

# Semi-Bright Nickel Guide

*NiMac Semi-Bright Systems*



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# Semi-Bright Nickel

## NiMac Semi-Bright Systems

### What is semi-bright nickel plating?

Semi-bright nickel is the term given to nickel deposits containing less than 0.005% sulfur. Semi-bright nickel usually forms the first layer in a multilayer nickel system, providing a high purity nickel layer designed to significantly improve the corrosion resistance of electroplated nickel/chromium deposits. The largest use of semi-bright nickel is in high performance automotive applications, although other uses can be found where highly corrosion resistant nickel/chromium coatings are required, for example bathroom and kitchen.



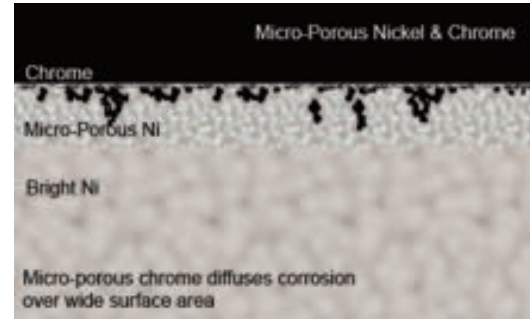
**Semi-Bright :** The term semi-bright comes from the use of nickel baths to produce deposits with a low sulfur content to help provide increased corrosion resistance in duplex nickel coatings. Very early duplex deposits simply used dull nickel deposits that were polished prior to bright nickel plating. Additives such as coumarin were subsequently used to improve deposit leveling. These early coumarin-type systems produced deposits which were smooth with a columnar structure, giving a finish that ranged from matte to almost fully bright (brighter in low current density areas). Hence they were christened semi-bright due to the hazy appearance of the deposit. Today most platers use non-coumarin systems. Deposits from these newer systems can also range from full matte to almost fully bright. Despite the bright finish that can be obtained with these systems, the description semi-bright has remained. Semi-bright nickel deposits are characterised by having a sulfur content of <0.005%. Sulfur-free would perhaps be a better generic description.

**Multilayer:** Multilayer nickel can refer to duplex nickel layers, but often duplex nickel is supplemented by a third or even a fourth layer of nickel. The third layer is either a microporous or microcracked top nickel layer or a high sulfur nickel layer between the semi-bright and bright layers. Sometimes all four layers are used to provide maximum corrosion resistance underneath the final layer of chromium.

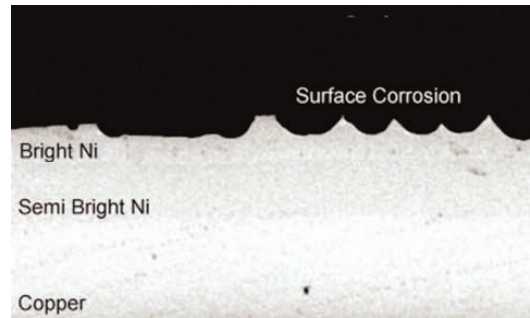
*High Sulfur Nickel; A high sulfur nickel deposit is sometimes used in multilayer nickel systems between the semi-bright and bright nickel layers in specifications requiring service condition 5. The high sulfur layer is characterised by having a sulfur content of >0.15%. This layer will account for less than 10% of the total nickel thickness.*

**Multilayer Nickel Plating:** In multilayer nickel plating, each nickel layer provides different properties. Specifically, each layer has a different electrochemical potential. These differences in electrochemical potential are the main factor that determines the corrosion resistance of the nickel/chromium layer. The potential differences between the layers can be measured, usually by a method called the STEP test. Below is an overview of the corrosion mechanism which illustrates how the different layer types affect the performance.

**Microporous Nickel Corrosion:** The use of a microporous nickel layer over a duplex nickel further enhances the corrosion resistance of a plated component. Instead of penetrating a single corrosion site as illustrated, the corrosion current is distributed over many smaller sites. This results in hundreds or thousands of smaller sites which corrode much more slowly.



**Barrier Layer Corrosion:** Plating a single layer of nickel, such as bright nickel, over a reactive metal such as steel or aluminum will provide corrosion resistance to the part only so long as the barrier is intact. Once the nickel barrier is penetrated, corrosion of the base metal will begin.



**Multilayer Nickel Corrosion:** By plating two layers of nickel, with the top layer being more active (i.e. less noble), a new level of corrosion performance is reached. This is generally accomplished by plating bright nickel over semi-bright nickel. Once the initial bright nickel barrier is penetrated, the corrosion spreads laterally instead of penetrating the less active semi-bright nickel layer. The effect can be improved by plating a high activity/high sulfur layer between the semi-bright and bright nickel layers. This high sulfur layer will also corrode laterally, offering increased protection of the semi-bright layer.



**STEP:** "Simultaneous Thickness and Electrochemical Potential" is a method to measure the difference in electrochemical potential between each of the layers in multilayer nickel deposits. This test measures the thickness of the relevant nickel layers at the same time, hence the test title. Over time, the term STEP has become synonymous with the measurement of the electrochemical potential difference rather than thickness.

# Semi-Bright Nickel

## Plating To Specification

ASTM B 604, ASTM B 456 and ISO 1456 list the following service conditions for high performance nickel chromium plating. Semi-bright nickel is used in the most demanding service condition applications, and typically constitutes 50 – 70% of the total nickel thickness.

Service Condition Number	Description	Details
SC5	Extended very severe	Service conditions that include likely damage from denting, scratching and abrasive wear in addition to exposure to corrosive environments where long-term protection of the substrate is required; for example, conditions encountered by some exterior components of automobiles.
SC4	Very severe	Conditions that include likely damage from denting, scratching and abrasive wear in addition to exposure to corrosive environments; for example, conditions encountered by exterior components of automobiles and by boat fittings in salt water service.
SC3	Severe	Exposure that is likely to include occasional or frequent wetting by rain or dew or possibly strong cleaners and saline solutions; for example, conditions encountered by porch and lawn furniture, bicycle and perambulator parts, hospital furniture and fixtures.
SC2	Moderate	Indoor exposure in places where condensation or moisture may occur; for example, in kitchens and bathrooms.
SC1	Mild	Indoor exposure in normally warm, dry atmospheres with coating exposed to minimum abrasion.



**Automotive:** Cars and chromium have been linked together for decades. Reaching its peak in the flamboyant styling of the 1950's, chromium wheels, trim and accents have historically been used by car designers to help impart a distinctive look to their cars. In the 1980's exterior chromium almost vanished, in part due to fashion, styling changes and weight reduction efforts for improved fuel efficiency, but also because of concerns over quality, particularly problems with premature corrosion. Since then, advances in plating technology have made it possible to dramatically improve the performance of chromium plated parts.

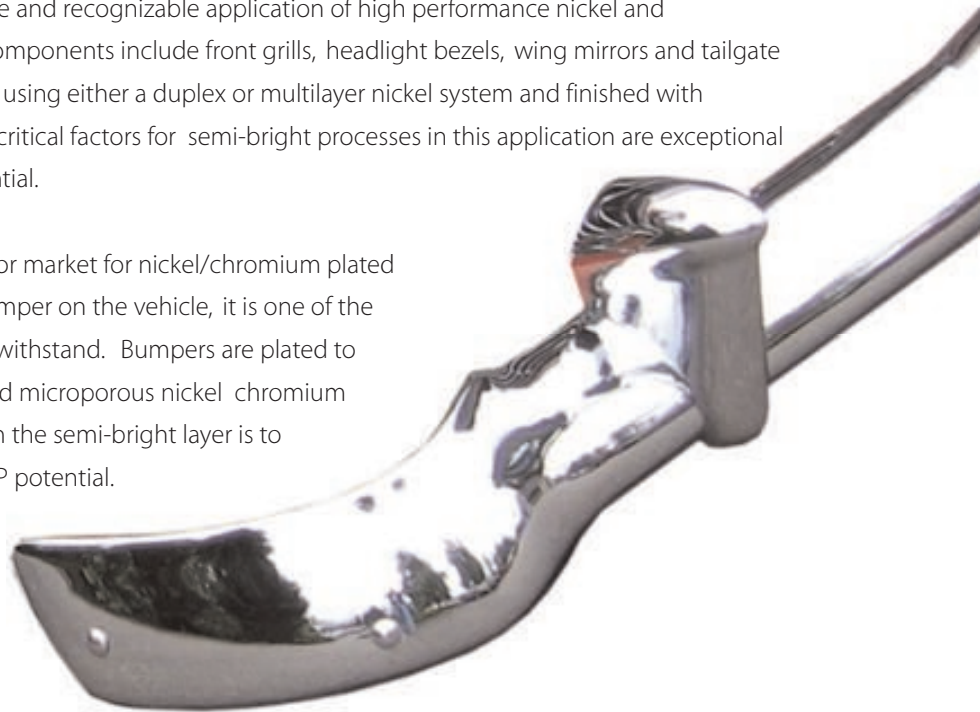
One of the most significant advances was the increased use of semi-bright nickels. The high purity of this nickel layer helped to spread corrosion laterally between the bright/semi-bright interface, thus delaying penetration to the base material and extending component life. New semi-bright nickel systems also have excellent ductility (or elongation) characteristics meaning that they prevent premature coating cracking on 'flexible' substrates such as plastic.

**Plastic Exterior Trim :** Perhaps the most visible and recognizable application of high performance nickel and chromium plate is exterior automotive trim. Components include front grills, headlight bezels, wing mirrors and tailgate handles, typically plated to service condition 4 using either a duplex or multilayer nickel system and finished with microporous nickel and chromium. The most critical factors for semi-bright processes in this application are exceptional deposit ductility and reproducible STEP potential.

**Steel Bumpers:** North America remains a major market for nickel/chromium plated steel bumpers. Due to the positioning of a bumper on the vehicle, it is one of the toughest applications the coating will have to withstand. Bumpers are plated to service condition 5, using multilayer nickels and microporous nickel chromium to achieve high performance. The demand on the semi-bright layer is to deliver ultra high leveling and a consistent STEP potential.

**Aluminum Wheels:** Nickel/chromium plating of aluminum wheels is a complex and highly skilled procedure. The technology involved in both the pretreatment and plating must be robust and able to deliver consistent STEP results and bright covering power. When specified as original equipment on a new vehicle, wheels will be plated to service condition 5 or even more stringent requirements, using multilayer nickel and microporous nickel and chromium. This ensures that the customer receives aluminum wheels that not only look spectacular in the show room, but continue to look good after many miles of driving.

**Plumbing Applications:** Zinc base diecastings and copper alloys can be cast into very intricate shapes and are extensively used to manufacture equipment for bathroom/plumbing applications. However these metals are quite reactive and therefore need good protection from the damp atmospheres found in these environments. The use of duplex nickel is common to meet service condition 2 in these applications, providing corrosion protection for the base material. This type of application puts high emphasis on leveling to smooth out polishing lines.



# Semi-Bright Nickel

	NiMac SF	NiMac 456	
<b>Typical Application</b>	POP, Steel Bumpers, Aluminum	Steel Bumpers, POP, ZBDC	
<b>Type</b>	Non-Coumarin	Non-Coumarin	
<b>Leveling</b>	High	Very High	
<b>Appearance</b>	(Bright low to medium CD, semi-lustrous high CD)		
<b>Batch Purification</b>	Infrequent	Infrequent	
<b>Typical STEP</b>	140mV	140 mV	

## NiMac SF

**Process Description :** NiMac SF is a non-coumarin, sulfur-free nickel plating process which produces a very ductile deposit with good leveling. Unlike coumarin based semi-bright nickels, NiMac SF does not require frequent batch purification treatments, resulting in less down time, reduced labour and less waste. NiMac SF Blend can be used as a single component additive to replace the NiMac SF Maintenance, NiMac SF Leveler and NiMac SF Ductilizer. NiMac SF Blend is specifically formulated for use in facilities where auxiliary anodes are extensively employed.

## NiMac 456

**Process Description :** NiMac 456 is a non-coumarin, semi-bright nickel designed specifically to provide maximum leveling while still maintaining excellent STEP and deposit ductility. NiMac 456 can be used on all substrates including plastics, but is particularly suitable for applications requiring high leveling from the semi-bright nickel layer, without the disadvantages associated with coumarin based additives. Depending on the application, NiMac 456 can operate as a single or dual additive system.

**Recommended Application :** Plating on plastics, aluminum wheels and plating copper alloys.

**Typical Specification :** ASTM B604 PL/Cu15a Ni30d Cr r, PL/Cu15a Ni25d Cr mc/mp, ASTM B456 Cu/Ni15b Cr r ISO 1456 Al/Ni40d Cr mc/mp, Cu/Ni10b Cr r

**Recommended Application :** Steel bumpers, plating on plastics, copper alloys and zinc based diecastings.

**Typical Specification :** ISO 1456 Fe/Ni35d Cr mp/mc ASTM B604 PL/Cu15a Ni30d Cr r, PL/Cu15a Ni25d Cr mc/mp ASTM B456 Fe/Ni35d Cr mp/mc, Zn/Cu5 Ni15b Cr mp/mc, Zn/Cu5 Ni20b Cr r, Cu/Ni15b Cr mp/mc, Cu/Ni20b Cr r

NiMac 604	NiMac 8105
POP, Aluminum	Steel Bumpers
Non-Coumarin	Coumarin
Medium	Very High
Even brightness across full CD Range	Semi-lustrous
Infrequent	Very Frequent
140mV	140mV

#### NiMac 604

**Process Description :** NiMac 604 is specifically designed for use on plastic substrates. The process conforms to ASTM B604 for semi-bright nickel and provides a bright clean nickel layer across the full current range even at extreme low and high current density areas. Deposits are low in stress and are extremely ductile.

**Recommended Application :** Plating on plastics

**Typical Specification :** ASTM B604 PL/Cu15a Ni30d Cr r, PL/Cu15a Ni25d Cr mc / mp

#### NiMac 8105

**Process Description :** NiMac 8105 is a coumarin-based process which is approved for plating steel bumpers. NiMac 8105 uses one additive to maintain the very high rates of leveling and the deposit STEP. NiMac 8105 can also be used as an additive in other semi-bright nickel solutions to increase deposit leveling. NiMac 8105 is particularly recommended for applications requiring high leveling from the semi-bright nickel layer, i.e. polished steels. When using NiMac 8105 additive, frequent carbon purifications are required to remove organic breakdown products.

**Recommended Application :** Steel bumpers

**Typical Specification :** ISO 1456 Fe/Ni35d Cr mp/mc  
ASTM B456 Fe/Ni35d Cr mp/mc

*Coumarin is a chemical compound found in many plants. It has a sweet scent, readily recognized as the scent of newly-mown hay. It is used as a leveling agent in some semi-bright nickel systems. Although this material gives excellent deposit leveling and ductility, the breakdown products are harmful to the process and the solution needs regular full carbon purifications.*

# Semi-Bright Nickel

## Purification Of Semi-Bright Nickel Solutions

In order to maintain the desired deposit properties from some semi-bright nickel plating solutions, (eg NiMac 8105) regular purifications to remove organic and inorganic contaminants are essential. Contamination may not only change the cosmetic appearance of the semi-bright deposit, but also alter its performance characteristics. Changing these characteristics may cause premature failure of the nickel/chromium plated layers in service. However, unlike purification of other systems such as bright nickel plating solutions, there are some points which have to be taken into account:

- The use of sulfur containing liquid purifiers to remove metallic contamination such as copper and zinc must not be used in semi-bright plating solutions.
- The introduction of any additives from a non-recommended source, i.e. bright nickel additives, will effectively render the semi-bright nickel solution unsuitable for multilayer nickel plating applications.

### Removing Organic Contamination

**Carbon Treatment:** The usual signs of organic contamination in a semi-bright nickel solution are pitting, poor response to maintenance additions and dark or dull deposits that cannot be corrected by the normal means. 1 kg per 1000 litres, (2.0 lbs per 250 gallons) of activated carbon packed on to a filter will normally remove unwanted organics, but more serious contamination may require full batch carbon treatment.

**Ultra Violet (UV) Light Purification:** One alternative to carbon treatment avoids the environmental, health and safety issues associated with carbon treatment. The method is purification by the use of hydrogen peroxide in conjunction with ultraviolet light (UV). It avoids operators having to physically handle the plating solution and carbon dust, as well as avoiding the need to dispose of the nickel-contaminated carbon waste. As the system can be used on a continuous basis, it also helps a plater to keep within pre-defined limits of contamination. The system works by using UV light to irradiate hydrogen peroxide thus generating hydroxyl radicals. Hydroxyl radicals are very powerful oxidants and react very rapidly with bath organics, oxidizing them to carbon dioxide.

### Removing Metallic Contamination

**Plating Out Or Dummying:** Metallic contamination should be kept to a minimum through effective rinsing of parts prior to plating in the semi-bright plating solution. Iron, copper, zinc and lead are the most common metallic impurities in semi-bright nickel and are removed by dummy plating at  $0.5 \text{ A/dm}^2$  ( $5 \text{ A/ft}^2$ ).

**Filtering:** Prevention of build up in copper and zinc can be achieved by conventional plate out techniques or the use of a special filter aid powder, NiMac MRP. This purifier can be used with semi-bright nickels without altering the deposits STEP characteristics. When plating steel substrates, iron can be oxidized with hydrogen peroxide and filtered for removal.



# Which Bright Nickel?

In most applications, the semi-bright layer will be coated with a bright nickel which provides the final deposit leveling and lustre. The choice of bright nickel will depend on the substrate and end use of the component. The NiMac range of bright nickels includes systems that have been designed to complement the underlying semi-bright layer in applications such as bright exterior automotive trim, plated aluminum wheels, steel bumper bars and plumbing fittings.

	POP-Exterior/ Interior	Steel Bumpers	Aluminum Wheels	Plumbing Cu Alloys	Plumbing ZBDC
NiMac Challenger Plus		★	★★	★	
NiMac Clarion II	★★	★	★		★
NiMac Clarion 3	★★	★		★★	★
NiMac GB	★			★	★★

**NiMac Challenger Plus:** NiMac Challenger Plus is a high performance PPS-based system particularly suited for applications requiring high leveling. NiMac Challenger Plus is approved for use as the bright layer in the multilayer nickel plating of aluminum wheels.

**NiMac Clarion II:** NiMac Clarion II is an index based system designed for producing a final deposit on multilayer nickel plated plastics. It gives deposits which have excellent ductility, with good brightness and leveling across the full current density range. The system is low in harmful breakdown products meaning that regular batch carbon treatments are not necessary.

**NiMac Clarion 3:** NiMac Clarion 3 is a non – PPS system designed for producing a highly leveled final deposit on substrates such as plastics, copper alloys and zinc based diecastings. For such a high leveling system the deposit has very good ductility. The system is low in harmful breakdown products meaning that regular batch carbon treatments are not necessary.

**NiMac GB:** NiMac GB is a high performance PPS-based system particularly suited for plating metals that require the bright layer to have good leveling. The system exhibits very good deposit ductility and chromium receptivity. If required, NiMac GB can be used in low nickel formulations, reducing solution dragout costs.

*Bright nickels are often classified as containing 'PPS' or 'PPS-OH'. Systems that are free from either of these chemicals are often called non-PPS or Index systems. The primary advantage of PPS / PPS-OH systems are their ultra high leveling. The disadvantage is that the breakdown products can be harmful to the bright nickel and lead to poor deposit ductility.*

# Semi-Bright Nickel

## Nickel Data & Facts

<b>Symbol</b>	Ni
<b>Atomic Number</b>	28
<b>Atomic Weight</b>	58.69
<b>Discovered</b>	Cronstedt 1751
<b>Electron Configuration</b>	[Ar]4s <sup>2</sup> 3d <sup>8</sup>
<b>Name Of Origin</b>	German Nickel: Satan or Old Nick, also, from kupfernickel: Old Nick's copper
<b>Isotopes</b>	14 known isotopes, 5 stable and 9 unstable. Natural nickel is a mixture of the 5 stable isotopes.
<b>Properties</b>	<p>Melting Point 1453°C            Boiling Point 2732°C            Specific Gravity 8.902 (25°C).</p> <p>Nickel is a silvery white metal that takes a high polish. It is hard, ductile, malleable and ferromagnetic. It is a fair conductor of heat and electricity. Nickel is a member of the iron-cobalt group of metals (transition elements). Exposure to nickel metal and its soluble compounds should not exceed 1 mg/m<sup>3</sup> (8 hour time weighted average for a 40 hour week). Some nickel compounds (nickel carbonyl, nickel sulfide) are considered to be highly toxic or carcinogenic.</p>
<b>Uses</b>	Nickel is used primarily for the alloys it forms. It is used for making stainless steel and many other corrosion resistant alloys. Copper-nickel alloy tubing is used in desalination plants. Nickel is used in coinage and for armor plating. When added to glass, nickel compounds give a green color. Nickel plating is applied to metals to provide a protective coating. Finely divided nickel is used as a catalyst for hydrogenating vegetable oils. Nickel is also used in ceramics, magnets and batteries.
<b>Sources</b>	Nickel is commercially obtained from pentlandite and pyrrhotite. Nickel is also present in most meteorites. Iron meteorites (siderites) may contain iron alloyed with 5-20% nickel. Deposits of nickel ore are located in Ontario, Australia, Cuba and Indonesia.
<b>Outlook</b>	Nickel use is growing at about 4% each year with use of nickel-containing stainless steel growing at about 6%. The fastest growth today is in the newly and rapidly industrializing countries, especially in Asia. At the end of life (EOL), nickel-containing products can be collected and recycled for re-use. Nickel is one of the most recycled materials globally. It is collected and recycled, mostly in the form of alloys. About half of the nickel content of a stainless steel product today will have come from recycled sources.
<b>Safety</b>	<p>Nickel has some properties which have led to its soluble salts being classified as hazardous substances. Soluble nickel can, in certain circumstances be associated with toxicity, carcinogenicity and with dermal sensitization. The nickel industry is collaborating in the formal assessment of all the risks associated with nickel that is currently being undertaken.</p> <p>Most of the practical risks associated with nickel are seen in certain complex processes used in nickel production and refining. The risks are well known and are managed and controlled by specific workplace regulations.</p>

# NiMac Semi-Bright Nickels

*High Performance Decorative Coatings*

## The “active” barrier, between success and failure!

Sometimes the difference between success and failure in performance testing is just a few millivolts. That’s certainly the case with semi-bright nickels because they are not all developed to deliver the highest degree of corrosion protection. **NiMac Semi-Bright Nickels** are the exception.

The low stress deposits from **NiMac Semi-Bright Nickels** consistently deliver STEP test values in excess of 140mV, ensuring you meet the most demanding corrosion specifications for today’s critical decorative plating applications.

So when you need a 100% reliable semi-bright nickel deposit, count on the company that says “Yes We Can”. MacDermid.

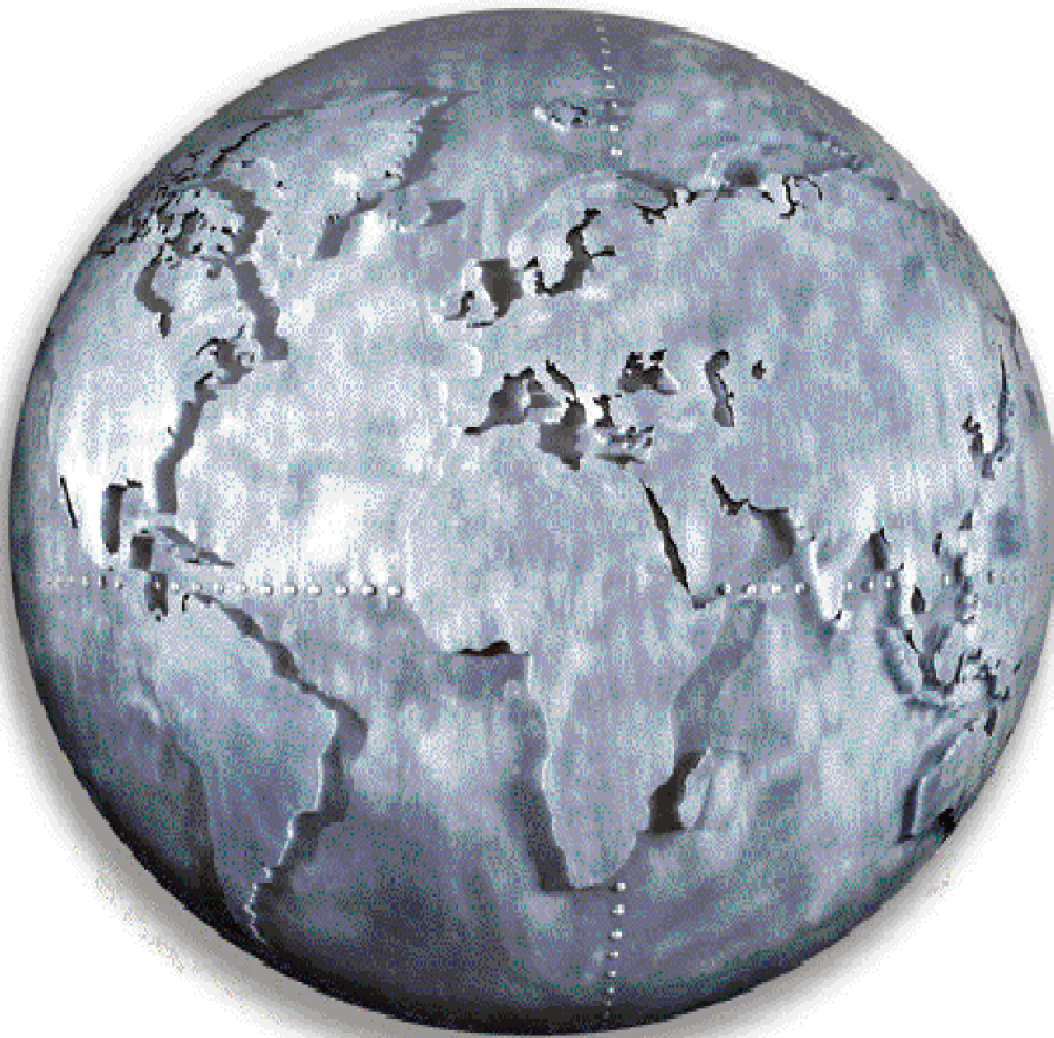
### Key Features

- Exceptional STEP performance
- Highly levelled and ductile deposits
- Active corrosion barrier
- Coumarin free additives



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Industrial Solutions



## YES WE CAN<sup>SM</sup>

It takes more than innovative, high performance products and superior technical service to help our customers compete and win in today's global marketplace. It takes a total commitment to understanding their needs and the ability to provide the right solutions—every time.

When success is your only goal, trust the company that says "Yes We Can."



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