Water Supply and Distribution

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A successful water system will supply the correct quantity of water of adequate quality and temperature for each application. There are many end use points for water in a milking center and on the dairy. The water supply system must meet the needs of several of these uses simultaneously. The water distribution system should be designed so water pressure is adequate at all locations and water is conveniently available at locations of frequent use. The water use strategy and design of the water system and will result in requirements for a well, or series of wells, that can provide the water quantity and peak flow rate required. The milking center will also produce a certain amount of wastewater that must be dealt with after its last use. A carefully developed plan for water use, reuse and disposal will result in significant savings in water use, well and pumping costs and treatment and disposal system costs.

Water Quantity

The maximum flow rate of coincident water use is referred to as the peak use rate. Careful planning and management can significantly reduce the required maximum capacity of the well. The peak use rate on dairy operations usually occurs during cleanup after milking and may last for 1 to 2 hours. The use of holding tanks is recommended to reduce the peak rate required from wells and to take advantage of the many opportunities for water reuse. When water is reused, attention must be paid to the order of intended use so that water quality requirements for the various end uses are not violated. The major water uses in the milking center, estimates of quantity and peak flow rates and reuse options are listed below and summarized in Table I.

Daily water use for cow preparation generally below 1/2 gallon per cow per day when a pre-dip and recommended low water volume methods are used for cleaning dirty udders and teats before milking. Up to 4 gallons of water per cow can be required if hand operated wash hoses are used excessively. Spray pens or other automatic cow preparation schemes use more water per cow but are normally used only in hot dry climates.

Automatic Clean-in-Place (CIP) systems for milking machines require from 100 gallons per wash for small parlors to over 500 gallons per wash for large parlors equipped with milk meters or weigh jars. The length and diameter of the milklines and wash lines and number of cycles per wash have a big influence on the water volume required to clean the milking

system.. Consult your milking equipment dealer for an estimate of the hot and cold water requirements for cleaning the type and size milking system that you intend to install. The first rinse of the milking machine should be discarded as it contains waste milk. The water from the other cleaning cycles can be reused for washing floors and walls if handled properly.

The floor and walls of the milkroom and parlor floor will requires 50 to 100 gallons of water per wash. A typical ¾-inch hose will supply 5 to 10 gallons per minute. Multiply this flow rate by the anticipated time required to wash the parlor and milkhouse floors. To estimate total daily use, multiply the above figure by the number of milkings per day. Locate hose reels for easy access to all parts of the milkhouse and parlor. Water connections should be located to limit hose length to 60 feet.

The cow platform and holding area are usually washed with a high volume hose or with automatic flushing systems. Wash hoses used for major solids removal are typically 1.5 to 2 inches in diameter and deliver 10 to 20 gallons per minute. Total water use ranges from 500 to 1000 gallons per wash. Removal of major solids by hand scraping will significantly reduce the amount of water required. If Automatic flushing systems are used, the water quantity can be as high as several thousand gallons per wash. Both hose and automatic flush systems are normally fed from a holding tank. Hose systems typically use a pump to supply the required water volume and pressure.

Pre-coolers use large quantities of well water to cool milk as it is being delivered to bulk tanks. Water to milk flow rates through most pre-coolers range from 1:1 to 2:1. To estimate the amount of water used by the precooler multiply the total milk expected per milking by2. Pre-cooler water remains potable after use, and can be stored for potable uses, cattle watering or floor wash down. Size the holding tank large enough to hold water from one milking.

Water softeners generate from 70 to 120 gallons per regeneration cycle for 24,000 and 30,000 grain capacity water softeners. Water hardness, water softener grain capacity, and the softness goal strongly influence wastewater generation volumes. For most milking center applications, the amount of water generated per regeneration cycle can be estimated at 80 to 90 gallons for 30,000 grain softeners. This amount should be increased to 110 to 120 gallons for 24,000 grain softeners. Weekly water use can be estimated by multiplying per cycle amounts by the total number of regeneration cycles per week. To obtain daily average figures, divide the above number by seven.

The importance of water as an ingredient of the ration of the dairy cow should not be overlooked. Dairy cattle require 4.5 to 5 pounds of water for each pound of milk produced. Recommended peak flow rate to waterers is 0.5 to 1 gallon per minute for every 10 animals. Provide adequate pipe size and head to supply this flow rate.

Table I. Approximate milking center water use.

Bulk Tank Washing	3 to 5% of bulk tank volume per day
Cow preparation	
Manual, with udder wash	1 to 2 gallons per cow per milking
Manual, with use of pre-dip Manual	0.2 to 0.5 gallons per cow per milking
Automatic	5 or more gallons per cow per milking
(Automatic cow washing is not usually used in northern climates)	
Milking System CIP	100 to 500 gallons per milking
Milkhouse and Parlor Floor wash	50 to 100 gallons per milking.
Cow platform and Holding area Floor Washing	
High Pressure Hose	500 to 1000 gallons per milking
Automatic Flushing	500 to 1000 gallons per flush
Well water pre-cooler for milk	2 times milk volume per milking
Water Softener Flushing	70 to 120 gallons per regeneration
Toilet and Other Domestic Water use	50 to 100 gallons per person per day
Water Ring Vacuum Pump	4 gallons/minute / 100 cfm of pump capacity
Water for Livestock	
Milking cow	4.5 to 5 times milk volume
Others	1.5 gallons per day per 100 lb. body weight

Hot Water

Heated water is required for various cleaning operations. The highest temperature requirement is for the detergent cycle used for cleaning the milking machine and bulk tank. A sufficient volume of water at 160 to 180 ◦ F must be provided to clean the milking machine after each milking (a minimum of twice per day) and to clean the bulk tank whenever it is emptied. The initial rinse, acid rinse and sanitize cycles used as part of the cleaning regime for milking machines and bulk tanks is typically 100 – 120 F. Water of this temperature may also be used to wash interior surfaces of the milkroom and for cleaning dirty udders. This lower temperature (100 - 120◦ F) water can be obtained from a high temperature water heater (160 - 180◦ F) with the use of a mixing valve, or from a separate water heater or bulk tank heat recovery tank set at the lower temperature.

The water heater should be sized to meet the maximum hot water requirements during the milking system and bulk tank cleaning cycles. Consult your milking equipment dealer for hot water requirements for cleaning milking equipment and check local guidelines for minimum water heater size requirements.

Hot and cold water should be supplied to all sinks and vats in the milkhouse. Provide a mixing faucet for hot and cold water with a hose and nozzle for cleaning the bulk tank, floor, and walls. All hot water pipes should be insulated.

Water Quality

Water from wells must be tested for bacteriological and chemical quality to know whether it is acceptable for its intended uses. Water can be treated to remove a variety of impurities if needed.

Acceptable quality depends on the ultimate use of the water. For example drinking water must be potable (safe to drink) and palatable (acceptable flavor, appearance and odor). Water for livestock does not usually need to be as free of impurities as water for humans. But water containing certain biological or chemical impurities can adversely affect the growth and health of livestock.

Check with local health or extension service personnel about bacteriological and chemical testing laboratories, proper procedures for drawing a water sample, and testing fees. Select and install treatment equipment only after determining you water quality needs and checking the quality of available water. Some of the more common water treatment methods are described below.

Hard water is a relative term used to describe the amount of dissolve calcium and magnesium. Hardness is expressed as mg/l as Calcium Carbonate ($CaCO_3$) or as grains per gallon (gpg). Softening water exchanges calcium and magnesium ions with sodium ions on the surface of an ion exchange resin in a tank. Hard water will form scale in hot water pipes and water heaters. These minerals also interfere with the cleaning action of detergents. Water with hardness more than 10.5 grains per gallon may require softening. Consult your supplier of cleaning chemicals for a water test and recommendations on installation of a water softener.

Iron can be a major nuisance in water supplies. It gives a bitter, metallic taste, stains clothes and fixtures and promotes growth of iron bacteria slimes in plumbing. A number of treatment processes are available for removing iron including water softeners, polyphosphate water treatment, and oxidation filtration. Nitrates can cause health problems in young humans and animals. Sulfates can cause palatability problems. These minerals are not removed by softening.

One of the newest water treatment processes is reverse osmosis, in which a membrane acts as a molecular filter to remove up to 95% of dissolved solids. Water pretreatment, such as

calcium removal with a water softener, is usually required to assure effective performance. Reverse osmosis is effective in producing acceptable level of total dissolved solids, fixed solids, hardness, sodium, bicarbonates, chloride, nitrate, sulfates, fluorides and others. These are expensive systems and should only be considered if a water quality problem is identified, and alternate treatment methods and water sources have been explored. If the only water available is highly mineralized, specialized treatment to remove or reduce the minerals may be the only economical solution.

Disinfection will be required to make water potable if harmful bacteria are found in the water source. Disinfection is most commonly accomplished using chlorine. Heat, ultraviolet light, iodine, and ozone are also used in special cases.

Water Distribution

The water distribution system is composed of the pipes, valves, holding tanks, and pumps, which supply water to its end use points at the required flow rate and pressure. Water connections should be located to limit hose length to 60 feet. Pipes must be sized so pressure drops due to frictional are not excessive.

If well yield does not meet the peak flow requirements of the system a pressure tank can be installed to provide peak flow demands. A pressure tank provides a small amount of storage, usually 10 to 30 percent of the tank size. This provides a small amount of water without starting the pump. It also helps satisfy water needs during short peak use periods. Size pressure tanks volume for about 10 minutes of pump operation. Multiply the pump capacity, in gpm, by 10 to get the size of the pressure tank in gallons.

When the water source and pressure tank cannot deliver the required flow rate, an intermediate storage and two-pump system can be used. Intermediate storage also facilitates water reuse, which can significantly reduce total water quantity requirements.
The first pump usually the well pump has a low level cut-off and a capacity slightly less than the well yield so as not to pump the well dry. This pump fills an intermediate storage with water for peak use periods. A second pump draws the water from the intermediate storage and forces it into a pressure tank. Size the second pump to provide the peak use flow rate. Intermediate storage can be plastic, concrete or steel tanks. Protect the storage from contamination. The intermediate storage may be elevated to avoid the use of pressure tank and second pump.

If the water source can deliver the required flow rate most of the time; size the intermediate storage for the duration of peak flow. If your source tends to decrease or dry up for short periods, consider an intermediate storage with at least one day's total water needs. Additional storage capacity will also allow for future expansion and emergencies such as at least 1200 gallons for fire protection.

Pipe Material and Size: The types of pipe generally used in water systems are galvanized

steel, copper, and plastic. Galvanized steel pipe is suitable for all piping inside buildings. Plastic and copper are preferred for underground installations. Highly mineralized water greatly reduces the life of steel pipe.

Before beginning layout and sizing of the piping system prepare a schematic water use diagram illustrated in Figure 1. This diagram can be used to explore options for reuse and to develop a layout of the piping system that minimizes the length of pipe runs and number of fittings. The peak flow rates for each section is used for pipe sizing.

A general design rules of thumb for pipe sizing is that friction loss should not exceed 5 psi from the pressure tank to the service entry and should not exceed 10 psi form the pressure tank to any isolated fixture. This criterion is generally met if peak flow water velocities are limited to 4 feet per second. The water flow rate, in gallons per minute, that produces this velocity for various pipe sizes are given below:

	Water Flow Rate (gpm) Pipe Material		
Nominal Pipe Size	Steel	Copper	Plastic
1/2 "	3	2	3
3/4 "	6	6	6
1 "	10	10	10
1 1/4 "	18	14	18
1 1/2 "	25	20	25
2 "	40	35	40
2 1/2 "	50	-	50
3 "	90	-	100
4 "	140	-	140

This information should be used only as a rule of thumb to estimate pipe sizes. The pipes in the distribution system should meet or exceed the minimum requirement of the national plumbing codes and local codes. The plumbing in milking centers should be done by a plumbing contractor. Provide the plumbing contractor with a list of all intended tasks and equipment that will use water and the physical location of end use. Equipment manufacturers can provide water quantity and flow requirements for their equipment.

For more detailed information on the design of water supply and distribution systems consult Midwest Plan Service Publication number 14, Private Water Systems Handbook.