



Avoid Nickel Plating Losses— Protect the Environment and Improve Profitability

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Avoid Nickel Plating Losses— Protect the Environment and Improve Profitability

Guidelines to Help Prevent the Loss of Nickel and its Salts From the Finishing Shop

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INTRODUCTION

A recent survey of the nickel plating industry in UK and Europe revealed some gaps, in knowledge and awareness, with regard to the route of nickel losses to the environment.

Essentially the manager of a finishing shop should be aware of the potential of his plant to generate losses of nickel to the atmosphere, as liquid waste, or as solid waste. Some of these losses are easily seen—others are not.

The hard fact, however, is that the primary resources of the operation, and the overhead costs of the factory, are wasted if they are not utilised to produce good components. What useful purpose is served by water rinses that are allowed to flow when the plant is not in use? Water may be a natural resource but it is not free of charge.

It is therefore the responsibility of the finishing shop manager to be aware of the limits of discharge that are set by local and national authorities, so that he may observe them, and also to be aware of the source and the route of his losses, so that he may minimise them. He must understand that many of his resources have a double cost—their purchase cost, and also the cost of their treatment and disposal.

In the case of nickel, he must understand and believe that any nickel that does not leave his plant as a component is a triple loss. He made an initial purchase of the metal, but instead of making his profit on it, he must now pay for its treatment and also for its disposal. Additionally, all of the resources that were used to lose the nickel, such as labour, plant, power, heating, water and air, have been wasted. Some, such as water and chemicals used in the process, will also have treatment and disposal costs, and must therefore be utilised fully, creating as little waste as possible.

To help the manager with his task, the Nickel Institute have commissioned this short document, which illustrates some of the causes of nickel loss, and some of the measures that may be employed to reduce this loss.

The problems highlighted are all real, and the preventative measures discussed are all practical ones, they have been used and are known to be effective. They require commitment from the manager, who must overcome wasteful working practices within his workforce and generate enthusiasm for new ways of thinking and working.

Not all of the suggestions will be relevant to all installations, or even practical to implement in some cases, but they may prompt other ideas that are better. The end result will be a reduction in the quantity of nickel that is lost to the environment, and an improvement in the profitability of the finishing shop.

THE NATURE OF LOSSES

“Losses” in this context refers to any nickel—in whatever form—that leaves the plating department by any route other than as a satisfactory deposit on a component, or—in some cases—as the component itself. Nickel that is re-used, or sold as scrap, is not considered to be “lost”; however, a reduction in the quantity of nickel taking this route should still be considered to be a saving.

The loss routes are defined as being to effluent outflow, to atmosphere and to landfill.

Losses in Liquid Form

Losses of Dissolved Nickel to Waste Treatment Plant or Effluent Outflow

Losses of nickel in liquid form are the most important, since they are the most common, represent the greatest financial loss, and have the greatest impact on the environment. A major percentage of nickel electrolyte lost will eventually finish its journey as landfill; being precipitated in the treatment plant and filtered or settled out before the plant effluent becomes outflow from the site.

Preventable Losses

Preventable losses of electrolyte represent the opportunity to achieve the greatest financial return, since the savings may be frequently made with little or no capital expenditure.

The primary requirement is a strong and consistent management commitment to good housekeeping practices, without which nothing will be achieved. Initially this may require a major change in attitude, with application, effort and constant attention to detail, but becomes rapidly easier as good practices become the norm. Given management commitment and workforce co-operation, the savings in material can be considerable.

Losses by Dragout

Electrolyte has two costs—the initial cost of labour, chemicals and factory resources to introduce it to the bath, and the additional cost of treatment and disposal; any saving of electrolyte is therefore a double saving.

As an approximation, a normal nickel plating bath, with adequate anode area, will remain more or less in balance i.e. the nickel deposited will be replaced by anode dissolution. Any additions of nickel salts may therefore be considered as replacement of electrolyte losses. A calculation of the annual spend on nickel salts will indicate the savings that are available; the calculation should also include the cost of labour and plant resources in making the additions, and an estimate of disposal costs. Reclamation of lost electrolyte is a poor substitute for prevention of loss, since this too carries an on-cost of labour and plant resources.

Dragout losses may be defined as any electrolyte that is removed from the plating bath by components or fixtures—either jigs or barrels. It may be sub-divided into that electrolyte that clings to the surface of the components and fixtures (surface dragout) and that which is removed by the inability of the electrolyte to drain away (carry-over).

Surface dragout is relatively small—generally accepted to be 0.1 litre/m² for jigged, flat components, with an adequate drainage period.

Carry-over, from cup shaped components, could be as much as a hundred times that quantity; generating totally unacceptable losses of electrolyte.

Surface Dragout

It is essential that fixtures are given an adequate drain period while still suspended over the process tank. Obviously this will be greater for a barrel, which should be assisted in the drain process by rotation while suspended over the plating bath. The design of the barrel will also help drainage—the perforations should be as large as is practical, with regard to component size. This will also help the deposition process by allowing good electrolyte movement. The purchase of a correctly designed barrel for common components should give savings in lost electrolyte and shorter plating times.

The savings made by taking the time to allow a barrel to drain properly over the nickel tank will pay, several times over, for the small increase in process time.

Consider the initial overall cost of making up 2 or 3 litres of nickel solution (for this quantity may be easily carried out by a 30" barrel that is insufficiently drained); add the cost of the effluent treatment chemicals required to dispose of it, and the additional cost of precipitate removal from site—and then multiply that by the number of barrels processed per annum. Obviously this cost will vary from plant to plant, but the result of this calculation will always be a much higher cost than expected—a cost that is unnecessary and avoidable.

While jigged work will also benefit from adequate drainage time, it is possible for workpieces to become passive if allowed to flash dry after immersion in a hot nickel bath. One possibility might be the provision of a mist sprays that will allow some rinsing of the emerging jig while still over the plating bath, without appreciably increasing the solution volume. Depending on the plant, this “fog spray” may be hand operated or automatic, but obviously only needs to operate as jigs are withdrawn from the bath.

Carry Over

In an ideal world the component will have been designed for plating, promoting an even deposit thickness and adequate drainage; unfortunately, in the real world, this is rarely so. In an “in-house” finishing shop it is essential that the person responsible for plating be given the opportunity to comment on a new design *at the design stage*. Where there is conflict of interest it is inevitable that the functional use of the component will take priority. The best that the finishing manager can then do is to design his jigs so that an even deposit and minimal carry-over is achieved.

Other Operational Losses

Electrolyte is frequently, but less noticeably, lost to effluent by planned maintenance operations on the plant. Consider the following scenarios:

- a) The electrolyte is pumped to storage for routine maintenance such as cleaning out of the tank, removal of dropped components, refilling of anode baskets, cleaning of anode and cathode bars etc. It is imperative to allow sufficient drainage time for anode bags and ensure that air or solution pipework has drainage holes at the lowest point. *It is essential that all of the electrolyte is removed*, the last few centimetres of solution in a large bath could represent more nickel lost at this time than during a whole week of plating. Any new tanks should be designed with a sloping bottom to box sumps so that drainage may be complete. A well-designed tank may cost a little extra on the purchase price; a badly designed tank will cost a little extra money every time it is emptied—for its entire working life. (cf. Annex B.)

- b) A filter is taken off line to be serviced. If the electrolyte is not removed and the filter pack washed through before being serviced, a considerable quantity will again be lost—either as effluent or as solid waste, which will be discussed later. (cf. Annex C.)
- c) The electrolyte becomes contaminated by organic material; the necessary carbon or carbon + permanganate treatment could result in the loss of up to 20% of the electrolyte volume.
- d) Finished components exhibit surface roughness caused by dissolving dropped work or a damaged anode bag. The operation of pumping out and filtering back after thorough cleaning of the bath will cost dearly in lost electrolyte.

Operational losses are best avoided by good housekeeping and by training. Operatives may not be aware of the cost—both financial and environmental—of their actions. While a great deal of thought may be applied to the design of a plant as a production unit, there is less attention paid to the peripheral maintenance activities. Good process engineering design and good housekeeping will ensure that as little electrolyte as possible is lost during planned maintenance activity.

“Accidental” Losses

This section could be more accurately entitled. “Losses due to carelessness, lack of training, lack of planning, lack of maintenance and poor process engineering”.

Consider the catalogue of disasters that may befall the average plating shop:

- Tanks overflow because a hose was left unattended during a “topping-up” operation.
- Electrolyte sucked into the extraction ducting because the level was too high.
- Pumps and filters leak because of poor re-assembly or because a seal has failed.
- Drain valves left open when a solution is returned from storage.
- Heating or cooling coils leak because they were made of an inappropriate material.
- Plastic tanks melt because a heater control failed.
- A barrel lid comes loose and dumps the whole load of components into the bath.
- Incorrect jiggling causes components to fall into electrolyte.
- An electrical short circuit causes rectifier fire.
- Electrolytes contaminated because the plant was operated when the rinse tanks were empty or the rinses were not running.
- Electrolytes contaminated by badly maintained jigs.
- Electrolytes contaminated by damaged anode bags.
- Electrolytes contaminated by filter media.
- Plant operated with process tanks at incorrect temperatures.
- Incorrect quantities of chemical make-up added.
- Wrong chemicals added.

These are but a few examples of an almost endless list of economic and ecological disasters that have occurred in plating installations. They have all happened. Any plating shop manager will have seen several of the above, and will probably be able to add several more “accidents” to this list.

Sadly, in forty years of metal finishing, I have seen all of them!

Action Required to Prevent Future Incidents

- a) Training: Ensure that operatives are supervised and adequately trained before they are allowed free access to the plant. Ensure that they are aware of the consequences of carelessness, and the resultant impact on the environment. Label all valves and ensure that there are process instructions in place for plant management, i.e. start-up/shutdown, electrolyte transfer etc.
- b) Planning: Plan for failure, carry out a truthful risk assessment and implement corrective measures. What happens if a tank fails? Is there a bund system in place? Is it kept clean and fit for use? Will pumps and rectifiers switch off if an electrolyte level falls? Are you still topping-up with hoses? Consider automatic level control; install a fail-safe cut-off mechanism for pumps and water supply in the event of electrolyte levels becoming too high. What happens if a pump connection leaks? Is the pump enclosed by a bund system? Who does what in the event of an incident?
- c) Maintenance: Use the risk assessment results to instigate a programme of planned preventative maintenance. Planned maintenance is always less expensive than emergency repairs and lost production in the wake of an “incident”.
- d) Engineering: Prioritise engineering upgrades in the light of experience and risk assessment. Ensure that previous experience dictates the selection of good process engineering practices applied to all new plant.
- e) In the event of an “accident”, act quickly to minimise effects. Inform local authorities as soon as possible so that problems are contained or minimised. As soon as possible, hold a “who, what, where, when, why” inquiry, not to apportion blame, but to review the risk assessment programme and its management.

Inevitable Losses

Inevitably, there will be a certain volume of electrolyte that cannot be immediately returned to the bath. It is still possible, however, to prevent the majority of this volume from escaping to the effluent plant; therefore reducing the environmental impact of the plant still further. (cf. Annex A.)

Rinsing Techniques

Water is an expensive commodity, for which we must pay twice—on the way in and on the way out, where there is the cost of effluent treatment and final disposal.

The quantity of water that must be used will vary with every plant, dependant on the nature of the operation. Frequently an excess of water is used because it dilutes the final outflow. This is a false economy; savings in water can be made if the quantity of lost electrolyte can be reduced.

The following suggestions must be considered in the light of operational needs and existing plant design, and the most suitable options selected.

The first consideration is whether or not the nickel layer is to have a final topcoat, e.g. chromium, gold, etc. Should this be the case, then one of the primary considerations is to maintain a chemically active surface to promote adhesion of the next deposit. This may preclude the adoption of some suggestions because they may cause passivity of the surface.

Static Rinses

The most obvious concept of a static rinse, i.e. a rinse without a flow of fresh water, is that the nickel electrolyte from it will be fed back to the plating bath in one way or another. The simplest scheme is to use the rinse to replace evaporation losses, although this may, in time, lead to an increase in metal concentration that must eventually be addressed.

Should there be space to do so on the plant, it is a good idea to circulate the water in the static rinse back to the rinse *prior to nickel plate*. Jigs and components will then be dragging in a dilute electrolyte to part-balance the dragout. If the dragout rinse and the drag-in rinse are joined by a low volume circulation system, the drag-in will increase in nickel content and help to maintain the equilibrium. (cf. Annex A.)

There is an important warning when considering the use of drag in and drag out tanks. Dilute nickel solutions have been known to cause passivity of components, particularly when stray DC current is possible. Obviously the material used to construct the drag-in and drag-out tanks must be acceptable as a material for the plating bath, preferably non-metallic.

Agitation of static rinses is frequently neglected, but the improvement in rinsing (and therefore the reduction in nickel carried over to the next rinse), by removing the boundary layer of electrolyte, is considerable. Nickel tanks that run at a low temperature may not evaporate sufficiently for the dragout to be fed back. In this case there are several methods, i.e. reverse osmosis, evaporation etc., of concentrating the dragout before return.

If, for special process considerations, it is not acceptable to return dragout material to the process tank, then the dragout may be treated to remove the nickel, or concentrated for disposal or batch treatment. It is rarely possible to sell this concentrate; there is also a limited market for nickel metal that has been removed by electrolysis, due to the comparatively small quantities for disposal. Note that this deposit is rarely suitable for re-use as anode material, and should never be mixed with sulphur-activated nickel anode material. It will be seen that there are diverse decisions to be made before embarking upon a

reclamation process, one of the most important being a realistic assessment of commercial viability.

Running Rinses

Shop floor space has a cost attached, and the value of floor space must be balanced against desired rinse efficiency. No matter what the final number may be, running rinses that follow nickel plating should be operated as counter-current (or counterflow) rinses, including (if utilised) the final hot rinse. There is no reason why this hot water should not be fed back to previous rinses, it will increase the temperature of the components and reduce the thermal load on the final rinse heating system. Any additional water input to the final cold rinse should be controlled by a conductivity meter, and all the rinses should be agitated for best efficiency. Two cold rinses and a final hot rinse, operated in this manner, will use a surprisingly small quantity of fresh water, whilst maintaining an excellent standard of rinsing.

Minimise Liquid Losses

- Reduce dragout by improving barrel, jig and component design.
- Return as much dragout as possible to the plating bath, using better rinse techniques.
- Prevent losses during planned maintenance, using better process engineering.
- Prevent accidental losses with suitable bund systems.

Losses to Atmosphere

Nickel Salts Escaping to Atmosphere as an Aerosol Mist

Losses to atmosphere may impact on the health of operatives and the general public who occupy the immediate surrounding area. The permitted level of nickel in the atmosphere (Threshold Limit Value) in the immediate vicinity of the plant and in its surrounding environment will be specified by local Health and Safety regulations, as will that in the discharge of extraction to atmosphere. However it is possible, with a little thought, to reduce these losses to a minimum.

Preventable Losses

It is unlikely that a cold, still, nickel plating bath would generate any detectable nickel-bearing mist.

Given that the deposition efficiency of a nickel electrolyte is in the order of 96–98%, (and therefore there is very little gassing from electrolysis), the application of DC current for deposition is unlikely to increase the presence of nickel in the immediate atmosphere by any significant quantity.

Add a gently rotating barrel to the scene, and there would be no significant change. It is questionable whether a whole

department of cold, Watts nickel, barrel plants would create an appreciable quantity of nickel in the atmosphere.

So what are the activities that create the problem?

Raise the solution temperature to 60°C and molecular activity increases significantly, there could well be nickel aerosol in the immediate vicinity of the electrolyte surface.

Add the violent air agitation found in many plating shops, and the likelihood of nickel presence in the atmosphere becomes a certainty.

Turn on the excessive extraction that so many operatives believe necessary, and you have a scenario for substantial nickel losses a) to atmosphere and b) as nickel salts from the aerosol mist, as they rapidly crystallise in the extraction ducting.

Include a fume scrubber to remove nickel from the extracted air, and we now have a worst-case scenario. Nickel is lost to atmosphere, to effluent (from the extract scrubber) and as a solid (when the salts have to be chiselled out of blocked extraction ducting).

There cannot be many more ways of throwing away profit while nickel plating.

Remember that the initial objective was to make the environment safe for our operatives.

Electrolyte Heating

There is no doubt that both the rate and the quality of nickel deposition benefit from the use of a warm electrolyte. The cost of bringing a bath to temperature and then maintaining that temperature is quite high. There are savings to be made by first determining the lowest temperature at which the operation is efficient, and then investing a very small sum of money in thermostatic control to accurately maintain that temperature; an additional small sum for over-temperature cutout is very cheap insurance.

By reducing the bath temperature to an operational minimum, we also reduce molecular activity to an operational minimum, preventing unnecessary aerosol mist over the electrolyte and requiring less work to remove it.

Electrolyte Agitation

It is necessary to arrange some movement of the electrolyte in order to present fresh electrolyte to the anode and cathode surfaces and maintain the efficiency of the process; additionally it will prevent the growth of gas bubbles at the cathode face that give rise to rejected work due to "gas pitting". This only applies to rack plated components, since the tumbling action of barrel plating renders any other method of electrolyte movement unnecessary. Movement of the cathode (workpiece) through the electrolyte will often suffice for the cathode, but does not have the benefit of also providing fresh electrolyte at the anode face, resulting in undesirable pH changes in that area. The mechanics of arranging cathode movement are often clumsy and sometimes dangerous to operatives, the mechanism being difficult to guard effectively.

Traditionally, the popular method of agitating a nickel plating bath is by airflow through the solution. Plant

operators seem to think that it is better to have as much agitation as possible, as long as it doesn't actually remove the components from the jigs!

There are several disadvantages to this method of moving an electrolyte.

a) The Cost and Quality of Compressed Air

General factory compressed air supplies are rarely suitable for use on a plating plant. Many supplies are intended to operate machinery and have oil deliberately included for machine lubrication. This contaminated air is often fed to the plating plant without any thought, and may frequently be best described as aerated oily water.

If there is an oil separator in the agitation air supply line that *ever* needs to be emptied, there is a real danger of organic contamination.

If there is not an oil separator in the line, it would be sensible to fit one, if only to check the quality of the air.

Oil in a nickel electrolyte will give dark deposits in the lower current density areas, will often adversely affect the organic additions to a bright nickel bath, will increase the need for carbon treatments and, as a consequence, result in considerable losses of nickel salts to effluent, and to landfill. Carbon treatments will, of course, also remove your expensive organic additives along with the oil contamination.

The cost of producing compressed air is very high, but since it is rarely charged to the plating shop, it is rarely included in the basic cost calculations of electroplating a component. Conversely, rejected components caused by poor agitation air quality are rarely charged to the true cause of the rejects.

A dedicated, low pressure, dry air supply is quite an expensive proposition, and will be charged to the finishing department, but the cost may be offset by the reduction in rejects and in reduced electrolyte maintenance, often with a surprisingly low capital amortisation period.

The cooling effect of vigorous air agitation is another considerable, but unseen, on-cost.

If a bath is brought to temperature, and allowed to stand without agitation, it will cool quite slowly (depending on the quality of the tank insulation). If the same experiment is repeated, but this time with vigorous agitation, the results will be very interesting. It is then quite easy to work out the energy losses and the heating cost of air agitation.

Add this to the original cost of the air supply.

If the air quality at the surface of a still, heated nickel plating bath is determined, and the readings then repeated with the inclusion of vigorous air agitation, the results will again be quite interesting.

The cost of air agitation and its impact upon air quality in the immediate vicinity of the bath may well convince us that agitation by airflow is no longer the best method.

b) The Alternatives

There can be no immediate change to a plant that has air agitation. The best that can be done is to ensure that the air

is as clean as possible, and that the agitation pipework is in good order, capable of supplying air in the correct volume and in the required places. Very often the air volume has to be increased because the pipework has deformed at temperature and is now not supplying air in the required places. If the agitation pipework is maintained in good order it may be possible to reduce the airflow considerably; thus reducing the mist created by it.

During recent years, a replacement for air agitation has appeared on the scene. This is a system that uses the existing electrolyte pumped return from filtration, passing through similar pipework to that used by air agitation to a series of *eductors*. Eductors are components that enhance the flow volume of the returning electrolyte, through a venturi-type arrangement that gives a flow volume enhancement by a factor of five or more. There are no gases involved and the electrolyte movement, whilst generally more than sufficient, is therefore less likely to create additional aerosol effect. The engineering is necessarily more precise, and requires more thought; the results, however, are excellent and the improvement in air quality is measurable. The outlay is not too great, and can be set against the reduced consumption of compressed air and of energy required for tank heating. One thought to bear in mind. Air agitation increases in effectiveness as it nears the top of the solution; eductor efficiency reduces as the flow moves further from its source. This is not a major obstacle; it just requires a little more process engineering. (cf. Annex E.)

The object of the exercise is to provide sufficient electrolyte movement at the anode and cathode surfaces, it is not required to produce violent movement at the electrolyte surface.

Inevitable Losses

If, having completed all of the plant improvements designed to reduce aerosol mist, the levels of nickel detected in the immediate vicinity of the plating bath are still out of compliance, the fume must be extracted. The extract must also be suitable for discharge to atmosphere. Good process engineering considerations will still save money.

Extraction

Essentially, the nature and magnitude of the problem must first be determined. Unfortunately, it is not easy to determine the exact amount of extraction required; it is prudent when specifying a system to allow a margin for error. While it is not proportionally expensive to buy two or five or even ten times the volume of extraction required it would, however, be prohibitively expensive to utilise it. It is certainly sensible to have some extra facility in hand, but there must be control so that it can be moderated to only what is required. Control may be affected by flap valves in the ducting, adjustable restrictions at the intake, variable fan efficiency and variable fan speed.

It is worth remembering that:

- Any warm plant air that is removed must be replaced with cold air from outside—which must then be heated.
- Excessive airflow across the surface of the electrolyte may actually reduce pressure locally and promote the release of aerosol, which defeats the object.
- Operatives who have to work in a draught caused by excessive extraction will soon be complaining of stiff muscles.
- The object of the exercise is to create sufficient air movement, across the surface of the electrolyte, to remove any aerosol mist.
- Should the air volume to be removed be considerable, (for a long tank), or should the width of the tank be greater than one metre, it may be worth considering the provision of a low pressure air input at the opposite side of the tank to the extract, i.e., a push-pull system. (cf. Annex D.)

As an alternative to the option of extraction on both sides of the bath, this system has several advantages:

- Very little warm air is extracted from the plating shop.
- Input air will reduce the volume and velocity required of the extract air.
- It is possible to direct the input air, and therefore a well-designed system would give an “air curtain” effect, thus preventing escape of fume into the plant vicinity.

The additional cost of this type of extraction system, will be quickly paid back by the savings in heating and improved efficiency of the system, which will result in longer periods between maintenance and less nickel salts in the system.

A well-designed extraction system, together with a well-designed agitation system, may make the use—and expense—of a fume scrubber unnecessary. The environmental impact upon the surrounding area will certainly be reduced, as will the inevitable losses.

Additional Engineering

There is a possible addition to this system, depending on the type of plant in use and the components being processed. It is sometimes possible to enclose the bath surface by using a lid to cover the tank. This may allow extraction to be reduced considerably. Obviously if the process times are short, and the lid must be frequently lifted, then there is no point in having it. There are, however, processes that require extended plating times, and it is for this type of operation that the lid may offer an engineering advantage and possible savings in the cost of electrolyte heating and reduction of fume.

Where a full lid is not practical, it may still be possible to use a hinged flap to cover a large percentage of the tank while retaining access.

Where covers are used it is important to ensure that the enclosed copper busbars are not attacked by fume, allowing copper contamination of the nickel electrolyte.

Croffles may be used to retain heat and prevent aerosol losses, but they frequently prove to be more trouble than they are worth, having to be constantly retrieved from downstream of the plating bath, where they are carried by workpiece holders. (“Croffles” are spheres of a suitable plastic material in a range of diameters, used to form a blanket on the electrolyte surface, thus reducing losses of heat and electrolyte mist.)

Minimise Airborne Losses

- Engineer electrolyte movement to reduce excessive agitation.
- Consider the use of eductors.
- Maintain good temperature control.
- Engineer extraction to suit plant air quality requirements.

Losses to Landfill

Losses of Nickel as Metal, as Nickel Salts, or as Precipitate in Sludge or Filter Cake

Preventable Losses

Losses to Effluent Treatment

All of the previous discussion has been aimed at reducing the quantity of nickel that leaves the plant as anything other than a nickel coating on a good component:

- Reduction of dragout from the tank will reduce the quantity of nickel in the effluent cake or sludge.
- Good plant housekeeping, reducing the frequency of filter, or carbon pack, changes will reduce the quantity of nickel salts that are lost at this time.
- Well-designed extraction, reducing the quantity of nickel salts that have to be chiselled out of the extract ducting.
- Clean electrolyte agitation, reducing the need for major carbon treatments and subsequent losses of electrolyte.
- Prevention of electrolyte losses during routine maintenance, ensuring that all electrolyte is removed from the process tank by good tank design.

Reduction of losses of electrolyte, as detailed above, will reduce the quantity of nickel lost to landfill, because this is where all of these losses would eventually arrive. Very little of the nickel electrolyte originally lost “to effluent” will be permitted in the final outflow from the plant. It must be removed by effluent treatment, at considerable cost. Every minor saving made by whatever method, reduces this cost—as well as the initial cost of the chemicals and the departmental costs of maintaining the electrolyte.

Added to these “losses to landfill” is the nickel-contaminated waste from the filtration system—filter media (papers, cloths, cartridges and filter aid) and carbon pack.

Losses of Solid Nickel

Solid nickel scrap is produced in several ways:

- On the jig contacts.
- On plating-out sheets.
- On rejected components.

Some of this obviously comes under the heading of “inevitable losses”, but the quantity produced can be controlled and the excess is most certainly “preventable”

a) The Contacts of the Workpiece Holder (jig)

There has to be a contact point for the jig to pass current to the workpiece to make it cathodic. Ideally this contact area is restricted to a small surface, sufficient to make contact. If the jig is well maintained this will remain a small surface; but if not, the exposed surface will become larger with wear and will start to enlarge with each additional layer of nickel. Eventually the jig will start to “rob” the component of deposit and will cause rejected work. Good jig maintenance is a part of good plant housekeeping. Although the deposit on the jig may be good nickel, it is of little use and fit only to be sold for scrap.

b) Plating Out Sheets

Many plants have a facility for low current density removal of metallic contaminants such as copper and zinc, (plating out). Inevitably nickel will still be the majority of this deposit.

On some plants the incidence of dropped work (which dissolves rapidly as it becomes bi-polar) is so great that continuous plating out is required. Good engineering and good housekeeping should limit this to the point that continuous plating out is not a necessity. The presence of metallic and organic impurities can be detected with a ten minute Hull Cell plating check. Plating out may then be employed for a short period. This will result in a fairly substantial saving in nickel (and components). (cf. Annex F.)

c) Rejected Components

The nickel plating on a rejected component is but a small part of the story, since the component has been through its initial fabrication and preparation, as well as the whole plant sequence. Nevertheless it represents a preventable loss of nickel, and is frequently not worth the cost of recovery. Additionally the presence of copper and nickel may prevent reclamation of the raw material, and so a whole cocktail of metals is added to the landfill site. Even if substrates such as brass and zinc were re-melted, much of the nickel would be removed as surface dross from the molten metal, and would

be discarded to landfill. Many buyers of brass castings, such as tap manufacturers, specify a maximum permissible nickel content. Nickel on steel would melt with the steel and be used.

Any nickel, removed by nickel stripper for component recovery, would almost certainly become landfill, since it is rarely recoverable from stripping solutions.

Inevitable Losses

A percentage of all of the losses, detailed above as preventable, must be accepted as inevitable. However these losses are rarely included in the accountant's cost calculations and therefore come straight off the bottom line, i.e. out of the profits. It is essential that they are managed well, not only because of the impact on the environment, but also for the impact on profitability.

Nickel is also inevitably lost as a result of mechanical polishing or abrasive satin finishing of the surface. This is lost to landfill as polishing debris.

Minimise Nickel Solids Losses

- Prevent metallic contamination.
- Correctly maintain jig contacts.
- Be aware of the % Ni in effluent cake and filter cake.
- Regulate extraction volumes to air quality requirements.
- Act quickly to reduce rejects.

CONCLUSION

The aim of this article has been to put forward some general process engineering recommendations, in the hope that they will prompt more plant-specific ideas from the people who are responsible for the efficient operation of nickel plating plant.

Very few of the suggestions are original, although some are the result of hard-won experience; I freely admit to having tackled most of the problems described, during forty years of process chemistry and process engineering.

Although our survey was probably answered by some of the best in the trade, reading "between the lines" would probably show that good practice is not always followed.

The intention has been to indicate that plant improvements that will reduce losses to the environment do not always have to cost money. Indeed, they can be demonstrated to save money on many occasions; after all, the materials that are being lost to the environment have already been purchased, and their disposal will carry an additional cost burden.

A disciplined annual review of plant operations, using a "Cycle of Improvement" technique to review losses, (Identify – Monitor – Analyse – Correct) will frequently show that additional savings can be made.

It is essential that labour and plant utilities costs must also be included in the considerations; plant maintenance is frequently a premium-time activity.

AVOID LOSSES—PROTECT YOUR PROFITABILITY AND THE ENVIRONMENT

This publication has been sponsored by the Nickel Institute, as part of its service to nickel users. It is designed to help surface finishing companies use nickel in a more cost effective and environmentally friendly manner. Although it refers only to nickel savings, the engineering suggestions will obviously have other applications, which will make the proposals even more financially viable.

Many other such publications may be found on the Nickel Institute web site: www.nickelinstitute.org.

ANNEXES

- Annex A Schematic of Drag-in, Dragout + Rinse Systems Following a Ni Bath
- Annex B Schematic of Process Tank with Box Sump
- Annex C Schematic of Filter Pack Rinsing
- Annex D Push-pull Extraction
- Annex E The Eductor
- Annex F The Hull Cell
- Annex G CETS and the Nickel Working Group

ANNEX A

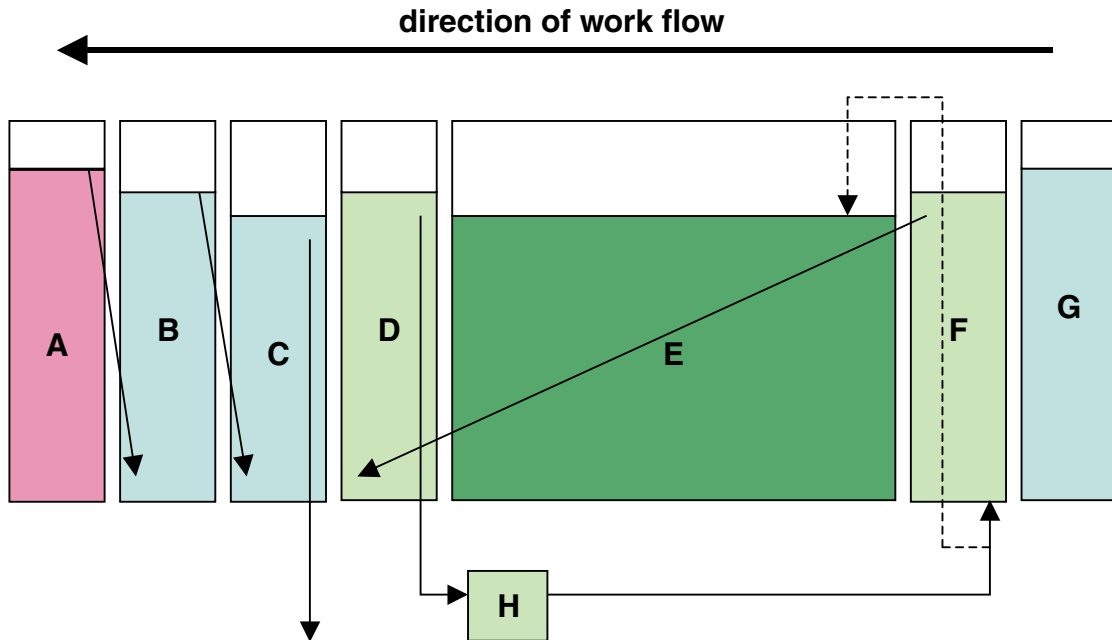


Figure A1 Schematic diagram (side view) of a rinse system comprising drag-in and dragout tanks, followed by counterflow rinsing. The assumption is that nickel plate is the final layer.

Key

- A hot rinse with low input of fresh water, 1–2% tank volume/minute, running counterflow into
- B agitated warm rinse with additional fresh water input controlled by conductivity, running counter flow into
- C agitated cold rinse running to effluent
- D drag-out tank, with low-flow pumped circulation into
- F drag-in tank with flow return to D or periodic top-up feed to
- E nickel plate bath
- G final rinse of previous operation
- H low capacity pump > 5% tank volume/minute

Notes

- Drag in from rinse F will help balance the drag out from the plating bath.
- If required, the return to tank E may be concentrated by evaporation. Should there be any doubt regarding the quality of the material in tanks D & F, the return to electroplating tank E may be made via the normal addition system, i.e. via a filter.
- The rinse system can be balanced, so that if the “conductivity” rinse water runs very infrequently, the fresh water supply to the hot rinse may be reduced. Agitated rinses are more efficient than still rinses, and make full use of the rinse water. The slightly raised temperature of rinse B will help reduce the heating requirement of rinse A.
- It is an obvious prerequisite that the water in rinse G is free of contaminant, since it is essentially feeding the nickel tank though drag-in to rinse F.

ANNEX B

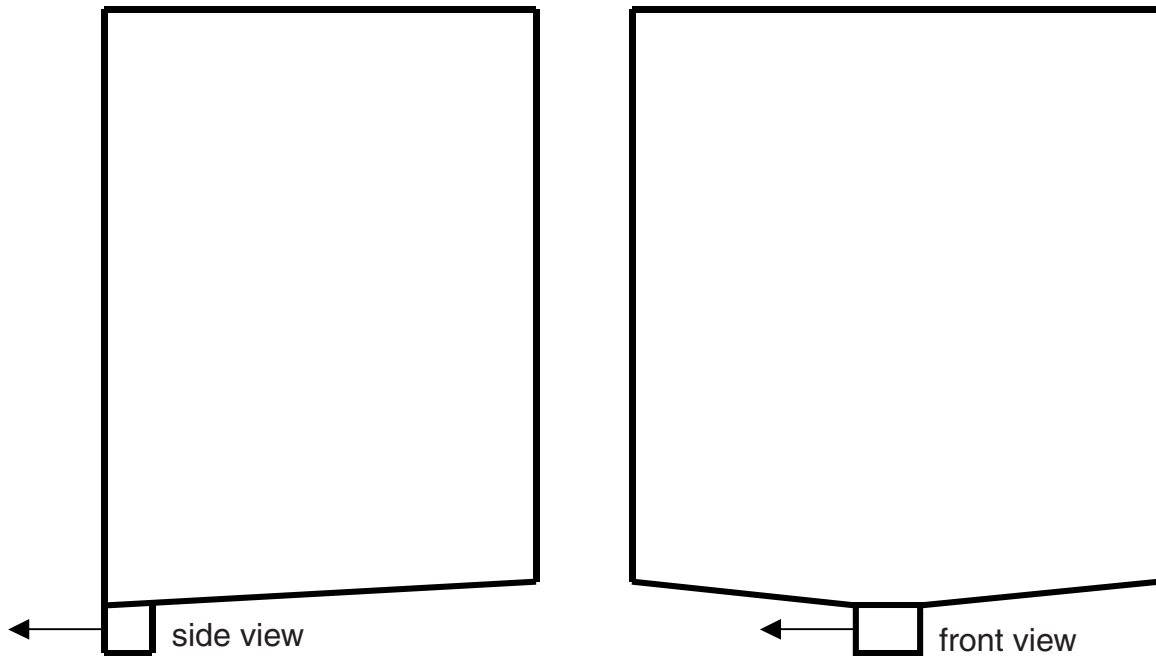


Figure B1 Schematic diagrams of a tank designed for efficient drainage, with a gently sloping base and a box sump.

Notes

- This design, using a sloping tank bottom and a box sump, will ensure that all electrolyte is removed from the tank before maintenance. It is not essential that main circulation pipework is connected to the sump, it can be finally evacuated with a low-flow scavenger pump—a pump that does not require flooded suction—and will run dry without damage.
- The box presents a good method of collecting and removing debris from, say, anode basket wash-down before re-bagging and electrolyte return.
- Pipework from this box should also run to the effluent treatment plant—ideally via a holding/settling tank, which will hold back any metallic debris.
- The additional cost of this engineering will be repaid many times over the lifetime of the tank.

ANNEX C

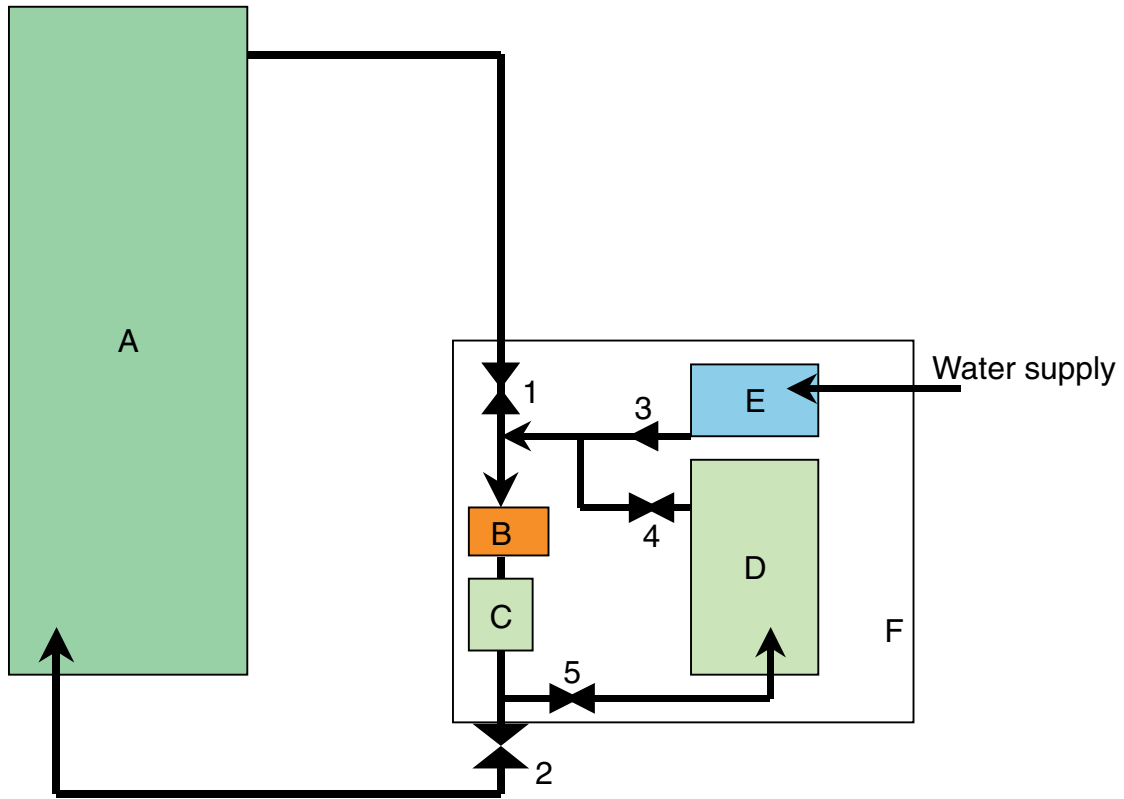




Figure C1 Schematic diagram (top view) of a pipework system that will allow washing of the filter system before maintenance is carried out; thus preventing unnecessary loss of nickel electrolyte.

Key

- A nickel plating bath
- B filter/circulation pump
- C filter housing
- D additions tank
- E water supply tank
- F bund tank surrounding electrolyte maintenance area
-  flow direction
-  valve

Notes

- With the exception of the water tank E and its associated pipework, a system similar to that shown should already exist. Before filter maintenance, the pump should be switched off and main valves 1 & 2 closed. With an appropriate volume of water in tank E, valves 3 & 5 (4 remains closed) should be opened and the filter pump started. This will wash the electrolyte through to the additions tank, where it may remain until further nickel salts additions are to be made. The filter pump is then switched off, and the filter dismantled for maintenance and filter medium replacement in the normal way.
- Following filter maintenance, valves 3, 4 & 5 are closed, 1 & 2 opened, and the filter pump switched on again, returning the system to normal filtered circulation.

ANNEX D

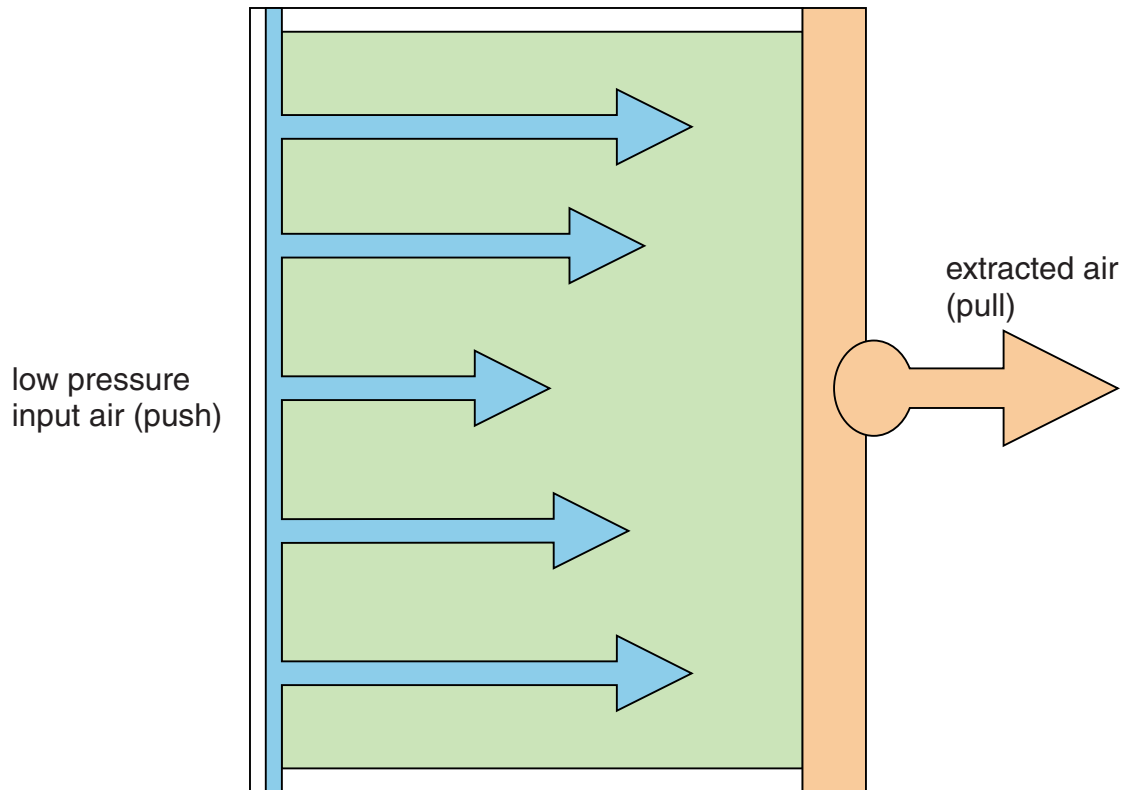


Figure D1 Schematic diagram of a push-pull extraction system (top view).

Notes

- The provision of low pressure, air as shown above, may be used to boost the performance of an inefficient extraction system. Clean, low pressure air may be accurately directed across the surface of the electrolyte, providing an “air curtain” that will prevent loss of fume to immediate plant atmosphere.
- Volumes of input and extract air should be balanced so that the extract is a little higher than the input. They should be regulated for best effect in order to achieve the desired air curtain. Once this system is operating efficiently, it is recommended that airflow measurements are recorded, so that the system can be monitored in future, and quickly returned to the status quo if it has been disturbed.
- Ideally this system should be installed as a whole, but it is possible to make the addition of input air to an existing system. It is recommended that the advice and engineering expertise of experienced ventilation engineers is utilised.
- The design of input and extract ducting should allow for adjustment in order to promote an even airflow across the whole surface.
- Practical experience and air quality measurements will determine the ideal airflow velocities, which will generally be considerably lower than the previous extract velocity. Savings in the cost of factory heating may well be observed.

ANNEX E

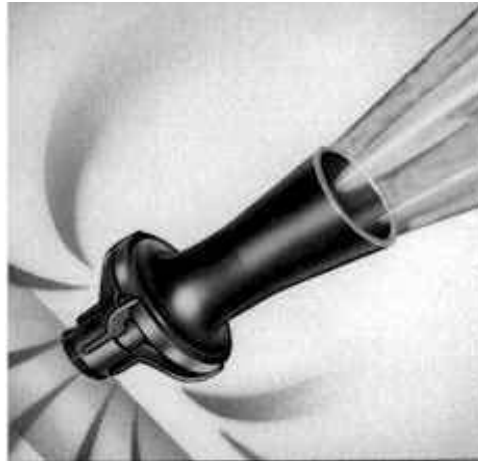


Figure E1 The Eductor.

A good system will achieve a five-fold increase in volume movement, as is shown in this cross-sectional schematic.

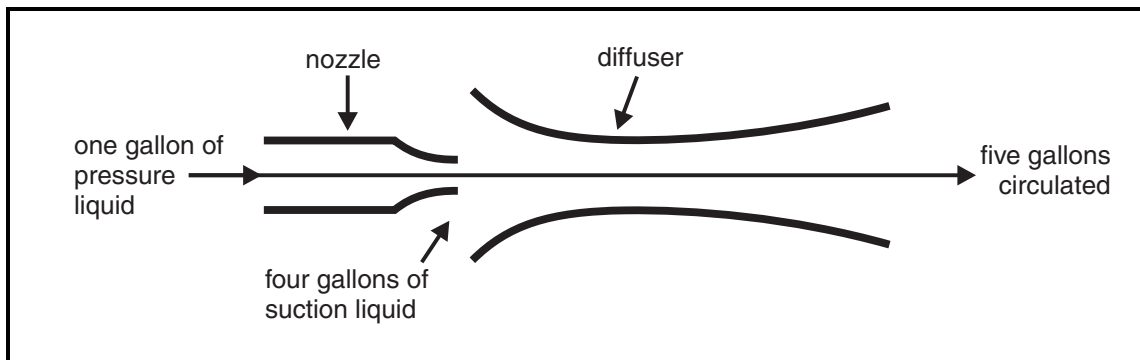


Figure E2 Cross-sectional schematic.

Notes

- Eductors may be used instead of air agitation for nickel plating baths. Returning electrolyte is pumped through a pipework system similar to that of air agitation, but the pipework has threaded holes into which the eductors are screwed. Electrolyte is piped to the nozzle under pressure. Electrolyte ejected through the nozzle creates low pressure at the intake to the trumpet (diffuser), which draws in an additional volume of liquid, all of which is expelled from the mouth of the trumpet.
- It is essential that the pipework is properly designed for these systems, weighted and stiffened to prevent distortion and movement. Considerable thought must be given to arrangement of the eductors for best effect.
- In deep baths some thought may be given to the use of a second set of eductors halfway to the top of the electrolyte.
- Information regarding these systems can be found on the Internet.

ANNEX F

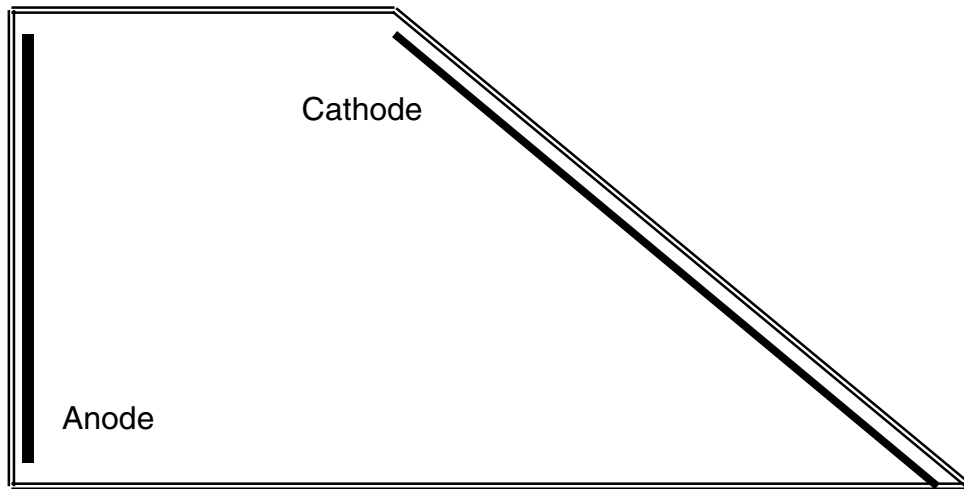


Figure F1 The Hull Cell (top view).

Notes

- The Hull Cell is in effect a small plating bath of specific dimensions. The cathode current density is varied along the length of the test piece by placing it at an angle to the anode, thus providing a simple but effective method of visually testing the quality of a deposit over a wide current density range.
- Used regularly, it can provide practical information on the condition of an electrolyte and, with a little experience, becomes an inexpensive and invaluable tool for use in the control of bright nickel (and chromium) electrolytes.
- By this method it is possible to pre-determine the effect of additions or of a purification treatment, or to assess the effect of suspected impurities on deposit appearance and other physical properties.
- Some Hull Cells contain all of the electrolyte, the standard one holding 267 ml, others have holes in the bottom of the cell so that it may be immersed in a larger quantity of electrolyte; many have a facility for air agitation along the cathode face.
- The panel used for nickel tests is generally of polished brass strip, 0.25 mm thick. Obviously the surface must be clean and free of water-break, as would any component that is to be plated.
- Other equipment needed to carry out the test is a small DC source giving 8–10 volts, 15 amps, with volt and amp meters and a facility to adjust the current. Ideally, some facility to maintain temperature and circulate electrolyte is required for bright nickel tests.
- For some reason this equipment is not as frequently observed in modern plating shop laboratories, however, the information provided by this simple apparatus is probably more relevant now than it ever was.

ANNEX G

What is CETS?

The initials represent Comité Européen des Traitements de Surfaces, roughly translated as The European Committee of Surface Treatment companies, which was established in 1981. The prime objective of this group was to provide a facility for European manufacturers of surface treatment plants and processes to share common needs, such as:

- Exchange of information regarding statutory regulations and business statistics.
- Market research
- Market development and sales promotion
- European standardisation
- Health, safety and environmental issues.

CETS encourages dialogue between process suppliers and their customers, and provides a forum where the national trade associations within Europe can debate and exchange information on common issues. The CETS forum also provides the focal point for contact between the European surface engineering industry and the European Commission.

There are currently around 18 European CETS members.

What is the Nickel Working Group?

Nickel metal and a number of nickel salts are currently undergoing a comprehensive Risk Assessment, which is being carried out by the Danish Environmental Production Agency, on behalf of the European Commission.

Environmental and human health risks associated with all nickel first-use and end-use applications are being studied, and they include plating, plated products, and the exposures associated with them.

Failure on the part of the nickel industry to provide relevant data could well result in “worst-case” assumptions being made by the risk assessors. This, in turn, would result in greatly increased costs for nickel platers—both electrolytic and electroless—and could result in exclusion from certain markets.

At the April 2002 meeting of the Plating section of the CETS Committee, it was decided to form a working group to monitor and respond to threats arising from European regulatory measures concerning nickel. The prime focus of this group is the effect that these measures would have on the acceptability of nickel and nickel-chromium plated articles in their many and varied applications in the marketplace.

The current members of the Nickel Working Group are:

Galvanevet Plating (Italy)	Sidasa (Spain)
Atotech (UK)	Kohler Mira (UK)
Sessler Galvanotechnik (Germany)	Nickel Institute (UK)
Gillette (UK)	MacDermid UK
Cookson Electronics (Enthone)	

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