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WORKING BACKWARDS WITH FILTRATION TO ACHIEVE QUALITY CONTROL

How can plating quality be achieved?

Platers pay premium prices for high purity salts, anodes and proprietary chemicals.They make up solutions with deionized or softened water which is also filtered.

Is a more uniform electrolyte or electroless solution the answer? Obviously so, but whatever the requirements are, they must be maintained day by day, hour by hour, or as plating is done — minute by minute. There are no coffee breaks, time outs or holidays with an automatic plating line. Statistical quality control dictates the need to know the conditions of the plating solution at the precise moment that plating will commence and that an acceptable condition must be maintained during the entire time the part is in the tank, whether it be on the rack just starting or the rack just finishing. Platers will need to know that the parts per million of insolubles (dirt particles) are being maintained at the lowest possible level to assure quality results.

If we have taken all of these extraordinary measures to keep the purity of the bath high, where does the dirt come from? Pretreatment is usually the culprit! As soon as we put dirty parts in the tank, the trouble starts.The cleaner is quickly laden with particulate matter and oily scum. Now, as the work travels down the line, the contamination travels along.

Platers long ago realized that the art of filtration can be their best friend, helping them out of some otherwise impossible situations. We can also learn from the efforts of those involved in the sophisticated plating of computer memory disks or from electroformers who seek the ultimate in quality — two producers who abhor the inclusion of solids or the codeposition of organic impurities which cause roughness, pitting, burning and poor adhesion.

"Clean Room" or in plating . . . "clean solutions" are the key bywords

Electronics manufacturers utilize CLEAN ROOMS for the fabrication and assembly of circuit boards and memory disks. CLEAN ROOMS are specially controlled environments with critically controlled particle filtration, temperature and humidity. In plating, CLEAN SOLUTIONS are our CLEAN ROOMS.

In the past, platers considered filtration as a "necessary evil", which certainly is not the case with today's improved equipment and media. Gone, for the most part, are the tanks with layers of sludge, carbonates and super-saturated brightener lying on the bottom of an alkaline zinc cyanide bath, or murky solutions of copper and nickel or silver and cadmium. Instead, plating today is or could be done in sparkling, clear solutions.

We stress the importance of increased solids holding capacity brought about by various grades of filter media and the advantages of increased flow rates in achieving fast particle removal from a plating tank — but we would also stress the advantages of preventing particles from getting to the plating tank in the first place. In other words — solids which don't get past barriers at earlier stages of the process, won't be a problem to be solved at the precise moment plating is being started.

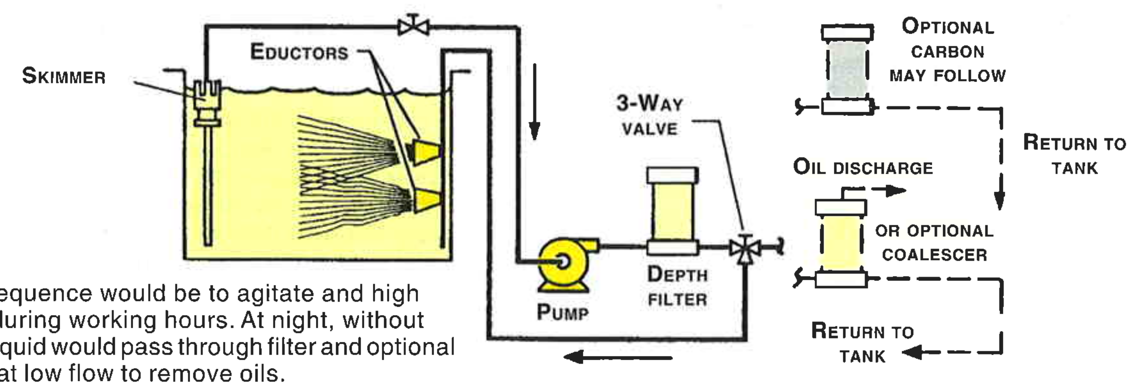
We must take into consideration any and all ways in which solids or other impurities such as oily substances could get into the plating tank, and eliminate these contaminants at their source.

Start with the cleaning cycle

Special attention to the cleaning cycle is perhaps the best place to start noting that even plastic parts which appear to be clean may have silicone mold release on their surface. Therefore, the proper cleaner with vigorous agitation in what was formerly a static tank, may prove worth considering. To meet today's environmental concerns, why not filter the cleaner with an appropriate coarse media to maximize solids holding capacity and lengthen the cleaner's active service life at the same time? Should a layer of oil develop, it can be removed by decanting or skimming the surface when the solution is not being agitated. Additional oil removal can be achieved with the use of a coalescing media which will separate the immiscible oil from the aqueous cleaner (See Fig. 1).

A prefilter is required to keep the coalescing element free of solids. Subsequent electrocleaner solutions followed by various rinses can also be clarified in this way with the addition of a chamber of carbon through which to pass the solutions to achieve the maximum final adsorption of any oily

Fig. 1.



A typical sequence would be to agitate and high flow filter during working hours. At night, without agitation, liquid would pass through filter and optional coalescer at low flow to remove oils.

substances (keeping in mind that manufacturing process oils should never reach your plating solution). As a final precaution, rinses prior to the plating tank may also require the use of ion exchange resins to pick up soluble salts, and even reverse osmosis may be required when troublesome salts might be present in rinse water which may come from a recycled source.

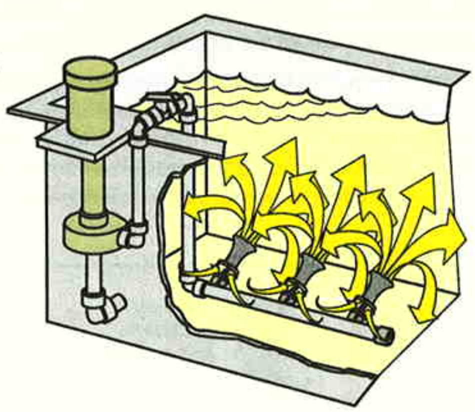
It should also be stressed that the use of a skimmer connected to a pump on each tank in the pretreatment cycle will minimize carryover of surface contaminants to the next tank by way of surface tension.

We now have probably prevented 50-60% of solids and other impurities from getting to your plating tank. So, what else should or could be done to help prevent solution contamination? Of course, quality of anodes, make-up water, chemicals should all be considered — even the air which passes over the tank to an exhaust vent may be dropping solids due to the moisture in the air right over the tank. It is also possible that air used for agitation is not clean (that is, free of insoluble particles); it may be carrying vapors from other process operations into your plating solution. These vapors can be absorbed into the solution with the aid of your wetting agents.

Agitation

A relatively new technique now being used by some platers to agitate the plating solution uses high flow centrifugal pumps which draw solution from the tank and redeliver it through a sparger system similar to that used for air agitation. It also includes eductors strategically placed along the distributor pipe to direct the plating solution. Depending upon the nature and configuration of the parts being plated, the distributor pipe and eductors are positioned so that the solution can be directed across the surface of the work, across the bottom of the tank, up a cylinder or into difficult-to-plate, low current density areas. Each eductor delivers up to five times the actual pumped liquid being delivered to its orifice. This means instead of 1 GPM, you will be circulating up to 5 GPM with the horsepower requirement of only 1 GPM. (See Fig. 2)

Fig. 2.



We have received reports suggesting almost universal success of this new method of agitation. Consider these advantages:

- Eliminates vapors being introduced into the plating solution
- Eliminates temperature stratification in the bath
- Eliminates cavitation and loss of prime caused by air bubbles entering the suction lines of centrifugal pumps
- Minimizes brightener breakdown due to oxidation
- Eliminates the cooling/heating effect and the introduction of dirt particles from air blowers
- Reduces emissions of chemicals from the plating solution
- Eliminates salt crystal formation in the holes of the distribution piping
- Produces more uniform deposits, saving metal cost

With pumped/eductor agitation, we can now plate with a solution that is totally self-contained, where temperature is more easily controlled and the amount of solids or vapors introduced from other process areas has been reduced. It brings us one step closer to the desired "Clean Room Solution Environment". We now can proceed to filter the solution to remove any particles which got past the barriers established at earlier steps in the process and, if necessary, add a carbon treatment for removal by adsorption of any brightener breakdown. Because of the steps taken in the pretreatment stages, the amount of carbon required for the plating tank will be greatly reduced and, in turn, the reduced quantity of carbon will remove less usable brighteners.

Choosing the right filter

The choice of a filter to achieve the final clarification will depend on a number of factors — how much carryover of particles actually did occur on the product to be plated, or what amount of insolubles are being introduced from anode impurities, the atmosphere, precipitates from chemical reactions or from any other source. Will the particles be slimy as in an alkaline zinc bath, which would blind off the flow through a surface filter media, or gritty and therefore easy to filter as from an acid copper tank, or contain precipitated iron from plating on steel in an acid zinc or nickel bath?

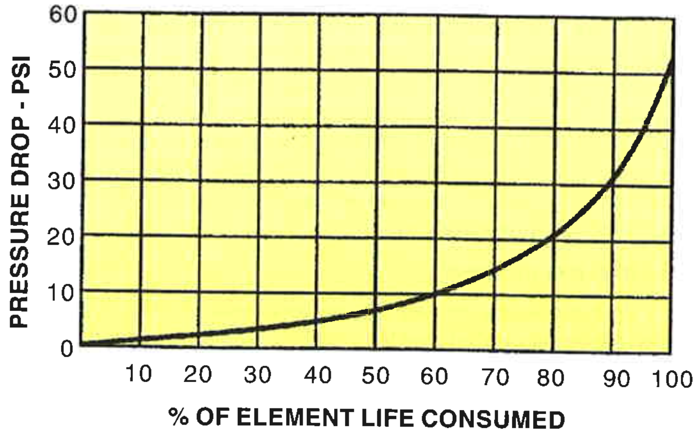
A quick evaluation will at least help you get started in the right direction — 15 to 75 micron retention for the slimy zinc or precipitated iron, and denser on most other baths. Depth type filter media provides for this range of particle retention. Otherwise, if surface media is employed, an extended area must be considered to achieve the solids holding capacity necessary to maintain good flow rates.

The key to extending the life of filter media, therefore, requires a matching of particle retention ability of the media to the range of solids present in the liquid. Unfortunately, we usually don't know the percentage of solids of each size and must rely on past experience. This usually works adequately but, if necessary, coarser or denser media can be substituted to obtain the desired results.

Having sufficient solids holding capacity has to be the main requirement of a filter, so that the pressure drop across the media is minimal over the time between servicing. This is one factor in favor of depth type cartridges, because psi drop is usually low over 85% of their life, whereas surface media follows a straight line increase in pressure drop.

Note that flow rates across the media will somewhat change the percentage or efficiency of retention because of the different levels of velocity per square foot of surface or per cartridge. It is worth considering an increase in the amount

Element life as a function of applied pressure drop



of filter media to reduce velocity. Reduced velocity across the filter media will pay big dividends by reducing the actual amount of cartridges expended or frequency of surface cleaning necessary. For example, to pump the same flow rate across four cartridges instead of one, would result in a 50% reduction in the number of filter cartridges. Some similar reduction in the frequency of cleaning of surface media would also be expected.

Economics of filter chamber oversizing

Oversizing Factor	Number of Cartridges in Chamber*	Dirt Holding Factors per Cartridge	Time Between Cartridge Change	Cartridge Consumption/ Cost reduced by	Labor cost Downtime Solution loss reduced by
1	C	D	T	0	0
2	2 x C	1.4D	3T	29%	67%
3	3 x C	1.7D	5T	42%	80%
4	4 x C	2.0D	8T	50%	87½%

* Based on average sizing i.e. 1 x 10" (25cm) cartridge per 50 gallons (200L).

Recirculation vs. in-line ("The law of diminishing return")

It must be observed that when pressure increases across the media, flow decreases (based on the assumption that virtually all pumps used with plating solution filters are centrifugal). A reduction in flow is critical to the ability of the filter to remove particles from the plating tank when using recirculatory filtration on a reservoir (the plating tank) instead of in-line clarification, as might be the case of a filter on an incoming water line.

Filter media stops most, but not all, of the solids on the first pass. Therefore, a second, third, or fourth pass through the filter may be necessary to produce the desired result. For instance . . . if a filter media having an efficiency of 90% retention of 5 micron particles is used, it also is removing some lower percentage of finer particles, let's say 50% of 3 micron. Therefore, if the porosity of the media didn't change, you could expect to pick up an additional 50% of the 3 micron particles on the second pass, now leaving 25%. With constant recirculation it is possible that all of the 3 micron particles could be retained in the media. However, since clarification only applies to the solution which passes through the filter, turnover rates become vital to the determination of a properly sized filtration system.

There is also the effect of increased density caused by the particles collected on the media. They may speed up or increase the percentage of retention, or their presence may hinder the flow and slow down the turnover rates. This latter effect would suggest that too dense a media may have been used.

Filter media with a broad range of porosities lends itself to recirculation applications. Consider the possibility of using coarse filter media instead of fine on any of your applications, or two filters in series with different grades of media on the same tank.

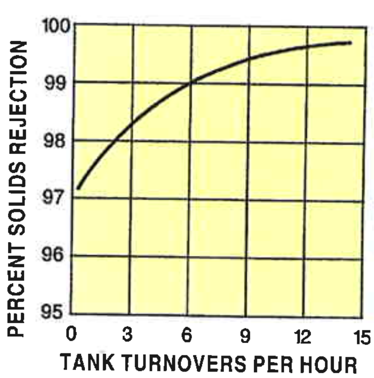
A significant benefit of using less dense media to achieve the desired particle retention is the increased solids holding capacity offered by coarser media. There are many examples of success with coarse media. For instance, 30 micron cartridges will keep hydraulic oil looking like new, will change a neglected swimming pool from green to clear overnight and turn a slimy, oily alkaline zinc solution from milky to clear. Coarser media may provide up to five times the solids holding retention before flow is reduced to an unacceptable rate.

Working well in other industries

Will recirculatory filtration work? Well, it has been used for years by many industries and it is regularly being done on swimming pools and hydraulic and lubricating systems. However, the presence of solids could not be tolerated in finished products such as beer, whiskey, soft drinks, food oils and syrups, chemicals, etc., hence the need to either do a good job of filtering the first time, or recirculate until the desired clarity is achieved. Although plating and other types of finishing processes allow for some solids to be present in a limited amount until removed, the difference between these applications and plating and other finishing processes is that plating and finishing applications usually don't have a "dirty tank" and "clean tank", and therefore must rely on continuous recirculation of the liquid passing over the filter media until the desired results are achieved.

In plating, increased solids holding capacity — with subsequent flow (turnover rates) will solve most roughness problems. It all depends on the number of passes, which dictate the flow rate required. For instance, a 4500 gallon batch being transferred at 45 GPM would take one hour and forty minutes, but if we turned the tank over ten times to achieve 100% contact with the filter, a pump of 750 GPM and one hour for turnover recirculation would be required. Result... the "dirty tank" would be clean, the solids would be in the filter, and the desired level of solution cleanliness would be achieved.

Effect of turnover rate on solids rejection. Hydraulics indicate a turnover rate of 14 times is required to have all the liquid pass through the filter once. Now consider the turnover rate necessary to maintain clarity in your plating tank when you may be introducing new parts every minute.



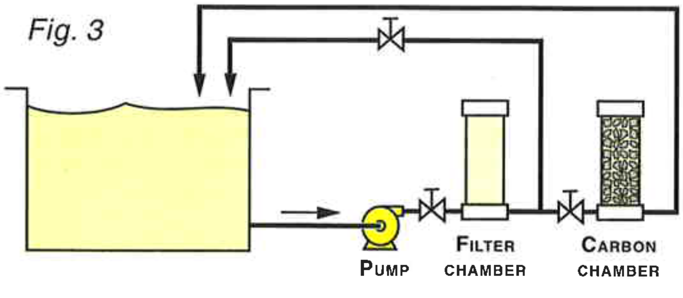
To take the approach one step further, bearing in mind that quality plating is the number one objective, ten turnovers per hour might come close to having all of the solution pass through the filter at least once. Is a turnover of ten times per hour needed? Probably not, but plating occurs every time parts are inserted into the solutions and our original intent was to filter out the particles to achieve quality plating. So, turnover rate must be considered to achieve the objective.

If organics are also a problem due to their decomposition, then separate carbon treatment would be required. But today there are still some platers who used powdered carbon to adsorb organic impurities. They suggest the need for fast adsorption of organic impurities and insist that it be accomplished either in a batch process or with the carbon coated on the surface of the filter. Their usual practice was to insert a filter aid which would precoat the surface of the filter media, making it possible to support or retain a mixture of powdered carbon and filter aid. This practice required frequent filter servicing because of the density of the powdered carbon or the restriction of the flow it caused. This also reduced the amount of solids which could be retained by the filter before the low flow rate indicated that service was necessary.

As a result, platers turned to granular carbon because it didn't reduce the flow rate as much, but they felt that the rate of adsorbency was lower because solids would plug the pores at the surface of the granule. It wasn't until platers switched to the sequence of filtering first, then allowing the solution to pass through the unrestricted pores in the granular carbon that equivalent adsorption was achieved.

However, if uniform purification is necessary, then gradual, consistent adsorption purification is necessary. Gradual, consistent adsorption downstream of the filter works well, offering some significant advantages which contribute to solution clarification so the desired quality can be attained. A separate carbon chamber, therefore, allows the filter to achieve maximum solids holding capacity and maintains a low level of organic impurities without the mess of handling the dusty, black powder (See Fig. 3).

Fig. 3



Recirculation has other benefits

There are other benefits which the plater will appreciate. Most significant will be a reduction in manual evaluations in the laboratory and, when troubleshooting is required, it will be comforting to know that bath contaminants are not the cause. Statistical quality control can monitor results attained from increased filtration and separate carbon purification and indicate the need to further increase either or both until the ultimate quality goals are achieved.

Be like the surgeon

In conclusion, be like the surgeon who scrubs, disinfects and follows all procedures to provide a safe environment for the operation. Go back to the pretreatment steps and use those preventive methods downstream from the plating bath which will minimize the total solids getting to the plating tank:

(1) Prefilter as much as possible with preventive barriers and, if required, use carbon adsorption in a separate chamber. Then . . .

(2) Recognize the effect flow rate (turnover) will have on getting the solids to the filter. Use high flow rates with the coarsest possible media to achieve maximum dirt holding capacity. For example use 3 micron media instead of 1 micron, or 30 micron instead of 15 micron, but not 100 micron instead of 1 micron.

(3) Consider using coarse filter media for the extra solids holding capacity which it can provide or the benefits of using 2 different grades of filter media in series.

(4) Remember to increase the number of filter cartridges so that flow rate per cartridge is low, thus reducing velocity across the media.For example, using 4 cartridges instead of 1 will reduce media consumption by 50%. In other words, 12 cartridges instead of 3 with the same pump will consume 50% less filter media annually.

(5) Use pump with eductors in place of air agitation to minimize the introduction of airborne contaminants to the bath, as well as improving deposit quality and reducing emissions from the tank.

The result of providing this level of filtration and purification will be less rejects, reduced waste disposal costs and fewer laboratory staff involved in problem solving. Instead, they will be able to devote their efforts to the ongoing improvement in quality.

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