Electroplating Tip Sheet
Rinse Water Reduction

Rinse Water Use Reduction

In the electroplating industry, rinsing is used to remove chemical residue that was applied in a previous step. In most operations, this is performed by dipping workpieces into a tank of water. To offset the buildup of chemicals in the rinse water, the rinse tank is equipped to provide a steady flow of clean water into the tank to constantly dilute the rinse bath to an acceptable level. Most electroplating facilities use substantial quantities of rinse water, and there are frequently numerous opportunities to make significant savings in the amount of water needed. Water savings are directly related to the reduction of wastewater that requires treatment or disposal. The use of any one of the below suggestions can help to prevent pollution, but the implementation of a combination of suggestions can significantly increase waste reduction. It is up to each facility to determine what combination of suggestions will work best for them, being sure to weigh all advantages against disadvantages. For a detailed schematic of a typical electroplating process without pollution prevention control methods, see Appendix A. Several considerations are basic to rinsing:

- Perfect rinsing, where 100% of the residue is removed, is not possible. Therefore, facility management should determine the acceptable level of residual concentration that can be tolerated in final rinse baths. As cleanliness requirements increase, the associated cost will rise rapidly. This is usually done through practice and experience, because academic guides are not readily available.

- The water used in the rinse bath must not introduce materials that are detrimental to subsequent baths. This could be a problem in areas with “hard” water.

- The average level of drag-in concentration present in the rinse tank is controlled by the drag-out rate of the previous bath and the rinse water flow rate. The drag-out rate is determined by the production rate and the drag-out control measures. The residual concentration level will rise as new drag-in is introduced from workpieces and then will decline as rinse water continues to flow. Rinse tank volume is seldom a significant factor to be considered. In most cases the rinse tank volume is controlled by the size of the workpiece and the workpiece handling systems.

Rinse Tank Design Guidelines

Effective design and application of the rinse tanks are major keys to the successful removal of drag-out. The principle considerations are (See Figure 1):
• Select the smallest rinse tank in which the parts can be rinsed and use the same size for the entire plating line. This will help to keep chemical usage to a minimum.

• Locate the water inlet point at one end near the bottom of the tank. The water should be distributed through a series of high-flow rate openings or nozzles to create a rolling action that will help to scrub the workpiece.

• Locate the tank outlet at the end opposite the water inlet as near to the surface as possible. This will ensure a full-tank turbulent flow for effective rinsing.

![Schematic of Basic Elements of Rinse Tank Design](image)

**Figure 1**

*Schematic of Basic Elements of Rinse Tank Design*

• Enhance the cleaning action through rinse water agitation. Some popular methods include:

  ♦ **Air Agitation**: An air injection system where air is blown into the tank through a tube situated parallel to the rack design or directly under the workpiece. The air inlet holes are placed at approximately 1 - 5 inch intervals in a 1-inch PVC pipe with the end capped.

  ♦ **Mechanical Agitation**: A means to physically shake the workpiece while it is immersed in the rinse tank. Alternatively, a pump or a powered propeller in the bath water could be used to mechanically circulate the water across the workpiece.

  ♦ **Double Dipping**: The insertion of the workpiece into the rinse tank, withdrawing it, and then reinserting it, provides agitation and improves the rinsing effectiveness.
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♦ **Ultrasonic:** The use of a system of ultrasonic transmitters is an effective means of rinsing. Ultrasonics increases the reaction between water and drag-out on the part, resulting in a more efficient rinsing process.

♦ **Spray Rinsing:** Using high pressure/low flow rate water rinsing for an effective, economical rinsing method. This method is workable for predominately flat plate workpieces, but may not be effective or adequate if the parts contain cavities and complex surfaces, or if there are particularly stringent cleanliness requirements.

**Water Reduction Recommendations**

The options outlined below for rinse water reduction, developed by operating facilities, have been shown to dramatically reduce the amount of water consumed and wastewater generated. These reductions provide a major opportunity for pollution prevention as well as for improved economics of operation. Some attractive options are:

1. **Counterflow Rinsing:** In counterflow rinsing, 2 or more tanks, arranged as shown in Figure 2, are used for the rinse. A summary of counterflow theory is shown in Appendix B along with examples of its effectiveness. In general, for a given situation of drag-out rate, drag-out concentration, and required rinse water concentration, the total rinse water flow rate can be reduced 90 - 99%, with no sacrifice in quality or production rate.

![Figure 2: Schematic of Counterflow Rinse](image)

2. **Timed Water Additions:** It is reasonable and effective to incorporate a system that introduces a specific volume of rinse water each time a work piece is lowered. Generally, such a system (See Figure 3) will require a solenoid shut-off valve that can be opened for a measured time period each time a workpiece enters the tank. This system will ensure that the correct amount of water is used for each production piece, and less waste is created. This system is most effective when there are frequent and significant variations in production rate or workpiece quantity. Before this system is implemented, facilities should determine what is the optimal amount of water that should be added each time.
3. **Conductive Water Control**: This system incorporates an analyzer to measure the current concentration level in the rinse tank (See Figure 4). If the concentration level is too high, additional water is added. In like manner, when the concentration level falls below the quality threshold, no further rinse water is admitted. In most cases, the concentration level can be determined through measurement of the electrical conductivity of the rinse water solution. The analyzer reads the conductivity and opens a solenoid valve only when additional rinse water is needed. This system provides the correct amount of rinse water continuously regardless of variations in production or drag-out rates.

4. **Solenoid Shut-Off**: The installation of a simple solenoid shut-off valve will result in significant water use savings (See Figure 5). This valve is activated by the operator who will shut off the water when production is interrupted and no new water is required. Many operations allow the continuing flow of rinse water even when the flow of parts is interrupted for, lunch, work flow, system maintenance, and so forth. This is usually due to the lack of a convenient way to stop it.
5. **Re-evaluate Actual Requirements**: Some cases have been observed where a specific rinse water flow rate is used simply because it has always been that value, or it was a value that was dictated by the city water supply, or the tank plumbing. It may be possible to generate significant water savings through positive evaluation of what the flow rate requirements should be, and to then implement that rate.

6. **Reactive Rinsing**: Rinse water can be recycled through the production line. This technique for water reuse, known as reactive rinsing, takes advantage of the chemical makeup of the rinse water to reduce water usage, increase rinsing efficiency, and improve plating quality (See Figure 6). In this case the rinse water flow rate is reduced to one-third by reusing it in 3 rinse baths.

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**Figure 6**  
**Schematic of Reactive Rinsing**

In this example, nickel rinse water is recycled back to the acid dip rinse tank. The nickel plating solution dragged out of the process bath is dragged into the acid rinse bath. This will not harm the nickel rinse and will allow the fresh water feed to the acid rinse bath to be turned off. The acid rinse water can then be recycled to the alkaline cleaner rinse tank. This not only allows the feed water to this tank to be shut off, but will improve rinsing effectiveness by helping to neutralize the dragged in alkaline solution. The acid bath life is prolonged since the rinse water dragged into it is already partially neutralized. The acid bath will not need to be dumped as often. In this example, rinse water flow rate is reduced from 9 to 3 gallons per minute without compromising the production rate or quality. In a facility that contains multiple plating lines, it may be possible to extend this concept to all of the appropriate tanks on all of the lines. The greater the reuse of rinse water, the greater will be the reduction in water consumption.
Appendix A
Schematic of a Typical Electroplating Line
Without Any Pollution Prevention Control Methods

Work Flow

Rinse Water         Rinse Water            Rinse Water      Rinse Water
Rinse Water         Rinse Water            Rinse Water      Rinse Water
Rinse Water

Caustic Clean        Rinse        Acid Pickle        Rinse        Bright Nickel Plate
Clean               Pickle          Nickel                Plate

To Water Treatment System

Wastewater Pretreatment

= Constant Waste Stream

= Batch Dump

Cr Reduction
pH Adjustment
Precipitation/Filtration
Sludge Filter Press
Sludge Dryer

Wastewater Treatment Facility
Appendix B

Derivation of Counterflow Rinse Effectiveness

The basic formula for determination of flow rate is:

\[ Q_r = D_r \left( \frac{C_t}{C_r} \right)^{1/n} \]

where:
- \( Q_r \) = Flow rate of the rinse water in gallon per minute or liters per minute.
- \( D_r \) = Rate of drag-out entering the bath in gallons per minute or liters per minute.
- \( C_t \) = Concentration in the process bath in milligrams per liter or ounces per gallon
- \( C_r \) = Rinse purity concentration level required in the final rinse bath in milligrams per liter or ounces per gallon.
- \( n \) = The number of baths connected in counterflow.

Some examples of application of this formula are shown in the following table:

<table>
<thead>
<tr>
<th>Bath Concentration ((C_t))</th>
<th>Electroplate</th>
<th>Acid Pickle</th>
<th>Nickel Plate</th>
<th>Hard Chrome</th>
</tr>
</thead>
<tbody>
<tr>
<td>mg/l</td>
<td>75 000</td>
<td>50 000</td>
<td>470 000</td>
<td>265 000</td>
</tr>
<tr>
<td>oz/gal</td>
<td>2.65</td>
<td>1.76</td>
<td>16.59</td>
<td>9.35</td>
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<tr>
<td>Drag-out Rate ((D_r))</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>l/min</td>
<td>0.144</td>
<td>0.144</td>
<td>0.180</td>
<td>0.204</td>
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<tr>
<td>gpm</td>
<td>0.038</td>
<td>0.038</td>
<td>0.0476</td>
<td>0.0539</td>
</tr>
<tr>
<td>Rinse Purity Required ((C_r))</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mg/l</td>
<td>500</td>
<td>300</td>
<td>100</td>
<td>20</td>
</tr>
<tr>
<td>oz/gal</td>
<td>0.01765</td>
<td>0.01059</td>
<td>0.00353</td>
<td>0.0007</td>
</tr>
<tr>
<td>Required Rinse Water Flow Rate ((Q_r)) gpm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Stage</td>
<td>5.7</td>
<td>6.33</td>
<td>178</td>
<td>714</td>
</tr>
<tr>
<td>2 Stages</td>
<td>0.465</td>
<td>0.49</td>
<td>3.26</td>
<td>6.204</td>
</tr>
<tr>
<td>3 Stages</td>
<td>0.202</td>
<td>0.209</td>
<td>0.797</td>
<td>1.275</td>
</tr>
<tr>
<td>Percent Reduction in Flow Rate Due to Counterflow</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Stages</td>
<td>91.8%</td>
<td>92.2%</td>
<td>98.2%</td>
<td>99.1%</td>
</tr>
<tr>
<td>3 Stages</td>
<td>96.5%</td>
<td>96.7%</td>
<td>99.6%</td>
<td>99.8%</td>
</tr>
</tbody>
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