Finishers' Think Tank

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2001: A Plating & Surface Finishing Odyssey The Journey Continues, Part 6

Having completed our tour of the Brass state, dinner, and show, we board the shuttle bus for a short trip to the Brass Arms Hotel. Check-in has placed us on the 41st floor of the Yellow Pavilion. At the crack of a beautiful "red brass dawn," we enjoy breakfast at the Lemon Tree Cafe. Checking out, the itinerary is a quick ride on the Brass Rail Express 15.1. We disembark at Sunburst Square. After a refreshing stroll to the Brass Depot, we check our gear before departing for the Zinc-nickel state. Time to purchase some brass-plated mementos. Everyone has some neat samples to share: clothing fixtures, furniture end pieces, washers, screws, rivets, miniature assortments (lamp bases, railings, door fixtures), keys, and other items.

Our brass reverie evaporates as the public address announcer declares, "Zinc-nickel Express departing from track 10/15." We hasten to board our train, the 28:30 Outbound. With a short, definitive lurch, the train pulls out of the station. Approaching the border, we encounter a refreshing shower. As the skies clear, we appreciate nature's "good-bye," leaving the Brass state. It's a beautiful rainbow, richly splashed in earthy colors of yellow, green, pink, and red. Up ahead is a signpost (no relation to Rod Serling), pointing our train to the Zinc-nickel state. Our adventure and exploration of enhanced corrosion protection now begins.

Approaching the 65/58 juncture, the express emits three whistle blasts, signaling our entry into Zinc-nickel. There is stormy weather on the approach to the NiZinc technical district. Our train must traverse a habitually windswept corridor along the seacoast. We're relieved to learn the express will travel a direct route, over the Alloy Zinc Suspension Bridge, crossing directly through this inclement weather. Our conductor explains that bridge engineers were strapped with a big problem 15 years ago. Back then, the Cable & Stretch Bridge was shut down after 45 years of operation. The problem was continuous, biting, corrosive salt spray caused by the windswept storms rolling up from the ocean below. Galvanized zinc coatings, and combinations of chromate and powder coat just couldn't hold off the problem of incessant corrosion. Acknowledging the end was near for Cable & Stretch, the engineers searched for better coatings to more smartly dress a new bridge. They found the answer in Europe and Japan. Alloy zinc, or specifically a zinc-nickel alloy, was it. Comparative ASTM B-117 salt spray tests provided startling results. The zinc-nickel coating with chromate consistently exceeded 1,500 hours to red rust, surpassing zinc and chromate by a factor of six! Now, there was a bridge to build on.

During its 12 years in service, maintenance and safety checks confirmed the Alloy Zinc Suspension Bridge to be in excellent service condition. To our satisfaction, this was a safe bridge to cross. Passing along the bay, our train gathered momentum. In short order, we entered a scenic, almost pastoral setting of sun-splashed landscape. Fields of satin silver prairie grass, only found here, stretched to the horizon. Our conductor explained the alloy zinc-nickel deposit is not bright, shiny, or meant to be decorative. Rather it's a functional gray-silver, satin deposit. We learned that zinc-nickel is not a "show piece" finish, but a "behind-the-scenes corrosion fighter."

Traveling along, our train approaches a majestic sight in the distance, Mt. Zincnick. It's powerful base structure rises above the clouds, signaling the highest elevation in Zincmalia. This geographic panorama certainly signifies the strong corrosion protection afforded by zinc-nickel deposits. Our hop over the bridge was a good example. A few short whistle blasts and the train slows down, entering the Zinc-nickel state. Soon we pull into the NiZi terminal, disembarking at track 8.9. Our gear followed us on a separate express train, stopping at track 7.14. Waiting for us, the tour group leader was anxious to complete the roll call. He told us there would be a full itinerary in the NiZinc technical district. Our shuttle bus departed on time. Quickly, we blended in with traffic on the Alloy Parkway. After a short trip, the bus exited at Millerite Ave. and Niccolite Sq. A large billboard proclaimed "Welcome to The Technical District."

The first exhibit we toured was Rusty Springs. This presentation focused on surface finishing's ongoing efforts to overcome corrosion, the main reason for our industry's existence and continued process developments. Several previously field-exposed and used parts were displayed, along with an explanation of specific failure or shortened service life. Costs related to early or premature corrosion failure, along with physical defects, set the stage for proc-

ess improvements. This exhibit prepared us for the comprehensive zinc-nickel presentation.

Our tour of R&D, product development, and plating installations followed in a timely progression. The following strong points related to zinc-nickel deposits as compared to standard zinc are:

- Salt spray corrosion protection of the deposit & chromate is at least four times greater than zinc plate & chromate.
- Excellent thermal, high-temperature corrosion resistance and deposit adhesion.
- Deposit hardness and scratch resistance are improved.
- Very ductile deposit, in fact the best of all zinc alloys.
- Deposit of choice when required to plate cast iron, malleable steels, and hardened surfaces.

Zinc-nickel deposits are also excellent replacements for cadmium, where corrosion protection is a factor.

Alkaline Zinc-nickel Solutions

Alkaline (non-cyanide) and acid electrolytes can be used to plate the zinc-nickel alloy. Table 1 provides general process information for each system.

For rack and barrel plating applications, anodes are usually a combination of three-quarters nickel-plated steel to zinc. The bath is similar to alkaline zinc and operated similarly. Zinc forms a zincate in the caustic soda electrolyte. Nickel is supplied as a complexed liquid concentrate additive. Nickel in the deposit may range from 5-9 percent, critical to maintaining excellent corrosion protection. Alkaline zinc is also available, providing 10-20 percent nickel in the deposit. The percentage of nickel in the deposit is very consistent for either system, over a wide range of current densities, affording a very uniform corrosion protection.

Table 1
Alkaline Zinc-Nickel—Typical Plating Solution

Component	oz/gal range	oz/gal opt.	g/L range	g/L opt.
Caustic soda	14-20	17	105-150	127.5
Nickel metal	0.14-0.20	0.17	1.0-1.5	1.2
Zinc metal	0.6-1.3	1.0	4.5-9.8	7.1

Alkaline Zinc Nickel—Typical Operating Parameters

Temperature	75-85°F	24-29°C
Anodic current density	40-100 amp/ft^2	4-10 amp/dm^2
Cathodic current density	10-60 amp/ft^2	1-6 amp/dm^2

The Plus Side (5-9% Nickel)

- Excellent chromatability
- Good deposit ductility

The Minus Side (5-9% Nickel)

- Slower rate of barrel deposition compared to the acid bath

The Plus Side (10-20% Nickel)

- Consistent nickel in the alloy deposit, affords very good corrosion protection
- Excellent chromatability
- Very good heat resistance
- Exceptionally hard deposit

Table 2

Acidic Zinc-Nickel—Typical Ammonium Chloride Plating Solution

Component	oz/gal range	oz/gal opt.	g/L range	g/L opt.
Amm. chloride	16-18.7	17.3	120-140	130
Nickel chloride	9.4-14.0	11.7	70.4-105	88
Zinc chloride	10.3-15.3	12.8	77-115	96

Acidic Zinc-Nickel—Typical Potassium Chloride Plating Solution

Component	oz/gal range	oz/gal opt.	g/L range	g/L opt.
Nickel chloride	11.1-16.5	14	83.2-124	104
Pot. chloride	19.7-29.3	24.5	148-220	184
Zinc chloride	11.1-16.5	14	83.2-124	104

Acidic Zinc-Nickel—Typical Ammonium Chloride Operating Parameters

Temperature	75-85°F	24-29°C
pH	4.5-6.0	5.6, opt.
Zinc current distr.	55-65%	60%, opt.
Nickel current distr.	35-45%	40%, opt.
Cathodic current density	40-35 amp/ft^2	0.4-3.5 amp/dm^2

Acidic Zinc-Nickel—Typical Ammonium Chloride Operating Parameters

Temperature	77-95°F	25-35°C
pH	4.5-6.5	5.5, opt.
Zinc current distr.	75-85%	80%, opt.
Nickel current distr.	15-25%	20%, opt.
Cathodic current density	10-50 amp/ft^2	1-5 amp/dm^2

The Minus Side (10-20% Nickel)

- Slower plating rate
- Less efficient
- Less ductile deposit

Acidic Zinc-nickel Solutions

Table 2 provides general process information for each system.

For rack and barrel plating applications. Operation is similar to acid chloride zinc systems. First generation baths required the use of two rectifiers, with separate connections to zinc and nickel anodes. Improvements led to the use of one rectifier with only zinc anodes. Nickel is supplied as a liquid proprietary additive. The deposit may contain 10-15% nickel. Corrosion protection maximizes at 15% nickel. Unlike the alkaline formulation, zinc and nickel are not complexed in the acid bath. This contributes toward the acid bath having approximately twice the efficiency of the alkaline bath. However, the distribution of nickel from the acid bath is not as even over the range of current densities. The acid bath does conform rather well to strip reel-to-reel plating.

The Plus Side

- Faster plating speed versus alkaline system
- Excellent chromatability

The Minus Side

- Deposit less ductile versus alkaline zinc-nickel
- Thickness distribution of deposit is not consistent throughout current densities.

Table 3
Neutral Salt Spray Protection
Zinc-Nickel & Yellow Chromate

Deposit Type	Hr to White Rust	Hr to Red Rust
8% nickel	400, min	1,200, min
12% nickel	1,000, min	1,700, min

Dressed for Action

Chromates initiate the first corrosion barrier of the zinc-nickel coating to surface attack. Their function is just like chromates over the zinc-plated deposit. Additional R&D efforts were required to develop functioning chromates for zinc-nickel alloy deposits. Available colors are: black, bronze, and iridescent yellow.

Examples of protection per ASTM B-117 salt spray are given in Table 3. Individual test results may differ slightly, based on specific process cycle parameters, quality of surface preparation, etc.

Control of the zinc to nickel deposit ratio is very important. Chromating ability decreases as nickel in the deposit increases above 20 percent. Additionally, higher levels of nickel reverse the sacrificial protection that is achieved when nickel is below 20 percent.

Check It Out

Zinc-nickel plating baths require standard analysis, consisting of these procedures for the specific bath:

- Titration. Zinc metal, total chloride, caustic soda
- Atomic absorption or spectrophotometric. Nickel metal
- pH measurement
- Hull cell to evaluate deposit condition across the range of current densities

Thickness of deposit is rapidly and accurately determined by non-destructive X-ray method. The same instrumentation can be used to determine the ratio of zinc to nickel in the deposit. Other methods, such as thickness by deplating, strip and weight loss, and magnetic determination, can also be used. Corrosion tests of the deposit can be determined by specific ASTM methods, such as: neutral salt spray, wet sulfur dioxide (Kesternich), compound cyclic, and spot lead acetate.

It's been a long, but certainly rewarding day. We learned much about the systems available, operating parameters, strong and weak points. Alloy zinc-nickel offers a whole spectrum of corrosion fighting, quality finishes. Military, automotive, and aerospace are some of the major specifiers for zinc-nickel. Two key factors influenced changing specifications: alternatives to cadmium and improved corrosion protection. Commercially, zinc-nickel finishing has been in use for approximately 30 years (about 20 years in the U.S.). Ya gotta have it! It's that good!

We assemble outside the NiZinc auditorium, having finished the tour. Our guide hails the shuttle bus. The ride crosses Spot Test Drive, joins Kesternich Boulevard, and exits on to Salt Spray Circle. We check into the Alloy Arms Hotel. After refreshing for an hour, we meet for dinner and a night on the town.

Next month our journey takes us to some interesting, outlying districts of the Alloy State. *P&SF*