by Pat McCool

Summer challenge of chlorine residuals: concentrate on tanks

Many systems first realize nitrification and residual loss in the water lines in late July or August. However, the problem first develops in the water storage tanks where water warms sooner due to sunlight on the tanks and due to air temperature being warmer than ground temperature.

One of the responsibilities of operating a water supply system is maintaining chlorine residuals in the distribution system. Maintaining residuals in the summer months becomes more of a challenge because chlorine residual die-off increases. Proper residual monitoring and proper operation of storage tanks will increase the likelihood that residuals can be maintained.

Requirements, problems and causes

Kansas regulations require that a chlorine residual be maintained throughout the distribution system. The minimum residual required is 0.2 mg/l if free residuals are being used in the distributon system and 1.0 mg/l if combined residuals are being used.

Pat McCool
Consultant

During the warmer water temperature months, maintaining residuals is difficult if surface water is the water supply source. The water temperatures in the distribution system are warmer during this time if a surface water source is being used as opposed to a groundwater source. Warmer waters result in faster biological processes and chemical reactions.

Also, maintaining residuals is particularly difficult if combined chlorine is being used. This difficulty is because bacterial growths develop in the distribution system. The ammonia added to the water to form combined chlorine is a food source for this bacteria.

This bacteria is called nitrifying bacteria. The process involved with the bacteria and chlorine loss is called nitrification because the ammonia is eaten by the bacteria and, consequently, the combined chlorine is reduced. Nitrification begins at a water temperature around 70 to 76 degrees F and increases with increasing water temperatures.

In Kansas, nitrification will begin sometime from as early as early June to as late as late July or August. Water temperatures determine when nitrification begins. Water temperatures are affected by air/ground temperatures, rainfall, and storage tanks.

Many systems first realize nitrification and residual loss in the water lines in late July or August. However, the

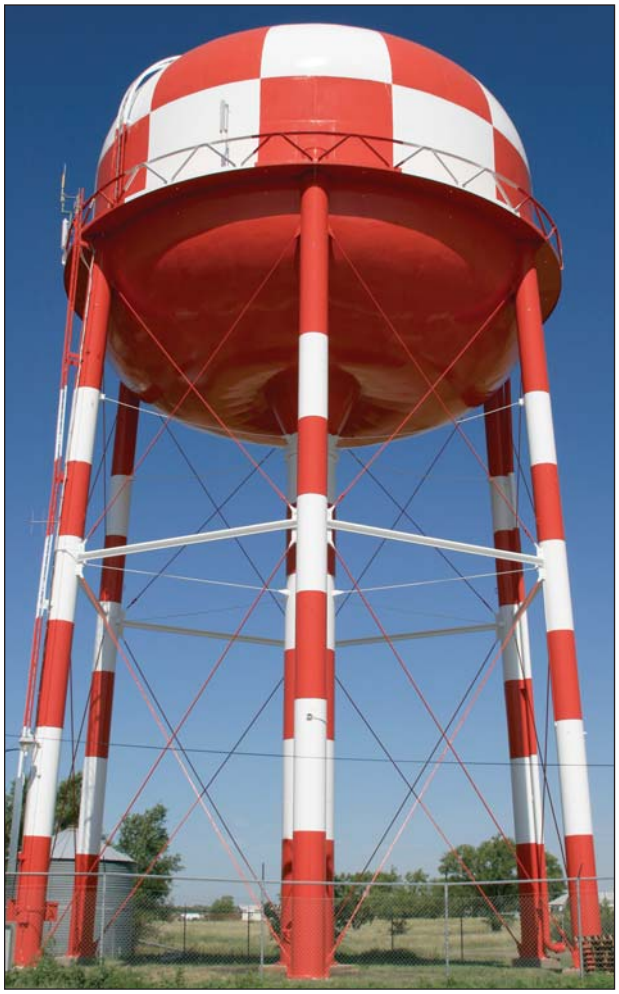

PHOTO BY JAMES BROOKSHIRE, CUNNINGHAM SANDBLASTING AND PAINTING CO. INC.

Chlorine residuals in large storage tanks should be closely monitored, especially during summer. This photo is of the water storage tank in Syracuse, Kan.

problem first develops in the water storage tanks where water warms due to sunlight on the tanks and due to air temperature being warmer that ground temperature.

Distribution lines

Although residual loss likely occurs first in water storage tanks, most operators first realize residual loss in distribution lines. Most residual samples are taken from residences, businesses and flush hydrants. Storage tanks are not routinely monitored. Monitoring residuals in lines is a lagging indicator of residual loss.

First, residual loss in distribution lines can be caused by low-use, dead-end lines and by low-use, looped lines. Also, cast iron lines with many years of corrosion deposits contribute to residuals loss. In these situations, only flushing can hopefully keep residuals at required levels.

However, many times the residual loss first realized in distribution lines is from water that has totally lost or has decreased residuals from water storage tanks. In this such cases, low or lower residuals can also be found in heavily used main lines in addition to dead-end, looped and cast iron lines. If this is the case, flushing may only increase the residual loss with more water entering the lines from the storage tanks.

Storage tanks: the problem

Water storage tanks are where nitrification first occurs because the water temperatures first increase here and there is considerable detention time. The warm air temperatures and sunlight on the tank increase the water temperatures as opposed to the "in-ground" water temperatures.

If the residual loss problem can be handled or mitigated at the storage tanks, then the residual loss problem may not spread to the distribution lines or may be delayed. Proper residual monitoring at the tank and proper tank operation are needed to address the problem there.

Most elevated storage tanks and standpipes have an inlet/outlet line at the bottom of the storage. This will result in stratification of the water where the water higher up loses its residuals first. Then the residual loss will begin to "spread" to lower water. If not addressed, the residual loss/nitrification will affect the lower water leaving the tank and entering the distribution system. Eventually, the residual loss/nitrification will occur in water lines in the distribution system.

Storage tanks: monitoring

The monitoring of chlorine residuals at the storage tank is very important in knowing what is happening and in how operations and changes in operation are working. When and where residuals are taken is critical.

Many times operators test residuals on the line to/from the

Adequate chlorine residuals are probably not a problem in this tank during winter months. This tank serves the city of Bentley, Kan.

tank. If this residual is taken when the tank is filling or has recently been filled, the operator is in fact monitoring the residual presently or recently entering the tank. When residuals are taken on this line, the sample should be taken when the tank water level is the lowest just before filling begins. In this manner the sample will better indicate how low the residual leaving the tank is.

The chlorine residual in the storage tank is the lowest in the water at the top. This is in a tank that has the inlet/outlet at the bottom of the tank. In this case, a much better location to measure the tank residual is the water overflowing the tank. An operator should take a residual of the overflow of the tank at least every two weeks during the colder months and at least weekly at times when residual die-off is suspected during the warmer water temperature months. If samples are taken of the water during overflow of the tank, then an operator will have good information on what is occurring in the tank.

Storage tanks: operation

The problems with low residual water (and nitrifying bacteria) leaving the tank can be lessened or mitigated by the operation of the tank. One method is fluctuating the water levels more in the tank, that is, increase the measure between the low-water level turn-on (of the pumps) and the high-water level turn-off. This allows more fresh water with a higher residual to enter the tank.

A second method is lowering both the low-level and high-level water levels. This results both in less water stored and in a higher proportion of fresh water entering the water already in the tank. This is only advisable where the tank is very large so as not to affect needed storage requirements. This is not an uncommon method to be used because many storage tanks have excess capacity.

Both these methods may only keep (or only delay) the problem of residual loss from leaving the tank. Another method that will work with, or possibly in lieu of the previously mentioned methods is overflowing the storage tank. Since the water with the lowest residual is at the top of the tower, overflowing the tank will bring in fresh water with a good residual while discharging the worst water with the lowest (or no) residual. Early in the summer months, this method is much, much better than later flushing water lines after the problem has spread to the water lines.

If the problem cannot be handled by these methods mentioned, then "dumping" of the tank should be considered. Dumping refers to discharging the tank water with low/no residual nearby on the ground through a flush/discharge hydrant. Dumping is better than allowing the tank water with low/no residual to enter the distribution line that results in the problem going anywhere/everywhere that results in "chasing" the low/no residual water throughout the distribution system and flushing. In short, early dumping of tanks gives better results than later on flushing the lines.

Modify tank inlet/outlet piping

Some tanks in Kansas have recently been constructed or modified with inlet/outlet piping that addresses the stratification of the water in the tank. The piping is such that the water filling the tank enters near the top of the tank and the water leaving the tank during drawdown is from the bottom of the tank.

Existing elevated storage tanks or standpipes can be fitted with piping to accomplish "fill-at-the-top" and "discharge-from-the-bottom." Essentially, the existing inlet pipe is extended to near the top of the tank so as to fill the tank near the top.

This pipe extension also has a double tee near the bottom of the tank with each tee having a check valve. The two check valves allow water to flow from the lower tank water to the inside of the pipe enabling the discharge of water to the distribution system for the bottom of the tank. However, during filling, the check valves do not allow water to flow into the tank through the check valves. Thus, water enters the top of the tank and leaves from the bottom of the tank.

Rechlorination at storage tanks – is it possible?

Rechlorination at water storage tanks is seldom used because of the complexity of adding chlorine at a storage tank. At most storage tanks, adding chlorine is difficult if not impossible because of several factors.

The most significant factor affecting adding chlorine is that the flow rates into and out of the tank vary considerably due to varying customer demand during filling and discharging. For example, the flow rates leaving the tank range from extremely low flows at night (say 1-10 GPM) to high flows during certain times of the day (say 100-250 GPM).

Secondly, the residual entering the tank is good but the residual leaving is low. The chlorine residual can vary greatly. Both flow rates and residuals can vary significantly during the day and even during an hour's time. Another big "wild card" is the ammonia concentration in the water is not known, cannot be accurately measured on a continuous basis, and may vary greatly on a daily and weekly basis. Thus, adding chlorine (and possibly ammonia) at a storage tank is a complex and difficult operation, even much more so than in water treatment plant operations.

Butler County RWD 5

Butler County RWD 5 Manager Pat Shaffer and Operator Terry Brown have been addressing the loss of residuals in the district's storage tanks. Terry made a presentation at the 2008 KRWA Conference on residual loss and steps taken and being taken to address the loss.

Good monitoring of tank residuals will enable an operator to know when the chlorine residual loss is starting. Monitoring the residuals will tell how tank operation is helping avoid, lessen, or delay the problem of residual loss.

The district has two large elevated storage tanks called the Benton Tower (near the city of Benton) and the Kellogg Tower (near Kellogg Street/US54). Both towers had inlet and outlet flow at the bottom of the tower. Both towers are equipped and monitored with continuous chlorine monitoring of the residual entering and leaving. All data is stored on the district's office computers. The reader should note the availability of excellent data.

In the summer of 2006 both tanks lost chlorine residuals and considerable operations did not satisfactorily correct or improve the situation. Between the summer of 2006 and 2007, the Kellogg Tower had fill-at-the-top and discharge-from-the-bottom piping with check valves installed. The Kellogg Tower was selected because of its far-end location and lower water usage. The Kellogg Tower was the tower of the two that is first and most affected by residual loss. It was hoped that this would result in the Kellogg Tower not losing chlorine residual.

In the summer of 2007 the residual at the Benton Tower gradually decreased and the residual was lost in early August. At that time the residual at the Kellogg Tower was still good and the situation appeared optimistic. Then about three weeks later the Kellogg Tower lost residual too. Thus, the change in piping helped but only delayed residual loss.

After the summer of 2007, the district installed a chlorination system at the Kellogg Tower. Because the pumps filling this tower can be operated manually, and because the size/usage of this tower allows a fill-and-draw that can be determined by the operator, adding chlorine may work. This summer will be the first test.

Conclusions

The loss of chlorine residuals is significant in systems having combined chlorine and a surface water source. This loss is from nitrification and occurs first in storage tanks and probably "spreads" from there.

Good monitoring of tank residuals will enable an operator to know when the chlorine residual loss is starting. Monitoring the residuals will tell how tank operation is helping avoid, lessen, or delay the problem of residual loss.

The fill-and-draw water levels in the tank, the overflowing and dumping of water, and the type of inlet/piping all address the problem.

Remember, in the end only by monitoring and trying these operational methods can an operator address storage tank residual loss. Each water system is somewhat different but all systems are challenging in regard to chlorine residual loss in storage tanks.