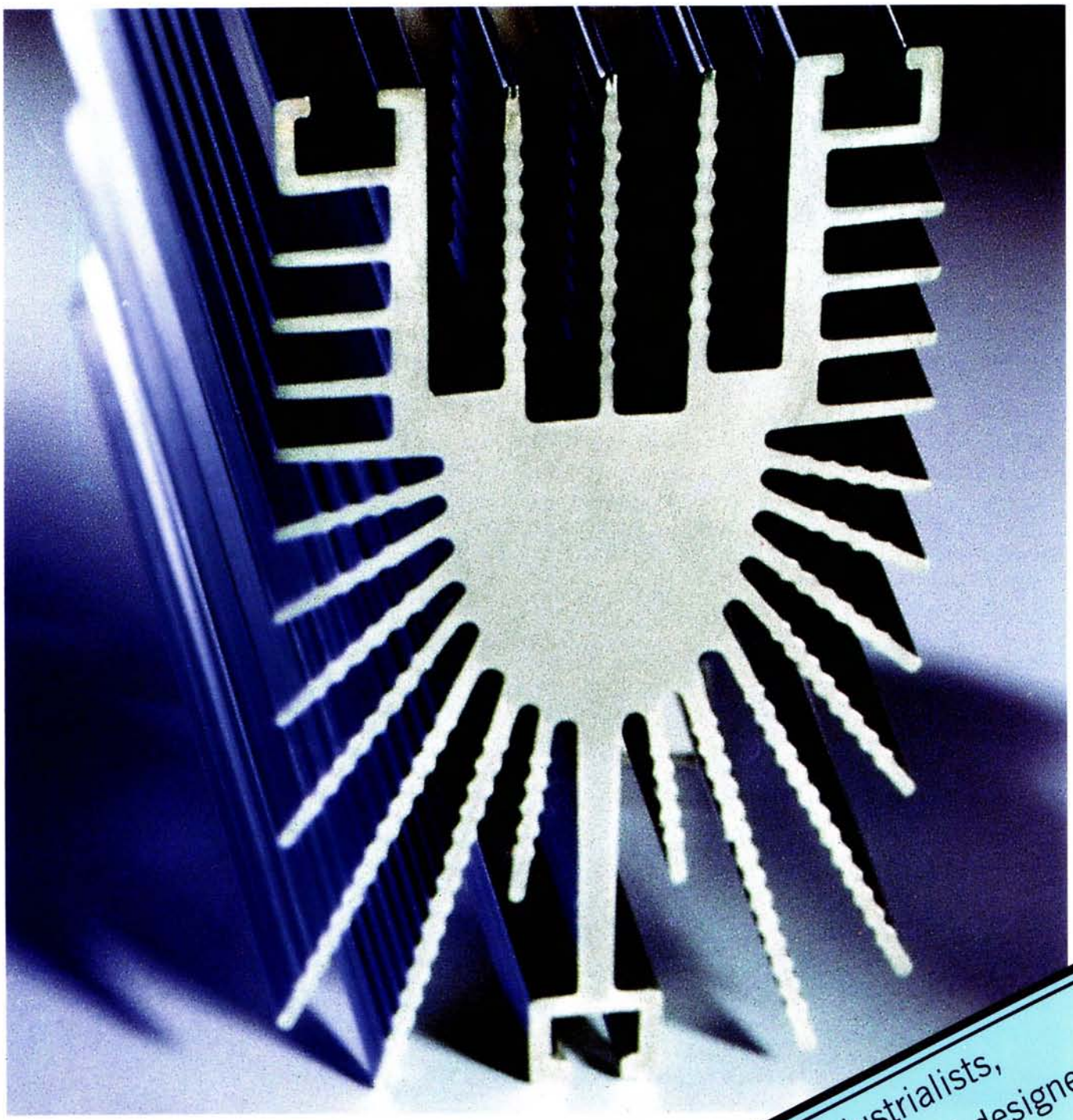
Functional surfaces with

Electroless nickel



British Surface Treatment
Suppliers Association

Information for industrialists, marketing specialists, technical designers, managers and buyers...

Process basics

What is electroless nickel?

The electroless nickel process produces a nickel alloy that can be deposited without an external power source. The electroless nickel solution consists of nickel ions, reducing agents and other chemicals. The most commonly used reducing agent is sodium hypophosphite. Nickel phosphorous alloys can be deposited on to specially activated surfaces, which act as a catalyst. The depositing mechanism can be simplified as follows:

Ni^{++} + Hypophosphite ⟶
Ni + Orthophosphite

The deposited metal layer has the great advantage of having an even thickness over all surfaces of the component virtually regardless of its shape. This cannot be achieved with electrodeposited coatings.

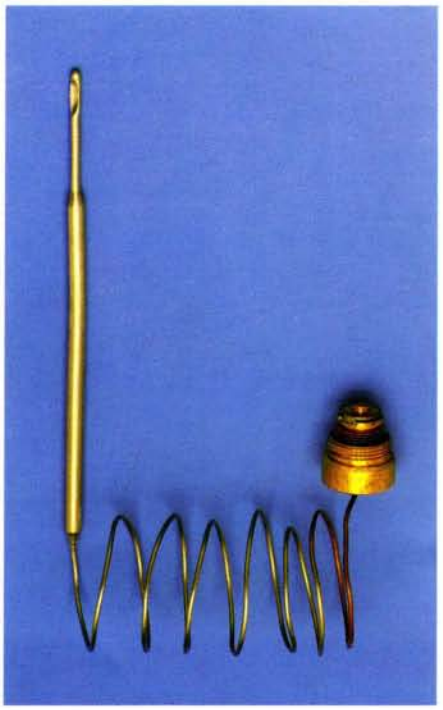
How does an electroless nickel solution work?

The parts for electroless nickel plating have to be suitably pre treated. Electroless nickel solutions operate specifically according to their end requirements in a pH 4 – 9 medium at a temperature of between 25 – 92°C. The plating speed of the solution is between 2 to 25 µm/hr and the deposit thickness generated on the parts depends upon the operating conditions and time.

Depending on solution composition and working parameters it is possible to deposit nickel phosphorous alloy layers with a phosphorous content between approximately 2 and 14% by weight.

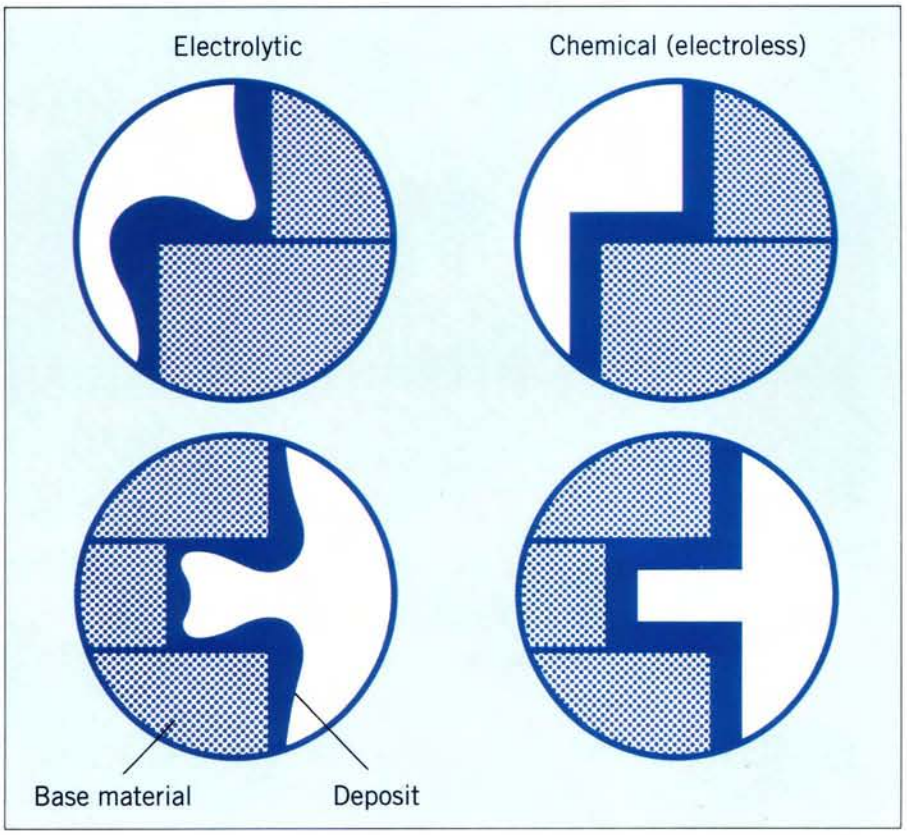
Which base materials can be plated?

It is possible to plate almost all metals (steel, stainless steel, aluminium and its alloys, brass etc.) and non-conductive materials (plastics, ceramics). Each type of material requires a specific pre treatment. The quality of the electroless nickel deposit is dependent upon the quality and surface finish of the substrate material. In contrast with many electroplated nickel coatings the electroless nickel deposit reproduces the substrate surface finish.



Due to the numerous deposit features there are more and more applications. Illustration shows temperature probe used in food industry

Deposit distribution on a complicated shaped component (electrolytically plated (left) electroless plated (right))



Numerous applications

Engineering

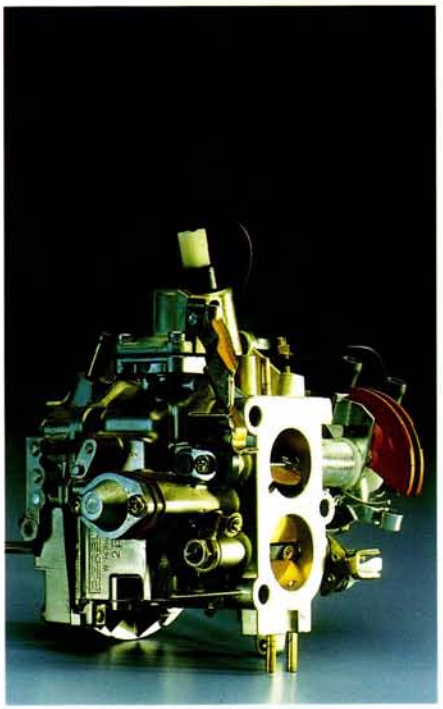
Components made of steel, aluminium and brass as well as alloys can be protected from corrosive and abrasive wear by electroless nickel deposits. It is possible to achieve even deposits and specified thicknesses on complicated shaped components provided that the plating solution can freely circulate in contact with all surfaces.

Textile industry

The high hardness and great abrasion resistance of heat-treated deposits of electroless nickel and the use of composite coatings, extend the working life of parts that are in contact with fast moving textile products.

Automotive industry

There are many applications for electroless nickel deposits due to their good corrosion and abrasion resistance. For example, the coating of the plates of a viscous clutch, nickel-plated parts for ABS systems, fuel injection pumps and carburettors.



Oil and gas industry

Electroless nickel plated components for pipelines and valves have been used successfully for many years. Components exposed to off shore environments demand a very high level of protection. Electroless nickel layers of about 50 µm on steel have very good resistance to marine environments.

Chemical industry

Electroless nickel coatings are resistant to a wide range of chemicals, which makes them suitable for many applications in the chemical industry. For example, stirrers, valves, reaction tanks and covers. In many cases it is possible to use electroless nickel plated steel as a substitute for stainless steel.

Paper industry

Electroless nickel plated rolls (cylinders) and string guides have been used for many years. Compared to hard chromium deposits there is no mechanical post treatment required.

Proven in numerous fields

Electronics and computer industry

The applications for electroless nickel deposits in this industry are numerous. The deposits are used as diffusion barriers, as a soldering aid, as shielding and to enhance corrosion and abrasion resistance. Deposits containing more than 10% phosphorus possess no ferromagnetic properties. These deposits are used as the base for magnetic memory discs, which have a ferromagnetic memory top coating.

Nuclear industry

The remarkable properties of electroless nickel coatings enable it to be used in many applications in the nuclear industry.

Aerospace industry.

Electroless nickel finds many applications. For example: Defrosting valves for plane engines, plugs, oil pump cases and bolts. The excellent deposit distribution, good corrosion and abrasion properties are the principal reasons for selecting electroless nickel.

Compressor, pump and valve industry

Electroless nickel deposits are very corrosion and wear resistant as well as being uniformly distributed. This offers advantages over electroplated nickel deposits.

Hydraulic industry and mining.

The most important applications in this are hydraulic units such as drilling and support equipment. Electroless nickel deposits with a thickness of 30 to 50 µm on steel cylinders for support equipment provide excellent resistance even against strong corrosion and abrasive wear. By using electroless nickel composites on drilling components it is possible to extend their working life significantly.

Plastics industry

Electroless nickel is successfully used in the plastics industry to maintain and repair tools and moulds. It is also used as a corrosion protection layer on surfaces in contact with cooling water. It is widely used as an undercoat to improve adhesion of electroplated coatings on plastics mouldings.

The deposit properties

Generally

The deposit properties of an electroless nickel layer and the performance of the plated component depend upon its phosphorous content, its purity, the substrate, the pre treatment and the thickness.

Structure

Nickel phosphorous deposits are homogenous and are generally pore free. They are either micro crystalline or amorphous, which is a form of metallic glass.

Chemical resistance and corrosion protection

Electroless nickel deposits are resistant against most organic and inorganic chemicals apart from oxidising acids. The resistance is especially good in neutral and alkaline solutions. With a protection layer of 25 µm on steel or aluminium it is possible to achieve many years lasting protection even against aggressive industrial and marine conditions. There are recommended deposit thicknesses for specific corrosive conditions.

Mechanical properties

Electroless nickel deposits can be plated either with tensile or compressive stress. The micro hardness of these layers is between 500 to 700 Vickers Pyramid Number. The ductility is between 0.1 and 2% depending on the type of deposit.

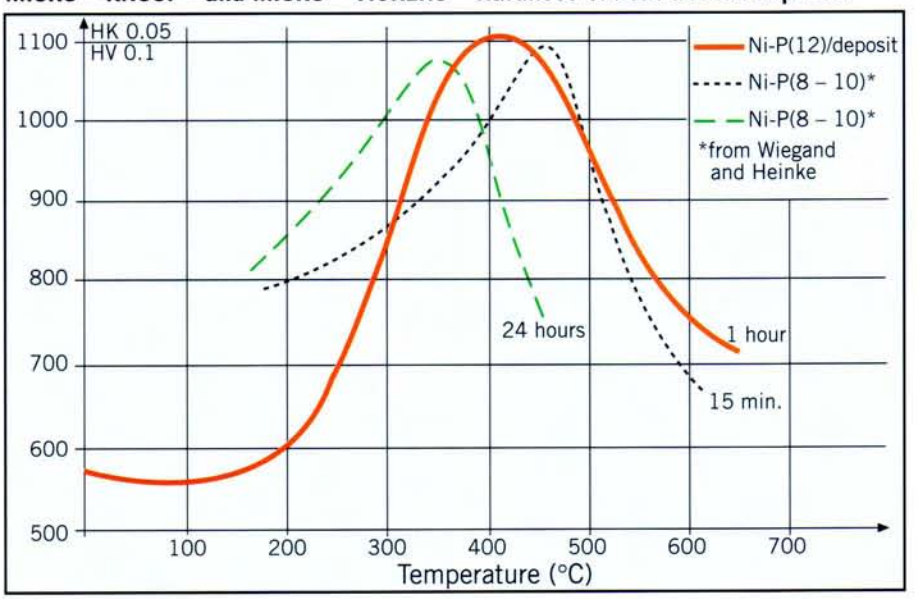
Composite deposits

Electroless nickel layers can also be co-deposited with different inclusions for many applications particularly to give improved abrasion resistance. For example: Electroless nickel + silicon carbide, PTFE or diamond.

Heat treatment and abrasion resistance.

Electroless nickel deposits may be heat treated to improve abrasion resistance, increase hardness and enhance adhesion. The heat treatment temperature must be above 240°C. To obtain the maximum hardness it is necessary to treat parts at a temperature of 400°C for 1 hour according to the above table. Heat treatment at different temperatures (table right) achieves hardnesses of about 1000 V P N (HK 0.05/HV 0.1). By using heat treatment it is possible to enhance the abrasive wear resistance. The average coefficient of friction is about 0.3 and can be much smaller in certain cases (0.03).

MICRO – KNOOP - and MICRO – VICKERS – Hardness of heat-treated deposits.



Hardness against heat treatment temperature

Quality

Customer and processor have to work closely together to achieve the required quality

Quality depends on a lot of different factors such as:

- Substrate
- Pre treatment
- Type of electroless nickel process
- Plating parameters
- Thickness
- Post treatment

There should always be discussion between the processor and end user of these deposits prior to specifying the plating process in order to set optimum process parameters. A quality monitoring system can guarantee a faultless electroless nickel process. The quality control system should not control only the plated deposit but also the electroless nickel process parameters and the pre treatment. If all these factors are considered it is possible to guarantee a high quality finished product.

"The Electroless deposition of Nickel was first developed by Brenner and Riddell in 1946. Since then the process technology has improved substantially and the process is well established in many industrial areas. However the basics of the original chemistry have seen limited change until recently.

In response to increasing Environmental and Legislative pressures, greater attention has been given to waste minimisation and the use of more environmentally friendly chemistry and techniques.

The introduction of the End of Vehicle Life (ELV) legislation and the Waste Electrical and Electronic Equipment (WEEE) directive seek to eliminate any materials or deposits that will not allow easy and acceptable recycling of components in the Automotive and Electronics industries.

ELV compliant processes are available to allow applications within the Automotive and Electronics industries to be fulfilled eliminating the co-deposition of unacceptable elements, thus allowing the safe recycling of Electroless Nickel plated components at the end of their useful life.

Longer-life chemistries based upon alternative Nickel compounds to the traditional Nickel Sulphate versions can extend the working life of the plating bath by a factor of two or more. The use of membrane technology - Electro dialysis - to extend the life of more traditional formulations by the continuous removal of undesirable by-products is available.

Such techniques are already helping to reduce waste considerably, by extending the plating bath life almost indefinitely.

Details of suppliers of these advanced technologies and/or of any Electroless Nickel technology can be obtained from the: **British Surface Treatment Suppliers Association"**

Mission Statement

The British Surface Treatment Suppliers Association is dedicated to the promotion and continuous improvement of the surface treatment industry to the mutual benefit of its members and the customers they serve. Members are committed to upholding the highest standards of quality, health, safety and environmental protection.

Aims & Objectives:

- To expand the market for surface treatment products.
- To promote the benefits of surface treatment products and processes to manufacturing industry.
- To promote development and use of innovative surface treatment technology.
- To encourage higher standards of quality in the surface treatment industry.

The Surface Engineering Association

The SEA represents the interests of leading trade associations in the surface finishing industry. **Expert technical advice is freely available on the SEA Help Line on 0121 233 0121 or by email on finishes@waverider.co.uk.**

The BSTSA supports The British Electroless Nickel Society. For further information or advice on application of electroless nickel coatings telephone: **0121 237 1122.**

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The BSTSA is a member of the Surface Engineering Association