CHAPTER 16
ANIMAL FACILITY PIPING SYSTEMS

This chapter will discuss various piping systems uniquely associated with the physical care, health, and well-being of laboratory animals. Included will be 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 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. This will eliminate as many variables as practical (or desirable) to ensure accuracy of the ongoing experiments being conducted. Regardless of the type of facility, 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, potable water, and drainage lines for the facility.
2. lO-CFR-58 is the code for Good Laboratory Practice for Nonclinical Laboratory Studies.
3. 2l-CFR-2 11, 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 National In-

stitutes of Health (NIH) as assurance that the facility is in compliance with Public Health Service (PHS) policy.

ANIMAL DRINKING WATER SYSTEM

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

System Types

The far greater 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 piped from the source directly to each cage, kennel, or pen or separate drinking bottles or watering devices manually placed in individual cages or pens.

System Description

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 otherwise treated water source, 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, among other parameters.

Animals in cages are kept in animal rooms. Cages are usually placed in multi-tiered portable or permanent cage racks that 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 PP, nylon, or EPDM. This hose is flexible, generally ⅜ 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 in 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 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 so that the flow is stopped 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 adding a solenoid valve at the end of the main run and providing a return line to drain from this point. Another method would be to flush the mains and the room distribution piping by adding a 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, at a minimum of twice daily. An approximation of the amount of water in the pipe is to 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 Lpm). If the drinking water is not purified, it is recommended that the piping be flushed at least twice daily for about 2 mm. For purified water, flush once daily for about 1 mm. Flushing can be done manually by means of a valve in the pressure-reducing station enclosure or automatically by adding a bypass and solenoid valve to the pressure-reducing station around the low-pressure assembly. The sequence and duration of the automatic flush cycle is controlled from a flush sequencer panel.

DRINKING WATER TREATMENT

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 will be added to the water at this time if required.

System Description

There are no generally recognized and accepted standards for animal drinking water quality. Purity and consistency requirements depend on the incoming water quality, established protocol of the end user, the importance of either initial or 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 study or experiments are conducted.

The most often used treatment for drinking water is reverse osmosis (RO). Other possible treatment methods are distillation and deionization (DI). A discussion of these purification methods appears in Chap. 4. Refer to Table 16.1 for commonly used water treatment options and generalized contaminant removal properties.

Reverse Osmosis (RO). When a higher-quality water is required and other types of purified water are not available in a facility, the RO treatment method is normally selected. Since the amount of water is usually small, a package type of 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. All equipment is available in a wide range of sizes and materials. A schematic detail of a typical central proportioner is illustrated in Fig. 16.1.

Chlorination. Chlorination is a recognized biocidal treatment that leaves a residual of chlorine in the entire central distribution system. Hyperchlorinated 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 to 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 medication.

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. Above 3 the mixture is not considered an effective germicide.

TABLE 16.1 Water Treatment Methods

	Reverse osmosis	Distilled	Deionized	Chlorination	Acidification	Ultraviolet
Dissolved inorganics	X	X	X			
Dissolved organics	X	X	X			
Suspended particles	X	X				
Microorganisms	X	X		X	X	X

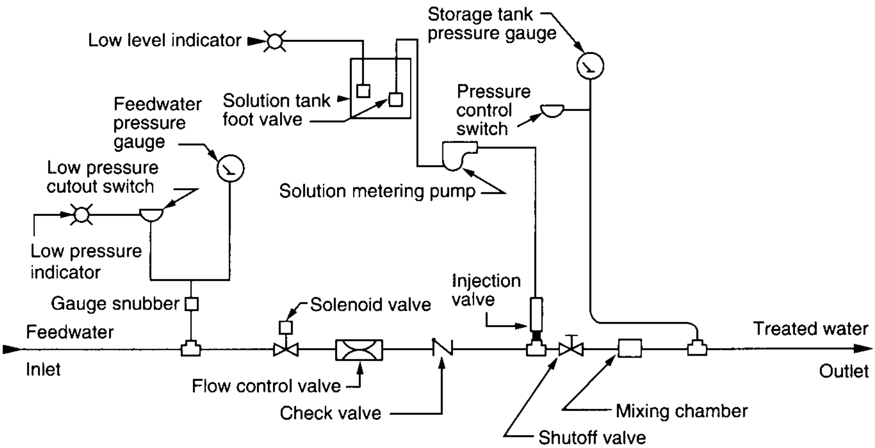

FIGURE 16.1 Typical central proportioner unit.

Adding Medication

Medication is added to the drinking water using the same proportioning equipment that adds disinfectant.

DRINKING WATER SYSTEM COMPONENTS AND SELECTION

Pressure-Reducing Station

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

The pressure and flow rate depend on the type and number of animals to be supplied. Also usually included is a 5 μm water filter, pressure gauge, and backflow preventer. Timing devices to automatically control flushing duration is provided by a remote flush sequencer panel that controls all flushing sequencing operations. The recommended pressures for animal room piping distribution to various animals are:

1. Small animals such as rats and mice: 3 to 5 psi (20.4 to 34 kPa)
2. Primates: 3 to 5 psi
3. Dogs and cats: 3 to 5 psi
4. Swine and piglets: 6 to 12 psi (41 to 81.6 kPa)

The secondary pressure-reducing assembly used to automatically provide a room distribution pipe flushing water operates at a pressure of 15 psi (102 kPa). This assembly is installed as a bypass around the low-pressure assembly. Manual operation at a lesser 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 individual small-animal rack manifolds, often referred to as *drops*. This will allow one station to control more than one animal room. The pressure-reducing station is a preassembled unit that is complete with all of the various valves, fittings, and reducing valves required for a specific project. All components are installed in a cabinet that requires only mounting and utility connections.

Drinking Valves

Drinking valves are used by the animals to obtain water from the distribution system piping. There is an internal mechanism that keeps the valve normally closed, and the animal drinking from the valve must open it by some action, such as moving the entire valve itself or operating a small lever inside the body of the valve with its tongue. Many kinds of valves are available to supply any type of animal that may be kept in the facility. They 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 drinking water system filling and flushing. The two most often used configurations are the reverse S and the H.

The reverse S, illustrated in Fig. 16.2, 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 control valve at the top, and the other has a drain valve at the bottom. Either location is optional, 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 the facility personnel when filling the piping after washing. The vent is a manually operated air bleed that is 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 of time and water usage. This configuration is used far more than any other manifold style. It is easily converted to automatic flushing by installing solenoid devices on the valve. It is recommended when microisolator cage systems are installed. The complete online rack manifold flushing system is illustrated in Fig. 16.3. This cage system has the advantage of 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 Fig. 16.4. This configuration has the advantage of complete online flushing and lesser 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 Fig. 16.5, although rigidly installed and with positive venting, is not suitable for online flushing. Because of this, it is rarely used except for larger animals that will consume all the water in the rack piping manifold.

The most common piping materials are C PVC and 304L stainless steel. CPVC conforms to ASTM D 2846 and has an 0.875 O.D. with a 0.188 minimal wall

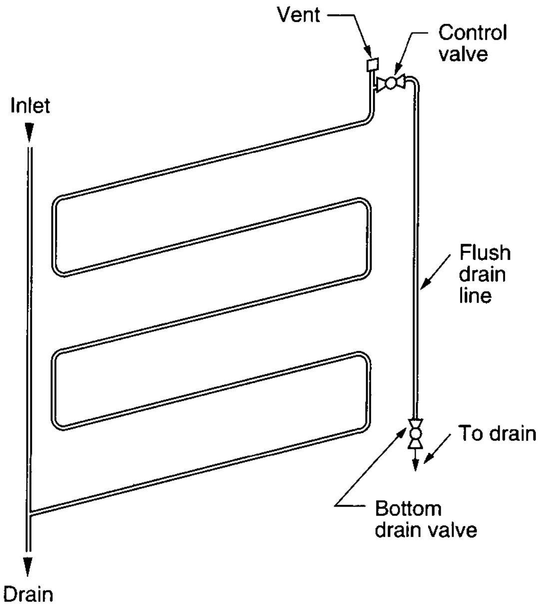

FIGURE 16.2 Reverse-S-rack watering manifold.

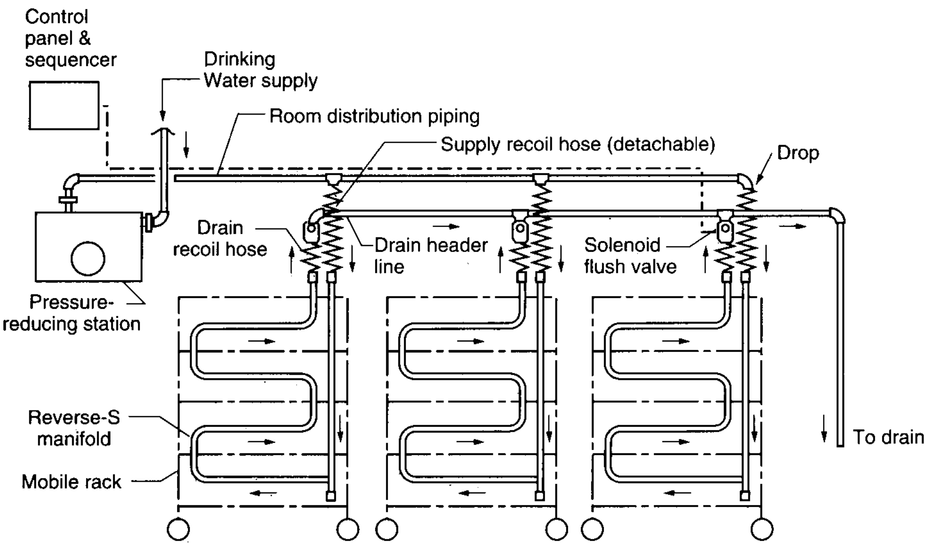

FIGURE 16.3 Typical room distribution on-line rack manifold flushing system. (*Courtesy Edstrom Industries.*)

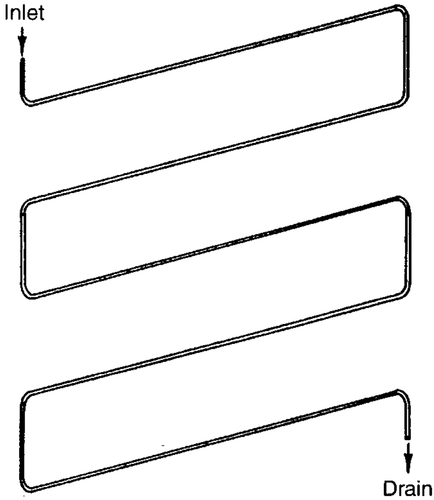

FIGURE 16.4 Standard S-rack watering manifold.

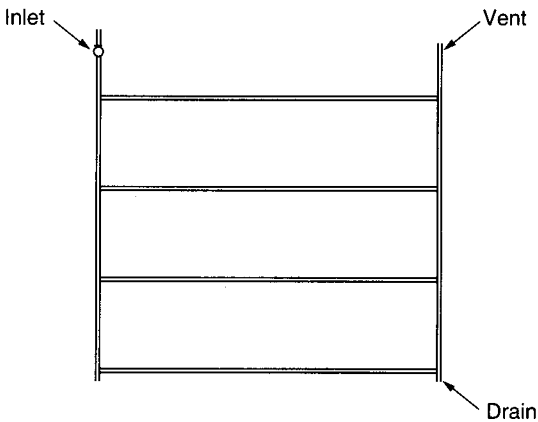

FIGURE 16.5 Standard H-rack watering manifold.

thickness. Jointing uses solvent cement socket joints. The drinking valves are installed with a proprietary drilled and tapped fitting. Stainless steel (SS) tubing, type 304L, has an 0.50 O.D. with a 0.036-in minimal wall thickness. Fittings are made with O ring joints and socket fittings or compression fittings. Mounting of both pipe materials is accomplished with the use of 304 SS clamps and fasteners.

SYSTEM SIZING METHODS

The water consumption of small animals in cages is usually very low. Table 16.2 provides animal laboratory information on the amount of water consumed daily

TABLE 16.2 Laboratory Animal Information

	Environmental considerations									
Species	Age or weight	Room temp., °F	Relative humidity, %	Ventilation changes per hour	Comfort zone temperature, °F	Amount of food required daily	Amount of water required daily	Amount of urine excreted daily	Amount of feces excreted daily	Average Btu heat produced per animal per hour	Lighting requirements
Baboon	Young adult weighing more than 5 kg	70–78	Not less than 50	12–16	65–83	2–3 lb	300–500 mL	25–45 mL/kg B.W.	150–300 mg/kg B.W.	60–140	Light cycle 12–14 h
Cat	2–4 kg	70–72	45–60	10–20	60–75	4–8 oz	100–200 mL	22–30 mL/kg B.W.	2–8 oz	25–30	Light cycle 12–14 h
Cattle	Adult	35 minimum	40–80	10–20	50–80	16–28 lb	10–14 gal	3–5 gal	60–90 lb	800	Light cycle 6–12 h
	Calves	60 minimum	No greater than 70	10–20	60–70	4–15 lb	2–4 gal	1–3 gal	3–14 lb	350	Light cycle 6–12 h
Chimpanzee	Adult	70–78	40–60	12–15	68–84	2–4 lb	600–1500 mL	½–1 L	140–410 mg/kg B.W.	40–220	Light cycle 10–14 h
	Juveniles										
Sheep	Adult	35 minimum	No greater than 70	10–20	69–77	2–4.5 lb	½–1½ qt	1–2 qt	3–6 lb	800	
Swine	Adult	60–75	55–75	10–20	42–70	4–8 lb	1–1½ gal	½–1 gal	6–7 lb		
	Sow with litter					6–15 lb	5 gal	1–2 gal	8–11 lb		
	Miniature swine	65–72	60–75	10–15	50–72	0.5–no more than 2 lb		¼–½ gal	1–2 qt	2–4 lb	250–450

(*Continued*)

TABLE 16.2 Laboratory Animal Information (*Continued*)

	Environmental considerations										
Species	Age or weight	Room temp., °F	Relative humidity, %	Ventilation changes per hour	Comfort zone temperature, °F	Amount of food required daily	Amount of water required daily	Amount of urine excreted daily	Amount of feces excreted daily	Average Btu heat produced per animal per hour	Lighting requirements
Rat	50 g	70–80	50–55	10–20	81–86	$\frac{1}{3}$–$\frac{2}{3}$ oz	20–45 mL	10–15 mL	$\frac{1}{4}$–$\frac{1}{2}$ oz	4.0	Equal light or dark periods or longer light than dark
Opossum	Adult	70–76	45–65	10–12		3–5 oz	100–150 mL	50–75 mL			
Pigeon	Adult	40–60	45–70	10–15	60–80	1–3 oz	Ad lib		Droppings, urine, and feces 2–6 oz/day	1–2	Breeding birds 12–14 h light daily
Rabbit	3–5 lb	60–70	40–60	10–20	82–84	1–3 oz	60–140 mL/kg B.W.	40–100 mL/kg B.W.	$\frac{1}{2}$–2 oz/day	34	
Monkey (Macaca muletta)	Adult	70–78	40–60	8–15	68–84	0.25–2 lb	200–950 mL	110–550 mL	110–320 mg/kg B.W.	65–200	Minimum of 8 h light per day
Mouse	Adult	70–80	50 as minimum up to 80	6–12	82–87	0.10–0.25 oz	4–7 mL	1–3 mL	0.05–0.10 oz	0.6	14 h light–10 h darkness
Guinea pig	Adult	64–69	45–60	2–8	84–88	0.5–1.0 oz; require source of vitamin C	85–150 mL	15–75 mL	0.75–3 oz	5.6	Up to 15 h light per day
	Young										

TABLE 16.2 Laboratory Animal Information (*Continued*)

		Environmental considerations									
Species	Age or weight	Room temp., °F	Relative humidity, %	Ventilation changes per hour	Comfort zone temperature, °F	Amount of food required daily	Amount of water required daily	Amount of urine excreted daily	Amount of feces excreted daily	Average Btu heat produced per animal per hour	Lighting requirements
Hamster	Adult	70–76	45–65	6–10	82–88	0.1–0.8 oz	8–12 mL	6–12 mL	0.2–0.8 oz	2.5	12-h cycle light-darkness
Horse	450–550 kg, 4–7 years old	35 minimum	40–70	6–12	50–70	17–36 lb	5–12 gal	½–3 gal	25–50 lb	550–750	
Mink	Adult	40–65	40–65	8–15		5–7 oz	75–100 mL	25–50 mL	½–4 oz	30–60	
Gerbil	Adult	70–75	55–65	8–10	81–86	0.3–0.5 oz	None if greens fed	2–3 drops	Minimal 0.1 g or less	4.0	Even tight darkness ratio; protect from direct sunlight
Goat	Adult	45 minimum	55–65	6–12	55–70	1.5–10 lb	1000–4000 mL	700–2000 mL	3–6 lb	350–550	
	Kids	60 minimum	60–70								
Chinchilla	Adult	60–70	40–60	10–15	81–86	1–2 oz/kg	65–130 mL	25–50 mL	½–1 oz	34	Light 12 h
Chicken	Adult	60–70	45–70	10–15	62–82	3.4 oz/day	Ad lib		4–8 oz/day urine and feces (droppings 4–12 oz)	30	13 h daylight or artificial light
Dog	Adult	65–75	45–55	8–12	68–70	½ lb–10-lb dog 2½ lb–100-lb dog	25–35 mL/kg B.W.	65–400 mL		80–150	

along with other useful criteria for the design of animal facilities. It is also probable that the animal room may not be used to full capacity. Because of this low flow, 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 from 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 according to such factors as the number of pressure-reducing stations, solenoid valves, and recoil hoses, as well as friction loss through the piping network. Allowance must be made for a flow rate and water velocity sufficiently high to efficiently provide the flushing action desired.

CLEANING AND DRAINAGE PRACTICES

General

Keeping the animal rooms and cages clean is an extremely important facet of facility practice. Cleaning of the animal room is accomplished either by sponging the walls, floors, and ceiling or hosing down the room. Cage racks can be cleaned by means of washing with a hose or in a large washing machine. Cages are cleaned in a cage washer. Pen and kennels are hosed down. Floors in pens are cleaned with hoses, and the feces with bedding are 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 in 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 containing 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. 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 washwater. When used to clean rooms, it 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 that 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 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 for use only for these rooms. A typical schematic detail of a single-station detergent system is illustrated in Fig. 16.6.

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 to dispense 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 Fig. 16.7.

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, it 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 Fig. 16.8.

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-

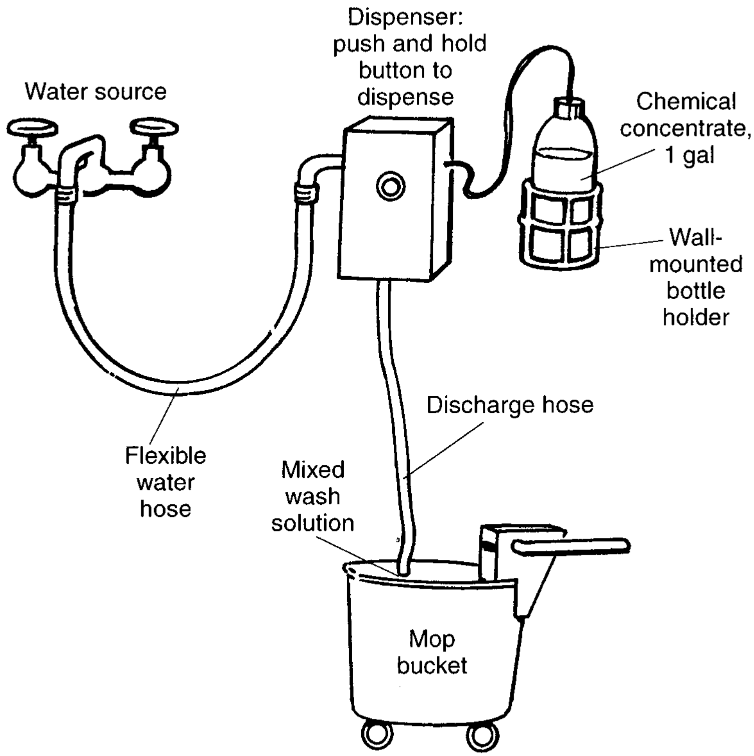

FIGURE 16.6 Typical single-station detergent-dispensing system detail.

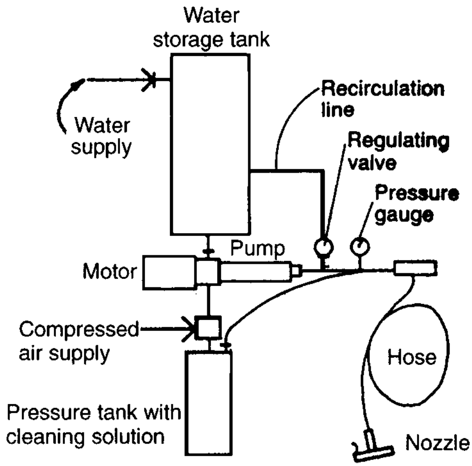

FIGURE 16.7 Typical central supply detergent-dispensing system detail.

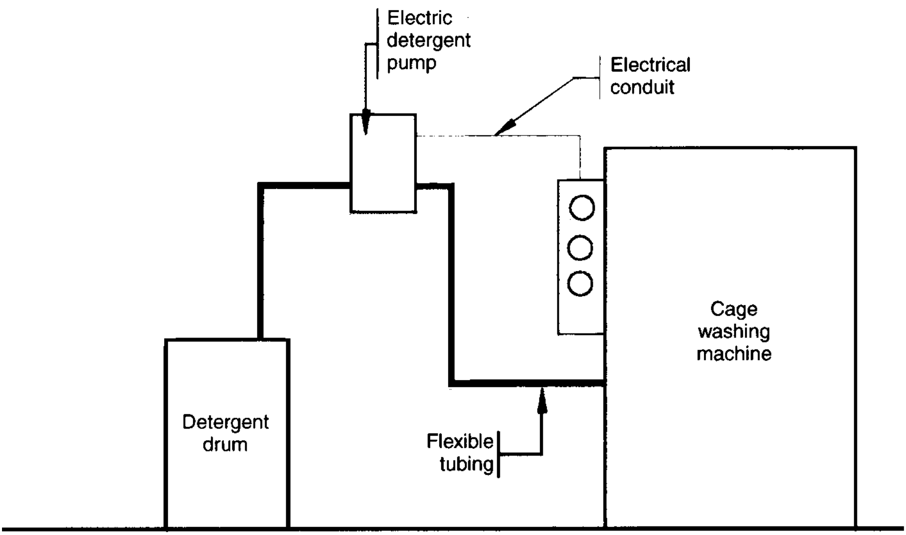

FIGURE 16.8 Typical cage washing detergent-dispensing system detail.

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 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.

The water supply could be a reservoir placed on the rack that is filled with water, which automatically discharges onto the pans at preset intervals determined by experience. Generally water is discharged from one to three times daily. Another method uses a solenoid valve to automatically discharge water onto the pans 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 one or two cages high. Current practice is to have these gages 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 that has a different quick disconnect end than that of the drinking water recoil hose to avoid cross connection. Refer to Fig. 16.9 for a detail of a typical cage rack utility connection arrangement.

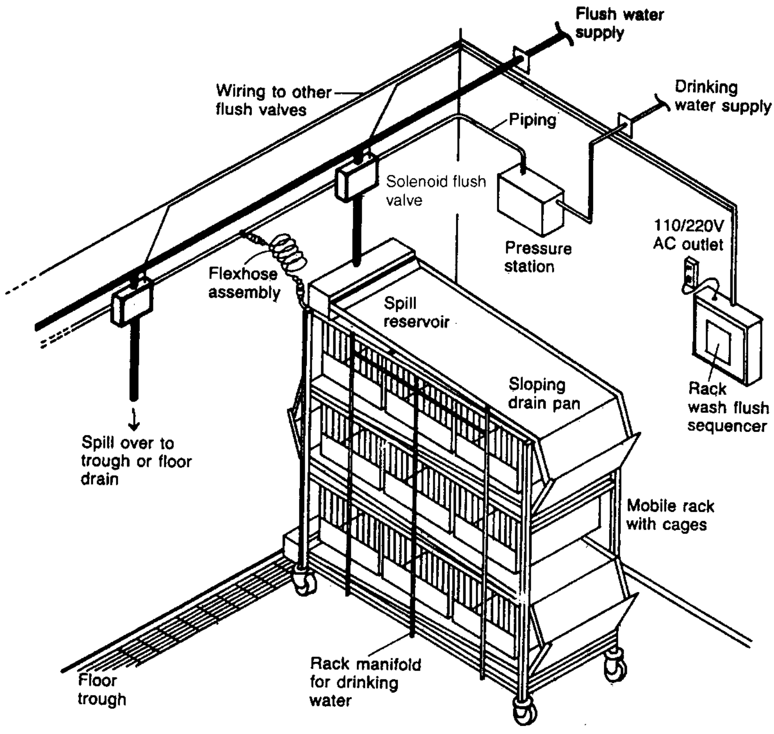

FIGURE 16.9 Typical cage rack utility connection arrangement.

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 makes up the largest quantity of this solid waste. It is necessary to determine the quantity of bedding before a decision is made as to the most cost-effective method used to dispose of it.

Bedding can be disposed of into an incinerator, a regular garbage bin, or into the sewer system. Incinerators are costly and require compliance with many regulatory agencies and multiple permits, and often they must be built over the objections of 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 and involves the collecting, moving, and storing 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. The bedding shall be water soluble and shall not float, and it shall be made to thoroughly mix with water. This mixture is called a *slurry.* Experience has shown that if done properly, discharge into an adequately sized drain line with a minimum size of 6 in (150 mm) has caused no problems, since the slurry 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 that grinds the waste into a slurry and sanitizes it, a water extractor that removes 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. This system has the advantages of reducing water use, reducing operating cost by eliminating handling of the waste by operating personnel, compacting the waste to about 20 percent 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 and requires water intermittently for pulping at the rate of about 10 to 30 gpm (63 to 190 Lpm). Hose bibbs should be installed for washdown. The pipe should be sized for a maximum velocity of 8 fps (1.75 mps), with typical slurry lines ranging between 2 (50 mm) and 4 in (200 mm) and return lines generally 2 in (50 mm) in size. The extractor discharges into a drain that should be 4 (100 mm) or 6 in (150 mm) depending on the flow. A typical schematic diagram of a multiple installation is illustrated in Fig. 16.10.

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

There are several considerations to be reviewed 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 the 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, are considered if the floors will only be squeegeed rather than hosed down. This is also a consideration in contagious areas where

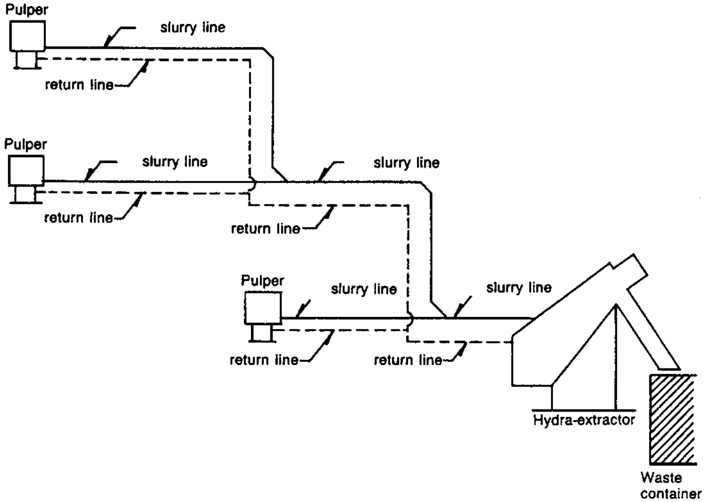

FIGURE 16.10 Typical schematic of a waste disposal system. Valves, fittings, and cleanouts not shown. (*Courtesy Somot.*)

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 ⅛ 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 remaining contamination in the trough as possible. Wall troughs, similar 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 this 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 ¼ 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) size drain is considered adequate. In most other locations, it is recommended that a 6-in (150-mm) size drain be provided. A flushing rim type of drain should be considered to flush all types of waste into the drainage system.

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

Drainage System Sizing

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

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 washers used: batch and conveyer (tunnel). Batch washers require manual loading and unloading and are used where a small number of cages and racks are washed. A conveyer is similar to a commercial dishwasher where the cages and racks are loaded on a conveyer 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 internally sanitized, not merely washed. 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 they are usually installed in the cage wash area. Washing could be done manually or automatically. The hoses are flushed for 1 to 2 min with 4 gpm (16 Lpm) 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. Hoses are dried by blowing 10 scfm of oil-free compressed air at 60 psig. 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 is used to connect the tank to the injection port. The disinfecting solution is a mixture of chlorine and water to make 20 ppm of chlorine. The mixture should maintain a contact time in the piping for 30 to 45 mm. Refer to Fig. 16.11 for a detail of the portable sanitizer and injection port.

MONITORING SYSTEMS

The monitoring of various animal utility systems is critical to keeping within a range of values consistent with the protocol of the experiments being conducted at the facility from time to time. 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 from various areas of the facility will be helpful for maintenance, monitoring, and alarms.

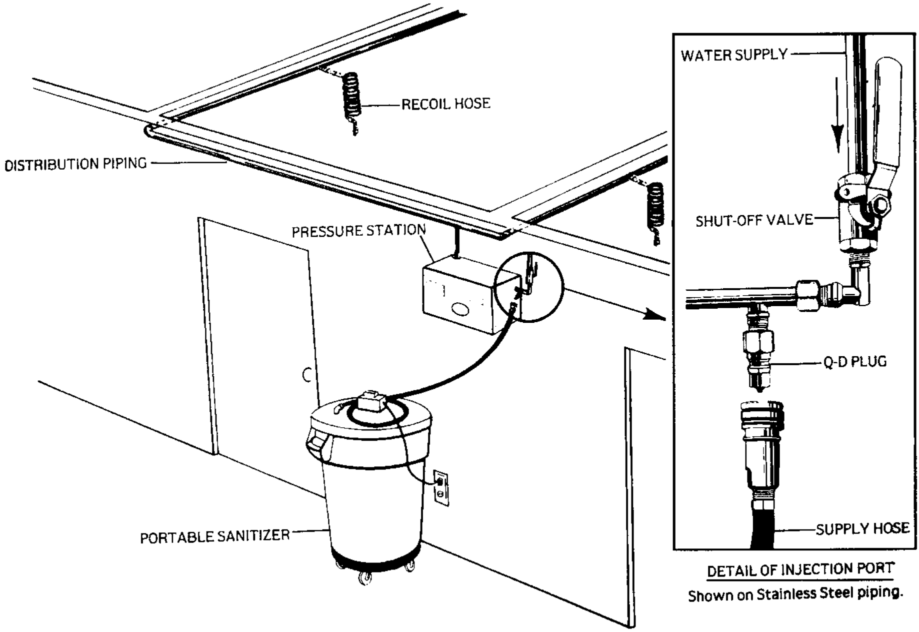

FIGURE 16.11 Detail of portable sanitizer and injection port. (*Courtesy Edstrom Industries.*)

GENERAL 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 will allow the accumulation of dirt and bacteria behind them.

SWINE COOLING SYSTEMS

Swine do not sweat and become stressed when the temperature reaches 75°F and higher. The effect could be death. It is therefore necessary to cool down the swine when these conditions are possible.

Two methods are used. The first is a drip hose used generally for sows when farrowing and for animals kept in individual pens. A small amount of water is dripped out of a hose mounted above the animals onto their neck and shoulders.

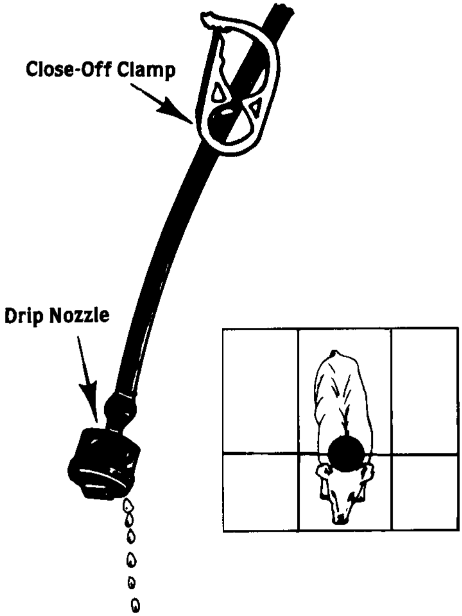

FIGURE 16.12 Detail of drip cooling outlet.

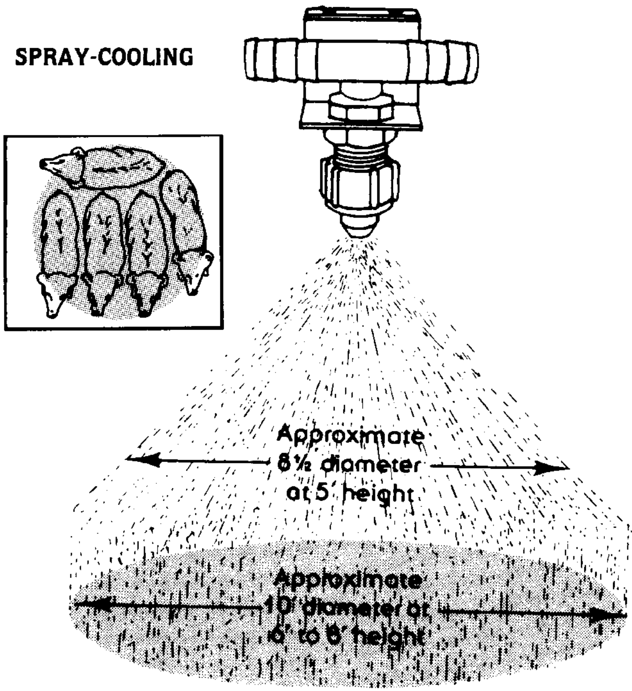

FIGURE 16.13 Detail of spray cooling nozzle.

They learn to move into position if this system is used. Little or no runoff is produced. Refer to Fig. 16.12 for a detail of the drip hose outlet.

The second method uses a spray nozzle that intermittently produces a coarse spray of water onto animals housed in group pens. Refer to Fig. 16.13 for a detail of the spray nozzle installation.

Both systems are operated from a controller. The controller is capable of operating multiple nozzles and drip hoses. It has adjustable settings for temperature at which water releases, intervals between release, and the duration of wetting.

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