

NICKEL

THE MAGAZINE DEVOTED TO NICKEL AND ITS APPLICATIONS

Stainless Steel Rail Cars:
Durable and Cost-Effective

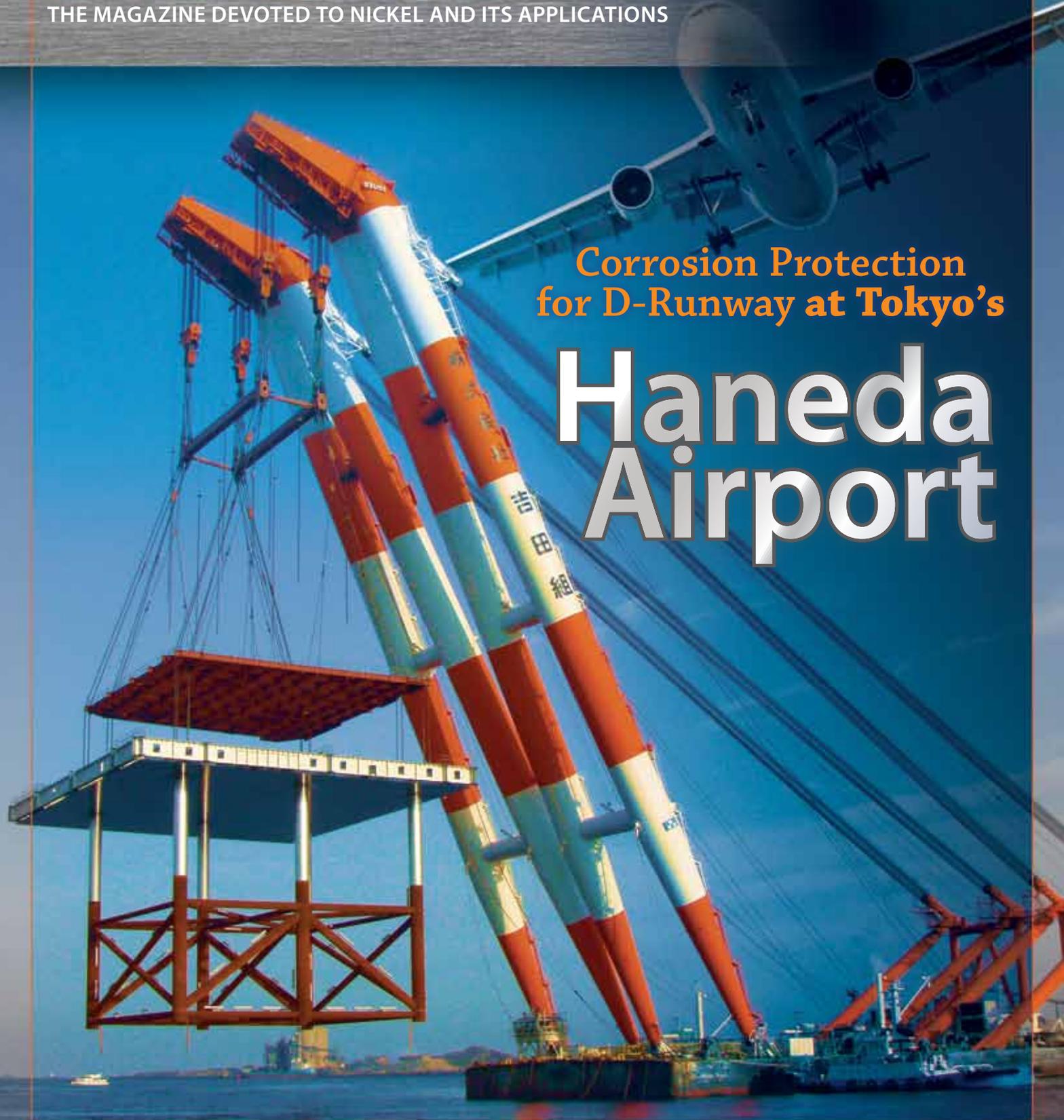
Municipal Infrastructure:
Modest but Durable

Bridge In A Hurry:
Stainless Steel Rebar

June 2011 Vol. 26, N° 1

Corrosion Protection
for D-Runway at Tokyo's

Haneda Airport



THE NICKEL INSTITUTE IN 2010 KNOWLEDGE FOR A BRIGHTER FUTURE

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NICKEL

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iSTOCK PHOTO © ANTHONY BROWN

TOMORROW'S INFRASTRUCTURE

The need for efficient infrastructure is rarely proportional to the ability to pay for it. Governments everywhere struggle to balance their revenues with the demand for more and better roads, rail lines, medical and educational facilities, water supply and waste water treatment systems, and so on – in short, all the things that enable society to function.

Decisions that affect infrastructure design are always, to varying degrees, determined by economics, and that includes material specification. Depending on the public or private ownership model, there is a need to reduce costs, both to lighten the tax burden and ensure an adequate return on capital.

For accounting and costing purposes, it is important to include the long-term cost of ownership (including maintenance and repairs), as well as the one-time cost of construction. All of these are reasonably easy to estimate (though not all estimates turn out to be accurate).

Less easy to measure are indirect, long-term costs, such as are incurred when infrastructure fails or has to be repaired or refurbished. Highway repairs, for example, create longer travel times for workers and goods, increased traffic to and from the worksite, need for new materials and disposal of waste materials, traffic diversions to residential streets, increased fuel consumption, and so on. These and other indirect costs also take their toll on the environment.

How much better it is when materials are chosen to reflect the full life-cycle cost of construction, use, and final disposal and recycling.

This issue of *Nickel* looks at several projects which reflect this more balanced approach. Included are articles on:

- the new D-Runway at Tokyo's Haneda Airport, which demonstrates the valuable role nickel plays in ensuring low-maintenance durability, and corrosion resistance;
- replacement of the Highway 417 bridge, near Ottawa, Canada, which was done in record time; and
- the use of stainless steel in municipal projects in salt-exposed environments.

The builders of tomorrow's infrastructure will need more examples like these as they work to ensure that the health of citizens and the environment is not compromised. Thanks largely to nickel and nickel-containing alloys, the goal is within reach.

Stephanie Dunn
Editor, Nickel Magazine

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Nickel-containing alloys enable 100 year design life at Tokyo's Haneda Airport

The opening of Haneda Airport's new "D" runway in October 2010 ensures the continued success of this airport, now ranked the second busiest in Asia and the fifth busiest in the world.

Marine challenges

The new runway was built at the mouth of the Tama River in Tokyo Bay. To minimize its effect on water and tidal flows, a third of the runway is a steel pier that allows the free movement of river and Tokyo Bay waters. Corrosion is a particular threat to the metal components of the pier in this maritime environment. Wave and tidal action will inevitably lead to a build-up of corrosive salt and rain water will not wash it away.

Engineers needed to protect a large amount of structural steel from corrosion using methods that would not require difficult and expensive repairs. They chose three complementary corrosion-protection methods: using titanium sheet to cover the lower surfaces of girders that support the runway, protecting the steel pipe piles in the tidal and splash zones that support the pier by covering them with a seawater-resistant stainless steel jacket and finally, cathodic protection for totally immersed carbon steel components.

Seawater-resistant Stainless Steel Sheathing

More than 400 tons (approximately 114,000 m²) of seawater-resistant austenitic stainless steel UNS S31254 (SUS312L), one of the 6%Mo grades, was used to sheath (loose clad) the carbon steel

pipe piles. This grade contains more chromium, nickel and molybdenum than conventional austenitic stainless steels such as UNS S31603 (SUS316L) and is far more resistant to pitting and crevice corrosion in marine environments. Its service life in the Haneda runway application is expected to be about 100 years.

The stainless sheets applied in the general pier section were only 0.4mm thick. Joining of overlapping sheets was done by a combined welding method using both indirect seam welding and plasma welding with UNS N06625-type filler wire. This specially developed welding technique prevents deformation due to thinness of the sheets. The welding was completed in the shop and the pieces transported to site on barges.

Life cycle considerations

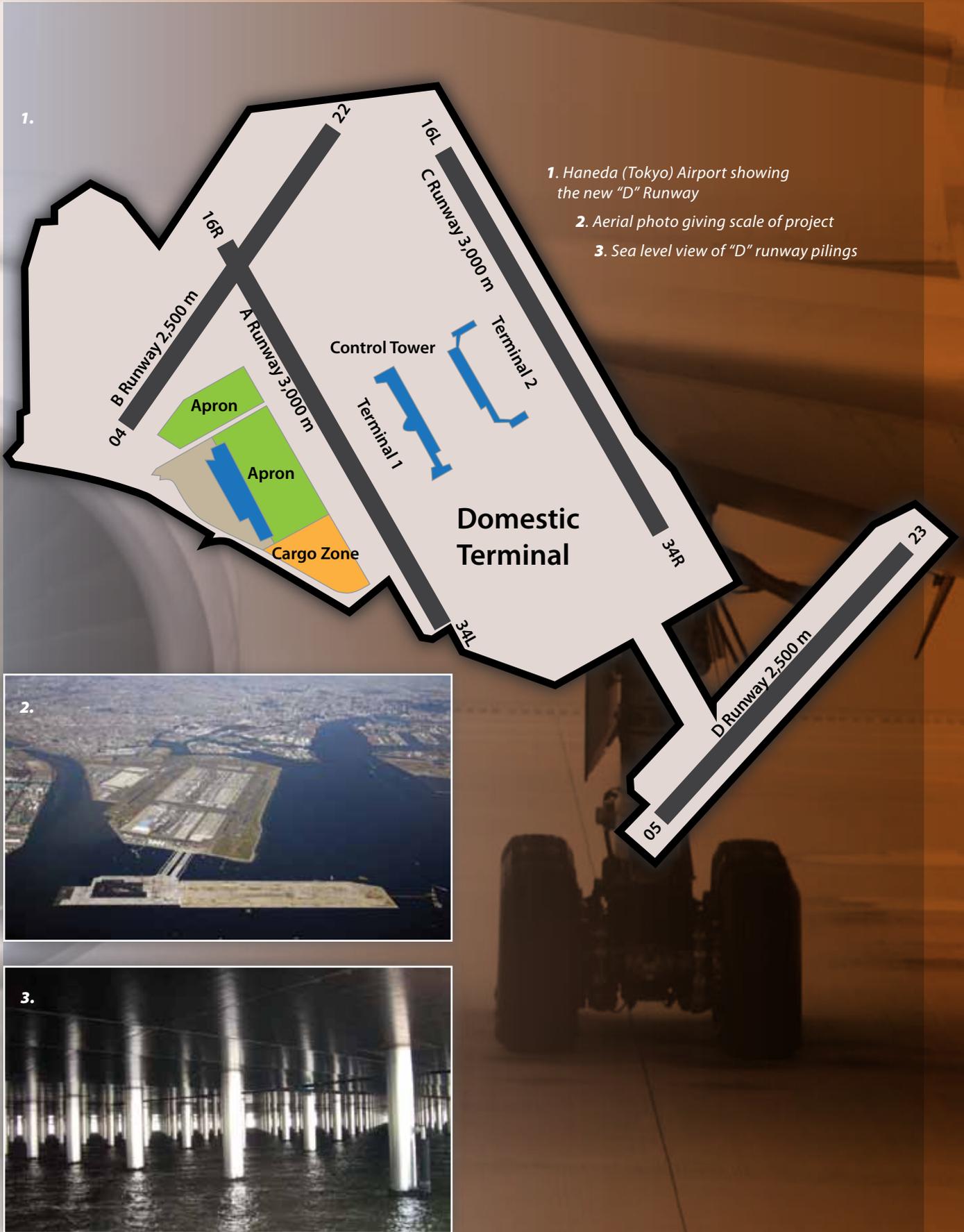
As part of the design phase of the project a life cycle cost evaluation was undertaken to model the differences between "lower initial cost/high maintenance costs" and "higher initial cost/lower maintenance costs". The analysis showed the short term savings in capital costs being overwhelmed by the maintenance costs associated with the long anticipated life of the structure. The development of a sheathing method using very thin stainless sheet with high quality welding contributed to the savings in capital cost and is expected to provide extra-long term durability. And while not a formal consideration in the evaluation, it is reasonable to expect that the nickel-containing stainless steel will be profitably recovered and recycled at the end of the life of the structure. **NI**

Corrosion protection methods used on the pier

- Structure inside girder is coated and will be dehumidified
- Titanium cover plate on the bottom of the girders
- Tidal and splash zones
Seawater-resistant stainless steel sheathing
- Submerged and subsea zones are cathodically protected



ISTOCK PHOTO © BENNEWITZ



1.

1. Haneda (Tokyo) Airport showing the new "D" Runway

2. Aerial photo giving scale of project

3. Sea level view of "D" runway pilings

2.

3.

PHOTOS COURTESY OF: HANEDA AIRPORT EXPANSION PROJECT JV

Modest Structures, Enduring Results

Engineers in Gold Coast City and Ottawa choose nickel-containing stainless steels to prevent corrosion in infrastructure



△ Holman Street bridge railing, Brisbane, Queensland, north of Gold Coast City on Australia's east coast



△ The Corktown Footbridge over the Rideau Canal

Infrastructure is not always grand in scale. Most infrastructure decisions at the village and city level are modest from an engineering standpoint, and yet they affect the quality of life of citizens both directly and over long periods. Depending on the materials chosen, such projects also affect the costs shouldered by tax payers over long periods.

Marine Environment Solution

The eastern coast of Australia has a hot marine environment which can be very demanding on materials. Paul Conolly, coordinator of technical governance for the Gold Coast City Council (GCCC), recalls that in 1998 stainless steel was specified for a modular toilet structure in a city park in the foreshore zone. (The foreshore, or intertidal, zone is the area that is above water at low tide and under water at high tide.) However, it was decided that alternative materials would be used to reduce the capital cost.

With the passage of time it became clear that the service life of such structures was going to be limited. What's more, the visible deterioration that resulted was affecting the aesthetics of the park.

"A lot of our public facilities were in the foreshore zone and some materials weren't performing as well as we had hoped," recalls Conolly. "Then we started to look at corrosion issues and how best to manage them. We began using stainless steel for critical elements such as joint interfaces for concrete works, bolts, brackets and cleats for boardwalks, and high-use facilities like rubbish bins.

"Our observations led us to believe that stainless was the way to go in the foreshore zone, but we had no tangible justification which the designers could use to validate such a decision. We needed clear evidence to prove that the initial cost of stainless steel was justified over the life of the structures."

That evidence was found in a study conducted by a Griffith University scholarship student in conjunction with GCCC in which lifetime, capital and maintenance costs were calculated for hot-dipped galvanized (HDG) steel, paint systems, duplex systems using both HDG and paint, and stainless steel. There is no one material that is appropriate for all uses all the time, but for structures with a design life of 19 years or more, stainless steel is the first choice in terms of capital cost alone.

The selection guide that grew out of the Griffith University study is now influencing material choice decisions up and down the Gold Coast.

On the Other Side of the World

The citizens of Ottawa, Canada's capital, are familiar with severe winters and how salt, when applied to roads and walkways, can make movement safer. Unfortunately they are also familiar with how salt can damage roads and bridges – damage which disrupts traffic and drives up taxes.

In 2005, the city began building a pedestrian bridge – the Corktown Footbridge – over the Rideau Canal, a UNESCO World Heritage site. The design and engineering team, led by the firm of Du Toit Allsopp Hillier, decided on "high quality, durable, compatible materials and finished to provide premium appearance over time and minimize ongoing maintenance." Those materials were predominantly 304 (UNS S30400) stainless steel, which the builders applied to anchors, railings and various other elements of the safety barrier. The finished bridge, noted for its superior design, has proved highly popular with pedestrians, cyclists and tourists.

Back in Australia, where the use of stainless steel in playground equipment and shade sail structures is gaining ground, Paul Conolly sums up: "It's just a matter of making that little leap toward recognizing the whole-life cost and ensuring delivery of a durable product – common sense, come to think of it." ■

A BRIDGE IN A HURRY

Major urban arterial span gets quick makeover



△ Original bridge before replacement



△ Transporter vehicle carrying old bridge span



△ New bridge spans on supports in staging area

Using traditional methods, replacing a bridge can be a long, drawn-out process. However, on one warm August night in 2008, the twin spans of the Clyde Avenue Bridge on Highway 417 in Ottawa, Ontario, Canada were replaced in their entirety.

The highway was closed to traffic at 6:00 on the evening of Aug. 2, the existing bridge spans removed, and the new bridge spans installed. Traffic was allowed to flow again shortly after 9:00 the next morning.

The existing 21-metre-long (68-ft.) bridge, which consisted of east- and west-bound spans, was almost 50 years old and approaching the end of its design life. In addition, it needed to be widened from three lanes each way to four in order to accommodate future improvements to the busy highway.

The original bridge spans consisted of reinforced concrete road decks supported on heavy steel girders. The old concrete contained carbon steel reinforcing bar. This “rebar” had suffered corrosion damage due to de-icing salt which had been spread on the highway during long snowy winters. The new bridge spans were built separately on top of two huge support structures in a staging area nearby. Their design is similar to the original spans, but with one important difference: the concrete decks and barrier walls of the new spans are reinforced with

Thanks to stainless steel rebar’s resistance to the corrosive effects of de-icing salt, the new bridge spans are expected to last at least 75 years

Alloy 2205 (UNS S31803) stainless steel rebar. Altogether, more than 40 tonnes of stainless steel rebar were cut, bent and delivered to the project.

In the months prior to the bridge’s replacement, the existing east and west abutments were repaired and extended to accommodate the new, wider road decks. Starting at 6:00 pm on Saturday, the old spans were disconnected from the abutments, and remotely controlled transporters were used to pick them up and move them out of the way. The transporters, which resemble huge, multi-wheeled flatbed trailers, were then used to pick up the new spans and carry them to the bridge so that they could be connected to the modified abutments.

This \$9.6-million project represents the second time the Ministry of Transportation Ontario (MTO) has used this state-of-the-art technology to lift and move complete bridge spans on this part of Highway 417.

cont'd on page 15



△ Stainless rebar in new decks (before pouring of concrete)

◁ In a mere 11 hours, traffic flowed again. The twin spans of the Clyde Avenue bridge were replaced in their entirety with a bridge that has an increased lifespan to at least 75 years.

CENTRE PHOTO: MTO

PHOTOS: FRANK SMITH

◁ Edward G. Budd Manufacturing Company's Zephyr

Always cost effective
even as design and speed evolve

Stainless for the long haul

△ Bombardier's Zefiro250

PHOTO COMPOSITION: CONSTRUCTIVE COMMUNICATIONS. ISTOCK PHOTO: BOILA DULSE-AND

Corrosion resistance combined with aesthetic appeal make stainless steel an ideal metal for the manufacture of passenger rail cars

When, in 1976, Hollywood producers set a comedy-thriller on a train hurtling across America, the choice of title was obvious: “Silver Streak” was a nod to the glistening stainless steel passenger cars featured in the movie.

No less obvious is why those cars were built from stainless steel: it has been the go-to metal for fabricating rail cars since the 1930s, when the Budd Company (now ThyssenKrupp Budd) of Philadelphia and its visionary founder, Edward G. Budd, first used it to build the iconic, streamlined Zephyr train.

The ensuing years have only strengthened the case for stainless. Contemporary engineer experts such as Władysław Jaxa-Rożen of Bombardier Transportation North America in Montreal, Canada, insist that austenitic stainless steels are the perfect material for rail car manufacturing. “Cold-worked stainless steels are ideal for rail cars,” says Jaxa-Rożen, adding: “They have high strength, attractive aesthetic qualities, give long life, and are easy to manufacture.”

Bombardier is a leading global supplier of rail vehicles – a full range of products, from subway and urban commuter cars to high-speed intercity trains – and delivers, in total, more than 100,000 units per year to customers in North America, Europe, China, India, South Africa, Brazil and Australia. The Transportation Division operates in 23 countries, employs almost 35,000, and posted revenues of \$9.1 billion in the 2010 fiscal year.

Governments worldwide are ramping up infrastructure spending, with improved public transit among the priorities. New and expanded rail systems offer key advantages such as lower fuel costs and reduced greenhouse gas emissions. All of which is good news for Bombardier Transportation, which has adopted the timely slogan: “The Climate is Right for Trains.”

Although it builds most of its cars using aluminum and carbon steel, Bombardier has



1936 Advertisement for Edward G. Budd Mfg.

produced about 5,000 stainless steel rail cars for the North American market since 1983. Cars with an outer skin of stainless steel were introduced in Japan in the late 1950s, followed a few years later by all-stainless cars. In the period 1984-1990, the metal was used to build more than 6,000 passenger cars. The International Stainless Steel Forum reports that Japanese fabricators still build between 1,000 and 1,200 cars using stainless alloys each year.

It is the transit customer's preferences and specifications which dictate what material is used. Jaxa-Rożen notes that in North America, shiny stainless cars are admired because they are aesthetically pleasing. However, in Europe, which accounts of three-quarters of Bombardier's rail car sales, there is a preference for painted cars, which in turn makes stainless steel a tougher sell. And yet there are many exceptions, the most notable one being the giant shuttle cars used to ferry passengers through the Eurotunnel connecting Britain and France. These are the largest stainless steel cars and were partially built at Bombardier's plant in



△ High strength to weight ratio means structural components can be thinner, reducing overall weight of the car

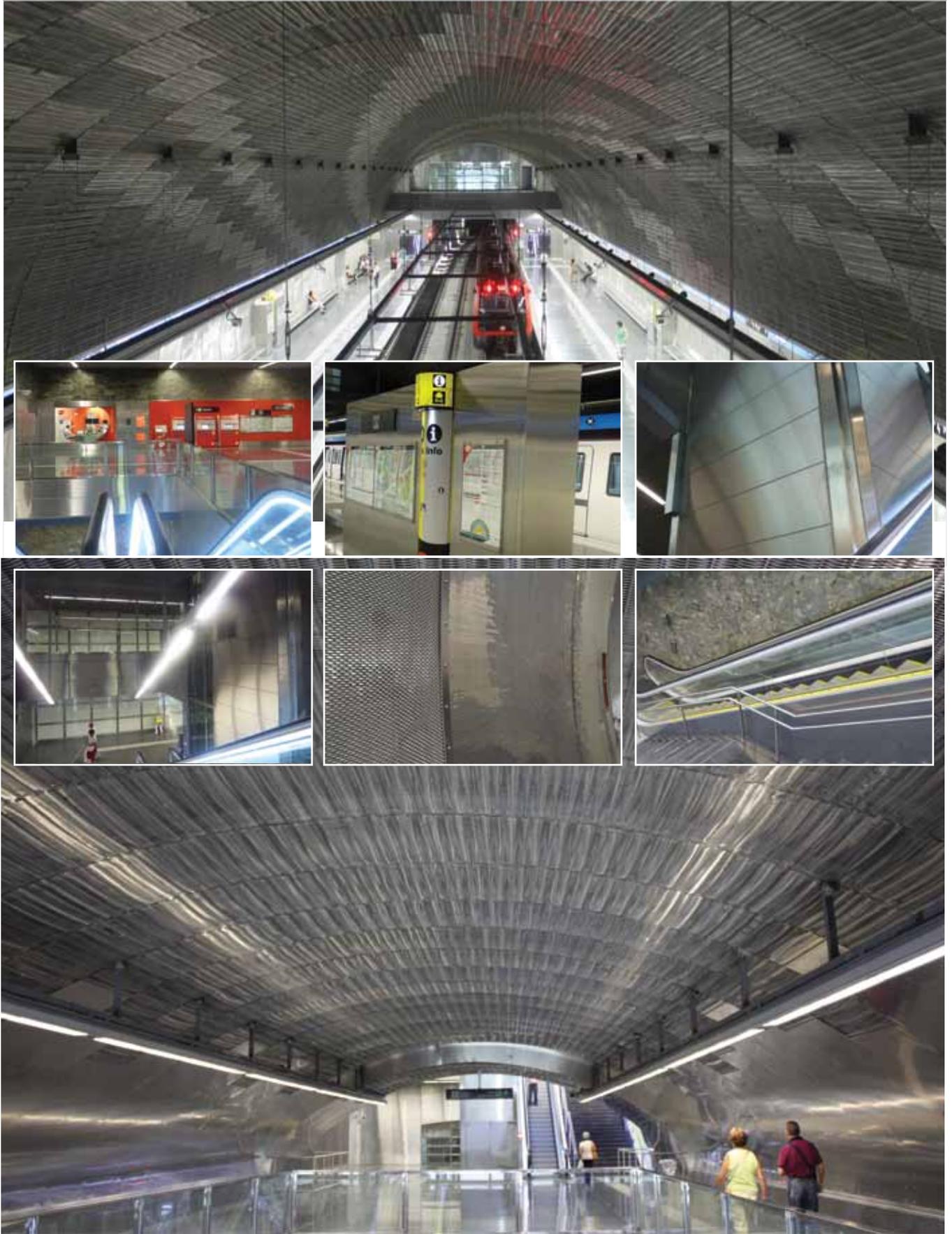
“Cold-worked stainless steels are ideal for rail cars,” says Jaxa-Rożen, adding: “They have high strength, attractive aesthetic qualities, give long life, and are easy to manufacture.”

La Pocatière, Canada and finished in Belgium and France. Another major exception is the German city of Hamburg, which has operated stainless cars on its rail transit system since the mid-1960s, and began taking delivery of a new generation of the cars in 2009.

Jaxa-Rożen says cold-worked austenitic stainless steels – typically 301L (UNS S30103), 304L (UNS S30403) and 201L (UNS S20103) – are best-suited to rail car production, offering a high strength-to-weight ratio. Rail cars, he adds, “are a major example of a structural application where the mechanical properties of stainless steel are successfully used to its maximum.”

The added strength that comes from cold-working and cold-forming the metal means structural components can be thinner; this in turn reduces the overall weight of the car, making it more energy-efficient. The Budd Company is no stranger to stainless steel: it built airplanes out of the metal in the 1930s and 1940s, which attests to its high strength-to-weight properties.

cont'd on page 15



PHOTOS COURTESY OF VARGASA METAL AND CODINA GESTIÓ

Stainless Steel accelerates Barcelona's Metro Line Expansion Project

Stainless steel mesh satisfy both aesthetics and safety requirements

The coastal city of Barcelona, Spain, has begun a project aimed to increase their metro system's size by one third. At the cost of €6.5 billion, the city will get 52 new stations, 20 of which will connect with other lines. This project is expected to attract 350,000 riders daily.

One phase of this project was the lengthening of the L5 line to 48km, which required the construction of several new metro stations. Three Spanish companies were active participants in the decoration of the stations with nickel-containing stainless steel.

Choosing 316L means maintenance requirements can be kept to a minimum since the grade's corrosion resistance is well-suited for the city's atmospheric characteristics

Codina, who specializes in the manufacture of metallic mesh produced 8,700 m² of stainless wire mesh for the cladding of the station ceilings, decks, and halls. All were made of 316L (UNS S31603) stainless steel.

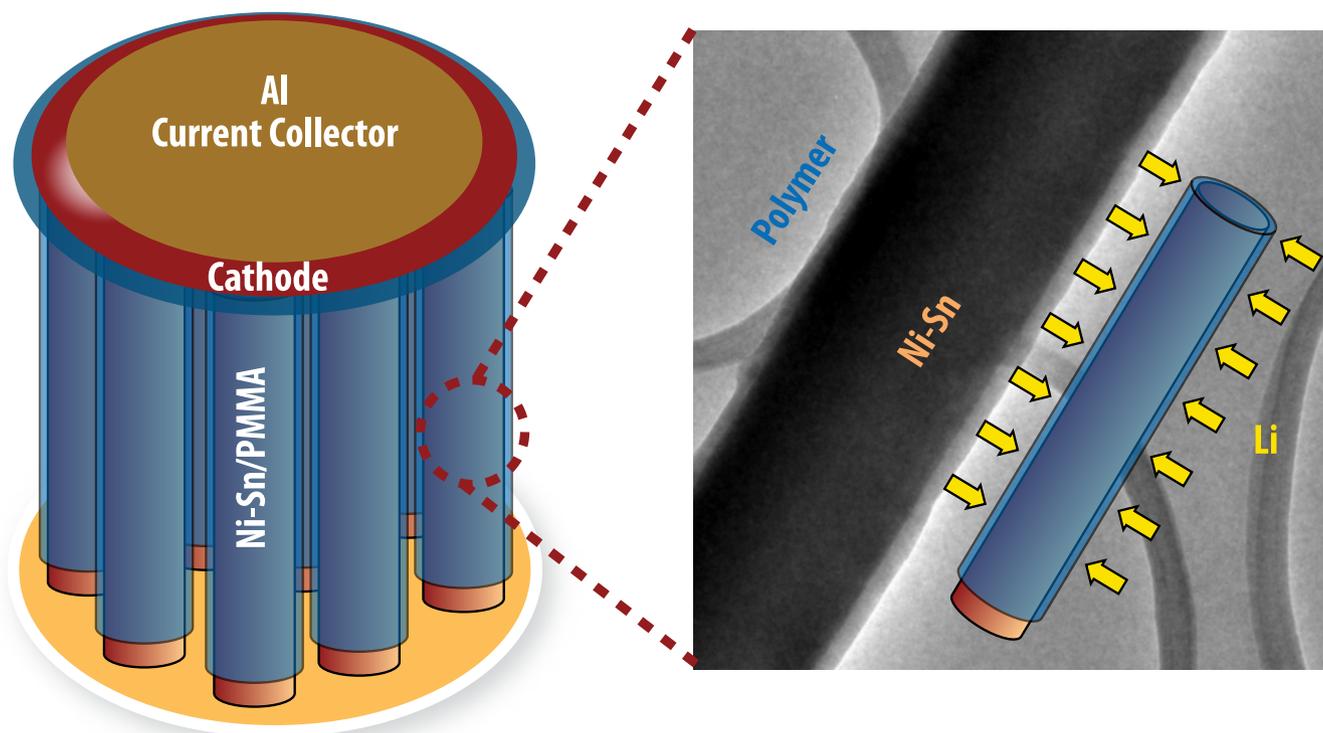
The use of 316L means maintenance requirements can be kept to a minimum since the grade's corrosion resistance is well-suited to Barcelona's atmospheric characteristics. Stainless steel mesh has high aesthetic qualities, yet is durable, strong and has high fire resistance. The mesh is available in a variety of patterns and screen openings (apertures). The mesh is transparent enough to create a sense of lightness for open spaces, yet can be used to conceal unattractive features, for example cement ceilings.

Other Spanish companies which contributed to the L5 metro line project include Vargasa Metal who fabricated and installed polished 304L (UNS S30403) stainless panels and handrails, and Inoxarte, who did similar work. Some of the latter company's panels were installed in such a way that they can be easily removed for cleaning and maintenance.

The result is attractive metro stations that should retain their pleasing appearance for years to come.

Ni





Nickel-Tin Nanowires Spell Energy Efficiency

Researchers at Rice University in Houston, Texas, are using nanowires composed of nickel and tin to produce 3-D batteries that can be charged more rapidly and hold their charge longer than conventional lithium batteries.

"Nickel-tin alloys have been used for some time in lithium battery applications because of their capacity for energy storage," says Pulickel Ajayan, leader of the nanomaterials lab at Rice's Department of Mechanical Engineering and Materials Science. He adds that while pure tin also has a high storage capacity, a battery with such a composition would die after a few cycles without the addition of nickel, which improves cycling stability considerably.

Another advantage of intermetallic nanowires (composed of about half tin and half nickel by weight) is that they can be made cheaply and easily. Ajayan and his team, including lead researcher Sanketh Gowda, can grow millions of nanowires on a chip the size of a fingernail. They are mostly used in scalable applications such as smart cards and wireless sensors.

Each nanowire is coated with a layer of a PMMA (Plexiglas®)-based gel electrolyte to build the 3-D structure from the bottom up. The

...a battery [of pure tin] would die after a few cycles without the addition of nickel.

coating insulates the wires from the counter-electrode without obstructing the flow of ions, which in turn allows for greater efficiency. It is this coating step that differentiates Rice University's batteries from similar 3-D lithium models. "The electrolytes are very thin, and the electrodes are very close," says Ajayan. "The electrolyte, in our case, is coated coaxially around nanowires; this makes the unit more efficient from a charging/discharging perspective."

Ajayan and his team grow the 10-micron-long nanowires by electro-deposition in the pores of an aluminum template. The researchers then widen the pores using chemical etching and coat the wires with an even casing of PMMA. In this way, they are able to produce 1-cm² batteries which store more energy than thin-film batteries that have the same electrode length – and all without sacrificing the kinetics of the lithium ion. **NI**

NICKEL HYDROXYCARBONATE

An important precursor chemical

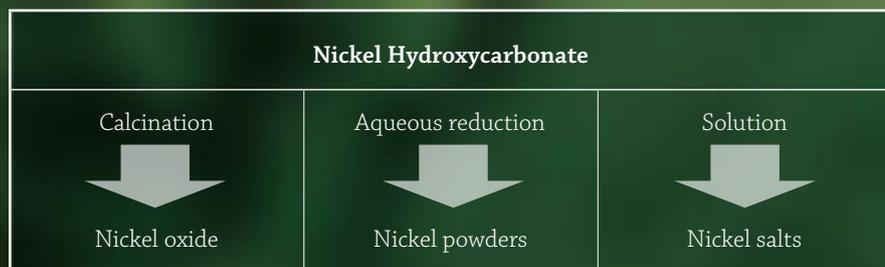
This is the third of a series of articles spotlighting chemicals containing nickel. (See Volume 25, Number 2 for information on nickel sulphate and Volume 25, Number 1 for information on nickel (II) hydroxide)

Nickel carbonate under CAS number 3333-67-3 is very difficult to produce in its pure form, due to its extreme instability, the more commonly used form is usually called nickel hydroxycarbonate, containing the hydroxide ion as well as carbonate ion at a wide range of ratios. It can also contain different amounts of crystalline water, and thus is generically written as $x\text{NiCO}_3 \cdot y\text{Ni(OH)}_2 \cdot z\text{H}_2\text{O}$.

The largest use of nickel hydroxycarbonate is an intermediate use to produce nickel metal powder or other nickel salts. Another major use is the intermediate use as precursor in the nickel catalysts production. Less commonly, nickel hydroxycarbonate can be used in nickel plating solutions, as pH regulator or in the composition of tri-cation phosphating baths. Production of the various types of nickel hydroxycarbonate in Europe alone in the year 2000 was estimated at around 6500 tonnes for the above applications.

Production

Nickel hydroxycarbonate is found naturally as the mineral zaratite [photo] but this is rare and not of commercial importance. Most nickel hydroxycarbonate is produced by leaching nickel matte or as an intermediate product in hydrometallurgical nickel production. In both cases sodium carbonate reacts with a nickel salt, most often nickel sulphate but sometimes nickel nitrate, to precipitate nickel hydroxycarbonate. The purer "chemical grade" nickel hydroxycarbonate is produced in a slightly different way using lower temperature and lower pH. At that point it can be sold or continue as an input for the production of nickel oxide, nickel powder or various nickel salts. By far the greatest volume of purer "chemical grade" nickel carbonate is consumed in the production of nickel oxide through thermal decomposition (for the production of nickel alloys, dyes, pigments and various ceramic products), nickel powders (for many specialist alloy, battery, shielding and other applications), and nickel salts for the metal finishing industry.



The Risk Assessment on nickel hydroxycarbonate prepared by the European Union with industry assistance and the nickel hydroxycarbonate REACH registration dossier are the best and most recent publicly available source of additional information.

<http://www.nickelinstitute.org/Sustainability/EnvironmentalQuality/NickelRiskAssessment.aspx>

<http://apps.echa.europa.eu/registered/registered-sub.aspx>



Close up of Zaratite ▷

NICKEL HYDROXYCARBONATE

EC numbers:

235-715-9, 222-068-2

EC name:

[carbonato(2-)] tetrahydroxytrinickel

CAS numbers EC inventory:

12607-70-4, 3333-67-3, 12122-15-5

IUPAC name:

trinickel monocarbonate tetrahydroxide

Synonyms:

nickel carbonate, carbonic acid nickel (2+) salt, carbonic acid nickel salt, [u-[carbonato(2-)-O:O']] dihydroxy trinickel, [carbonato(2-)] tetrahydroxytrinickel, nickel carbonate basic, nickel carbonate hydroxide, nickel (II) carbonate hydrate, nickel (II) carbonate hydroxide, basic nickel carbonate

Annex I index number:

028-010-00-0

This description covers a range of compositions: the data below relate to one composition within that range.

Molecular formula:

$\text{CH}_4\text{Ni}_3\text{O}_7$

Molecular weight:

304.12

Appearance:

light green powder or crystal

Density: 2.96 g/cm³ at 22.5°C

Melting point:

nickel hydroxycarbonate decomposes without melting above approximately 240 °C

Water solubility:

sparingly soluble; 0.0329 g/L at 20 °C

Stability:

Self Ignition temperature >400°C



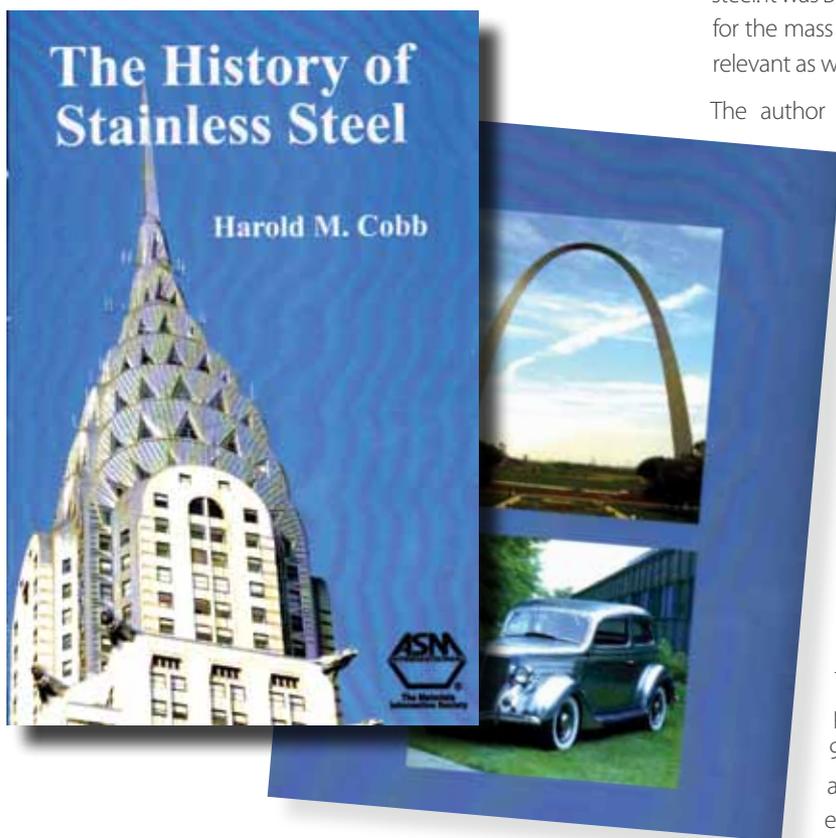
The History of Stainless Steel

Harold Cobb has a broad background in the American stainless steel industry, including work with the E.G. Budd Manufacturing Company and the aerospace and nuclear industries. Just as important as his technical knowledge of metallurgy is his ability to tell a good story involving the people and companies who contributed to the development of stainless steel – all of which is evident in his entertaining new book *The History of Stainless Steel*.

Cobb's account starts with the discovery of chromium in 1797 and traces the study of chromium-containing steels in various countries, including France, Germany, England and the U.S. We usually credit Harry Brearley with the discovery and commercialization of stainless steels in his native Sheffield, U.K., in 1913, but many others advanced the development of these alloys as well. In Germany, for example, a patent was issued in 1912 for a nickel-containing austenitic stainless steel. It was Brearley's stainless steel though which was first produced for the mass market (cutlery in particular). Cobb's book is especially relevant as we approach the centenary of that achievement.

The author covers the various early books and papers which influenced the development of stainless, including the important 1924 conference of the American Society for Testing and Materials. Also included are informative chapters on Brearley, American inventor Edward G. Budd, the Chrysler Building in New York City (which adorns the front cover), and the Gateway Arch in St. Louis, also in the U.S.A., as well as a discussion of melting and refining, various applications, and nomenclature systems. A 76-page stainless steel timeline starts with the discovery of nickel in 1751 and traces its development up to the present day. As we prepare to celebrate the centenary of the discovery of stainless steels, this insightful book will help those of us curious about the past to understand the present.

The History of Stainless Steel, by Harold M. Cobb. 360 pages. Published by ASM International, 2010. ISBN: 978-1-61530-010-1. Available from ASM (www.asminternational.org) in both soft and hardcover editions. Also available from select booksellers. 



UNS details Chemical compositions (in percent by weight) of the alloys and stainless steels mentioned in this issue of Nickel.

	Al	C	Cb	Cr	Cu	Fe	Mn	Mo	N	Ni	P	S	Si	Ti
G41400 p. 16		0.38-0.43		0.80-1.10		rem	0.75-1.00	0.15-0.25			0.035 max	0.040 max	0.15-0.35	
G43400 p. 16		0.38-0.43		0.70-0.90		rem	0.60-0.80	0.20-0.30		1.65-2.00	0.035 max	0.040 max	0.15-0.30	
N06625 p. 4	0.40 max	0.10 max	3.15-4.15	20.0-23.0		5.0 max	0.50 max	8.0-10.0		rem	0.015 max	0.015 max	0.50 max	0.40 max
S20103 p. 9		0.030 max		16.0-18.0			5.5-7.5		0.20 max	3.5-5.5	0.045 max	0.030 max	0.75 max	
S30103 p. 9		0.030 max		16.00-18.00			2.00-max		0.2 max	6.0-8.0	0.045 max	0.030 max	1.0 max	
S30400 p. 6		0.08 max		18.00-20.00			2.00-max			8.00-12.00	0.045 max	0.030 max	1.00 max	
S30403 p. 9, 11		0.03 max		18.00-20.00			2.00-max			8.00-12.00	0.045 max	0.030 max	1.00 max	
S31254 p. 4		0.020 max		19.50-20.50	0.50-1.00		1.00 max	6.00-6.50	0.180-0.220	17.50-18.50	0.030 max	0.010 max	0.80 max	
S31603 p. 4, 11		0.030 max		16.00-18.00			2.00 max	2.00-3.00		10.00-14.00	0.045 max	0.030 max	1.00 max	

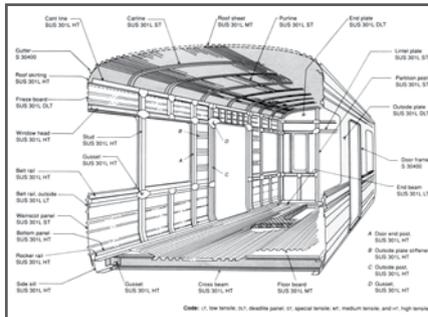
Rail Cars *cont'd from page 9*

Austenitic stainless steels also have excellent fabricability. They are easy to cut with plasma or laser processes, and equally easy to bend and form. A further advantage is good weldability, especially when resistance welding techniques are used. The austenitic grades can also be arc-welded, though distortion and discolouration limit the use of this method to the car's structural components (essentially the floor, sides and roof frames) – and is not used to attach the outer skin.

Stainless steels offer safety advantages. In the event of a crash, the end of a rail car is designed to collapse and absorb much of the impact energy, leaving the passenger section intact and protected. This is possible because austenitic grades have high potential for deformation without breaking or cracking, says Jaxa-Rožen. As well, stainless steel also offers increased fire resistance, thus making it easier for passengers to escape in the event of a crash.

Then there is stainless steel's longevity. It's high corrosion-resistance ensures lower maintenance and repair costs over a car's life – which, with proper servicing, can

exceed 50 years. "If the cars are taken care of correctly, they will never rust," Jaxa-Rožen explains. "The lack of corrosion means structural repairs are unnecessary, and the shiny, paint-free exteriors are as practical as they are attractive; it's easy to remove dirt and graffiti from the smooth surface."



Stainless steel is 100% recyclable, though refurbishing older cars is often an attractive and cost-effective option. A refurbished car can appear as silvery and shiny as on its first day. Via Rail, which operates Canada's long-distance passenger service, refurbished its fleet of about 180 stainless steel passenger cars in the 1990s, after four decades of service, and found that they were in excellent condition with virtually no corrosion. Last year VIA signed a deal to buy back Budd-built, self-propelled passenger cars which it had discarded a decade earlier. Once refurbished and updated, the 60-year-old cars will carry passengers on branch lines in the provinces of Ontario and British Columbia.

The present is bright and the future appears even brighter for stainless steel rail cars, and Jaxa-Rožen is proud that Bombardier and other car builders are following in the footsteps of Edward G. Budd. "We're perpetuating a glorious tradition," he proudly intones. **NI**

- △ Main stainless steel carbody materials
- ◁ Bi-level stainless steel railcars built by Bombardier Transportation

PHOTO AND ILLUSTRATION: BOMBARDIER

Bridge in a Hurry

cont'd from page 7

Using traditional methods, bridge replacements such as this one typically take 14-21 months to complete.

In an interview with *The Ottawa Citizen*, Frank Vanderlaan, the MTO Area Contracts Engineer, remarked: "The great advantage of rapid replacement is that it virtually eliminates the lane closures associated with conventional rehabilitation over a period of two to three construction seasons." By avoiding the traditional long replacement period, the MTO saved about \$2.4 million and motorists likewise saved time and money.

"With no congestion due to construction, the traveling public is not delayed by stop-and-go traffic, which is detrimental to fuel economy and a major factor given present high fuel prices," said Vanderlaan.

Thanks to stainless steel rebar's resistance to the corrosive effects of de-icing salt, the new bridge spans are expected to last at least 75 years with little maintenance or traffic disruption. All of which translates into a low life-cycle cost.

Stainless steel rebar has also been used in bridges which are exposed to marine environments, as well as in sea walls, piers, and other coastal structures.

Thousands of tonnes of stainless steel rebar are in service around the world. Many bridges in Europe have been built using stainless steel rebar and in recent years it was used for large bridges in Australia and Hong Kong. In North America, stainless rebar has been used in the decks and barrier walls of about 100 bridges, the oldest one dating back to 1985. **NI**

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Nickel Alloy Steel to the Rescue

The essential role of nickel in the Plan B shaft

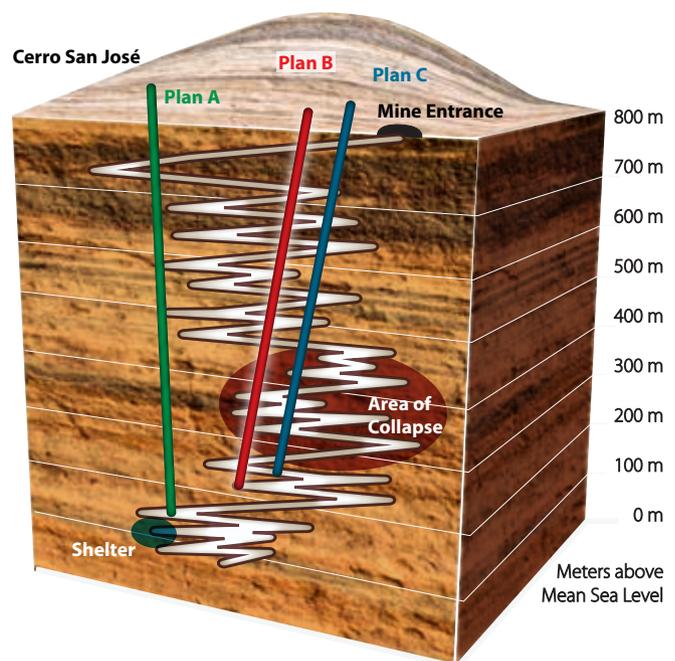
One of the most thrilling and widely publicized stories of 2010 was the rescue of 33 miners who had been trapped 625 metres below the surface at the San José copper and gold mine in northern Chile. But one thing got overlooked in the flurry of media coverage: a key component of the rescue was nickel-containing steel.

The disaster occurred on August 5 when the main mine shaft collapsed, cutting off all contact between the miners and the outside world. It took 17 days for the first small borehole to reach the refuge chamber, whereupon rescuers learned that there were 33 survivors. At first, rescuers thought it would take up to four months to drill a shaft large enough to allow the miners to escape.

Three rescue shafts using different technologies and different teams were being drilled simultaneously. The shaft by which the miners were ultimately rescued, known as the “Plan B” shaft, was created by reaming out an existing borehole which measured 14 cm in diameter. Rather than use traditional tricone drill bits, the Plan B team used a large-diameter pneumatic hammer drill which can deliver 1,500 blows per minute while rotating.

The drill proved ideal for fracturing the hard, abrasive rock that needed to be cleared – a job which placed high demands on the materials used. Five years earlier, Center Rock, a company based in Pennsylvania, U.S.A., had developed a special L.P. (low-profile) drill for drilling extremely hard rock formation. The unit consists of four air hammers. Most of the material in the canister and pistons is either AISI 4340 (UNS G43400, containing 1.65-2% nickel) or AISI 4140 (UNS G41400). Both grades are heat-treated to increase strength and hardness, though it is 4340 which is used where the impact is the greatest. At the same strength level, 4340 is far tougher than 4140 and has increased fatigue strength as well. It is also easier to achieve full thickness hardness with 4340 in heavier sections. The addition of nickel accounts, in large part, for these superior properties.

The trapped miners played an active role in their own rescue, as they had to clear away the hundreds of tons of rock cuttings



Thanks to the high drilling speed of the nickel-containing hammer drill bit, the Plan B shaft was the first to reach the miners

from the drilling that were forced down the borehole and into the mine shaft. With the removal of each load of cuttings, the miners knew that their rescue was that much closer.

Thanks to the high drilling speed of the nickel-containing hammer drill, the Plan B shaft was the first to reach the miners on Oct. 9, just over a month after work on that shaft had started.

On Oct. 13 a jubilant worldwide audience watched live footage of the first miner emerging via a rescue capsule painted in the red, white and blue colours of the Chilean flag. Twenty-two hours later, the last man arrived at the surface, a full 69 days after the collapse of the main shaft. And nickel played a small but significant part. Ni