

Tank Washing Nozzles: Comparing Cleaning Effectiveness of Common Commercial Models

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A plant operator who decides to take the step of tank washing with a specialized nozzle has a multitude of choices in the marketplace. Tank washing nozzles are available from more than a dozen manufacturers and come in countless shapes, sizes and configurations. Some work better than others and there is a huge range of prices.

The problem when making a choice is that there is hardly any information available that can help you make the selection. Each supplier has its own sales literature, but there is nothing reliable short of direct experience that will tell you that a model from manufacturer X is better than one from manufacturer Y. Even experiences shared from colleagues are suspect if the operating conditions have changed.

Given the scarcity of objective information, Lechler undertook a testing program to make direct, controlled tests of our tank washers under the same conditions to generate directly comparable information. This involved obtaining a test tank, designing the process and finding a suitable soil. All of these would ensure repeatable results. While we considered testing competitor's units, we made the selection from our own product line. From that information you may be able to extrapolate results to competitive offerings.

The testing method

We began by obtaining a representative tank. The unit chosen was a Chemtainer 2500 gallon polyethylene cylindrical tank, 95 inches in diameter and 89 inches tall. This seemed large enough to be a challenge but small enough to be manageable. We cut ports in the top for mounting the washing nozzle and in the sides for six test coupons. The nozzle was mounted off center to allow comparisons around the tank at various distances and thereby simulate different effective tank diameters. Figure 1 shows a schematic of the configuration and distances involved to the various coupons.

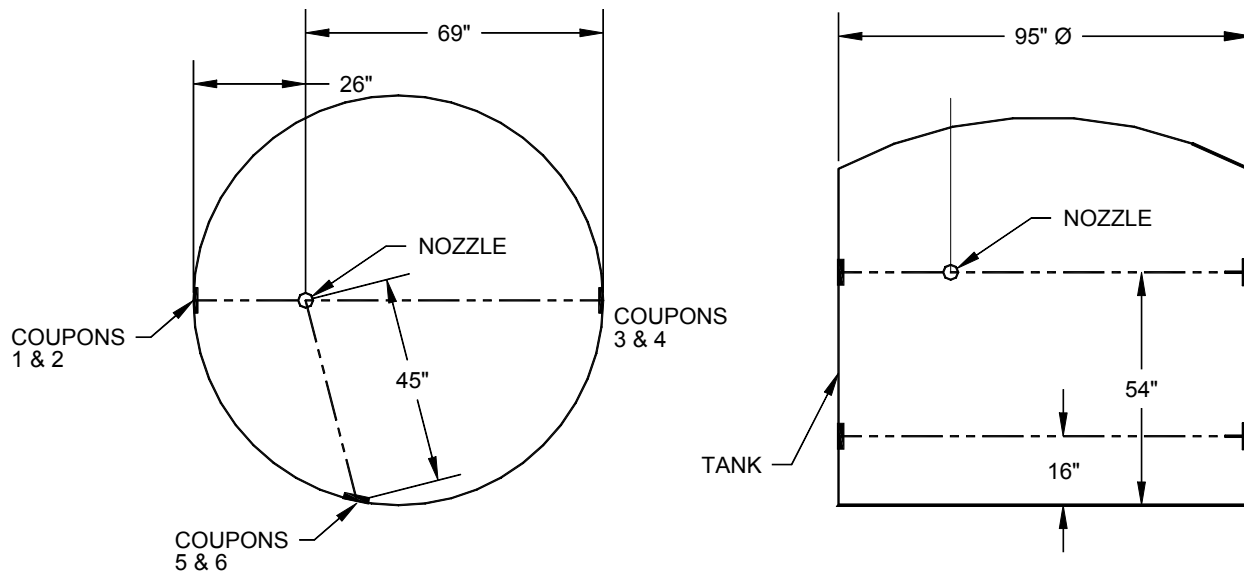
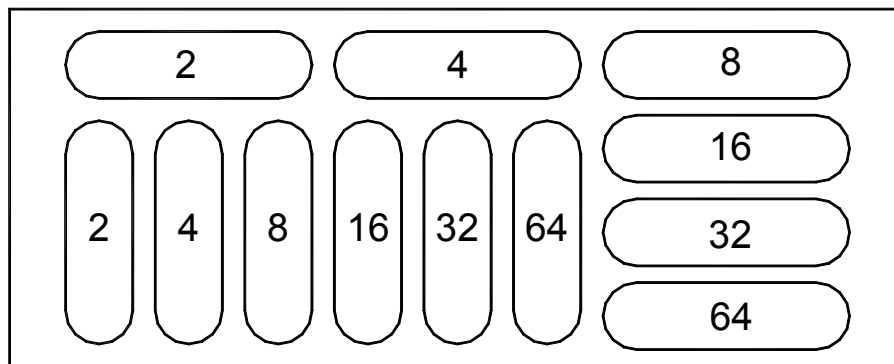


Figure 1

The test coupons were stainless steel plates designed to match the thickness of the tank walls. When mounted, the interior surface was substantially flush so any water running down the wall would wash over the face of the coupon, just as it would in a real application. Each coupon had 12 individual patches milled into the surface. Six patches were horizontal and six vertical. Each set of six was milled to different depths: .002"; .004"; .008"; .016"; .032" and .064". See Figure 2.



Numbers above are in thousandths of an inch.

Figure 2

The test soil consisted of PVA resin glue (Elmer's Glue-All) colored with red water based paint in measured proportions. The paint made the soil easier to see since the resin dries clear. We covered the surface of the coupon with the mixture and then used a stiff knife to squeegee off the surface. The mixture stayed in the patches, filling them to their full thickness. We allowed the mixture to dry thoroughly (overnight) so that by the next day it was a very tough layer of dry but water-soluble resin of a specific thickness.

After a few trial runs, we formulated a method which called for running the nozzle at a specific pressure for 10 minutes using room temperature water and then evaluating the material removal from the coupons. We photographed the finished coupons from every test run using a purpose built lighting and camera setup to ensure consistency in the recording for direct comparability.

Evaluating the results

Trying to compare photos of the coupons was not practical, so we devised a method to assign a score to each patch. This involved a scale to determine the amount of material removed with 10% for complete soil coverage (almost no cleaning) to 100% for a completely cleaned patch. Reading the shades in between required some judgment, so we had the same individual do the evaluation for the whole test process.

Since the patches are different thicknesses, we multiplied the percentage by the thickness so clearing a .032" patch had twice the value of clearing a .016" patch. When added together, each coupon had a score which ran from a theoretical low of 25.2 to a theoretical high of 252. There was no situation where we achieved either the low or high. The lowest score observed for any coupon was 76.0 and the highest was 239.2.

After running 30 tests on 15 different selected tank washing nozzles and reading 180 coupons, we felt we had enough data to draw some basic conclusions about the nozzles and tank washing in general.

Conclusions

Trying to list the individual scores of each nozzle at each of the operating conditions is beyond the scope of this presentation. Likewise, the results did not point out a specific tank washer as a universal best for all applications. Nonetheless, they showed us some information that is very instructive about the cleaning process and practices.

Choosing a tank washing nozzle has to begin with an understanding of the specific cleaning process. How does the soil actually come off the walls of the tank? What is the interaction of the soil and cleaning solution? In our example, the dried glue stuck to the coupons very aggressively. The cleaning followed a specific sequence of steps:

- The water hit and wet the glue surface.
- The water soaked into the top layer causing it to swell and soften.
- Subsequent sprays would remove the softened surface allowing water to reach farther down into the material and carry on the process with a fresh layer.

The diffusion rate of the water into the resin was limited, so the impact from the spray could only help to a certain extent. Higher impact helped strip the softened material faster, but it could not increase the diffusion rate. The water had a solvent action as is the case in most tank washing applications.

From the data, we determined that the actual cleaning rate was influenced by three major aspects: Impact, flow rate and distance. Looking at these can help you analyze your application and make the best selection.

IMPACT—Brute force only helps if the soil can respond. We tested an elaborate, gear driven tank cleaning machine that rotates on two axes and uses two large and powerful solid stream nozzles. Its performance was only fair, in spite of the fact that it was by far the most expensive and capable of cleaning much larger tanks. Its problem in this case was due to the fact that it would hit the coupon with a hard blast but then might not return for the balance of the test time. The soil would not come off *en masse* even with that much force due to its tenacity and resistance to the water's solvent action. In other applications where the soil is not so tough, that nozzle could do very well. Faced with a large tank and very aggressive soil, this type of cleaning unit could be the best or perhaps only choice, however it might require a long cleaning cycle time.

On the other hand, a lack of impact can noticeably retard the cleaning action. At the opposite end of the cleaning spectrum, we also tested a static spray ball. These do not rotate and spray the upper region of the tank such that the washing liquid runs down the walls. The entire interior surface gets covered, but very little receives direct spray. In our test, none of the coupons were hit directly. The performance of the spray ball was near the bottom of the range although it used a very large amount of water. Without the impact of the droplets to break up the softened layer, it does not wash away nearly as quickly. Nonetheless, spray balls are very popular and used in many cleaning operations. They work best in closed loop recirculating systems where the cleaning action is largely chemical in nature and impact is not required. Additionally, since they do not depend on rotation to perform, they can be used in critical applications where it is difficult to verify that the tank washer is actually turning.

In this test situation, the best performing nozzles were those that generated spray impact, even small amounts, and delivered it frequently. Even small rotating tank washers outperformed the static spray ball and used half or less the volume of water. The constant sweeping action combined with direct spray impact vastly improves the process.

The question becomes then, how much impact can a given head deliver? This is typically a function of flow for a given orifice. What this means is that you should be looking for a spray head that has the fewest number of nozzles for the highest flow rate you can tolerate. This brings up some interesting trade offs:

- Time vs. liquid consumption--What is more important? Liquid use or time? A large capacity tank washer will typically clean faster than a similar unit with a smaller flow. However, you will probably find that the efficiency (amount of cleaning per volume of water) decreases with the larger unit. A smaller tank washer running for a longer time can do the same cleaning job using less liquid than a larger one running for a shorter time.
- Pressure vs. impact--Watch your pressure! Increasing pressure can decrease impact. With tank washers, especially small free spinning units (<50 gpm) the optimal pressure can be as low as 20 to 30 psi. Going higher than that will not increase or even decrease impact while using more liquid. A double penalty.
- Rotation vs. impact--Speed hurts. Free spinning units have the down side that they can rotate too fast. This does not help the droplet propagation. (Imagine trying to spray sideways out the window of a moving car.) Controlled rotation designs help minimize this effect but the difference depends on the nature of your process.
- Flow vs. impact--If you need to increase impact, increase flow, not pressure. Go to a larger flow unit and keep the pressure down.
- Nozzle size vs. quantity--Watch the nozzle count. While having fewer nozzles is usually better, there is a trade off. Small nozzle numbers are desirable to keep the individual orifices large. Large nozzles generate large droplets with higher impact. However, when there are few nozzles, they have to be very wide angle. Wide angle flat fans tend to have lower impact. The optimum nozzle count is four. Three is almost as good. Five or more and the orifices begin to get small.
- Distance vs. impact--Distance doesn't help. The farther you are from the nozzle, the less the impact. Keep the nozzle sized appropriately for the tank.

FLOW RATE--Second, what is the operational flow of the unit, and how is it distributed? One of the most frequently asked questions we receive is "How much liquid does it take to wash my tank?" That is a very process specific question, but there are guidelines.

One of the most common rules of thumb is 2.5 to 4.0 gpm per foot of linear circumference for vertical cylindrical tanks where the height is less than 4x the diameter. Another is 0.25 to 0.40 gpm per square foot of interior surface for square tanks or those with more complex shapes. Sometimes the values go even higher. These guidelines originated around the process of washing tanks with stationary spray balls. These rates ensure that there will be enough flow down the walls that the entire surface will be covered and that the liquid can't pull itself into channels which open voids. The typical practice with spray balls is to cover only the top third of the tank with spray and let it wash down the sides. If you are using spray balls, these guidelines are good advice. However, when using rotating tank washers, the nozzle does not have to cover everything at once. Since the sprays move around the interior, they can eventually hit the entire surface. This means you do not have to use as much liquid. The impact from a well chosen rotating nozzle can more than equal the washing action from a spray ball using much more liquid.

Our test tank has an outside circumference of about 25 feet. By the rule of thumb, we should be using at least 62 gpm. Even so, we got respectable cleaning action from a simple rotating head with a flow of only 13 gpm running at 20 psi. That is only 0.5 gpm per foot of linear circumference. As a practical matter, that is lower than we would typically recommend for a tank that large. The cleaning cycle would be quite long, however the cleaning to liquid use efficiency would be very good. If you had the time it might be a good choice, especially if liquid availability or disposal is a problem. Likewise, if the cleaning task was not too difficult, it would do the job.

In most applications, it would be better to use a guideline closer to 1.0 gpm per foot of circumference for a well sized rotating tank washer. For different tank configurations, a guide of 0.1 gpm per square foot of interior will also work. These numbers may be too low if the cleaning action is particularly difficult. The ultimate selection is something you will have to base on testing and experience.

Application of the liquid in the tank can be just as critical. Is it hitting where the soil is? Most tank washers we sell are 360° coverage. The spray hits the entire interior, including the top and bottom. As a practical matter, there is always some shadow directly overhead, but a good design minimizes this. In a cylindrical tank of roughly equal height and diameter, this means less than half the spray hits the vertical walls. Most solution washes the top and bottom. If the top and bottom need to be washed, this is fine. Otherwise, there are units available that omit spraying straight up or straight down to concentrate more of the effort on the walls.

Tank washing machines that rotate on two axes spend most of their effort washing the areas immediately above and below the unit and have the least power directly opposite themselves horizontally. While this is unfortunate, so far there is no better, practical approach to washing large tanks.

DISTANCE--What is the distance from the tank washer? We found that the nozzles had their own characteristics and abilities to clean at different distances and angles. When there was a large difference between the effectiveness of the near and far coupons, it suggests that the nozzle is near the limit of its cleaning distance. Those where the effect was more consistent suggested a design with more potential for larger tanks.

Moreover, the cleaning angle proved problematic in certain cases. Some units had a hard time cleaning coupon #2. This one is close to the nozzle axially, but below it. That suggests problems with spray distribution uniformity.

One way to overcome distance is to wash a tank with more than one unit or from more than one place. This may not be the most efficient, but sometimes it may be the only practical approach.

Suggestions from the test data

As mentioned earlier, no specific tank washer jumped out of the selection as a clear front runner. Some designs did better than others, but none is always the best in every case. The results we observed may not coincide with yours due to the nature of your cleaning process. As a result, if these guidelines sound very conditional, it is because there are so many variables. There are no guarantees without direct analysis of a specific cleaning process.

Easy cleaning processes

If the cleaning task is not complex and the tank is not very large, just about any tank washer will work. If the tank is less than 8' to 10' in diameter, a small, inexpensive free spinning unit in stainless steel or plastic should fill the bill. The orifices can be flat fans, slits or solid streams. For simple rinsing, follow these steps:

- Make sure the nozzle has sufficient spray coverage to hit all the areas that need rinsing.
- Verify that the spray can reach far enough at the operating pressure to hit the most distant points.
- Keep the pressure appropriate for the design. More is not always better.
- The flow rate should be at least 0.05 gpm per square foot of interior surface. With less than that you may not have sufficient wash down the walls to cover areas where the nozzle may be weak. Increasing that to 0.1 gpm would be better.
- Place the nozzle in the center of the tank about 1/3 of the way down from the top.
- If there are internal obstructions, you may need more than one nozzle to cover everything.

More difficult situations

As the cleaning task becomes more difficult with a more aggressive soil, the choice becomes more critical. Free spinning units can still work well, especially those with higher flow rates. Designs with

friction bearings (no rolling elements) tend to turn more slowly naturally and that helps. Controlled rotation designs can also improve the impact. Tank washing machines are probably still overkill at this level.

- Watch your pressure. If possible, test with your unit at various pressures to find the optimum combination of cleaning effectiveness, liquid consumption and washing time. You may be surprised at how low it is.
- Size the unit appropriately. Use at least 0.1 gpm per square foot of interior surface. Maybe even 0.2 gpm or higher if your system can support it.
- Make sure your equipment can take water out of the tank as fast as you need to put it in. That can be a real headache.
- Don't waste coverage where you don't need it. If you don't need to wash the top, buy a unit that does not spray straight up. This will concentrate the washing liquid where it will do the most work.
- How many nozzles are there? Look for a head with three to five large flat fan orifices. These will minimize atomization and loss of impact. Turn away from slit or solid stream orifices for these more difficult applications.

Very difficult situations

These are the cleaning processes where everything has to work its best. There is a limit to how much liquid you can use, so look at the trade-offs carefully. This type of job is getting too difficult for free spinning units, especially those with ball bearings. Look for something with controlled rotation. Solid stream nozzles will make stripes, so you need full coverage, preferably with flat fan nozzles. Most of the same points for moderately difficult situations apply, plus—

- Consider a tank washing machine using large solid streams. To see if this is practical, see if the soil will wash off the wall with a large flow garden hose. If it will not respond to a powerful moving spray, you may have to explore other possibilities.
- Impact will increase more effectively by increasing the amount of water rather than turning up the pressure. However, the larger the tank washer, the better it can tolerate and profit from high pressure liquid.
- If possible, consider hot water and various cleaning chemicals. These can augment the performance of the nozzle and make the task more manageable.

Summary

There is no doubt that tank washing or a CIP system can benefit from an appropriately chosen tank washing nozzle. Our tests showed that there are many facets to the process of selection which are dictated by the nature of the cleaning requirements in your plant. With some simple analysis, your probability of succeeding will increase dramatically.