NICKEL COATINGS

Variations in Nickel Coatings

This article will discuss basic coating compositions, electrical function, and other factors which influence shielding cost per unit. In a time of rapid growth in devices needing shielding, and in view of the increasing pressure toward compliance caused by shielding regulations, it is difficult to decide which materials are most appropriate. Therefore, it is important to consider all relevant factors when comparing various nickel product offerings, and to choose those most suitable for the task at hand.

Today, nickel coatings have gained a growing position among the many options one might consider in shielding plastic housings. The number of suppliers of nickel coatings has also grown from five years ago. More suppliers and multiple product offerings give a designer many material choices and add to the confusion. How does one screen the available products to find the "best" product?

The disinclination to recognize differences between types of nickel paints has contributed to the overall degradation of shielded devices, due to lack of consideration in the choice of nickel paint. Studying the composition (the physical components) of nickel paints will enable better comparisons to be made.

Typical Composition

Nickel paint typically consists of three parts: pigment, binder, and solvent. Pigment is a basic building block which must have the proper particle size, purity, shape and treatment to impart conductive properties to the dry film.

There are different grades and shapes of nickel available to the paint formulator. The nickel treatment and method of dispersion affects coating resistance, electrical stability, and physical properties of the finished paint.

Binder, the resin composition that glues the coating together and bonds it to the substrate (plastic), varies from one formulation to another. This is true even within the same generic family, such as urethane or acrylic resins. The basic backbone of the resin can have a different length (different molecular weight) and different chemical attachments to it, adjusting physical and/or chemical properties toward very specific ends. The ratio of pigment to binder helps determine physical and electrical coating properties.

Similar resin systems don't behave exactly the same, nor are they always compatible with all substrate plastics. This has caused occasional problems in coating adhesion when substrate plastics are changed. Degraded shielding properties are common if the resin isn't right for use when the nickel paint has been top coated by noncompatible decorative paints.

Solvent, that fluid which acts to dissolve the resin, can behave quite differently as well. Often there must be a blend of different solvents and extenders, or diluents, to enable the paint to be properly handled during application, or to meet regulations limiting the amount of volatile organic content allowed in certain regions.

Variants in composition can include other pigments, fillers, and additives intended to modify conductivity, electrical stability, viscosity and settling/packing characteristics of the paint. From the above, then, the basic building blocks in nickel paints are quite different. Further, the formulation (e.g. ratio of pigment to binder to solvent) is often quite different as well.

To the EMC engineer, who sees only a coated housing that has a measurable resistance from point-to-point, the above background of formulation details may seem trivial, the reasoning being that if a nickel paint can be applied to achieve X ohms point-to-point, then it will provide sufficient shielding to allow the system in question to pass current levels of emission. However, some nickel paints have occasionally caused systems to emit higher levels of noise than were originally expected. Upon rechecking resistance point-to-point, it was determined that resistance had increased. Investigation revealed that environmental conditioning can and should be used to check the quality of electrical stability of the different nickel formulations.

Determining Mileage

The cost per part will be directly determined by the nickel conductivity of a dry film and by its volume percent solids. The first factor, resistance, can be easily checked (at the same film thickness) using conventional DC VOMs. It can easily be determined what system figure is needed from open field tests empirically. The second figure, volume percent solids, cannot be easily determined by the end user, and is an area where some sleight of hand can be played by the supplier.

First, the concept of coverage should be understood. From that basis, determination of cost per part is simple. If the volume of a one-gallon container were filled with a solid nickel /resin composition (no solvent), the area that would be covered (if the container contents were spread uniformly over a surface at a film thickness of one mil) is calculated at 1604 sq.ft./gallon/mil. At two mils thick, the gallon of 100 volume percent solids would cover 802 sq.ft. (This assumes 100% efficiency in paint application.)

Nickel paints are supplied with solvent at much lower volume percent solids (usually in the 20-35 volume percent solids range). Theoretical coverage is determined as follows:

Theoretical Coverage = 1604 X volume percent solids = sq.ft./gal. at 1 mil. Theoretical Coverage in the 320-560 sq.ft./gal. @ 1 mil would be typical for many nickel paints today. Theoretical coverage is that coverage which would be achieved without losses due to overspray. Overspray is a function of part size, configuration, and applicator technique. It is typical to have 40-50% efficiency in applying nickel paint by manual spray techniques.

Volume percent solids play a key roll in the real cost per square foot. Consider two products at $80 and $50 per gallon, respectively. Which one is the better buy (disregarding all factors except volume percent solids)? The following table answers the question.

Product	Cost/Gal	Volume % Solids	Theoretical Coverage	Cost/Sq. Ft. @ 1 mil
A	$80	35	561	0.14
B	$50	20	320	0.15

When applied, the apparent cost per gallon advantage of B over A does not prove to be so, due to the difference in volume percent solids.

The actual dry film thickness required by the system also plays a role in determining cost.

Thickness and electrical resistance are related as follows:

$$R = \frac{\rho l}{wt}$$

ρ = resistivity,
l = length of coating area measured,
w = width of coating area measured, and
t = thickness of coating in mils.

It is intuitive that, at the same price and volume percent solids, and to achieve the same resistance on a cabinet, the more conductive a nickel paint is, the better a buy it will be. This is due to less of its being required than another coating with a higher resistance.

There is a trap to avoid in resistance comparisons. This is the effect of humidity and heat cycling on the resistivity. Some nickel formulations are significantly more stable than others. Avoidance of that trap involves screening paints for stability in the operating environment. Resistance, for quality control purposes, is best determined *after* the system has been through environmental testing and has *passed* radiated emission and/or ESD susceptibility tests. By working backward from a qualified coating through its dry film thickness to its initial resistance, one can establish reliable QA guideposts for production painting of the particular system in development.

Resistance monitoring is a very effective QA tool for inspection and can be established by determining maximum allowable resistance for the part from its initial resistance value.

Optical dry film thickness gauges, which cut through the coating and allow visual measurement of coating thickness, are most reliable in the above procedure for determining coverage and uniformity of application. Those which depend upon loss properties of nickel can be misleading, unless appropriate standards are also used. Remember, nickels can vary from formulation to formulation.

Variation in coating density, as applied, can also mislead the latter thickness gauge reading. The wet film thickness gauge, also commonly used, assists a painter in judging the uniformity of paint application while it is still wet.

Basic product resistivity determines how much material will have to be applied to achieve a specific resistance on a coated plastic housing. Assume, for example, both products have the same coverage and prices of A ($80) and B ($50), respectively. Their resistivities are not known, but both are applied at various thicknesses until one ohm per square is achieved. Product A required 0.9 mils DFT vs. Product B 1.5 mils DFT.

Product	Price/Gal	Volume % Solids	DFT for 1 Ohm/Sq	Equivalent Cost/Gallon
A	$80	35	0.9	$80.00
B	$50	35	1.5	$83.33

The apparently cheaper B actually costs slightly more than A because of B's *higher* resistance.

Combination of different volume percent solids and resistance *after* environmental tests skew the picture even more dramatically.

Other factors which could be addressed regard wear resistance, respray, overcoatibility, adhesion via UL746C tests, lot-to-lot consistency, mixing, application ease, start-up technical assistance, uniformity of shielding testing (see *ITEM 84*, ASTM Emergency Standard), and distribution, to be addressed in future articles.

For now, the following conclusions apply.

1. Nickel formulations differ significantly, requiring a serious evaluation program to screen products for long-term assurance of performance.
2. The uninitiated can be easily misled in choosing the "best" nickel coating, if the only yardstick is $/gallon. Resistance, volume percent solids, and stability are fundamental in determining cost per part.

This article was written for ITEM '84 *by James J. Coniglio, Assistant Marketing Manager, Acheson Colloids Company, Port Huron, MI.*

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