Achieving Hydraulic Compatibility

On talk shows, often the question "Can this marriage be saved?" is posed to a husband, wife and audience. Pretend for a moment that we are together on a utility talk show with the subject "Can two elevated tanks live together in the same water distribution system?" The moderator, operator and engineer are earnestly discussing all the issues. Although the topic may not be titillating to the average viewer, it is for the system with this problem.

By Sterling L. Carroll

Can two elevated tanks work together in the same system?

Over the past months, the Florida Rural Water Association has had several water systems call about similar problems they are having with new elevated water tanks: The upper tank only operates on the lower portion while the lower tank overfills and never empties. The design engineer has tried to provide answers, but the water system is still deeply unsatisfied. The two tanks do not work together.

Why did this happen? Whose fault is it? Is it an operational problem or a design problem? What must be done to correct this problem, allowing two elevated storage tanks to operate in unison and float on the system without adjustment to operational levels?

Tank Operations

Elevated tanks hydraulically float on the water system, ensuring adequate water volumes to maintain system pressures at a uniform level. The tank empties during times of high demand, and it fills at night and during other times when water demands are low. Well pumps or high-service pumps supplement the pressure and flow from the elevated tank. As the water system grows, the high-service pumps provide more of the demand, but the elevated tank still rules or defines system hydraulics.

Water system hydraulics can be visually represented, shown in Figure 1 as a hydraulic grade line. The hydraulic grade line is a plot of the water pressure in a distribution system from the water plant to some remote point. During times of high demand, pressures drop in the system extremities and the hydraulic grade line drops slightly. When flows are low and system pressures stabilize, so does the hydraulic grade line—it flattens out.

Both elevated water tanks will have their own hydraulic grade lines, and it is up to the design engineer to make sure these grade lines match and that the tanks work together today and in the immediate future. There are several ways for the designer to ascertain that all of these components will match up, including: a water system computer model; system-head curves for average daily, maximum daily and peak-hour demands; and hydraulic grade line calculations. If the engineer overlooks this step, the two tanks could end up fighting one another.

Operational levels are not adjustable without additional mechanical devices or extraordinary daily adjustment. Continuous operational adjustment is contrary to the elevated tank design choice. It is not possible to simply allow both elevated storage tanks to float on the system in unison without changing major system components (i.e., number of customers, pumps or pipe sizes).

Possible Solutions

Consider the following potential solutions to this problem:

Install pumps to empty the lower tank and boost water into the upper tank. Pumps might be installed to force the lower tank empty and to fill the upper tank. This option is not realistic; elevated tanks should reduce pumping and operation and maintenance costs, not increase them.

Shorten the upper tank or raise the lower tank. Realistically, the new tank is several feet too short or the old tank too tall. Changing tank height is never feasible or cost-effective.

Pressure-reducing valve. The best fix for this problem is to divide the system into separate pressure zones—the upper portion from the lower portion. This separation is

Figure 1: Two elevated tanks in a distribution system.

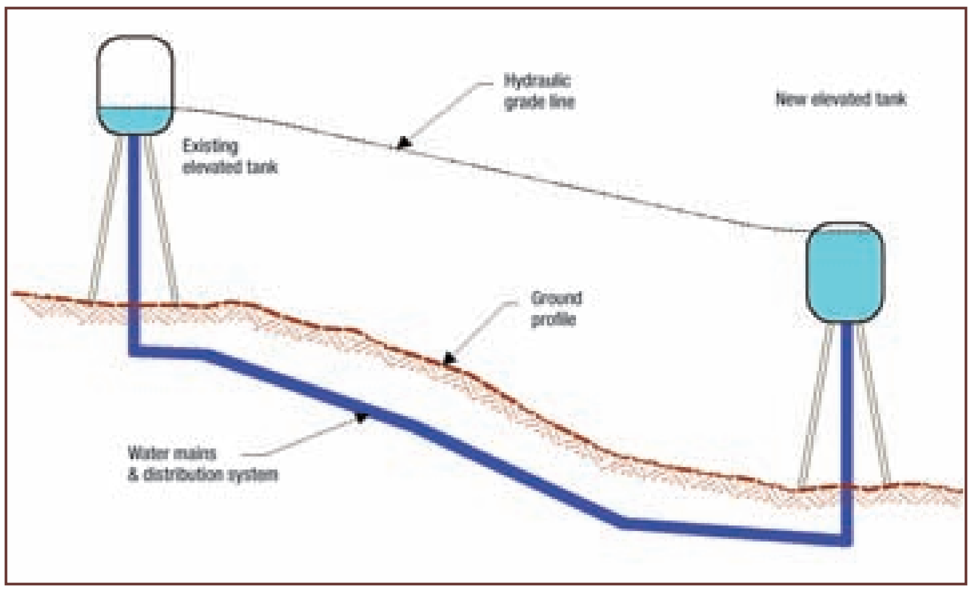
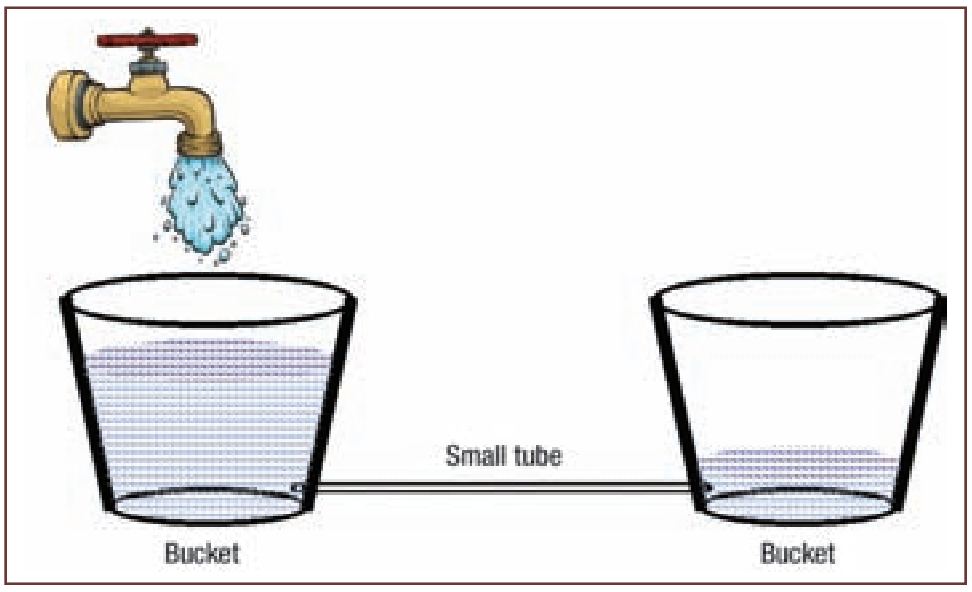


Figure 2: Frictional losses that occur when the first tank is closer to a pumping source than the second tank.



sidebar

Fluid Hydraulics 101

A hydraulic problem that frequently occurs with elevated tanks involves differences in frictional losses that occur when the first tank is closer to a pumping source than the second tank. In these instances, even though the overflow tank levels are set at the same elevation, the first tank will fill and run over before the second tank can be filled.

This phenomenon is caused by the need for extra energy to push the water through a long pipeline at the same velocity to feed the second tank. Think of it as filling a bucket of water with a small tube that is connected to a second bucket located a distance away at the same elevation but connected to the bottom of the first bucket with a small tube (see Figure 2). The first bucket will fill very fast and spill over before the second bucket can fill. This is because the small tube is resisting the flow of water by generating more friction.

Change in the pumping rate

It may be possible to fill two tanks at the same elevation which are located far apart without spilling water from the first tank by lowering the pumping rate during the fill cycle. Although this seems counterintuitive, the reason that the method may work is that the energy to overcome friction increases by the square of the velocity. Thus, a very small change in the pumping rate makes a big change in the frictional energy that needs to be supplied to equalize the tank levels when both tanks are filling.

Lowering the pumping rate can be accomplished by trial and error and does not result in any additional capital improvements. The objective, of course, is to ensure that the tanks are being filled to the optimal cumulative capacity without spilling any water. Demand closer to the first tank is typically easier to supply, and thus cumulative tank capacity will indicate the best tank levels that can be achieved using this method. WWD

accomplished by installing a pressure-reducing valve on the mainline. The valve allows flow between the two zones while maintaining higher pressures in the upper system without overflowing the lower tank. Arranging these pressure zones is not preferred, and the cost for installing a pressure-reducing valve station is about $65,000 to $85,000.

Some tanks work together just fine. Elevated water tanks can be designed to work together, hydraulically speaking. There are plenty of systems that have fully functioning tanks and too many systems with operational problems.

Sometimes the best solution for a troubled marriage is separation. In this case, separation of the two tanks is the best option for this water system. It is a costly separation to correct hydraulic problems, but an avoidable one. If you are about to get a second elevated tank, work closely with a design engineer to ensure that the two tanks are hydraulically compatible. WWD

Sterling L. Carroll, P.E. is state engineer for the Florida Rural Water Association. Carroll can be reached at 850.668.2746 or by e-mail at sterling.carroll@frwa.net.

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