INTRODUCTION
This chapter discusses various piping systems uniquely associated with the physical care, health, and well-being of laboratory animals. Included are various utility systems for animal watering, water treatment, room and floor cleaning, equipment washing, cage flushing and drainage, and other specialized piping required for laboratory and experimental work within the facility. Other systems involved with general laboratory and facility work, such as those for compressed gases and plumbing, are discussed in their respective chapters.

General
It is expected that a facility involved with long-term studies will have different operating and animal drinking-water quality requirements than one used for medical research. For critical studies, the various utility systems shall incorporate design features necessary to ensure reliability and provide a consistent environment. As many variables as are practical (or desirable) shall be eliminated to ensure the accuracy of the ongoing experiments being conducted. Regardless of the facility type, different users and owners have individual priorities based on experiences, operating philosophies, and corporate cultures that must be established prior to the start of the final design phase of a project.

Codes and Standards
1. The local codes applicable to plumbing systems must be observed in the design and installation of ordinary plumbing fixtures and potable water and drainage lines for the facility.
2. 10-CFR-58 is the code (by the agencies of the federal government) for good laboratory practice for nonclinical laboratory studies.
3. 21-CFR-211, cGMP, requires compliance with FDA protocols for pharmaceutical applications.
4. NIH publication 86-23, Guide for the Care and Use of Laboratory Animals.
5. American Association for Accreditation of Laboratory Animal Care (AAALAC). Inspection and accreditation by the AAALAC is accepted by the NIH as assurance that the facility is in compliance with Public Health Services (PHS) standards.

Animal Drinking-Water Systems
The purpose of the animal drinking-water system is to produce, distribute, and maintain an uninterruptible supply of drinking water with a specific and consistent range of purity to all animals in a facility. There are two general types of systems: an automated central-distribution system and individual water bottles.

System Types
The great majority of animals used by laboratories for medical and product research are mice, rats, guinea pigs, rabbits, cats, dogs, and primates. Smaller animals and primates are kept in stacked cages, often on racks. Medium-sized animals, such as dogs, goats, and pigs, are kept in kennels or pens. Larger floor areas are required for barnyard animals such as cows. Watering can be done either by an automatic, reduced-pressure, central system, which pipes water from the source directly to each cage, kennel or pen; or by separate drinking bottles or watering devices manually placed in individual cages or pens.

Automated, Central Supply-and-Distribution System
The purpose of an automated, central, drinking-water supply system is to automatically treat and distribute drinking water. Ancillary devices are used to flush the system and maintain a uniform and acceptable level of purity.

The system consists of a raw or treated water source, a purification system, medicinal and disinfection injection equipment if necessary, pressure-reducing stations, and a distribution piping network consisting of a low-pressure room-distribution piping system and a rack-manifold pipe terminating in a drinking valve for each cage or pen for the animals. Also necessary is an automated flushing system for the room-distribution piping activated by a flush-sequence panel, and a monitoring system to automatically provide monitoring of such items as drinking-water pressure, flow, and possible leakage.

Animals in cages are kept in animal rooms. Cages are usually placed in multi-tiered, portable or permanent cage racks, which contain a number of cages. The cage rack has an integral piping system installed, called a “rack manifold,” that distributes the water to all cages. The rack manifold could be installed by the manufacturer or in the facility by operating personnel. The rack manifold receives its water from the room-distribution piping. The connection between the room-distribution piping and the rack manifold is made by means of a detachable recoil hose generally manufactured from Polypropylene (PP), nylon, or Ethylene-Propylene Diene Monomer (EPDM). This hose is flexible, generally ⅛ in. (12 mm) in size and coiled to conserve space. It will stretch to a length of about 6 ft 0 in. (2 m). Each end is provided with a quick-disconnect fitting used to attach the hose to both the room-distribution piping and the rack manifold.

To maintain drinking-water quality, a method of flushing the room-distribution piping and the rack manifold shall be provided. Ancillary equipment includes flushing and sanitizing systems to wash the recoil hose and the cage rack-piping interior.
Water Bottles

Drinking water bottles are individual units with an integral drinking tube that are placed by hand on a bracket in each cage. These bottles could be filled either by hand or automatically via a bottle filler.

Automatic bottle fillers should be considered to reduce the time necessary to fill bottles and minimize water spillage. Bottle fillers are available with manifolds to fit any size bottles. They can be supplied with purified water from a central water supply and—with separate, programmable proportioners—could acidify, chlorinate, and medicate the water as required. The bottle filler automates the filling procedure so that the bottles are correctly positioned during filling and stops the flow when the water reaches a predetermined level.

Flushing System

In order to maintain drinking-water quality, the drinking-water distribution system should be flushed periodically. This is accomplished by having the same drinking water that is normally distributed to the animals flow through the piping system at an elevated flow rate, pressure, and velocity. The water is sent to drain and not recovered. This is initiated automatically at the drinking-water pressure-reducing station by the addition of separate regulating valves and pressure-regulating arrangements.

Different flushing arrangements are possible, depending on the cost, facility protocol, and purity desired. One method flushes only the main runs by the addition of a solenoid valve at the end of the main run and the provision of a return line to drain from this point. Another method is to flush the mains and the room-distribution piping by adding the solenoid valve at the end of each room-distribution branch with the return line to drain from each room. A third method flushes the entire system, including the rack manifold, by adding a solenoid valve on each cage connection to the room-distribution pipe, which flushes the recoil hose and the rack manifold.

It is accepted practice to replace all the drinking water in the room-distribution piping system at regular intervals, a minimum of twice daily. To approximate the amount of water in the pipe, allow 1 gal (4 L) for each 33 ft 0 in. (10 m) of pipe. General practice is to flush the system with water at about 15 psi (90 kPa) at a rate of 15 gpm (60 L/min). If the drinking water is not purified, it is recommended that the piping be flushed at least twice daily for about 2 min. For purified water, flush once daily for about 1 min. Flushing can be done manually by means of a valve in the pressure-reducing station enclosure or automatically by the addition of a bypass and solenoid valve around the low-pressure assembly to the pressure-reducing station. The sequence and duration of the automatic flush cycle is controlled from a flush-sequencer panel.

Drinking-Water Treatment Systems

The purpose of the drinking-water treatment system is to remove impurities from the raw-water supply to achieve the water quality required by the animals in the facility. In addition, disinfectant and medication can be added to the water during treatment if required.

Systems Description

There are no generally recognized and accepted standards for animal drinking-water quality. Purity and consistency requirements depend on the incoming water quality, the established protocol of the end user, the importance of either the initial or the operating cost of the proposed system, the species of animals housed in the facility, and the animal-housing methods. The overall objective is to eliminate as many variables as possible for the entire period of time the studies or experiments are conducted.

The most often-used treatment for drinking water is reverse osmosis. Other possible treatment methods are distillation and deionization. A discussion of these purification methods appears in the chapter “Water Systems.”

Reverse Osmosis

When a higher-quality water is required and other types of purified water are not available in a facility, reverse osmosis (RO) is normally selected. Since the amount of water is usually small, a package type unit mounted on a skid is provided and connected directly to the water supply. The RO system is flexible and, when used in combination with DI water supply, will provide water that is virtually contamination free.

Disinfection and Medication of Drinking Water

Disinfection chemical mixtures are added to the animal drinking-water supply to eliminate and control bacterial contamination in the central and room-distribution piping system. Medication is added to conform with experimental protocols if necessary. These mixtures are usually introduced into the piping system by a self-contained, central, proportioning (injector) unit using facility water pressure. Medication is added to the drinking water using the same proportioning equipment that adds disinfectant. All equipment is available in a wide range of sizes and materials. A schematic detail of a typical central proportioner is illustrated in Figure 7-1.

Chlorination

Chlorination is a recognized biocidal treatment that leaves a residual of chlorine in the entire central-distribution system. Hypercholorinated water is not as corrosive as acidified water and could be used with brass/copper distribution system components. Accepted practice is to provide a pH higher than 4, with a residual range of free chlorine between 5 and 12 ppm. Free chlorine in water dissipates in time with light, heat, and reaction with organic contaminants, making it ineffective when water bottles are used. Chlorine creates toxic compounds in reaction with some water contaminants and medications.

Acidification

Acidification has an advantage over chlorination in that it is more stable and lasts longer in the system. The disadvantage is that corrosion-resistant materials must be used. The pH range should be between 2.5 and 3 in order to be effective. A pH lower than 2.5 will cause the water to become “sour” and the animals will not drink it. At a pH above 3, the mixture is not considered an effective germicide.

Drinking-Water System Components and Selection

Pressure-Reducing Station

The pressure-reducing station reduces the normal pressure of the raw-water supply to a level required for the animal-room drinking-water distribution system. As an option, a secondary system can be added to provide a higher pressure in the room-distribution system for flushing.

The pressure and flow rate depend on the type and number of animals to be supplied. Also usually included are a 5-µ water filter, a pressure gauge, and a backflow preventer. Timing devices that automatically control flushing duration are controlled by a remote
Drinking Valves

Drinking valves are used by the animals to obtain water from the distribution-system piping. An internal mechanism keeps the valve normally closed; the animal drinking from the valve must open it by some action, such as moving the entire valve or operating a small lever inside the body of the valve with the tongue. Many different kinds of valve are available to supply any type of animal that may be kept in the facility. The valves can be mounted on cages, on the rack manifold, or on the walls of pens and kennels at varying heights with the use of special brackets.

Animal-Rack Manifold Configurations

The configuration of the piping on the animal rack plays an important part in the effectiveness and efficiency of the filling and flushing of the drinking-water system. The two most often-used configurations are the reverse “S” and the “H.”

The reverse “S,” illustrated in Figure 7-2, is the most often-used configuration. It has two basic styles based on the valve location in the flush drain line. One style has a supply control valve at the top and the other has a drain valve at the bottom. Either location is acceptable, with the deciding factor being the ease of operating the valve where the rack is installed. This configuration has the advantage of eliminating dead legs and offers more convenience to facility personnel when they fill the piping after washing. The vent is a manually operated air bleed used when the cage rack is reconnected to the room-distribution pipe. It is opened until water is discharged, thereby eliminating any air pockets in the manifold. This manifold style provides a positive exchange of water during flushing with a minimum usage of time and water. This configuration is used far more than any other manifold style. It is easily converted to automatic flushing by the installation of solenoid devices on the valve. It is recommended when micro-isolator cage systems are installed. The complete, on-line, rack-manifold flushing system is illustrated in Figure 7-3. This cage system has the advantage of the complete isolation of individual cages, with the accompanying capability for additional flushing and disinfection of the piping system.

One variation of the reverse “S” is the standard “S,” illustrated in Figure 7-4. This configuration has the advantage of complete on-line flushing and lower initial cost of the manifold. Disadvantages are the need for extra supports on the cage rack and the need for venting to be done manually or by the animals after being placed in service. This configuration is no longer recommended.

The “H” style, illustrated in Figure 7-5, although rigidly installed and with positive venting, is not suitable for on-line flushing. Because of this, it is rarely used except for larger animals, which will consume all the water in the rack piping manifold.

The most common piping materials are CPVC and 304L stainless steel. CPVC conforms to ASTM D 2846, is 0.875 outside diameter (OD) with 0.188 in. minimum wall thickness. Joining process is done with solvent cement socket joints. The drinking valves

flush-sequence panel, which controls all flushing sequencing operations. The recommended pressures for animal-room piping distribution to various animals are as follows:

- Small animals, such as Rats and mice: 3-5 psig (20.4-34 kPa)
- Primates: 3-5 psig
- Dogs and cats: 3-5 psig
- Swine and piglets: 6-12 psig (41-81.6 kPa)

The secondary pressure-reducing assembly used to provide automatically room-distribution pipe-flushing water operates at a pressure of 15 psig (102 kPa). This assembly is installed as a bypass around the low-pressure assembly. Manual operation at a lower cost could also be provided. This additional pressure for a short period of time will not cause the animals any difficulty if they decide to drink during the flushing cycle.

One pressure-reducing station can be connected to as many as 35 interconnect stations to small animal-rack manifolds, often referred to as “drops.” This allows 1 station to control more than 1 animal room.

The pressure-reducing station is a preassembled unit complete with all the various valves, fittings, and reducing valves required for a specific project. All the components are installed in a cabinet, which requires only mounting and utility connections.
are installed with a proprietary, drilled and tapped fitting. The 304L stainless steel tubing is 0.50 OD with a 0.036 in. minimum wall thickness. Fittings are made with O-ring joints and socket fittings or compression type fittings. The mounting of both pipe materials is accomplished by the use of 304 SS stainless-steel clamps and fasteners.

**System Sizing Methods**

The water consumption of small animals in cages is very low. It is also probable that the animal room will not be used to full capacity. Because of this low consumption flow rate, the flushing-water flow rate of the system is the critical factor in sizing the piping. Typically, the animal-room piping distribution network is a header uniformly sized at ½ in. (50 mm) throughout the animal room.

The pipe sizes in other areas of the animal facility are determined based on the requirements of maximum flow rate at the necessary pressure to supply the flushing velocity. Maximum flow rate depends on the flush sequencing, and the pressure drop depends on overcoming pressure loss through the equipment connected to the branch being sized—such as pressure-reducing stations, solenoid valves, and recoil hoses—and friction loss through the piping network. Allowance must be made to provide a sufficiently high flow rate and water velocity to efficiently provide the flushing action desired.

**Cleaning and Drainage Systems and Practices**

**General**

Keeping the animal rooms and cages clean is an extremely important facet of facility practice. The cleaning of the animal room is accomplished either by sponging the walls, floors, and ceiling or by hosing down the room. Cage racks can be cleaned by washing them with a hose or by placing them in a large washing machine. Cages are cleaned in a cage washer. Pens and kennels are hosed down. Floors in pens are cleaned with hoses and the bedding with feces is pushed into trenches with floor drains.

In specialized areas, such as holding or isolation rooms where only small animals are kept, it is common practice to have permanent cage racks or have the portable racks remain in the animal room. The litter is put into bags and brought to other areas for disposal. The cage racks are manually wiped down and no rack washer is required. A sink is usually provided in the animal room for the convenience of the cleaning personnel. Individual water bottles, if provided, could be washed in the sink. The cages are removed and washed separately in a cage washer. This type of animal room usually does not require a floor drain if the entire room will be sponged down. If hosing is practiced, a floor drain is required.

Rabbits and guinea pigs have a tendency to spray urine and feces. This requires that the racks be hosed down in the room. A wash station with a hose reel and detergent injection capability to hose down the cage racks and the room itself is usually placed in individual rooms. Citric acid is often used as a cleaning agent for rabbits.

**Hose Stations**

Hose stations usually consist of a mixing valve with cold water and steam to make hot water or hot water alone, a length of flexible hose, and an adjustable spray nozzle. Hot and cold water are also used. It can be exposed or provided with an enclosure when an easily cleaned surface is required.

**Cleaning-Agent Systems**

Cleaning agents are used to clean and/or disinfect the walls, ceiling, and floor of a room and to add agent to the cage wash water. When used to clean rooms, the equipment used for this purpose is commonly called a “facility detergent system.” When used to add agent to the cage washing water it is often called a
“cage-washing detergent system.” These are separate systems and are not capable of providing agent to each other.

A single-station detergent-dispensing system is used when rooms are cleaned with mops or squeegees. It consists of a wall-mounted unit having a holder for detergent concentrate and an injector unit. A container filled with detergent concentrate is placed in the holder and is used to supply agent to the injector that dispenses a metered amount of agent when a hose bibb is opened to fill the pail or container. These rooms usually have sinks and mop racks inside to be used only for these rooms. A typical schematic detail of a single-station detergent system is illustrated in Figure 7-6.

When used to supply a single or multiple-spray hose for cleaning floors and walls, a central system could be installed to supply several rooms within a facility by means of a detergent pump that dispenses agent. A 55-gal drum of agent should be used to reduce the number of times the supply has to be changed. A typical central-supply detergent-dispensing system is illustrated in Figure 7-7.

The cage-washing detergent system is usually located in the wet area of the cage-washing facility and, with the use of a detergent pump, could be used as a central system to supply cage and bottle washers. A typical schematic detail of a cage-washing system is illustrated in Figure 7-8.

It is common practice to have a central system or a wall-mounted cleaning-agent dispenser unit along with the hose station. Separate, portable units could be used when cross contamination between animal rooms is a consideration. A typical, wall-mounted, cleaning-agent system consists of separate water and cleaning-agent tanks; a water pump; and a special, coaxial hose that sprays a proportioned mixture of the water and cleaning agent. Compressed air is often used to provide pressure.

**Cage-Flushing Water System**

The removal of animal waste from cages can be done by several methods. One method removes the waste along with the bedding at the time cages are removed from the animal room to be washed. Another method uses an independent rack-flush system to automatically remove animal waste from cages on racks while the animals and cages remain in the animal room.

The independent rack flush is a separate system that uses chlorinated water automatically distributed to each animal room. The cages and racks are constructed so that the animal droppings fall through the cage floor onto a sloping pan below each tier of cages. Each tier is cascaded at the end onto the sloping pan below. Eventually, the lowest pan spills into a drain trough in the animal room. The flushing schedule is decided by facility personnel.

The water supply could be a reservoir placed on the rack that is filled with water and automatically discharged onto the pans at preset intervals. These preset intervals are determined based on experience and generally range from once to three times daily. Another method uses a solenoid valve to automatically discharge water onto the pans; the valve is sequenced by a timer set to alternate fill and dump cycles. The timer could be either centrally located or installed separately in each animal room. Larger cages, such as those for primates, are usually stacked no more than two cages high. Current practice is to have these cages manually cleaned by personnel who hose down the pans directly into floor or wall troughs.

Water is supplied to each cage rack by means of a recoil hose, which has a different quick-disconnect end than that of the drinking water recoil hose to avoid cross connection. Refer to Figure 7-9 for a detail of a typical cage-rack utility connection arrangement.

**Solid-Waste Disposal**

Solid waste consists of bedding, feces, animal carcasses, and other miscellaneous waste, including straw and sawdust used for larger farm animals. Bedding comprises the largest quantity of this solid waste. It is necessary to determine the quantity of bedding before a decision can be made as to the most cost-effective method to dispose of it.

Bedding can be disposed of by incineration, as regular garbage, or into the sewer system. Incinerators are costly, require compliance with many regulatory agencies and multiple permits, and often result in objections from adjoining property owners. Incineration is the preferred method of disposing of carcasses and large quantities of contaminated waste. Carcasses could also be autoclaved and disposed of as regular garbage. Regular garbage disposal is the most common method of disposal. It involves collecting, moving, and storage of the waste into large containers until regular garbage collection is made. This is very labor intensive.

Discharge into the drainage system must first be accepted by the local authorities and responsible code officials. This requires the bedding to be water soluble, that it shall not float, and provision be made to thoroughly mix the bedding with water. This mixture is called a “slurry.” Experience has shown, if done properly, discharge into an adequately sized drain line—minimum size 6 in. (150 mm)—has caused no problems, since the effluent has the same general characteristics of water.

A self-contained waste-disposal system is available that is capable of disposing of animal bedding and waste. The system consists of a pulping unit to grind the waste into a slurry and sanitize it, a water extractor to remove most of the water from the slurry, and the interconnecting piping system that transports the slurry from the pulper to the extractor and recirculates the water removed from the extractor back to the pulping unit for reuse. The solid waste is removed as garbage. Manufacturers are available for assistance in the design and equipment selection for this specialized system. The system has the advantages of reducing water use, reducing operating costs by eliminating the handling...
of the waste by operating personnel, compacting the waste to about 20% of the space required for standard garbage not compacted, and reducing the possibility of contamination by isolation of the disposal equipment. The disadvantage is its high initial cost.

This system could consist of single or multiple units of different capacities. It requires water intermittently for pulping at the rate of about 10 to 30 gpm (63 to 190 L/min). Hose bibbs should be installed for washdown. The pipe should be sized for a maximum velocity of 8 fps (1.75 m/s), with typical slurry lines ranging between 2 and 4 in. (50 and 200 mm) and return lines generally 2 in. (50 mm) in size. The extractor discharges into a drain that should be 4 or 6 in. (100 or 150 mm) depending on the flow. A typical schematic diagram of a multiple installation is illustrated in Figure 7-10.

**Room-Waste Disposal**

The rooms in which animals are kept must be designed to allow proper drainage practices and in accordance with the anticipated cleaning procedures of the facility. Floor drains, drainage trenches (or troughs) at room sides, adequate and consistent floor pitch to drains or troughs, and floor surfaces are all important considerations.

There are several considerations to be taken into account in locating floor drains. Experience has shown that placing drains in the center of a room is not acceptable because it is difficult to hose solids down a drain in this location. Another reason is that the floor must be pitched to the drain and if a cage rack is defective, it should roll to the side of the room. The best location is in a corner or at the side. Floor drains without troughs can be considered if the floors will only be squeegeed rather than hosed down. They should also be considered in contagious areas where contamination between rooms must be avoided. Gratings must have openings smaller than the wheels of racks or cages.

In rooms where washdown and cage-rack flushing are expected, the provision of a floor trough should be considered. Troughs are often provided at opposite ends of the room to minimize the amount of floor drop due to pitch. Accepted practice uses a minimum floor pitch of 1/8 in./ft of floor run. The floor is pitched to the troughs to facilitate cleaning and also to provide an easy method to dispose of waste generated from the rack-flush system. It is common practice to provide an automatic or manual trough-flushing system with nozzles or jets to wash down the trough sides and eliminate as much of the contamination remaining in the trough as possible. Wall troughs, similarly to roof gutters, are located at a higher elevation. This type of trough arrangement is sometimes provided in addition to or in lieu of floor troughs if the arrangement of elevated cages and racks make it an effective drainage method. Experience has shown that prefabricated drain troughs in floors are preferred over those built on the wall as part of the architectural construction.

The floor troughs are drained by means of a floor drain placed in a low point at one end. The troughs are usually pitched at 1/4 in./ft of run to the drain. The drain should be constructed of acid-resistant materials and have a grate that can be easily removed.
For small animal rooms where bedding is not disposed of in the room, a 4-in. (100-mm) drain is considered adequate. In most other locations, it is recommended that a 6-in. (150-mm) drain be provided. A flushing-rim type drain should be considered to flush all types of waste into the drainage system.

Floor drains should have the capability of being sealed by the replacement of the grates with solid covers during periods when the room may not be in service.

**Equipment Washing**

Most facilities contain washing and sanitizing machines to wash cages, cage racks, and bottles, if used. There are two commonly used types of cage washer: the batch type and conveyor (tunnel) type. Batch washers require manual loading and unloading and are used where a small number of cages and racks are washed. The conveyor type is similar to a commercial dishwasher, where the cages and racks are loaded on a conveyor and automatically moved through the machine for the washing and sanitizing cycles.

**Equipment Sanitizing**

Maintaining drinking-water quality requires that the recoil hoses and rack manifolds be not merely washed but internally sanitized. This is most often done at the same time the cages are washed. Separate rack-manifold and recoil-hose flush stations are available for this purpose and are usually installed in the cage-wash area. Washing can be done manually or automatically. The hoses are flushed for 1 to 2 min with 4 gpm (16 L/min) of water. Chlorine is injected into the water by a chlorine-injection station (proportioner) set to deliver 10 to 20 ppm into the flush water. Ten scfm of oil-free compressed air at 60 psig is blown through the hoses to dry them. If chlorine is used as a disinfectant, a contact time of 30 min is recommended before evacuation and drying.

Periodic sanitizing of the room-distribution piping system is required for maintaining good water quality. Sanitizing is done prior to system flushing. To accomplish this, a portable sanitizer is used to manually inject a sanitizing solution directly into the piping system. In order to do this, an injection port is required at the inlet to the pressure-reducing station. The portable sanitizer...
usually consists of a 20-gal (90-L) polyethylene tank with a submersible pump inside and a flexible hose used to connect the tank to the injection port. The disinfecting solution is a mixture of chlorine and water with 20 ppm of chlorine. The mixture should maintain a contact time in the piping of 30 to 45 min.

**Drainage-System Sizing**

As mentioned previously, for individual animal rooms where bedding is not disposed of in the drainage system, a 4-in. drain is acceptable. In general, a 6-in. drain is considered good practice. The size of the drainage system piping should be a minimum of 6 in., with a ¼-in. pitch when possible and the piping sized to flow ½ to ⅔ full in order to accommodate unexpected inflow.

**Monitoring Systems**

The monitoring of various animal-utility systems is critical to keep within a range of values consistent with the protocol of the experiments being conducted at the facility. This is accomplished by a central monitoring system that includes many measurements from HVAC and electrical systems. For the animal drinking-water system, parameters such as water pressure, flow rates, leakage, pH, and temperature in various areas of the facility are helpful for maintenance, monitoring, and alarms.

**Systems Design Considerations**

The amount of exposed piping inside any animal room should be minimized. The exception is the animal drinking-water system, which is usually exposed on the walls of the room. This piping should be installed using standoffs to permit proper cleaning of the wall and around the pipe.

The piping material used for all systems should be selected with consideration given to the facility cleaning methods and type of disinfectant. Where sterilization is required and cleaning very frequent, stainless-steel pipe should be considered.

If insulation is used on piping, it should be protected with a stainless steel jacket to permit adequate cleaning.

Pipe penetrations should be sealed with a high-grade, impervious, and fire-resistant sealant. Escutcheons should not be used because they allow the accumulation of dirt and bacteria behind them.
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CE Questions — “Animal Care Facility Piping Systems” (CEU 206)

1. An automated, central animal drinking-water supply system consists of which of the following?
   a. purification system
   b. automated flushing system
   c. monitoring system
   d. all of the above

2. The animal drinking-water distribution system should be flushed with water at about _______.
   a. 10 psi
   b. 15 psi
   c. 20 psi
   d. 25 psi

3. Purified drinking-water distribution systems for animals should be flushed _______ daily for about _______.
   a. once/two minutes
   b. twice/two minutes
   c. once/one minute
   d. twice/one minute

4. What is the most often-used treatment for animal drinking water?
   a. reverse osmosis
   b. chlorination
   c. distillation
   d. acidification

5. What is the recommended pressure for animal-room drinking water distribution piping to primates?
   a. 1–3 psig
   b. 3–5 psig
   c. 5–6 psig
   d. 6–12 psig

6. Which of the following is an advantage of the reverse S animal rack manifold configuration?
   a. eliminates dead legs
   b. offers complete isolation of individual cages
   c. easily converted to automatic flushing by the installation of solenoid devices
   d. all of the above

7. A central-supply detergent-dispensing system includes which of the following components?
   a. compressed air supply
   b. pump
   c. regulating valve
   d. all of the above

8. The pipe for a self-contained solid-waste disposal system should be sized for a maximum velocity of _______.
   a. 4 fps
   b. 6 fps
   c. 8 fps
   d. 10 fps

9. Which of the following is an acceptable location for a floor drain?
   a. center of room
   b. corner of room
   c. side of room
   d. both b and c

10. What is the recommended size for floor drains in most rooms except small animal rooms where bedding is not disposed of in the drainage system?
    a. 4 inches
    b. 6 inches
    c. 8 inches
    d. 10 inches

11. To sanitize the room distribution piping system, how long should the disinfection solution maintain contact with the piping?
    a. 30–40 minutes
    b. 30–45 minutes
    c. 35–45 minutes
    d. more than 45 minutes

12. The drainage system piping should be sized to flow _______ full to accommodate unexpected inflow.
    a. one-quarter to one-half
    b. one-quarter to one-third
    c. one-third to two-thirds
    d. one-half to two-thirds