Rinsing

Rinse Water Options
It may not be typical for all metal finishing operations but it is fairly common to have water costs at or near the top of the cost of operations. Rinsing is critical in the metal finishing process but more water use does not necessarily mean better rinsing.

Best practices for producing effective rinsing are:

- Double counterflow immersion rinse tanks between process tanks
- Reactive rinsing for the appropriate process chemistry combinations
- Spray rinsing
- Rinse controls such as automatic valves controlled by timers or water conductivity limits

Immersion rinse efficiency model
Often times, when the rinse appears to be inadequate, companies assume that the best method of improving an immersion rinse is to increase the flow rate. However, rinse flow rates can be deceptive in that high flow rates may not be as helpful as expected. Figure 1 displays a single rinse tank with chemical dilution over time at various flow rates. The initial conditions are:

- 100 gallon rinse tank
- Incoming (dragout) solution concentration of 100 grams/gallon
- Dragout volume per rack of 0.05 gallons

It is apparent from Figure 1 that the rinse tank does not dilute the dragged in chemical very rapidly. Even the 25 gpm flow rate takes approximately 5 minutes to drop the concentration from 5% to 2.5%. The main point is that a single rinse tank is relatively ineffective at providing critical rinsing. More importantly, increasing the flow rate in a rinse tank does not necessarily improve rinsing unless extremely high and costly flow rates are used.

By taking immersion rinse flow rates one step further, Figure 2 shows the same rinsing example as shown in Figure 1 with the exception that every 10 minutes an additional load of dragout chemical is added. Note that this causes the rinse tank concentration to rise to very high concentrations very quickly regardless of the flow rates used. This is the primary reason that counterflow rinsing is so effective. The concentration of the dragout chemistry between the first rinse tank and the second rinse tank drops dramatically in a double rinse setup. Thus the effective contaminant dilution rate is much faster as shown in Figure 3. For this model, the dilution between the first rinse tank and second rinse tank is a factor of 100.
Figure 1  
Rinse water flow dilution rates

Figure 2  
Parts rinsed in tank every 10 minutes vs. single rinse
**Counterflow (countercurrent) rinsing**

There are two means of reducing the water use in rinsing without reducing the rinse effectiveness. The first is called counterflow or countercurrent rinsing where the relatively clean rinse water from the second rinse in a rinse tank pair is flowed to the more contaminated primary rinse tank. Therefore cleaner water is always moving to less clean rinse tanks. The cleanest water is still used for the critical final rinse but the same rinse water is reused for the initial and least critical rinse. Figure 4 shows typical two-tank counterflow rinse systems, one for acid rinsing and one for alkaline cleaner rinsing.
Reactive Rinsing
The second less commonly used method of reducing water use is called reactive rinsing. It is a method of taking rinse water around a process tank to a previous rinse tank. The example in Figure 5 shows acid rinse water (acid rinse 1) flowing to the last alkaline rinse tank (alkaline rinse 2). The acid contained in this rinse water would normally be sent to waste treatment. With reactive rinsing, the acid from acid rinse 1 now goes to alkaline rinse 2 and neutralizes the residual alkalinity in that water. Any rinse water from alkaline rinse 2 being dragged out by parts and racks to the acid tank will now contain acid which previously would have been wasted. Therefore, no acid is being neutralized by alkaline dragout to the acid tank and acid previously lost in acid rinse 1 now is partially recovered by the reactive rinse flow.
**Spray rinsing**
The final method of reducing rinse water volumes but still obtaining excellent rinsing is by spray rinsing. This method is somewhat limited by the geometry of the parts being rinsed in that complex geometric shapes are difficult to thoroughly rinse with an automatic spray system. In a manual line, the operator can overcome the geometry problem of a part by manually spraying the part areas which are difficult to rinse by a normal battery of spray nozzles. Figure 6 compares a spray rinse to an immersion rinse. There are two major advantages to spray rinsing over immersion rinsing. First, the water hitting the parts is always clean unlike water in an immersion tank which always contains some residual contamination. Second, a spray rinse needs to be running water only when parts are being rinsed. The rest of the time there is no water use, which is both a cost and environmental savings. A third and lesser advantage to spray rinsing would be in the case of parts requiring a heated rinse. In-line demand heaters can be used to provide hot water as needed during the spray cycle rather than having to continuously heat an immersion rinse tank.

The spray system in Figure 6 illustrates the water savings associated with spray rinsing compared to immersion rinsing. The left illustration in Figure 6 is a typical immersion rinse tank running at 3 gpm. The right illustration is a spray rinse with a battery of 8 spray nozzles with a combined spray volume of 6 gpm. The spray rinse in this scenario is only turned on for two minutes while parts are in the tank. The next set of parts arrives eight minutes later. Since the spray rinse is turned on only for 2 minutes out of a 10 minute period, the average water use is 1.2 gpm which is less than half of the immersion rinse tank’s usage rate of 3 gpm.

**Figure 6**  Spray rinsing compared to immersion rinsing

![Diagram of spray rinsing compared to immersion rinsing](image-url)
**Rinse flow controlled by flow restrictors**
One final way to reduce rinse water use in immersion rinse tanks is by controlling the rinse water valves. This method is a means of limiting flow when rinse water control consists of manually operated valves. The simplest method is to insert flow restrictors on the water valves to limit the maximum flow regardless of how open the valve is.

**Rinse flow controlled by rinse water conductivity**
Another method of water valve control is to insert solenoid valves into the rinse water lines which open or close based on the conductivity of the rinse water in the tanks. This requires minor up front measurements of the water conductivity which is often directly related to the amount of chemistry being dragged into the rinse water. The valve conductivity controls are then set to turn the water on when the conductivity (contamination) gets too high and then turn the water off when the conductivity drops to a lower set point. The advantage of this system is that the water stops running when a plating line has a break in the work flow, rather than manually turning the water on and off at both the beginning and end of the day regardless of the amount of work running through the line. These conductivity controlled valves can be purchased as systems which include the solenoid valve, conductivity probe, and conductivity control box, and typically cost between $500 and $1000.

**Rinse flow controlled by timer**
A third method is to use a timed rinse. A timer controls a solenoid valve to open and close water flow to the rinse tank. The operator turns on the rinse timer when placing the parts in the rinse tank and the rinse water turns off after a preset time. In this way the water is running only when parts are in the rinse tank and is very useful for irregular process cycles or for processes where there are frequent periods with no parts going through the line.