CHAPTER 18
WATER DISPLAY FOUNTAINS AND POOLS

This chapter will describe the equipment and design criteria associated with water display fountains and reflecting pools.

GENERAL

Water fountains and reflecting pools are divided into four general types:

1. A *self-contained fountain* consists of a complete fountain including a pool, pump, fountain hardware, lighting, and pump. This kind of fountain is shipped complete so that only the excavation for the pool, adding water, and connecting the electrical supply are required to place the fountain into full operation. No permanent connection to the plumbing system is required.
2. A *fountain kit* is a preengineered fountain complete with pipes, pumps, nozzles, and all required hardware. This type requires installation into a previously constructed pool and permanent connection to a water source and electrical supply.
3. A *custom fountain* is designed to include many unusual decorative features and displays, including automatic and timed features such as ''dancing waters'' and other programmed effects. It is intended to be installed in a pool built specifically for the project.
4. A *reflecting pool* is a custom-designed body of water intended to achieve an architectural reflecting treatment without spray nozzles or other functions.

TYPES OF INSTALLATIONS

There are three general types of pool design: flow through, fill and drain, and recirculated.

The *flow-through design* has water passing through the pool continuously. This type should be used only where there is an almost unlimited supply of reasonably clear water and an easy means of supplying the water to the pool and returning the water to its source. The water supply should be filtered and the backwash returned to the source.

The *fill-and-drain* design has the pool filled with clear water, which is kept in service until it becomes turbid enough to be unfit for further use. At this point the water is drained, and the pool is refilled with water. This type of pool is usually limited to a capacity of approximately 500 gal and less.

The *recirculation design* is the most common. This design uses the same water continuously, with only small amounts added to make up for water lost through evaporation and wind drift. Water is pumped through filters to keep it clean with an algicide added if necessary to keep the pool free of algae. Often a vacuum cleaning system is provided to remove debris. It is generally accepted practice in pools of 1000-gal capacity or more to have a separate pumped pool circulation line that is filtered and treated and a second pumped spray nozzle water system that is not treated.

SYSTEM COMPONENTS

The equipment consists of pool spray (display) nozzles, lights, pool circulation system, water display system, pool makeup and fill methods, pool vacuum cleaning system, overflows, water treatment system, heaters, filters, and strainers.

EQUIPMENT

Spray and Jet Nozzles

Jet nozzles can direct a smaller, solid stream of water high into the air with pressure from a pump. Mushroom-type nozzles use a large volume of water to form a wider pattern of water lower to the pool surface. Spray nozzles are designed to produce a thin sheet of water in many possible patterns. Any of the above types of nozzles can be designed to produce an unlimited variety of patterns and spray height. If the design of a decorative fountain is to be made, become familiar with the patterns and limitations of the available nozzles in order to select a nozzle for a specific purpose. Each spray nozzle will produce the desired pattern only when supplied with the volume and pressure of water it requires. The manufacturer will provide the necessary nozzle information for each specific nozzle in its line.

By using a timing motor and automatic valves that are turned on and off in programmed sequence, very special shows that include lighting effects also timed to the nozzle operation can be achieved.

Lights

Lights, when provided, should be installed under the surface of the water, generally 2 in lower than the water level. The lights are used for both general pool illumination and specific direction. Different colored lenses are available for different effects. The lights can be directed either horizontally or vertically up toward a nozzle. Dimmers can be used to control the intensity of the lighting, and timers to vary the sequence of operation of individual lights to obtain special effects. The programmed sequencing units are not waterproof and should be located indoors and near the source of power for ease of wiring.

Pool Recirculation System

Used to keep the pool water clean and warm if desired, the recirculation system functions by drawing water from various pool drains, circulates the water through a strainer, main filter, and filter pump, and returns the water to the pool through separate inlets. In a fountain with special or programmed spray jets, the spray jets are usually separated from the pool circulation system. If the spray jets are uncomplicated, the filtered water can be returned to the pool through the jets.

A strainer is the first item in the recirculation system. It is used to protect the pump from damage and nozzles from becoming clogged by removing large-sized debris. A basket strainer is preferred for larger pools because of its large capacity. Where vacuum cleaning is an integral part of the circulating system and continuous operation of the fountain is desired, duplex strainers may be considered. Generally accepted practice is for the strainer to have openings one-half the size of the spray nozzle orifice.

The selection of a pool circulating pump is based on the pressure drop through all the components of the system and the gpm required to circulate the contents of the pool in 8 h. A centrifugal pump is most often used for this service.

The filter is usually a high-rate pressure sand filter. It consists of a pressure vessel containing sand of different sizes. A distribution header inside the vessel distributes water evenly over the sand bed. When the filter becomes clogged with dirt, water is reversed (backwashed) through the filter and the discharge is routed to the sewer. Experience has shown that this type of filter has the least initial cost and the least maintenance. An average filter size has a capacity of approximately 15 gpm/ft^2 of filter area. The backwash rate is the same as the filter rate. The need for backwashing is determined by reading pressure gauges installed on the inlet and outlet of the filter. The source of backwash water is usually separate from the display pool system, often originating from the potable water supply. If not separate, the pool water must be used for backwash and an equal volume used to fill the pool.

Another type of filter is a diatomaceous earth filter, which could be either pressure or vacuum type. For both, the filter medium (a fine powder) is distributed evenly on a fine mesh screen, and the water passes through the screen with the filter medium on it. This type of filter is more costly, and it requires costly controls, but it will produce clearer water than the sand filter. The vacuum type requires a different piping arrangement. Both types are maintenance intensive. For all of these reasons, this type of filter is rarely used.

In some installations, it may be sufficient to filter a smaller percentage of the capacity of the circulation pump. This would permit a smaller filter and a separate pump for the filter but will result in operating cost reduction. Smaller pools may use a cartridge filter that is discarded if the flow of water and the amount of debris are small.

Water is drawn into the recirculation system from drains and inlets located in various parts of the pool. Each pump suction creates a vortex, which is a funnel-shaped element below the water level having the larger open end at the water surface and extending into the inlet that has the smaller end of the vortex. This vortex allows air to be drawn into the piping, which is detrimental to pumps and causes sputtering in the display nozzles. In order to prevent this, drains shall be provided with an antivortex cover or inlet with an integral antivortex arrangement. In addition, inlet capacities to drains should be limited to 80 percent of the rated capacity, thereby reducing the velocity of the water entering the inlet.

Water Display System

Used to control the operation of the display spray nozzles, this system operates by using a separate drain in the pool that is connected to the suction side of the dedicated display pump. The pump discharge is connected to the display nozzle assembly. This assembly consists of piping, display control valves, and the display nozzles.

The pump is selected by finding the maximum flow requirements of the nozzles and calculating the total dynamic head by adding together the pressure loss from the water spray nozzle and pressure losses through all components of the piping system. The characteristics of each nozzle is obtained from the manufacturer.

Since it is almost impossible to obtain a pump with the exact pressure requirements for a perfectly matched display, part of the piping to the nozzles should include both in-line control valves and bypass valves at the nozzles to divert water to the pool and provide the exact gpm and head required. Valves installed on branch lines to individual nozzles will allow them to be isolated if repair or adjustments are found to be necessary. Plug, ball, and globe valves have proven to be satisfactory for regulating flow. The main drain used to obtain or discharge water from the bottom of the pool may have to be installed in a depression to avoid drawing in air along with the water if the pool is shallow. To avoid excessive noise and erosion of the piping, generally accepted practice is to limit the velocity of water in the system to 6 fps.

In order to avoid wind-carried water spray from wetting passersby, a wind control device could be installed that would shut down or lower the height of some or all spray nozzles that, because of the height of water discharge, would cause the drifting of water beyond that desired.

Pool Water Makeup

Water is lost from a pool by evaporation and wind drift from the water spray nozzles. The level of water in a pool should be kept within a narrow range so that the lights are covered and the nozzles are the same distance below water level. This can be done either manually or automatically.

The manual method has the least initial cost and requires a maintenance person to be present most of the time. When the maintenance person becomes aware that the level is low, the valve on the water supply shall be opened to fill the pool until it reaches the high water level. Manual operation shall be limited to small pools that cannot be damaged by a low water level.

If done automatically, it is possible to maintain two different levels of water. The first is the normal water level. When water falls below this level, water shall be added to the pool. The second level is the emergency low level that when reached will shut down lights or other devices that require that minimum height of water to function properly. The level device is placed in the pool within a stilling tube. This avoids premature starts and stops by wave action. This device sends a signal to an automatically operated valve that opens on low water and closes on high water and cuts off electricity at the emergency low level.

When potable water is used as the initial fill and for makeup, the pool supply should be over the rim to create an air gap. This dimension shall be either 2 in or 2 pipe diameters of the fill line, whichever is the larger dimension. If any below-water-level method is used, a reduced pressure zone backflow preventer must be installed in the inlet to the pool.

Vacuum Cleaning

Vacuum cleaning of the pool is required if the pool is outdoors where the public may litter the water. It is also easier to clean algae from the pool with a vacuum system. This can be done either with a built-in system or portable unit.

A built-in system has special outlets located below the surface of the water with the piping connected to the suction side of the pool circulation pump. The outlets have hose connector ends that make the attachment of cleaning hoses easy. The hoses have a brush or other special end and are of a length so that they can be extended to all parts of the pool. An average spacing of the outlets is 1 for every 40 ft, 0 in, of the pool perimeter.

Overflows

An overflow is required to prevent water from spilling over the top of the pool onto the surrounding area. There are two reasons an unwanted amount of water enters a pool: (1) accidental fresh water makeup from a public water supply and (2) rainfall, if the pool is located outdoors. The size of the overflow should be two sizes larger than the makeup water supply or sized to take the maximum amount of rainfall, whichever is larger. The local code must be followed to determine if the discharge is routed to the storm water or sanitary sewer system. The height of the overflow above the water level must allow for wave action from the pool splashing over the side.

EPA or local regulations may prevent the discharge of chlorinated water into the storm water drainage system, dictating the use of the sanitary system for discharge of the overflow and to empty the pool.

Water Treatment

The growth of algae in pool water causes the water to become cloudy and pool surfaces to be covered with slime and causes additional load on the filter. Algae grows faster in sunlight. To prevent algae growth, the pool water must be treated with an algicide or disinfectant. In small installations, they could be added to the water by hand. In larger pools, it is more easily done automatically with a chemical proportioning system. The two most often used chemicals are sodium or calcium hypochlorate, with sodium hypochlorate being the most common.

The chemical proportioning system consists of a chemical supply in liquid form and a proportioning pump that delivers the correct amount of chemical into the recirculating water stream.

Chemicals can be bought either as a powder that must be mixed by hand or as premixed solutions. The solution must be pumped into the water by means of an *injector pump,* commonly called a *hypochlorinator:* The suction is connected to the chemical supply, and the discharge into the circulated water line as close to the pool inlet as practical. The pump is arranged to be running only when the circulating water pump is running.

The dosage generally recommended for pool water is 5 ppm for indoor pools and 10 ppm for outdoor installations. The capacity of the pump can be found from the following formula:

$$P = 0.0005 \times \text{gpm} \times \text{ppm} \tag{18.1}$$

where P = pounds of chemical per hour
ppm = required dosage
gpm = capacity of the circulating water pump

For example, the following calculation is for a feed rate with a 15 gpm circulating pump for an indoor pool. Substituting in Eq. (18.1):

$$P = 0.0005 \times 15 \times 5$$
$$= 0.0375 \text{ pound of chemical per hour}$$

In order to be effective, the pH of the water should be within the limits established by the supplier of the chemicals used.

Pool Heater

A pool water heater is necessary if there is a possibility that the water in the pool may freeze. Frozen water will damage the nozzle piping and crack the sides of the pool and must therefore be avoided at all costs.

There are two types of heating systems. One type heats the pool circulation water. This requires only the additional piping to and from the heater. A second type, which has a much higher initial cost, is an independent, closed-loop system. It circulates a chemical solution (such as ethylene glycol in water) through a pump and a separate piping system embedded in the pool floor. This system also requires a compression tank. This type of system is selected for large pools that are intended to be shut down, but not emptied, for periods of time.

Although the heater can be oil, gas, steam, or electric fired, the most common is electric because of the low initial cost and the fact that no vent is required. Oil- and gas-fired heaters require vents that may not be possible to install in the area where the pool mechanical room is located.

The heater size is based on maintaining a pool water temperature in a range between 40 and 45°F. For outdoor pools, a wind velocity of 15 mph is assumed. The formula for finding the kW requirement of the heater is:

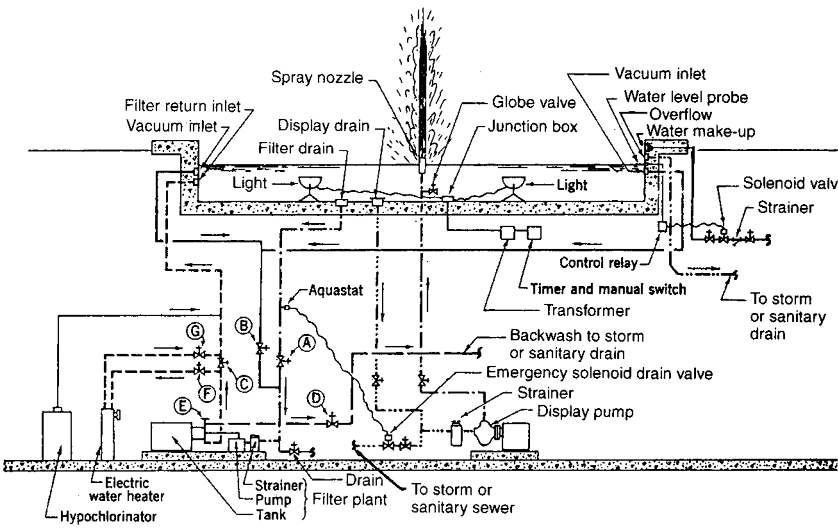
$$\text{Kilowatts} = \frac{\text{square feet of pool area}}{405}(40 - \text{lowest air temperature}) \tag{18.2}$$

To convert kilowatts to British thermal units, multiply kilowatts by 3.4.

Another important feature to consider installing is an emergency pool drain that will send an alarm and/or automatically operate a valve to empty the pool when the water temperature reaches 35°F. If there is no place that is occupied 24 h/day to put an alarm, install an automatic drain valve on the pool drain to the sewer.

SYSTEM CONFIGURATIONS

For a schematic detail of a typical large display pool, refer to Fig. 18.1. If multiple display pools are installed at different levels, refer to Fig. 18.2 for a typical arrangement. Some approximate dimensions for aspects of water spray nozzles are illustrated in Fig. 18.3.



Lettered valve schedule; A, normally open, closed when vacuuming; B, normally closed, open when vacuuming; C, normally open, partially closed in winter when heater is on; D, normally closed, opens in conjunction with E for backwashing; E, two-position valve is set for either filtering or backwashing; F and G, normally closed, open when water heater in on.

FIGURE 18.1 Piping diagram of typical decorative display fountain.

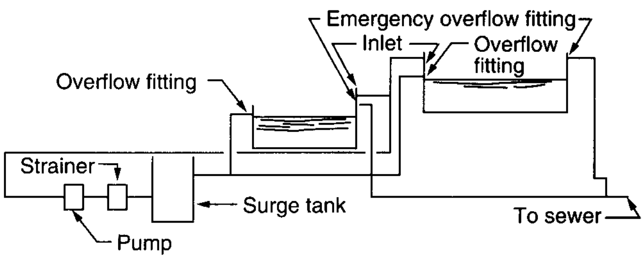
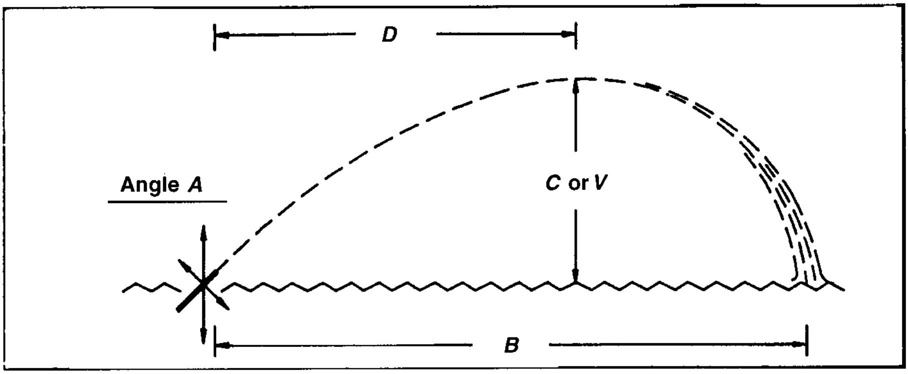


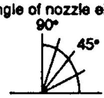
FIGURE 18.2 Piping diagram for display pools at different levels.



Design factors

A	E	C, % of B	D, % of B
5°	0.90	6	36
15°	1.33	11	46
25°	1.83	17	49
35°	1.94	22	51
45°	2.10	27	52
55°	1.80	36	53
65°	1.50	50	56
75°	0.90	99	59
85°	0.40	245	64

A Angle of nozzle elevation:



B Horizontal distance of throw from nozzle
C Height of trajectory in percentage of *B*
D Highest point of trajectory in horizontal distance from nozzle, measured in percentage of *B*
E Multiplying or dividing factor for spray design calculations
V Vertical spray height

	To find:	Procedure:
1.	*B*	$B = V \times E$
2.	Performance requirement of a spray pattern with known angle of nozzle discharge or the equivalent vertical spray height performance requirements	Establish horizontal distance of throw from nozzle, and divide by factor *E* on same line as shown discharge angle of nozzle. This will give vertical spray height, which is then used to find performance requirements. *A* – *B* *E* = vertical spray height
3.	Trajectory of a steam or jet of water *V*	Establish horizontal distance of throw (factor *B*) then calculate factors D and *C* therof, and combine the results with *B* to lay out the trajectory.
4.	The jet elevation angle *A*	Establish horizontal distance of throw (factor *B*), calculate highest point of trajectory (factor *C*) thereof, and read on the factors table the angle of elevation (factor *A*) on the same line as the result of the calculated height of trajectory (Factor *C*).
5.	Nozzle pressure to achieve *V*	Multiply vertical spray height (factor *V*) x 1.22 + 10%

FIGURE 18.3 Dimensions for aspects of water spray nozzles. (*Courtesy PIM.*)