Preserving Water Quality in Distribution Systems

By Mike Duer

Distribution storage tanks and reservoirs could have a negative impact on water quality due to short-circuiting, poor mixing and long detention times. Many of the water quality problems associated with storage tanks can be specifically attributed to the inlet and outlet pipes.

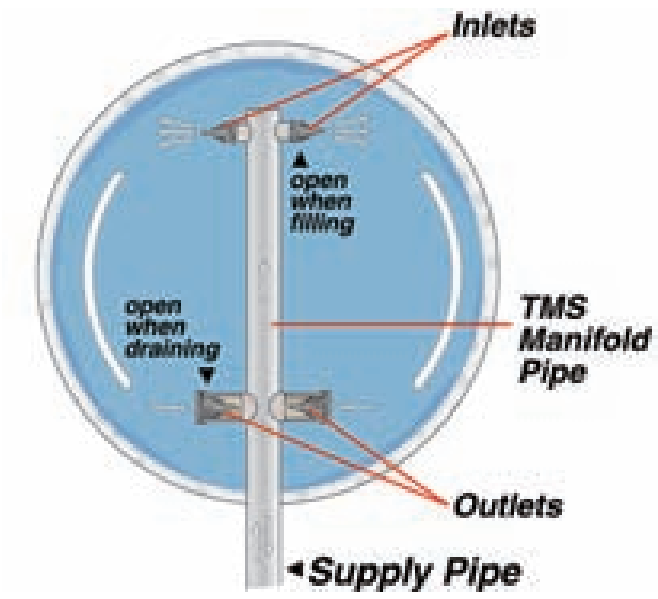
Mixing systems research and developments for water storage tanks and reservoirs

With new water quality regulations, the U.S. Environmental Protection Agency has put a great amount of emphasis on minimizing water age and improving water quality in distribution systems.

It is crucial to ensure the water storage tanks preserve water quality, not degrade it, in order to maintain safe drinking water throughout the entire distribution system.

There are three distinct hydraulic conditions that must be addressed to preserve water quality in distribution storage tanks: eliminating short-circuiting, achieving complete mixing and turning over (fluctuating) the tank levels to minimize water age. To prevent any water quality issues, all three need to be addressed.

Figure 1



The outlet valves are installed in a fitting near the tank penetration.

Eliminate Short-Circuiting

Short-circuiting is most severe with common inlet/outlet pipes or when the inlet and outlet are in close proximity to each other. The last water put into the tank is the first water that is drawn out. Stagnant areas develop outside this area of influence and the water in these areas can be days or weeks old, resulting in the loss of disinfectant residual.

Locating the inlet and outlet pipes at opposite sides of the tank will mitigate short-circuiting. Prior to the Tideflex mixing system (TMS), this would usually require installing two separate pipes and two tank penetrations, a valve vault outside of the tank, extra isolations and check valves; however, the TMS achieves inlet/outlet separation with a single manifold pipe installed outside the reservoir. Two sets of Tideflex check valves located on opposite ends of the manifold function as inlets and outlets (Figure 1).

The valves have an all-rubber/fabric matrix and have no mechanical parts. They are completely passive and operate solely on differential pressures, so the tank fills and draws based on distribution system and tank head without any outside energy source.

Water found in storage tanks, ground level reservoirs, standpipes and elevated tanks has a tendency to become stagnant. If the water entering the tank is not mixed thoroughly with the existing tank water, the disinfectant residual, temperature, DO and pH and other water quality parameters can be drastically different spatially through the tank, especially throughout the water depth.

As a result of extensive in-house and independent Computational Fluid Dynamics (CFD) and physical scale modeling, a solution to maintaining water quality in storage tanks was developed by using Tideflex and Waterflex check valves on a single manifold to separate the inlet and outlet and to utilize the jet velocity enhancement of the Tideflex check valves to achieve complete mixing. It was determined that optimal mixing is dependent on the following:

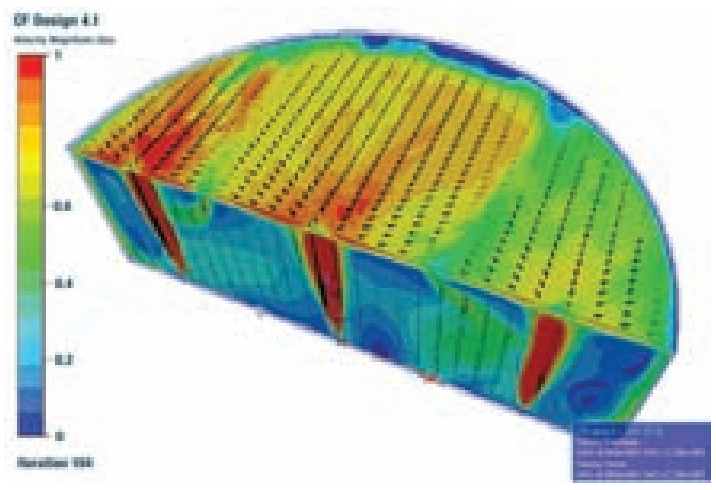
- Configuration and sizing of the multiport piping manifold;
- Quantity, size, geometry and relative stiffness of the Tideflex variable orifice inlet nozzles;
- Utilizing the jet velocity enhancement of the nozzles to achieve mixing at low flows;
- The spatial location, elevation and discharge angles of the variable orifice inlet nozzles; and
- Sizing and strategic location of the Waterflex outlet check valves.

The TMS is a passive system that operates on the differential pressure that already exists in the distribution system. There is no external energy source required. The TMS is installed in new and existing tanks and requires one tank penetration for tanks that operate in fill-then-draw.

CFD Modeling

To obtain an understanding of short-circuiting and mixing characteristics in storage tanks, hundreds of CFD models were run to determine optimum manifold configurations that resulted in the fastest mixing in each of the most common types of water storage tanks. CFD models are continually run for optimization of the TMS (Figure 2).

Figure 2



It was discovered that temperature differences between inlet water and tank water could change the circulation patterns in tanks, exacerbating problems with short-circuiting and mixing. In the summer, the inlet water is colder than the tank water. The colder water is heavier, so it tends to sink. The resulting lack of mixing and stratification can cause a significant increase in water age and other water quality problems, putting customers at risk. Based on the extensive CFD modeling and scale modeling results from the AwwaRF project, the TMS manifolds were customized to the configurations that result in the fastest mixing.

Standpipes are particularly prone to thermal stratification due to their depth. Stratification is most severe during summer when the inlet water is colder than the water inside the tank. The colder water is denser and tends to remain at the bottom of the tank. This results in very little or no mixing and long detention time in the upper portions of the tank. The fresh water at the bottom of the tank is also the first to be drawn into the distribution system so short-circuiting in standpipes is prevalent.

For standpipes, the TMS inlet and outlet are typically separated in the vertical direction—the inlets toward the top and the outlets at the bottom. This configuration reduces or eliminates stratification. In addition, multiple inlet diffusers are used to provide rapid mixing compared to a single outlet. The outlet valves are installed in a fitting near the tank penetration. The vertical riser pipe is installed above the fitting and is braced to the shell of the tank. Each TMS is specifically designed and hydraulically modeled for every tank and reservoir to ensure complete mixing based on the specific utility's distribution system hydraulics and their fill and draw cycles. WWD

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