RINSING FOR RECOVERY, EFFICIENCY AND BETTER WORK

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This presentation will review practical and proven rinsing techniques which ensure high quality standards, minimize the amount of water necessary and provide for recovery of most, if not all, of the process dragout.

The formulas required for exact calculation of rinse ratios and water requirements are cumbersome; they have been avoided in the body of this presentation. Those calculations included in the following text are simple estimating formulas adequate for everyday use.

We will demonstrate superior rinsing techniques providing solution recovery and rinse water minimization techniques that provide a cost savings sufficient to quickly recoup the cost of the inexpensive capital equipment needed.

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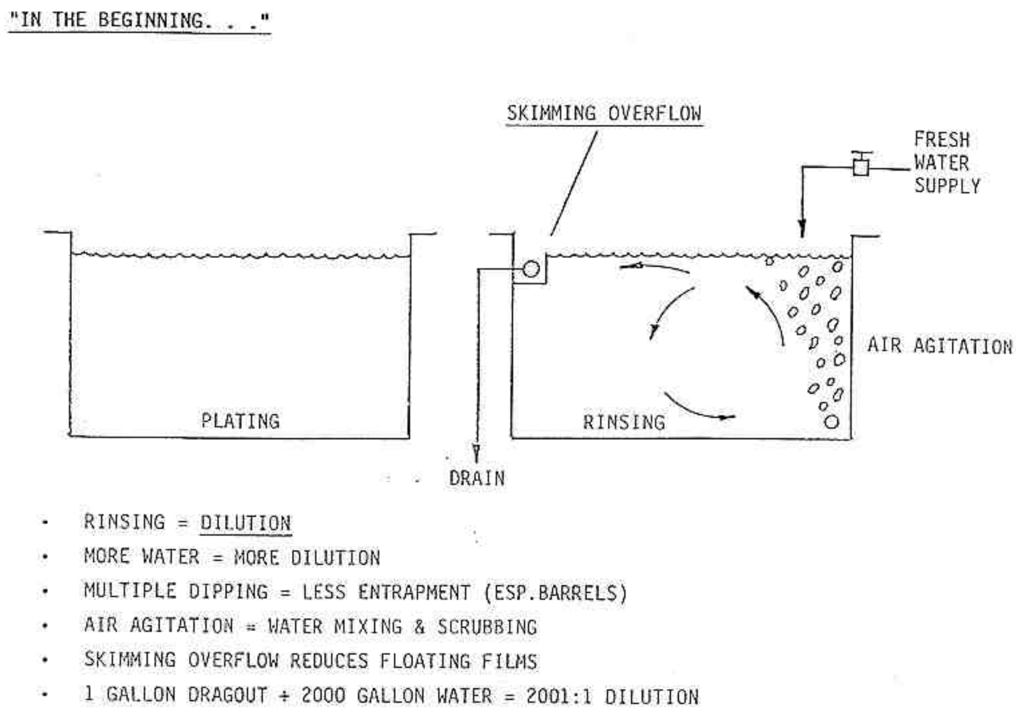
IN THE BEGINNING ……..

Most of us see the rinsing operation as removing a process solution from the surface of the work.

In practice, rinsing is the act of diluting the process film on a work surface-to the point that the low concentration of this film is no longer objectionable.
In this discussion, we will look at the most common form of rinsing; immersing the contaminated work in a tank of running water, as pictured here.[1]



Water usage was not a concern. Drag-out was not a concern. As long as the parts were plated and cleaned all was well. In the illustration above, if the parts need to be cleaner, just turn up the faucet, and let the water over-flow down the drain, and later to waste treatment.

Before we look at discussing improvements such as recovery and increased efficiency, we should ensure we are all coming from the same approach, and background. Therefore, let's review some basic concepts.

Rinsing is done by dilution.

A higher flow rate from the fresh water supply produces more dilution, or better rinsing. [1]

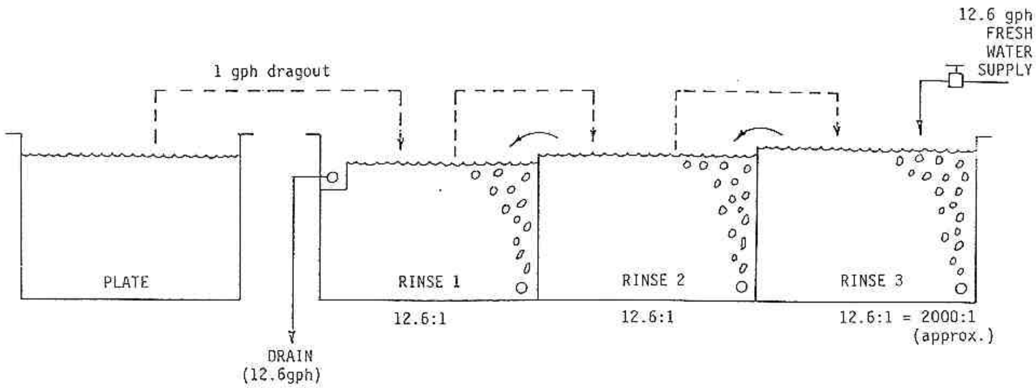
Multiple dipping of the work into the rinse tank produces a flushing action to reduce entrapment—especially important in barrel plating.

AIR AGITATION across the bottom of the rinse tank-away from the "overflow" produces a rolling motion and pushes any floating films toward the "skimming overflow". [2]

Over any period of time, say 1 hour, when 1 GPH of dragout is mixed with 2,000 gallons of clean water, the dilution ratio is 2,001 to 1. [3]

WATER CONSERVATION

As regulations changed to conserve resources and protect our environment, it became necessary to improve the rinsing, dilution, process.



SAME RINSING (dilution) WITH 12.6 GALLONS OF WATER.

The diagram above, illustrates a process tank followed by three counter-flowing rinses. 12.6 gallons per hour of clean water is introduced into the last rinse tank and counter-flowed by gravity through rinse two, then to rinse one, and then finally to drain. Each piece of work sees the same water stream 3 times, in progressively cleaner tanks.

The dilution ratio of the film on the work is about 12.6:1 in each rinse station. We can say that the "work film" is 12.6 times more dilute in each station. As the parts leave the process tank, the residual film on the parts is at full concentration, the same concentration as found in the process tank. This concentration is diluted 12.6:1 as the parts leave rinse one. This diluted film is diluted by another 12.6:1 as the parts leaves rinse two; by another 12.6:1 as the parts leave rinse three. This gives us a total dilution of about 2000:1. (12.6 x 12.6 x 12.6 = 2,000.376) [2]

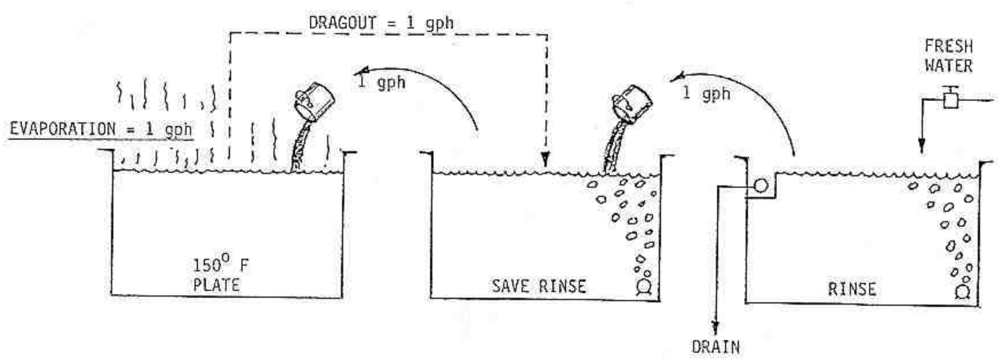
We get the same rinsing, or dilution, with 12.6 GPH in this triple counter-flowing arrangement as we did with one rinse tank using 2000 GPH.

SAVING THE RINSE

Water will naturally evaporate. Even water mixed in a plating bath will have natural evaporation occur. Obviously, the higher the temperature in any given tank, the high the natural evaporation rate will be in that given tank. We can use this natural evaporation to our advantage, by using our rinse water as make-up to the process tank.

If the volume of drag-in and drag-out are equal at the process tank, then the solution level will be reduced only by natural surface evaporation.

The diagram below shows an evaporation rate of 1 GPH due to the 150°F solution temperature. This fact allows us to "bucket", or "make-up" 1 GPH from the "save rinse" to the process tank.



SAVE RINSE DILUTION = $\frac{D/O}{D/O + RW} = \frac{1 \text{ gph}}{1 \text{ gph} + 1 \text{ gph}} = \frac{1}{2} = 50\%$

DRAGOUT RECOVERY = 100% - 50% = 50%

It is intuitive to reason that if the dragout of 1 GPH is mixed with 1 GPH of fresh water, then the mixture in the "save rinses" is at a 50% concentration level of the process tank.[4]

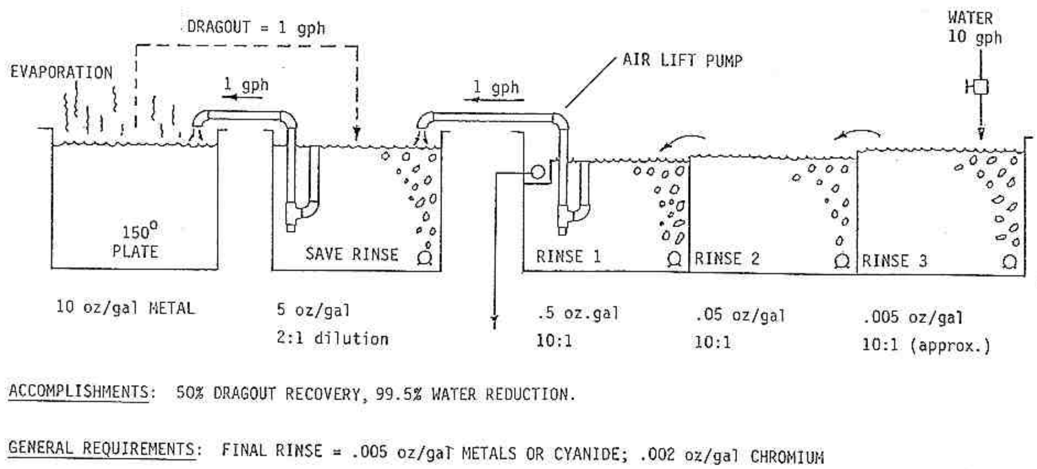
The formula for dilution in a one rinse tank system is as follows: dragout, divided by rinse water plus dragout. (D/O) ÷ (D/O + RW).[2]

Since we are returning 1 GPH of 50% diluted solution, the recovery rate is 50%.

Here, final rinsing is done in an overflowing rinse tank.

GETTING IT TOGETHER

It is near impossible to save all of the rinse water as described above. The volume of water needed to properly clean the part is far greater than the volume of water that will evaporate from the surface of the process tank from natural evaporation. Consider combining the water saving techniques of counter-flowing with the rinse water saving techniques.



In the sketch above, we see the combination of the water saving counter flowing with the "save rinse". [1]

As we just established previously, the dilution or rinsing in the "save rinse" is 50% in this case. Evaporation from the process tank remains at 1 GPH.

We are using simple "air lift pumps" to transfer the solution. *Air lift pumps are an inexpensive way to, essentially, counter-flow in tanks that are not so equipped.*

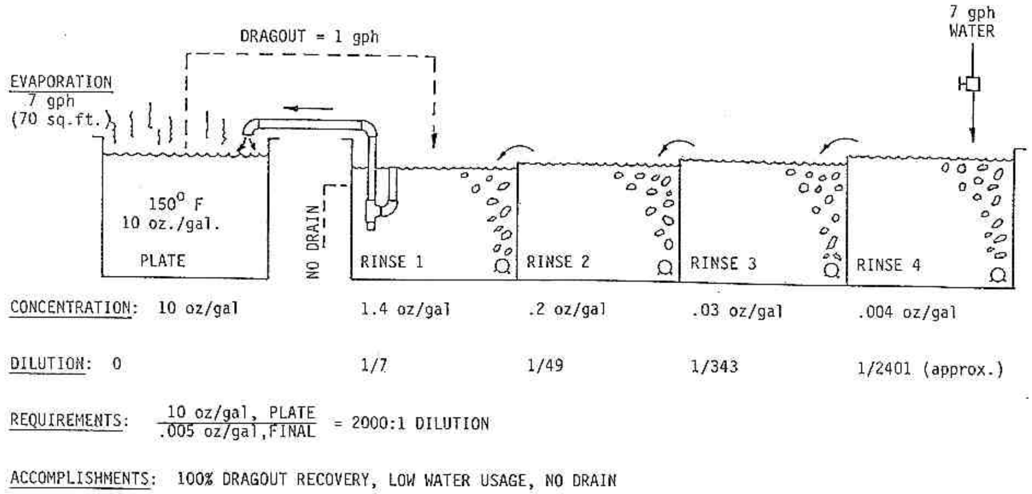
The first printed lined under the tanks, indicates the reduction of metal (in ounces per gallon) at each rinse station.

The next line show dilution ratios: 2:1 x 10:1 x 10:1 x 10:1 = 2000:1 (approximately). [3]

We are recovering 50% of the dragout, and we are saving 99.5% of the water that would normally be required if we were using a single rinse.

As discussed earlier, the process of rinsing is merely the dilution of the plating solution on the part. The goal is to dilute the solution to acceptable levels. The generally acceptable contamination of the final rinse is 0.005 ounces per gallon of metals or cyanide, or if rinsing chrome, 0.002 ounces per gallon.[4]

BEST OF ALL WORLDS



The above schematic has three minor changes from the previous set-up, but the results are significant.

1.) The process tank evaporation has been increased to 7 GPH – the "rule of thumb" is $^{1}/_{10}$ GPH evaporation per square foot of solution surface area at 150°F.
2.) We have 7 GPH flowing through the 4 rinses to balance the 7 GPH of evaporation.
3.) We have eliminated the drain.

The first printed line shows solution concentrations, ending up with .004 ounces per gallon in rinse 4.

Total dilution is about 2401:1.

The dilution requirements are defined as 10 ounces per gallon process solution divided by 0.005 ounces per gallon final rinse -- 2000:1. [3]

We have 100% dragout recovery, low water usage (7 GPH) and no drain.

As illustrated above, we have achieved an acceptable dilution ratio using only 7 GPH. This set-up is relying only on natural surface evaporation. With this low volume of evaporation, it is required to use four rinse tanks.

Most existing plating systems do not have the luxury of having four rinse tanks. Many older systems may only have two or three. Some of the older plating lines sacrifice live counter flowing rinses for a stagnant *drag-out* tank.

A drag-out tank will eventually increase in concentration until it reaches the concentration of the process tank. When that happens, why bother dipping into it?

As you can see by the second printed line on the schematic, the dilution ratio increases exponentially with each additional counter flowing rinse added to the stream. At rinse tank three, we have 0.03 oz/gal and a rinse ratio of 343:1. the next rise these numbers improve by the by another factor of seven.

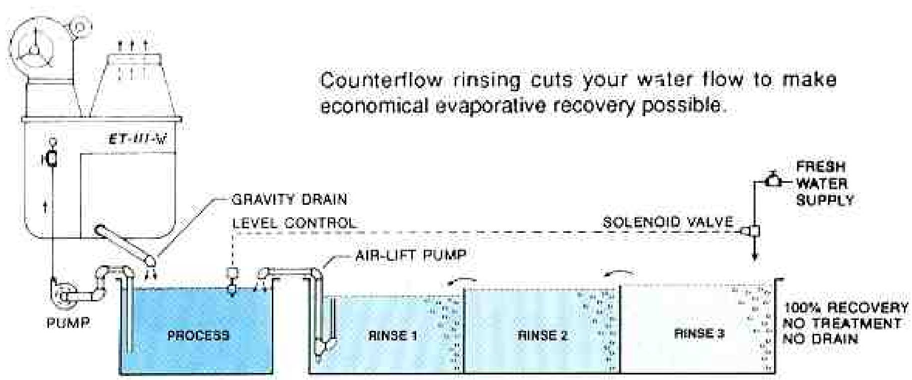
$$7^3 = 343; 7^4 = 2401.$$

It is strongly recommend that any stagnate drag-out tank be converted to a live counter flowing rinse tank. [3]

In many cases, it is just not feasible to have four rinse tanks after the process tank. If this is the case, the best option to achieve drag-out recovery is to increase the evaporation rate in the process tank.

INCREASE PROCESS TANK EVAPORATION

A simple and inexpensive method to increase evaporation from a process tank is to use an "atmospheric evaporator". [6]



In this case, process solutions is circulated through an atmospheric evaporator at about 45 GPM and sprayed into an evaporation chamber where air is introduced, and then the solution returns via gravity back to the process tank. As the air passes through the evaporator, it is wormed from the contact with the worm solution. As it is wormed in direct contact with the solution it will pick up humidity. [6]

This humid air passes through an efficient "mist eliminator" to remove any air-borne solution droplets, and then through an optional MeshPad to further demist the air. The humid air should be ducted to the outdoors, or through a condenser unit to remove the distilled water out of the air to make it available for reuse. The air is dried and ducted back to the evaporator for reuses to create a completely closed loop air system. No outside penetration, no make-up air, no more water make-up; save what is lost due to the natural evaporation form the various tanks that are not captured by the condenser unit.

In this diagram, as the process solution level drops, due to evaporation, a level control turns on a solenoid valve, allowing more rinse water to flow; the condenser unit would normally drain the condensate back to this rinse tank, and the solenoid valve would be used only for the minimal amount of make-up water needed to replace the losses due to natural evaporation.

The results: 100% recovery, no waste treatment, no drain.

THE AMOUNT OF RINSE NEEDED

Dragout Concentration (oz/gal) — Rinse Water requirements (GPH) for 1 GPH Dragout[1]

Counter Flowing Rinses

Chrome Metal	Other Metals	One Rinse	2 .	3 .	4 .	5 .
1	2.5	500	22	8	4.4	3.2
2	5.0	1,000	32	10	5.4	3.7
4	10.0	2,000	44	12	6.4	4.3
8	20.0	4,000	63	16	7.7	5.0
16	40.0	8,000	89	20	9.2	5.8
32	80.0	16,000	126	25	11.0	6.7

[3]

This table is based on the final rinse having 0.005 oz/gallon for metals or cyanide, or 0.002 oz/gallon for chromium. Flow rates are based on 1 GPH of dragout; *you can double the flow rates for 2 GPH dragout, ECT.* On any line, you can see how dramatically the required rinse water flow rates drop when we add additional counter-flowing rinse stations.

Your actual rinse ratio, evaporation rate, and ultimate, your counter flow rinse rates can be calculated on a case by case basses, depending on your specific application.

Other techniques may include an off line heated tank to accommodate those applications that require a low process tank temperature and a high evaporation rate.

Further, the last rinse tank may be an independent rinse tank. That is, near total recovery can be achieved by counter flowing even two rinse tanks with the third rinse tank over flowing to waste treatment. This independent rinse tank can have what ever flow rate is needed to maintain the proper final rinse ratio. The solution in this tank is not recovered, but it may only contain 5% or less of the solution dragout. The other 95% plus, is recovered by the counter flowing and evaporation. It is unusual to need to combine these techniques together, but it will not be problematic to do so.[4]

Experts agree that the first step in pollution control should be to minimize flow rates[5]

[1] For 2 GPH dragout, multiply by two, for ½ GPH multiply by 0.5 ECT.

This paper has presented practical and proven rinsing techniques that will ensure high quality standards, minimized the amount of water necessary for proper rinse ratio dilution, and provided for recovery of most, if not all, of the process dragout.

Implementing only the most basic of rinse concepts presented here, will demonstrate superior rinsing and provide solution recovery and rinse water minimization that provide a cost savings sufficient to quickly recoup the cost of the inexpensive capital equipment needed.

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2. Thomas Higgins, *Hazardous Waste Minimization Handbook*, Lewis Publishers, Inc., Chelsea, MI, 1989 (second printing), p.86.

3. Bill Yates, *Rinsing with Less Water. Metal Finishing.* (May, 1989)

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5. Editor, PF Survey: Dragout, Recovery. *Products Finishing*. (April, 1991)

6. William Yates, U.S. Patent #4790904 (May 19, 1987)