trip lever raises either a flapper or a ball, allowing the flush to be at the maximum siphon in the bowl, the flapper or ball reseals, closing off the tank from the bowl. The ballcock, located inside the tank, controls the flow of water into the tank. A float mechanism opens and closes the ballcock.

The ballcock directs the majority of the water into the tank and a smaller portion of water into the bowl to refill the trap seal. The ballcock must be an antisiphon ballcock conforming to American Society of Sanitary Engineers (ASSE) 1002. This prevents the contents of the tank from being siphoned back into the potable water supply. (See Figure 1-7.)

**Flushometer tank** A flushometer tank has the same outside appearance as a gravity tank. However, inside the tank is a pressure vessel that stores the water for flushing. The water in the pressure vessel must be a minimum of 25 psi to operate properly. Thus, the line pressure on the connection to the flushometer tank must be a minimum of 25 psi. A pressure regulator wall hung water closet must be capable of supporting a load of 500 lb at the end of the water closet. When the water closet is connected to the carrier, none of this prevents the pressure in the vessel from rising above 35 psi (typical of most manufacturers).

The higher pressure from the flushometer tank results in a flush similar to a flushometer valve. One of the differences between the flushometer tank and the flushometer valve is the sizing of the water distribution system. The water piping to a flushometer tank is sized the same way the water piping to a gravity flush tank is sized. Typically, the individual water connection is ½ in. in diameter. For a flushometer valve, there is a high flow rate demand, resulting in a large piping connection. A typical flushometer valve for a water closet has a connection of 1 in. in diameter. (See Figure 1-7.)

**Figure 1-7**  
(A) A Gravity Tank and (B) a Flushometer Tank

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The minimum siphon in the bowl, the flapper or ball reseals, closing off the tank from the bowl. The ballcock, located inside the tank, controls the flow of water into the tank. A float mechanism opens and closes the ballcock.

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**Figure 1-8**  
Flush Tank (Gravity)
Flushometer valve A flushometer valve is also referred to as a “flush valve.” The valve is designed with upper and lower chambers separated by a diaphragm. The water pressure in the upper chamber keeps the valve in the closed position. When the trip lever is activated, the water in the upper chamber escapes to the lower chamber, starting the flush. The flush of 1.6 gal passes through the flush valve. The valve is closed by line pressure as water reenters the upper chamber, closing off the valve.

For 1.6-gpm water closets, flushometer valves are set to flow 25 gpm at peak to flush the water closet. The flushing cycle is very short, lasting 4 to 5 s. The water distribution system must be properly designed to allow the peak flow during a heavy use period for the plumbing system.

Flushometer valves have either a manual or an automatic means of flushing. The most popular manual means of flushing is a handle mounted on the side of the flush valve. Automatic flushometer valves are available in a variety of styles. The automatic can be battery operated or directly connected to the power supply of the building.

FLUSH TANK REQUIREMENTS
There are certain essential requirements which must be satisfied when a flush tank is employed:

1. There must be an overflow to prevent tank flooding. The overflow should discharge into the water closet. (See Figure 1-8).
2. The ballcock, which controls the flow of water into the tank, should be equipped with a means of replenishing the trap seal after each flushing action.
3. The ballcock should be equipped with an adequate means of protection against back siphonage into the domestic water supply. A vacuum breaker is satisfactory for this purpose.

URINALS
A urinal was developed as a fixture to expedite the use of a toilet room. It is designed for the removal of urine and the quick exchange of users. The Energy Policy Act of 1992 included requirements for the water consumption of urinals. A urinal is now restricted to a maximum water use of 1.0 gal per flush. This change in water consumption resulted in a modified design of the fixture.

One of the main concerns in the design of a urinal is the maintenance of a sanitary fixture. The fixture must contain the urine, flush it down the drain, and wash the exposed surfaces. Prior to the passage of the Energy Policy Act of 1992, urinals were developed using larger quantities of water to flush the contents. This included a blowout model that could readily remove any of the contents thrown into the urinal in addition to urine. Blowout urinals were popular in high-traffic areas such as assembly buildings. However, the older blowout urinals require more than 1 gal of water to flush. The newer urinals identified as blowout urinals do not have the same forceful flush.

Urinals have been considered a fixture for the male population. However, that has not always been the case. Various attempts have been made to introduce a female urinal. The female population has never embraced the concept of a female urinal. Problems that have been encountered include a lack of understanding of the use of the urinal. (The first female urinals required the woman to approach the urinal in the opposite way a man would. She would be facing away from the urinal slightly bent over.) Another continuing concern is privacy during use. Finally, there have been concerns regarding cleanliness with its use compared with that associated with the use of a water closet. Hence, very few female urinals remain in use in the United States and Canada.

URINAL STYLES
Urinals are manufactured as floor mounted, wall hung, or free-standing in various sizes and shapes for men and women. Water supply for urinals must meet the same requirements as those for water closets. Siphon jet and blowout urinals provide a flushing action that will remove foreign matter deposited in the urinal such as paper towels and candy wrappers. The washout and wash-down models are quieter in operation but do not have the advantage of removing foreign matter. Theses type of urinals are intended to remove liquid wastes only.

Urinals are identified as blowout, siphon jet, washout, stall, and wash-down. A stall urinal is a type of wash-down urinal. Blowout, siphon jet, and washout urinals all have integral traps. Stall and wash-down urinals because they do not maintain a high level of sanitation after each flush.

The style identifies the type of flushing action in the urinal. The blow-out and siphon-jet types rely on a complete evacuation of the trap. Blow-out urinals tend to force the water and waste from the trap to the drain. Siphon-jet urinals create a siphon action to evacuate the trap. Washout urinals rely on a water exchange to flush and there is no siphon action or complete evacuation of the trap. Stall and wash-down urinals have an external trap. The flushing action is a water exchange; however, it is a less efficient water exchange than that of a washout urinal.

Urinals with an integral trap must be capable of passing a ¾-in. diameter ball. The outlet connection is typically 2 in. in diameter. Stall and wash-down urinals can have a 1½-in. outlet with an external trap. Blowout and siphon jet must have a 1½-in. outlet as an integral trap.

FLUSHING PERFORMANCE
ANSI/ASME A112.19.6 regulates the flushing performance for a urinal. There are three tests for urinals: the ink test, dye test, and water consumption test. In the ink test a felt tip marker is utilized to draw a line on the inside wall of the urinal.

The ink test confirms the cabailities of the urinal to wash the sides of the fixture. The urinal is flushed and the remaining ink line is measured. The total length of ink line cannot exceed 1 in., and no segment can exceed ½-in. in length.

The dye test uses a colored dye to evaluate the water exchange rate in the trap. After on flush, the trap must have a dilution ratio of 100 to 1. The dye test is performed only on urinals with an integral trap. This includes blowout, siphon-jet, and washout urinals. It is not possible to test stall and wash-down urinals since they have external traps. This is one of the concerns that have resulted in the restricted use of these fixtures.

The water consumption test determines that the urinal flushes with 1 gal of water or less.

INSTALLATION REQUIREMENTS
The minimum spacing required between urinals is 30 in. center to center. The minimum spacing between a urinal and the sidewall is 15 in. This spacing provides access to the urinal without the user coming in contact with the user of the adjacent fixture. The minimum spacing required in front of the urinal is 21 in. (See Figure 1-9.)
One of the debated issues regarding urinals is screening between urinals. A question of privacy is often raised during plumbing code discussions. At the time of this writing, screening is not required by any of the model plumbing codes. However, many local and some state plumbing codes require privacy barriers between urinals.

Urinals with an integral trap have the outlet located 21 in. above the floor for a standard height installation. Stall urinals are mounted on the floor. Wall hung urinals must be mounted on carriers that transfer the weight of the urinal to the floor.

Many plumbing codes require urinals for public and employee use to have a visible trap seal. This refers to blowout, siphon-jet, or washout urinals.

The building and/or plumbing codes review the walls and floor surrounding the urinal to be finished with waterproofed, smooth, readily cleanable, nonabsorbent material. This material must be applied to the wall for a distance of 2 ft to either side of the urinal and a height of 4 ft. It must also extend outward on the floor to a point 2 ft in front of the urinal. This protects the building material from damage that could result from splashing, which can occur with urinal use.

**FLUSHING REQUIREMENTS**

With the federal requirements for water consumption, urinals must be flushed with a flushometer valve. The valve can be either manually or automatically actuated.

A urinal flushometer valve has a lower flush volume and flow rate than a water closet flushometer valve. The total volume is 1 gal per flush and the peak flow rate is 15 gpm. The water distribution system must be properly sized for the peak flow rate for the urinal.

Urinal flushometer valves operate the same as water closet flushometer valves. For additional information see the discussion of flushing systems under “Water Closets” earlier in this chapter.

A modern version of the century-old waterless urinal is available where water savings are paramount. The waterless urinal has a special trap that is filled with a liquid that is lighter than water and urine. Urine travels down the interior sides of the urinal, through the liquid, and safely into the waste piping. The liquid must be replenished periodically, thus scheduled maintenance is required, the schedule depending on the frequency of use of the urinal.

**LAVATORIES**

A Lavatory is a washbasin used for personal hygiene. In public locations, a lavatory is used for washing one’s hands and face. Residential lavatories are intended for hand and face washing, shaving, applying makeup, cleaning contact lenses, and similar hygienic activities.

Lavatory faucet flow rates are regulated as a part of the Energy Policy Act of 1992. The original flow rate established by the government was 2.5 gpm at 80 psi for private use lavatories and 0.5 gpm, or a cycle discharging 0.25 gal, for public use lavatories. Since the initial regulations, there has been a change to 2.2 gpm at 60 psi for private (and residential) lavatories, and 0.5 gpm at 60 psi, or a cycle of 0.25 gal, for public lavatories.

**SIZE AND SHAPE**

Manufacturers produce lavatories in every conceivable size and shape, providing an unlimited selection. Lavatories are square, round, oblong, rectangular, shaped for corners, with or without ledges, decorative bowls, and molded into countertops. They can be classified into five different types: slab, splashback, shelf back, ledge back, and countertop. Several are illustrated. Special purpose lavatories can usually be placed within these five categories.

- The slab type lavatory comes in vitreous china and is supported by concealed or exposed arms, wall brackets, and chrome legs. The back of the fixture is usually installed 2 in. from the wall to facilitate cleaning of the wall behind the lavatory. (See Figure 1-10.)
- The splashback lavatory has an integral back and is recommended for sanitary purposes. Splashing, which can run down the back of the slab type, stays on the fixture. The fixture is made of vitreous china and is supported by wall hangers or by concealed or exposed arms. (See Figure 1-11.)
- The shelf-back lavatory reduces splashing and in addition provides a shelf for the storage of toiletries. The fixture is made of either vitreous china or enameled iron. (See Figure 1-12.)
- The ledge-back lavatory offers some splash reduction and some shelf area. This type as well as the others has depressions molded
into the fixture for holding bar soap. Manufacturers offer modifications to provide or delete additional holes or depressions. An additional hole may be provided for a liquid soap dispenser. (See Figure 1-13.)

- Counter self-rimming and undercounter mounted lavatories are the most recent and probably the most diversified of any category. They come in various materials, including vitreous china, enameled cast iron, stainless steel, plastics, fiberglass, and precast artificial marble. A development that has contributed to the popularity and acceptance of countertop lavatories is the self-rimming feature that does not require the use of a stainless steel rim.

The standard outlet for a lavatory is 1 1/4 in. in diameter. The standard lavatory has three holes on the ledge for the faucet. A normal faucet hole pattern spaces the two outside holes 4 in. apart. The faucets installed in these lavatories are called 4-in. center sets. When spread faucets are to be installed, the spacing between the two outer holes is 8 in.

For many years, the fixture standards required lavatories to have an overflow. This requirement was based on the use of the fixture whereby the basin was filled prior to cleaning. If a user left the room while the lavatory was being filled, the water would not overflow on the floor.

The engineer is warned to be especially aware of possible problems created when specifying the newer materials and to carefully analyze their application to a given installation. Special care must be exercised with these products regarding their abrasion-resistance characteristics. Abrasive cleaners tend to destroy the luster of the surface of these materials much more quickly than they do traditional materials. In addition, some of the newer materials are fire resistant while some are not.

**SINKS**

There is a wide selection of sink types available. They come in single, double, and triple-compartment models. Two-compartment sinks, with both compartments the same size, are the most widely used models (see Figure 1-15). It is recommended that one compartment be at least 15 in. by 18 in. in size for residential use to allow the acceptance of a roasting pan. Faucet spouts should be high enough to place a large pot beneath without any difficulty. Specialty sinks, such as the surgeon’s sink shown in Figure 1-14, are available.

**SERVICE SINKS**

The most popular service sinks are those that have a high back and are wall mounted and supported on a trap standard or low type mop basins that are mounted on, or recessed into, the floor. Protective rim guards are recommended for both.

**BATHTUBS**

Bathtubs are available in various sizes and shapes. The 5 ft bathtub has become practically a standard, but the public has recently indicated a preference for a much longer model. Perhaps there will be a return to 5 ft 6 in. and 6 ft 0 in. tubs, which were more readily available in the not too distant past.

Fiberglass and plastic models have recently entered the market. The plumbing engineer is strongly advised to check thoroughly with the manufacturer as to the hardness of the surface and the resistance to abrasive cleaners.

Enameled cast iron tubs have been preferred because of their ability to resist chipping and rusting, which frequently happens with enameled steel tubs. The thickness of the enamel coating on cast iron is two to three times heavier than that on pressed steel and has superior adherence to the base.

**SHOWERS**

Shower receptors are available in various sizes and shapes. They are available in standard precast sizes (minimum 30” x 30”) but may be obtained in custom built models to fit practically any application.

Where precast receptors are not employed, the built-up type is used. The pan for a built-up shower can be fabricated from lead, copper, or various compositions presently available. The pan should turn up at least 6 in. and turn over the threshold to provide a watertight installation. An exception to this is shower enclosures made to be wheelchair accessible.

**DRINKING FOUNTAINS**

Drinking fountains (nonrefrigerated) are available as free-standing, surface mounted, semirecessed, fully recessed, bi-level (regular height and handicapped accessible height), pedestal, or deck type for counter tops. When selecting a semirecessed or fully recessed model, the plumbing engineer should ascertain that the wall or pipe space is deep enough to accommodate the fountain and necessary piping.

Electric water coolers are available in as many variations as drinking fountains. It is extremely important to provide adequate wall thickness to accommodate the chiller unit and piping. Location of the chiller unit and grill finish should be coordinated with the architect.

**BIDETS**

The bidet is about the same size and shape as a water closet and could be classified as a small bath. It is used primarily for washing the anal regions after using the water closet.

The hot and cold water supply and the drain fitting are very similar to those used for lavatories. Instead of the water entering the bowl from a spout, however, it is introduced through a flushing rim. The tepid water flows through the rim and while filling the bowl it warms the china hollow rim which serves as a seat.

A spray rinse is optional, and recommended, for external rinsing. Although this rinse is often called a “douche” it should not be construed as being designed or intended for internal use.

The plumbing engineer should recommend that a soap dispenser and towel rack be provided within easy reach for the convenience of the user.

The foregoing has been a very brief discussion of the salient features of some of the most common fixtures. The reader is referred to the catalogs of various fixture manufacturers for a complete presentation of fixtures and trim. The catalogs are an excellent source of information and give all the detailed data required; it is unnecessary to fill these pages with that information, they are better devoted to design criteria.
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Note: In determining your answers to the CE questions, use only the material presented in the corresponding continuing education article. Using information from other materials may result in a wrong answer.

**CE Questions — “Systems and Fixtures” (PSD 182)**

1. **A plumbing engineer is responsible for the design of which of the following systems?**
   a. vacuum  
   b. water treatment  
   c. site drainage  
   d. all of the above

2. **Water closets with ________ are unacceptable.**
   a. invisible water seals  
   b. flushometers  
   c. two-piece tanks  
   d. plastic parts

3. **The flushometer valve connection is also called a ________.**
   a. coupler  
   b. spud  
   c. flange  
   d. trap

4. **What is the standard rough-in dimension from the centerline of a water closet outlet to the back wall?**
   a. 10 inches  
   b. 12 inches  
   c. 14 inches  
   d. none of the above

5. **The rim height of a water closet for juvenile use is what?**
   a. 18 inches  
   b. 14 inches  
   c. 13 inches  
   d. 10 inches

6. **What test can be used to certify the flushing performance of a water closet?**
   a. granule test  
   b. ink test  
   c. dye test  
   d. all of the above

7. **The minimum spacing required for a water closet is ________ from the centerline of the bowl to the side wall.**
   a. 12 inches  
   b. 15 inches  
   c. 18 inches  
   d. 21 inches

8. **The typical connection for a water closet flush valve is ________ in diameter.**
   a. ¼ inch  
   b. ½ inch  
   c. 1 inch  
   d. none of the above

9. **Per the Energy Policy Act of 1992, a urinal is restricted to how many gallons per flush?**
   a. 0.5  
   b. 1  
   c. 1.6  
   d. 3.5

10. **________ is a type of urinal.**
    a. washout  
    b. blowout  
    c. siphon jet  
    d. all of the above

11. **A ________ is a washbasin used for personal hygiene.**
    a. service sink  
    b. lavatory  
    c. bathtub  
    d. bidet

12. **What is the preferred material for a bathtub due to its ability to resist chipping and rusting?**
    a. enameled cast iron  
    b. plastic  
    c. fiberglass  
    d. copper

**About This Issue’s Article**

The November 2011 continuing education article is “Systems and Fixtures.” Plumbing engineers are responsible for systems that serve all types of buildings, including commercial, residential, and institutional buildings such as hospitals, laboratories, industrial plants, jails, schools, shopping centers, housing developments, power plants, research centers, and sports complexes. This chapter details the types and specifications of the typical fixtures found in such systems. You may locate this article at psdmagazine.org. Read the article, complete the following exam, and submit your answer sheet to the ASPE office to potentially receive 0.1 CEU.
Plumbing Systems & Design Continuing Education Application Form

This form is valid up to one year from date of publication. The PS&D Continuing Education program is approved by ASPE for up to one contact hour (0.1 CEU) of credit per article. Participants who earn a passing score (90 percent) on the CE questions will receive a letter or certification within 30 days of ASPE’s receipt of the application form. No special certificates will be issued. Participants who fail and wish to retake the test should resubmit the form along with an additional fee (if required).

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PS&D Continuing Education Answer Sheet
Systems and Fixtures (PSD 182)
Questions appear on page 10. Circle the answer to each question.

Q 1. A B C D
Q 2. A B C D
Q 3. A B C D
Q 4. A B C D
Q 5. A B C D
Q 6. A B C D
Q 7. A B C D
Q 8. A B C D
Q 9. A B C D
Q 10. A B C D
Q 11. A B C D
Q 12. A B C D

Appraisal Questions
Systems and Fixtures (PSD 182)
1. Was the material new information for you?  Yes  No
2. Was the material presented clearly?  Yes  No
3. Was the material adequately covered?  Yes  No
4. Did the content help you achieve the stated objectives?  Yes  No
5. Did the CE questions help you identify specific ways to use ideas presented in the article?  Yes  No
6. How much time did you need to complete the CE offering (i.e., to read the article and answer the post-test questions)?