SERFILCO

RAISING QUALITY STANDARDS BY COST EFFECTIVE FILTRATION AND CARBON PURIFICATION OF PLATING SOLUTIONS

Metal finishing companies are well aware of the quality revolution that has been gathering momentum over recent years and whilst the quality message, "right first time, every time" sounds simple, it requires much effort, dedication and commitment to achieve in practice. Plating involves many critical process solutions that become contaminated with soluble and insoluble impurities which must be removed to maintain acceptable quality standards for finished parts. This demand for efficient filtering equipment has been further stimulated by advances in high throughput automatic plating machines and high speed processes where deterioration of plating quality can result in substantial losses in production until the fault is resolved. In considering the role of depth cartridge filtration as a means to raising quality standards cost effectively, this paper reviews the sources of contamination and the importance of flow, pressure and dirt holding capacity when selecting cost effective equipment for filtration and carbon purification.

INTRODUCTION

Filtration of plating solutions is not a cure-all for all plating problems, but it remains a critical part of the whole effort to achieve success. It is a part that cannot be overlooked or understated. A little filtration is better that no filtration, but a lot of filtration is often the only way to ensure the level of quality required on many plated items.

Typically the benefits of an effective filtration system are:

- Faster Plating
- More Agitation
- Less Brightener Consumption
- Less Pitting
- Less Staining
- Better Temperature Control
- Better Throwing Power
- Less Roughness
- Less Porosity
- Less Maintenance
- Less Servicing
- Easier Carbon Purification

It is therefore somewhat surprising to find that platers treat filtration as a necessary evil and seldom give sufficient attention to equipment selection. It often seems that initial flow rate and price are the only two factors considered when new equipment is purchased. As a direct consequence, it is not uncommon to find plating plants with inadequate filtration especially in terms of flow and dirt holding capacity. Therefore, frequent servicing is necessary to maintain sufficient flow to prevent solid particles building up; rejects are therefore never far away. Only after a thorough understanding of the problems involved in achieving clarity and purity of the plating solution can selection of the proper equipment be made.

START THE CLEANING LINE

These days, even statistical process control might be needed to meet quality requirements, however once the degree of quality has been established, platers can proceed accordingly. Some platers tell us of their experiences which result in 5% rejects or more, others as low as 1%. The plating may be the same, but if the specifications vary, the reject rate will follow accordingly. It all reverts to cost and intention. What steps is the plater willing to take to achieve the desired results?

Quality control people say you can't take shortcuts, nevertheless all specifications have plus or minus tolerances which must be carefully monitored and controlled. How can we apply this approach to plating, and in particular, what does it have to do with cleaning? Remember, you can't expect to get good plating if the parts are not cleaned properly because dirty parts are bound to be carrying contaminants to the plating tank. Chemicals used in cleaning dissolve, loosen and free impurities and contaminants from the substrate, but it is the rinsing which determines whether or not parts are actually clean when they enter the plating tank.

OTHER SOURCES OF CONTAMINATION

1. Fume extraction passes large quantities of air over the surface of process tanks. This air carries with it all sorts of contamination from other operations near and even far away from the plating line. The electrolytes, aided by wetting agents, pick up anything that drops in along the way.
2. Agitation with air creates a similar problem, the solution acts as a fume scrubber, absorbing fumes, oil mist vapors, sand blast dust and any other contaminant that gets past the intake screen. (Some call it a filter, but in most cases, it is nothing more than a coarse mesh such as you might find in a domestic heating system)
3. Water can be a source of solids contamination. Whether it is city purified or recovered following waste treatment, the water will most certainly contain some particulate matter.

The plater has two options to counteract these sources of contamination. One is to remove the impurities after they get into the plating tank. The other is to isolate as many of the solids and other impurities as possible before they get to the electrolyte and disturb the plating process. Let us take a closer look at this second option.

Filtration of cleaners can be important for several reasons. First, it can add some life to the cleaner, which is a cost reduction capable in most instances of paying for the equipment necessary to do the job. Second, it will reduce the possibility of solids and oils from being carried down the line to the plating baths. This means that the plating filter will require less service and will be operating at higher average flow rates. The best way to filter a cleaner is to connect the pump to a floating skimmer and suction pipe assembly. The oily substances on the surface will be drawn to the skimmer while the heavier particles will be carried to the filter via solution movement and be retained in the filter media. Carbon may be used for additional absorption.

NOW TO THE PLATING TANK

Even if parts enter the plating tank completely clean and free of solid contaminants, they will encounter other sources of contamination, e.g.

1. Random dirt - from ceilings, hoists, racks etc.
2. Sludge - from unbagged anodes or from defective bags.
3. Reaction products - precipitated in the plating bath - especially iron hydroxide from nickel or zinc plating of steel parts.

The contamination from these sources, as well as drag-in of solids from prior steps, can produce a "dirt holding" that will require extreme vigilance to eradicate.

From the plater's standpoint, this influx of solid contamination represents a serious threat to his chances of achieving "zero rejects". His only recourse is continuous filtration of the plating bath. The question is: "How much filtration is enough to assure quality?"

FLOW RATE AND VELOCITY

Flow rate is usually defined as "turnovers per hour". Figure 1 shows the effect of turnovers per hour on solids removal and hence solution clarity. It can be seen that one turnover per hour is not very effective in removing solids, achieving only 60% removal. Two turnovers will achieve around 84% removal, three achieve 92-94% and four can reach 97-98%. For the ultimate in clarity, tanks should be turned over ten times per hour. Flow rate is the vehicle which provides the velocity or movement of solution which is necessary to carry particulate matter to the filter. The higher the flow rate, the greater the velocity, the better the filtration.

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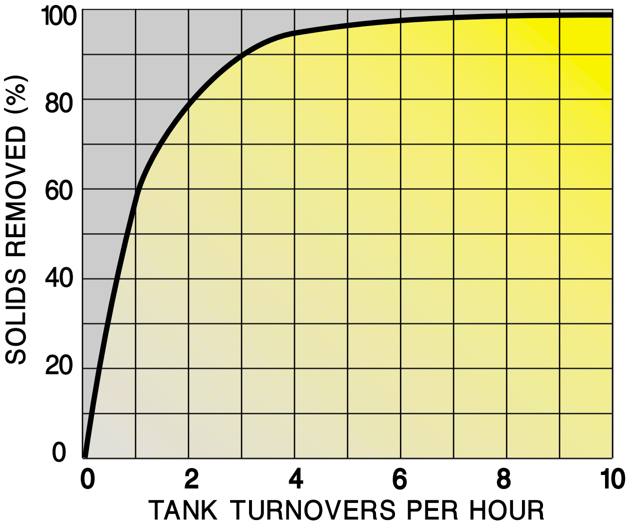
Figure 1. Effect of flow rate on solids removal



Whilst this statement is unquestionably true, one should guard against increasing flow rate without correspondingly increasing the size of the filter chamber, otherwise the important balance between flow rate and dirt holding capacity will be disturbed. The ideal balance should not exceed 1000 liters/hr. per 10 in. cartridge, otherwise pressure losses will increase, dirt holding capacity will be reduced and the equipment will need to be serviced more frequently.

WHY IS VELOCITY SO IMPORTANT?

1. Velocity enables fresh solution to be constantly brought back to work, replacing depleted solution and carrying new metal ions to be deposited; therefore velocity helps to increase the speed of plating.
2. Velocity prevents temperature stratification (layers of hot or cold solution).
3. Velocity can help prevent burning of the deposit in high current density areas.
4. Velocity can help direct solution to specific areas such as recesses or interior surfaces to achieve a more uniform deposit.
5. Velocity created by a pump may also be used instead of air agitation, eliminating the possibility of contaminants entering the electrolyte for the air blower.

FILTER CARTRIDGES

Having emphasized the importance of flow rate and velocity and recognizing that it is impractical to maintain a working solution totally free of particles, all steps must be taken to achieve the degree of solution cleanliness necessary to reach the quality objective with "zero rejects"

What then are the best choices of filter cartridge and turnover rate necessary to achieve the desired results?

1. Should the cartridge be very dense, stopping every possible particle which could cause roughness by co-deposition, which later could show up as rust or imperfection?
2. Should the cartridge be coarser, allowing higher flow rates to achieve higher turnover rates?

Perhaps the best way to answer these questions is to pose another, what is the size range of the particles and how many are there?

If the answer is few and small, a very dense cartridge is recommended (0.1 to 5 micron). If large and many, a coarse cartridge is best (10 to 100 micron), letting the solids form part of the filtering process.

In either case, the cartridge must be able to hold the amount of solids that enter the plating tank during the time between filter servicing. Years ago "surface area" was the measurement used, but it is more correct to refer to "dirt holding capacity".

For extremely critical applications requiring the utmost in clarity, absolute submicron (0.1 or 0.2 micron) surface type cartridges might be used. Therefore, if solid particles can be assumed to be at a minimum, flow at a high turnover rate in excess of ten times per hour could be maintained without flow reduction. If such cartridges plug up too frequently, then a pre-filter consisting of coarser cartridges might be added.

For the majority of plating applications and yet where quality is still very important, cartridges of 1 to 10 micron with a nominal retention rating will provide excellent results; however, an important question is can the solids be removed from the plating tank before they are co-deposited onto the surface of the work? This is again an example of the need for high flow rates which can be maintained for extended periods by the use of coarser cartridges and yet still achieve a high degree of solution clarity.

Oversizing the filter chamber adds additional dirt holding capacity, therefore when operating a filter with less flow per unit area, the result is less pressure drop. This provides a more permeable cake of contaminants thus allowing a bigger build-up of solids and subsequent reduction of operating costs.

Wound cartridges make this possible because their construction creates depth filtration (as opposed to surface filtration) as illustrated in Figure 2.

When a cartridge is manufactured, each layer is built-up from the center core, becoming progressively more coarse because of the increase in diameter. The micron rating is controlled by the diamond pattern and the tension applied in the winding process. As liquid passes through the cartridge, the larger particles are trapped in the larger exterior diamond openings and progressively smaller particles are trapped in the finer openings nearer the core.

It is a characteristic of wound cartridges that the coarser the cartridge, the lower the cost, the greater the dirt holding capacity and consequently the longer the service life.

Figure 2
Depth wound filter cartridges

Whilst all cartridge filters have the advantage of simplicity and convenience in operation when compared to disc filters, their greater dirt holding capacity with increased porosity can be used to great advantage in recirculatory filtration of plating solutions.

Another advantage is that the dirt is held more tightly within the cartridge and recontamination due to failure or bypass is much less likely. It is for this reason that wound cartridges are often used in breweries for final polishing after pre-coat filters.

SIZING THE FILTER CHAMBER

Technological developments are of little value unless the equipment is properly applied. Of particular importance is sizing the filter chamber, otherwise insufficient dirt holding capacity will mean frequent servicing to maintain a satisfactory flow rate. For most plating baths, a good guide is to allow 1 x 10 in. cartridge per 200 liters of solution but this figure should be adjusted depending on the particular application. For example, acid zinc or bright nickel plating onto steel parts creates a much heavier "dirt" load than say acid

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copper plating in a PCB plant. Both may demand a flow rate of 3-4 turnovers per hour but filter chamber sizing would be quite different. Examples of solutions requiring higher flow rates with proportionally smaller filter areas are electroforming and electroless nickel plating baths where the dirt load is relatively light. Because dirt holding capacity is increased when the flow rate velocity through each cartridge is decreased, it therefore follows that:

— Time between servicing is increased
— Cartridge costs are reduced
— Labor costs are reduced
— Solution loss is reduced

These benefits can be quantified as shown in Figure 3, from which it can be seen that oversizing by a factor of 4 doubles the dirt holding capacity per cartridge. Since the chamber holds 4 x the number of cartridges, the filter is opened only 1/8 as often, reducing the labor by 87.5% for cartridge changing.

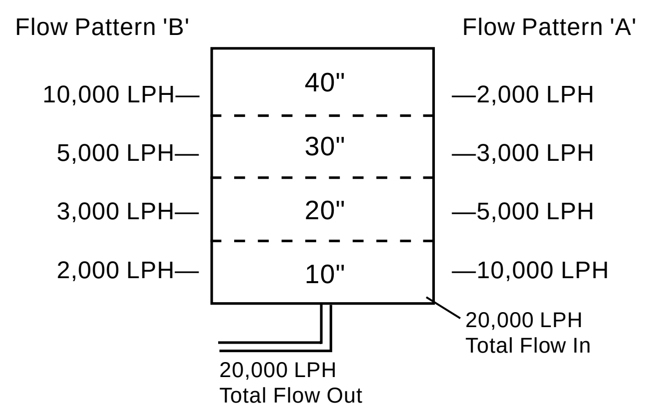
Figure 3. Economics of filter chamber oversizing

Oversizing Factor	Number of Cartridges in Chamber*	Dirt Holding Factors per Cartridge	Time Between Cartridge Change	Cartridge Consumption Reduced by	Labor Cost/ Solution Loss Reduced by
1	C	D	T	0	0
2	2 x C	1.5D	3T	34%	67%
3	3 x C	1.7D	5T	42%	80%
4	4 x C	2.0D	8T	50%	87.5%

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

Figure 4 shows how in cartridge filter chambers the flow pattern changes during the life cycle of a set of cartridges. In this example the chamber contains 48 x 10 in. (or 24 x 20 in.) cartridges and the total flow remains constant at 20,000 lph until flow pattern B is reached. Only then does the total flow start to fall.

Figure 4. Flow pattern through cartridge filter chamber



FILTRATION OF WATER

Clean water is an essential raw material for any plating or anodizing process. Water from natural sources such as a well, lake, etc. probably needs softening for calcium removal or carbon treatment for the reduction of organic impurities. Certain applications require that the water be essentially free from all ions. This can be accomplished with an ion exchange and/or reverse osmosis treatment.

Softening, carbon purification, reverse osmosis or ion exchange are not really filters in themselves, although they sometimes function as such. Each will operate to its maximum efficiency only if the water is filtered first, usually with 15 micron media, so as to be free of solids. Otherwise solids will coat over the resin in a softener or ion exchange bed and also over the carbon, or membrane in a purification unit, preventing efficient adsorption. Trap filters of 1 or 3 micron are recommended to prevent migration of resin or carbon media.

The quality of water required will vary depending upon its ultimate use such as makeup water for an electroplating solution or for rinsing. Solids entering the plating tank with the makeup water may amount to only 5% of the total to be filtered, but it is beneficial to remove at source, because it is easier to replace filter media in the prefilter to a deionizer than it is to regenerate and wash the resin bed. Filtration is especially important in the reverse osmosis process, since solids will plug the pores in the membrane and decrease its efficiency.

Conserve water . . . save money

Since the cost of water is continually rising, its efficient use is of increasing importance. This is also necessary in order to conserve limited water resources. Considerable reduction in rinse water volume can be achieved with multiple counter flow rinse tanks, spray rinsing of parts and longer draining time of plating barrels. Conductivity meters can monitor and automatically control the dissolved solids concentration in a rinse tank by means of a signal to a solenoid valve on the water inlet. The reuse of water is also feasible with an ion exchange or reverse osmosis treatment.

Filtration of either in-line water supplies or recirculatory systems may be accomplished with depth-type cartridges, providing particle retention from 100 down to 1 micron or less if necessary with absolute ratings of 0.25 to 1 micron. The choice of filter is usually dependent upon the amount of solids, the particle retention desired, available space and initial investment consideration. Filter chambers are available in both non-metallic and metallic construction. Pumps should provide adequate pressure to achieve the flow through the media on an economical basis before servicing of the filter is required.

Improve quality . . . prevent rejects

Water filtration can prevent spotting of parts on final rinsing after anodizing or plating and prevent spray nozzles from plugging up and causing a distorted spray. Even water used for flushing pump seals should be filtered to prevent gritty particles from causing premature seal failure and leakage of the solution being pumped.

CARBON PURIFICATION

Most plating solutions contain organic additives such as brighteners, stabilizers, levellers etc. During electrolysis some of these chemicals are converted into undesirable organic compounds which need to be completely removed or at least kept at a low level of concentration. Organic contamination can also be introduced from pretreatment chemicals, jigs, resists, etc. Depending on the solution, different methods of removal are employed.

Traditionally the whole bath is taken out of service and treated with powdered carbon at elevated temperature and then, after a period of settlement, the solution is transferred to a separate tank. This process is messy, time consuming and inevitably results in some loss of solution. Nickel plating solutions are often continuously pumped over powdered carbon which has been precoated onto the filters. Whilst this technique undoubtedly controls the level of organic contamination it is in itself a messy, labor intensive process requiring a certain degree of care on the part of the operator

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to ensure carbon does not enter the plating tank. The carbon is normally replaced on a weekly basis although it is doubtful any useful purpose is served after the first few hours of circulation. Unloading of the impurities back into solution can occur in some instances.

An alternative technique now well accepted by many platers, utilizes granular carbon packed into a separate chamber connected to the downstream side of the filter pump system. A manually operated control valve allows for bypass purification continuously or intermittently as required (see Figure 5). The process is both simple and effective, and because the filters are kept free of carbon, they operate at higher flow rates for longer periods before cleaning becomes necessary.

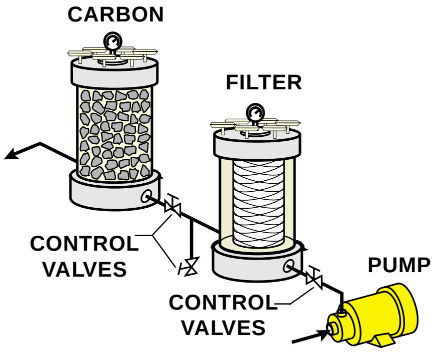

Figure 5. Filter pump with by-pass carbon purification chamber

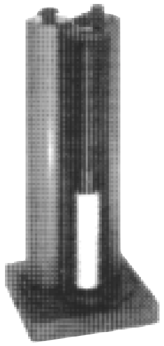

Figure 6. Carbon purification chamber with trap filter

Pumps

All filtration systems depend on a pump to circulate the solution and almost all are manufactured from plastic materials. Most are centrifugal, being either magnetic coupled without glands or seals, or directly coupled incorporating either single or double mechanical seals with water flush.

Double seal pumps have advantages over single seal because they eliminate the formation of salt crystals on the seal faces which would otherwise cause leakage from abrasive wear. They may be dry-run without damage and are particularly suitable for electroless nickel baths. For most solutions except electroless copper and electroless nickel, magnetic coupled pumps to 30,000 lph are generally preferred because of their simplicity, reliability and leak free capability.

Alternatively for all solutions including chrome and electroless processes, seal-less vertical pumps have distinct advantages to offer the plater. For example, they will run dry indefinitely and there are no seals to leak, neither are they unduly affected by the abrasive particles which are inevitably present in plating solutions. They may be installed in or out of tank per the illustration in Figure 7.

Regardless of which type of pump is used, there must be enough pressure to maintain the desired flow rate even though the filter cartridge becomes progressively clogged.

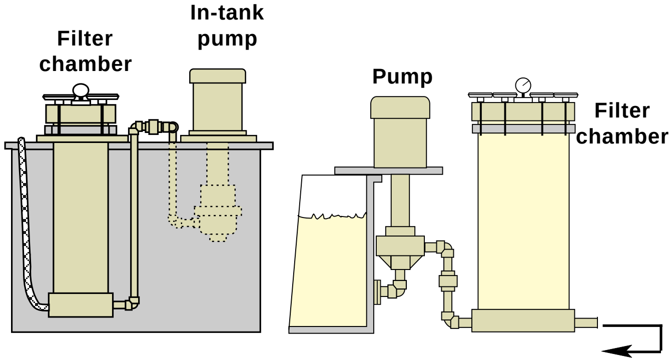

Figure 7. Typical installation arrangements

Conclusion

Flow rate, pressure, filter cartridge porosity and size of filter chamber all work together to affect solids retention by the filter in a given period of time. The coarsest possible filter cartridge should be selected to give the best clarity. If the filter does not provide the clarity required, the plater may select a denser cartridge that loads up faster but in the end removes less solids. At the other extreme, it is possible to go to a coarse cartridge and not get any filtering at all, even though the flow rate is very high. A judgement must be made with all aspects of the application considered. The bottom line is to achieve the highest solids removal because this maintains the cleanest tank and gives the fewest rejects. When selecting a filter system, don't forget the accessories. Valves may be added to control or direct flow. Always include a pressure gauge to indicate the condition of the filter, thereby ensuring that filters are serviced at the optimum frequency.

To sum up, the essentials of an effective filtration system are:

- Adequate flow
- Adequate pressure
- Adequate flow to cartridge ratio
- Corrosion resistant
- Separate carbon purification chamber
- Adequate velocity
- Adequate dirt holding capacity
- Control valves and pressure gauge
- Reliable and economical
- Easy to service

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