NICKEL

THE MAGAZINE DEVOTED TO NICKEL AND ITS APPLICATIONS

November 2012 Vol. 27, Nº 2

Safe and reliable water delivery for Toronto

Reverse osmosis desalination in Peru

Stainless steel couplings a crucial component

Nickel and Water: Making the most of the flows

The History of Stainless Steel—Part 2

The First Stainless Steels in the Laboratory

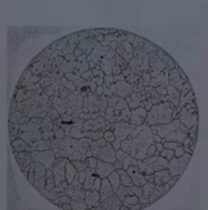
The availability of low-carbon ferro-chromium following a process developed by German chemist Hans Goldschmidt in 1895 was a key step leading to the discovery of stainless steels. In 1898 in France, A. Carnot and E. Goutal proved the detrimental effect of carbon in iron-chromium alloys through the formation of chromium carbides, which effectively reduced the chromium content available to provide corrosion resistance.

In 1903, British patent 23,681 was issued to La Societé Anonyme de la Néo-Metallurgie for a rustless iron. It was a medium-carbon alloy with chromium in the range of 24-57%, nickel from 5 to 60%, and iron from 16 to 38%. As with many patents of that era, the range of alloying elements is large. Such alloys were not only expensive, they were difficult to produce in product forms other than castings. Their alloy was used in high-temperature applications.

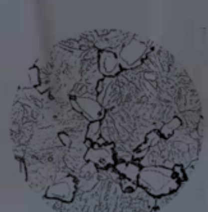
Léon Guillet, a professor of metallurgy in France, made a systematic study of the iron-chromium alloys. Similar work had been done earlier by Sir Robert A. Hadfield in England, but only for alloys with high carbon content. In 1904 Guillet published his findings, describing each alloy's metallographic structure, heat treatment, and mechanical properties. Some of those compositions are recognizable as stainless steel alloys used today from the ferritic and martensitic families. However, Guillet did not study their corrosion resistance and consequently did not appreciate their "stainless" property. He did note that these alloys needed a more aggressive etchant (a corrosive chemical used for etching) to reveal their microstructure. Two years later, in 1906, Guillet published the results of a similar investigation for iron-chromium-nickel alloys with austenitic microstructures. Thus Guillet was the first to report on the three major families of stainless steel. His work was further developed by Albert Portevin.

In Germany in 1908, Philip Monnartz started studying the corrosion resistance of iron-chromium alloys, mostly in different acids. In a landmark paper in 1911 he noted that the corrosion rate in nitric acid decreased with increasing chromium content until a level of 12-14% chromium was reached, with only a slight decrease in the corrosion rate as chromium was further increased to 20%. Monnartz identified the concept of passivity which occurs in iron-chromium alloys and noted the importance of maintaining the passive layer to ensure low rates of corrosion. He also understood that these iron-chromium alloys were useful in oxidizing conditions while somewhat less useful in reducing sulphuric and hydrochloric acids. The paper even noted that the detrimental effect of carbon could be eliminated by the use of stabilizing elements such as titanium. There is no doubt that Monnartz showed stainless steel's potential for corrosion resistance. In 1910 he and his director, W. Borchers, were issued a patent in Germany for a stainless steel.

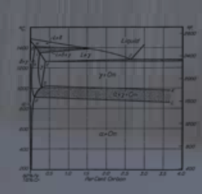
By 1911, stainless steels were definitely on the metallurgical map. In the next issue, the men who were the first to understand the commercial importance of such alloys, and thus lay their claim to be the true discoverers of stainless steel, will be discussed.



Ferritic microstructure (1935)



Martensitic microstructure (1935)



Fe-C Phase diagram for 18% Cr alloys

Léon Guillet

Philip Monnartz

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NICKEL

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Cover: Xiangjiaba Dam Turbine

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ISTOCK PHOTO @ JOHN BECKMAN JR

WATER, WATER EVERYWHERE

This is not the first time that *Nickel* magazine has paid attention to water, nor will it be the last. After all, the uses of nickel-containing materials are closely associated with the conservation, transportation and utilization of water. Three important articles in this issue show how nickel is assisting in the delivery of drinking water, making water potable, and helping to supply electricity through the use of renewable hydro power resources.

Even in a place such as Canada which seems have an abundance of water, the loss of drinking water during transmission can be considerable and costly—as can be the cost of replacing leaking and failing infrastructure. On pages 8 and 9 we explore how the City of Toronto is upgrading its water supply system using nickel-containing stainless steel and doing so in a way that ensures a century or more of maintenance-free delivery of high-quality drinking water. At the other end of the pipe, the Palomar Hospital in California (page 7) shows how nickel-containing stainless steel is being used in water distribution systems to improve the environmental performance of the entire structure.

Moving from the distribution of water to the production of usable water, on page 10 we examine how the use of nickel-containing materials are serving the people and industry in an arid area of Peru as seawater is desalinated to serve for both industrial process needs and drinking water purposes.

There are many reasons for building dams and weirs and they have a long history. Early industrialization used various water wheels to grind or pound. For more than a century now, however, those wheels have become turbines: still revolving, still providing power but on an infinitely greater scale and with high efficiency. On page 4 we investigate how nickel-containing stainless steels are essential to Francis turbines, the turbine design most associated with large high pressure (high "head") power generation.

Hydro-electric power generation is not without its human and environmental consequences but the alternatives—power shortages or greater consumption of fossil fuels—are even less attractive. The Xianjiaba powerhouse, for instance, will start contributing power to the Chinese electrical grid this November and when at full capacity, it will be producing 5.4 GW (5.4 billion watts). This will reduce China's dependence on coal which can be dangerous to mine and is the main contributor to China's carbon emissions.

Please read more about these and all the other stories in this issue and consider how you would like to receive your copy: print or electronic it will be our pleasure to add you to our distribution. Just go to **www.nickelstitute.org/nickelmagazine/subscription** and sign up.

Stephanie Dunn
Editor, *Nickel* magazine

Spinning Wheels:
Nickel and Hydro-Electric Power

Energy sources from bio-gas to geo-thermal, and many in between, make use of the properties of nickel. The importance is most obvious and impressive, however, in the power houses of the world's hydro-electric stations.

Nickel magazine reports on energy on a regular basis, most recently in its last issue ("Stainless steel drives China's energy sector", Vol.27-1) and here focuses on Francis turbines, the driving force for the 15 largest hydro-electric installations in the world. The 16th largest hydro-electric station—Yacryetá, on the border of Argentina and Paraguay—uses Kaplan turbines. (See figure below).

The example of Xiangjiaba

The Xiangjiaba Hydro Generating Station will be China's fourth-largest hydro-generating facility when completed in 2015 (the first generator was commissioned in October 2012), and a rated capacity of 6.4 GW, it is comparable in scale to the Grand Coulee Dam in the United States and the Sayano-Shushenskaya Dam in Russia.

Whereas the Grand Coulee (a much older facility) has a total of 24 generators, when fully operational Xiangjiaba will be using just eight 800 MW generators, all powered by Francis turbines. The use of nickel-containing materials has allowed the engineering advances that support such large-scale efficiency. Nickel is also responsible long service life and reduced material intensity per unit of electricity produced.

Turbines and runners

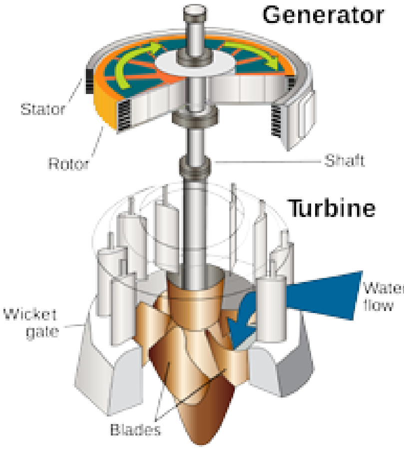
The design of the runners—the section that receives the water from the penstocks and gives the flow water its initial spin—is critical. Runners are large (406 tonnes and 10.5 metres in diameter in the case of the Xiangjiaba power house) and intended for long service. For that reason they are typically made from weldable martensitic stainless steels with compositions ranging from 13Cr-1Ni (CA15 - UNS J91150) to 13Cr-4Ni (CA6NM -J91540 as cast, 410NiMo - S41500 as wrought) to 16Cr-5Ni 1.5Mo (no UNS number, EN1.4418), depending on the operational parameters. Certain parts may be made of a softer austenitic stainless steel, such as either 304 (S30400) or even 316 (S31600). The turbines themselves are typically the cast martensitic stainless steel CA6NM. All these grades are highly amenable to the machining required to achieve the close tolerances that increase both service life and production efficiency.

And when refurbishment eventually does become necessary (often due to cavitation damage), it will be nickel-containing materials that restore and extend the service life of the units. This is typically done using cobalt-nickel, special high-nickel (up to 82% Ni), or special higher strength austenitic stainless steel welding rods.

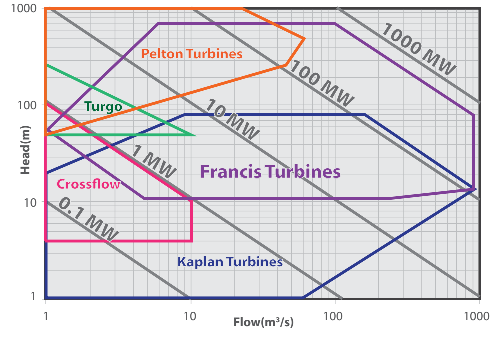
Large scale hydro-electric power generation helps to meet the need for new, low-carbon-emission sources of renewable energy, and nickel-containing materials are needed to make these plants efficient and long lasting. Ni

△ Grand Coulee Dam: Francis turbine runner being installed.

◁ The rotor of the #1 generating unit of the Xiangjiaba Hydro-electric dam is 19.97 m in diameter and is made of 2100 tonnes of martensitic stainless steel.



△ There is a turbine design for every need and Francis turbines handle the highest pressures ("heads") and flows to power the 800 MW Xiangjiaba generators.



Turbine Application Chart

△ Kaplan turbine schematic showing flows: When pressures are more moderate, Kaplan turbines can be the best choice.

Stainless Steel Couplings

a crucial component in piping systems

PHOTOS: TEEKAY COUPLINGS LTD

△ *Teekay Couplings are designed to accommodate angular deflection.*

△ *Installation of new pipework and modifications to existing pipework are all possible using Teekaay Couplings.*

Piping systems play a crucial role in many industries: transporting water, sea water, chemicals, petrochemicals and gases (including air) at various pressures and temperatures. Pipe materials range from carbon steels and cast iron, concrete and asbestos cement, and various polymers and composites, to stainless and copper alloys as well as other high-alloy groups. Pipe diameters can vary from a few millimetres to more than 4 metres.

Whatever the pipe material, the joining method plays a crucial role in anticipating the lifespan of a piping system. If the wrong method is used, leakage may occur at some stage in the service life. The downtime involved in locating a leak and repairing it can be costly.

Performing weld connections of metal piping on site is riskier than doing them in the controlled environment of a workshop. Often the high-level skills required are not readily available. Flange connections are one alternative method. Another is mechanical coupling, which is growing in popularity as confidence and service experience widen. The couplings commonly consist of a stainless steel casing which houses a gasket, plus a lock part to clamp the coupling in position.

Teekay Couplings has supplied such couplings for the civil, water, oil and gas, marine, building service, process and automotive industries for pipes between 21 and 4,200mm in diameter. The casings are made in either Type 304L (S30403) or 316L (S31603) stainless steel, depending on the severity of the external environment. Ian Webb, a co-founder and director of the company, has absolute faith in these alloys for virtually all service conditions. Occasionally, for particularly aggressive working conditions, the end user will specify a 22% chromium duplex stainless steel (UNS S32205). There is versatility in the fabrication of the alloys; examples include repair couplings and clamps, square couplings, and dismantling joints.

The couplings can be used to connect the most common piping materials. They can be axially restrained, or non-axially restrained depending on whether the pipe is, or needs to be, anchored. For metal pipes, galvanic corrosion between the casing and the pipe is not a concern. The casing is insulated from the piping material by a polymeric gasket lining which is often EPDM or Nitrile rubber. This lining can also be in other materials that handle the substance the pipe is carrying. The coupling is clamped to the pipe using fasteners which are mainly made of 316 (S31600) stainless.

The most popular applications of Teekay couplings are in the Marine sector. A fire-protected coupling with an internal fire sleeve and double casing was tested to military standards for shock and fire resistance and is now being used in naval destroyers and aircraft carriers. As well, the cruise and luxury yacht industry uses stainless steel couplings on major new builds such as the prestigious Disney Dream.

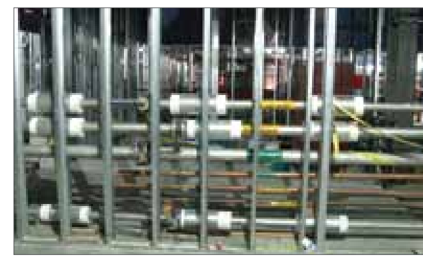
In terms of civil engineering, the couplings are suitable for joining pipes required in water treatment plants and for high-rise buildings such as the Shard in London, currently Western Europe's tallest building (see side bar). Ni

BARON PHILLIPS ASSOCIATES

Case Study:

At 310 metres high, The Shard is Western Europe's tallest building. It is also Europe's first truly mixed-use building comprising offices, the five-star Shangri-La Hotel, a range of restaurants, luxury residences, retail shops, and a triple-height viewing gallery. The Shard forms part of the 0.19 million m^2 (2 million ft^2) London Bridge Quarter, adjacent to London Bridge Station, which is being developed by Sellar Property Group on behalf of LBQ Ltd. Teekay Couplings were selected because of their guaranteed performance and attractive aesthetics as well as ease of installation, which were important for the installation of the vent cowls at the top of the air vent pipes. The couplings were used to connect each vent cowl to ensure that they all look identical. Teekay couplings were also used to join 355mm and 305mm stainless steel pipe in the basement.

BUILDING PHOTO: DAVE COX DPR



Stainless steel maintains water integrity at

California's new Palomar Hospital

The Palomar Medical Center West is the largest hospital in California and one of the largest in North America. Situated in Escondido, just north of San Diego, the recently-opened, 653-bed facility has received multiple awards for its design and construction innovation. The Medical Center has very high design and construction standards. While the clinical needs were foremost, the environmental and economic benefits are also significant.

The project makes extensive use of stainless steel (containing an average 60% recycled rate), which was chosen for its sustainability, resistance to corrosion, and ability to maintain water integrity. Behind the walls of the hospital are over 7,300 metres (over 24,300 feet) of dual-grade Type 316/316L (S31600/S31603) Schedule 10S stainless steel piping for the handling of both hot and cold water. Pipe sizes range from 2 to 12 inches (Nominal Bore 50-300 in mm) in diameter; the larger-diameter pipes are the risers while the smaller ones are the arms that supply water to the Type-L copper plumbing system which services the faucets and other outlets.

The building was designed by ME Engineers in Louisiana. El Cajon-based University Mechanical & Engineering Contractors built all the piping systems in accordance with the plans and specifications utilizing Building Information Modeling (BIM) to assist the engineer and coordinate all mechanical, electrical, and plumbing (MEP) systems. This required the use of computers to identify and position anchors, supports and hangers in preparation for the pouring of concrete. Plumbing fabrication drawings were developed utilizing the BIM which enabled University Mechanical to fabricate systems at their shop and ship to the project for installation.

One of the challenges with large and complicated piping systems is to order the proper quantities and sizes of pipe and fittings early in the project before the design is finalized. This is desirable in order to ensure availability of the components during construction while obtaining the best pricing. Thanks to the BIM system, 80% of the material call-off was accurately estimated, a significant accomplishment.

Semi-finished piping components were welded or pre-formed to precise lengths and sizes, then packaged onto skids and dispatched to the appropriate areas in the hospital. Prefabricated construction combined with controlled welding procedures resulted in high-efficiency installation.

△ *Palomar Medical Center West in Escondido California, construction near completion.*

△ *Some of the over 7,300 metres of stainless steel pipework being installed.*

△ *Stainless steel lines for hot and cold water.*

▽ *Stainless steel threaded couplings welded to pipe.*

DETAIL PHOTOS: MARY-JOY NEURU, EYE ON CONSTRUCTION

The use of grooved and shouldered joints plus ductile cast-iron fittings allowed for ease and speed in making bolted connections between sections of stainless steel piping.

J B Consulting & Associates of Oceanside, Calif., carried out the piping inspection, which was overseen by the Office of Statewide Health Planning and Development in Sacramento. Ni

Bury and Forget:

Toronto goes for nickel-containing stainless steel for water mains

It will take three and a half years to lay a four-kilometre section of upgraded water main along Gerrard Street, one of Toronto Canada's busiest downtown thoroughfares. Contractors are using pipes fabricated from nickel-containing stainless steel in critical vertical sections that bring water to the surface for distribution. The use of stainless steel should mean it will be a very long time before water main construction again disrupts traffic and inconveniences the neighborhood's businesses and residents.

"It's there for life," says engineer Barry Wilkinson, vice-president of Bardel Engineering Ltd., which is supplying five massive "risers" fabricated from Type 304 (UNS S30400) stainless steel for the project. "There's a big disruption just to put the risers there in the first place, and to have to go back and dig them out would be a nightmare." Happily, that won't be necessary since the durability and corrosion resistance of stainless steel eliminate the potential for leaks.

The 1.65-metre-diameter water main is constructed with 14-millimetre-thick carbon steel lined with cement mortar to provide corrosion resistance, and that accounts for most of the steel needed for the project. But the risers have been specified in Type 304 as extra insurance against possible corrosion or deterioration of the lining—an uncommon use in underground potable water distribution.

"We're using stainless steel pipes for the vertical sections because they do not require any internal cement mortar lining", explains Oscar Orellana, a senior project engineer for the City of Toronto, adding that the material's resistance to corrosion eliminates the need for maintenance. Stainless steel resists groundwater as well as the chlorinated drinking water (containing concentrations of

> "The durability and corrosion resistance of stainless steel eliminate the potential for leaks…the material's resistance to corrosion eliminates the need for maintenance."

△ *The massive size of the riser is clearly apparent. The use of stainless steel means that future maintenance and repair costs are avoided. And local traffic patterns and neighbourhoods will not be disturbed.*

ISTOCK PHOTO @ MICHAEL BODMANN CONSTRUCTION PHOTOS: CITY OF TORONTO

up to 200 milligrams per litre of chlorides) which the pipes will carry. Other benefits include ease of forming and welding.

The risers connect the deeply buried water main, which replaces an existing and smaller cast-iron main, to valve stations and distribution pipes closer to the surface. There are five large risers ranging in diameter from 1.37 to 1.67 metres and averaging 20 metres in length. Each riser weighs at least 15 tonnes. The first of these components was delivered to the construction site in one piece and installed in the fall of 2012. Three smaller risers—the smallest being 200 millimetres in diameter; the largest, 600 millimetres—bring the total weight of stainless steel needed for the project to more than 80 tonnes, Wilkinson estimates.

Bardel, a subsidiary of the Davis Group of Companies headquartered in Toronto and New York, is a major supplier of steel for water mains, bridges and buildings. It has supplied components of some of the new buildings constructed on the site of the World Trade Center. However, Bardel has never before used stainless steel to fabricate risers.

"This is the first time I've seen it done, and I've been [working with risers] for 35 years," Wilkinson notes. "It's strictly a corrosion-resistance issue." While the application is novel, he says rolling and welding the Type 304 stainless steel to fashion the risers was almost as easy as working with carbon steel. "Of the stainless grades, it's the most common and easiest to work with."

The risers are only the most extensive and visible use of stainless steel in the project. Sections of exposed pipe in valve chambers and shafts being installed above the water main are also specified in Type 304.

Valve chamber Number One, for instance, requires almost five metres of stainless steel piping while another requires 3.2 metres. The exposed pipes and connections required to join the new main to existing lines at the intersection of Jarvis Street require an almost 20 metre long section fashioned out of Type 304 stainless steel.

"Stainless steel is required since almost all the valve chambers are located on roadways," Orellana says, "and normally rainwater or in winter, water containing road salt, leaks into the chambers."

Wilkinson points out that Toronto is one of the few cities in && or the United States that specifies stainless steel for valve station piping that's exposed to the elements including winter road salt. "It's unusual" but "that's their standard practice," he notes. "You don't have to worry about painting or coating or any other form of protection."

Work on the $80-million project began in January 2012. To minimize disruption to traffic, residents and businesses, seven shafts are being sunk along the route so that tunneling equipment can clear an underground path for the pipe and excavated material can be easily removed.

The project is slated for completion in mid-2015. A construction notice issued by the city says the new pipes will "increase capacity and maintain the safety and reliability of the water supply." Thanks to the city's foresight and innovative use of stainless steel in the risers and valve chambers, the completed water main will serve Toronto residents for decades to come.

Wilkinson can only guess how long the water main's stainless steel components will last. "Hundreds of years, really," he says. "Who knows? Probably it will be around there when the cockroaches are ruling the world," he adds with a chuckle, "and we're long gone."

DUAL-USE DESALINATION PLANT

ISTOCK PHOTO: @ COURTNEY KEATING @ DAVID GOMEZ

Not surprisingly, the system relies greatly on the corrosion resistance and high strength of nickel-containing stainless steel.

Fresh water is a scarce resource in many parts of the world and therefore much in demand. Not only do people need it daily for drinking, washing and other sanitary uses, but industry needs it for its processing needs. When fresh water is especially scarce, sea water can be desalinated and used both industrially and domestically. A mining company in Peru operates just such a plant using a process known as Sea Water Reverse Osmosis (SWRO). Not surprisingly, the system relies greatly on the corrosion resistance and high strength of nickel-containing stainless steel.

The plant was designed and constructed by Anderson Water Systems Inc. of Dundas, Ontario, Canada, a division of Degrémont Technologies. Normal operating output for this unit is about 2,560 litres per minute, though twice that amount is achievable. It is a 2 stage Reverse Osmosis (RO) plant.

RO technology uses semi-permeable membranes to separate salt and other minerals from sea water. At this plant, water from the Pacific Ocean with a Total Dissolved Solids level of 42,000 mg per litre is pressurized to about 63 bar (910 p.s.i.). The inlet water temperature is around 20°C and warms up slightly in the process. On one side of the membrane, the salts concentrate up to 70,000 mg per litre while the water that passes through the membrane is low in salt and minerals. Water for city use is remineralized after the final RO unit. Since the water is being supplied to the city as potable, it must meet World Health Organization quality standards for drinking water. As well, Anderson selected these materials to meet the requirements of NSF/ANSI Standard 61, Drinking Water System Components.

Water from the RO concentrate outlet, at about 69 bar pressure, is used to power an energy recovery turbine installed on the sea water RO feed pumps. This design is unique to Anderson Water Systems, according to the company's project engineer, Lana Antiperovitch. Two main stainless steel alloy groups are used for the pipes, fittings and flanges and other pipe system components. One is 316L (UNS S31603), which is used mostly in contact with the permeate (low salt) water along with the cast version of 316, CF8M (UNS J92900), for ball valves). The other group is the 25% chromium super-duplex alloys, and primarily the S32760 alloy. Super-duplex alloys can withstand the corrosive effects of seawater as well as the SWRO concentrate. They are also high-strength, resulting in thinner walled equipment in pressurized systems. Pumps in super-duplex alloys were mostly in ASTM A890 Grade 5A (J93404), the cast version of the 2507 (S32750) alloy.

Other stainless steels used included 2205 (S32205), the 6% molybdenum grades (S31254, for example), and in the sulphuric acid part, both wrought (N08020) and cast (N08007) Alloy 20. In addition, some C-276 (N10276) components are used. Non-metallic materials include fibre-reinforced plastic, chlorinated polyvinyl chloride, and elastomer-lined cast iron.

Anderson Water Systems specializes in industrial-process water treatment systems. These are installed in power stations, oilfields, mines, refineries, and various plants (chemical, food and beverage, pharmaceutical, and pulp & paper) throughout the world. Ni

The SWRO system involves an intricate piping system, with several different types of stainless steel to give optimal corrosion resistance at the lowest cost. The system was delivered on skids for ease of installation in Peru.

COURTESY ANDERSON WATER SYSTEMS

Addition of **oxidation-resistant nickel** to copper nanowires stands to benefit printable electronics

Chemists at Duke University in North Carolina have synthesized a nanowire material made of copper and nickel which could potentially lower the cost of printing on electronics such as electronic paper, "smart packaging," and clothing with built-in interactive features.

These and other expanding applications, such as flat-panel TVs, e-readers, smart phones and the like, require a layer of film that allows for conductivity without blocking the transmission of light. Traditionally, Indium Tin Oxide (ITO) has been used in the transparent coating to create displays, owing to its conductivity and optical transparency.

But Indium, at US$600-800 per kg, is expensive and in short supply. The high cost of ITO film is mostly due to the slow vapor-phase coating process. It is also brittle and cracks easily.

The limitations of ITO prompted the Duke University research team, led by Benjamin Wiley, an assistant professor of chemistry, to seek alternatives that are less expensive and more flexible, and which can be deposited from liquids at high coating rates.

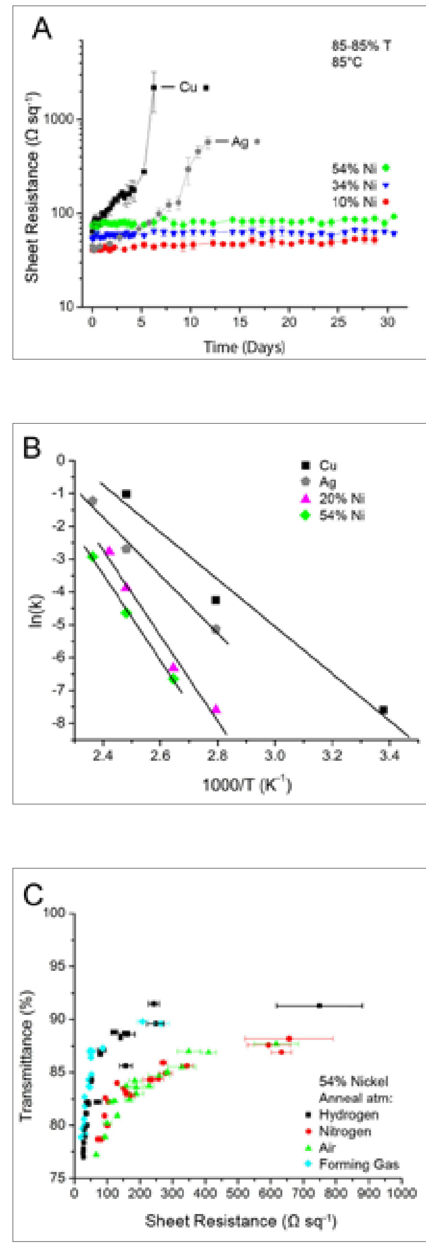
In 2011, Wiley's research team created copper nanowire films that can be deposited from a liquid in a process that is both fast and affordable. Not only are these conductive films more flexible than the current ITO film; copper is in 1,000 times more abundant and 100 times less expensive than indium.

But copper nanowires alone have two major drawbacks: copper corrodes, and it has a reddish-orange tint—characteristics which are undesirable for display screens. The team hypothesized that coating the copper nanowires with nickel could protect the copper from corrosion while also eliminating the orange tint. Wiley devised a way of adding nickel to the copper nanowires by heating them in a solution of nickel salt. After several tests, their hypothesis was confirmed.

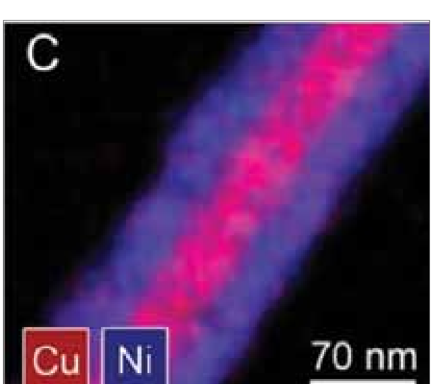
In a research paper, Wiley and his team note that "coating copper nanowires with nickel made the nanowire films 1,000 times more resistant to oxidation than films of copper nanowires and 100 times more resistant to oxidation than films of silver nanowires." The report explains how various copper-nickel nanowire formulations were tested before settling on a Cu:Ni ratio of 2:1. This resulted in the desirable neutral gray colour similar to silver and a transmittance efficiency of copper-nickel nanowire films of 94%. While this is not sufficient for the most demanding applications such as flat-panel displays, it offers high performance and greatly reduced cost for others.

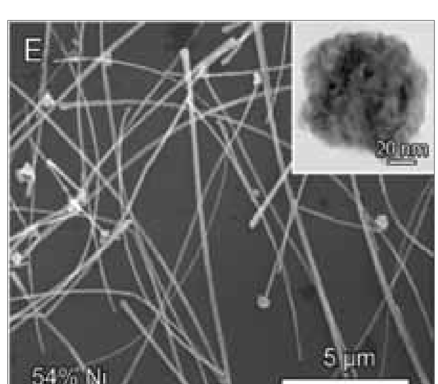
"To date, coating copper nanowires with nickel is the only way to obtain the desired corrosion resistance and neutral gray colour, while retaining a relatively high conductivity," Wiley tells *Nickel* magazine.

All these factors—excellent electro-optical performance, the neutral colour, extreme resistance to oxidation, the abundance of copper and nickel relative to silver—make copper-nickel nanowires highly desirable for the creation of transparent conductive films in printable electronic devices. Ni



△ *Test data showing the suitability of the nickel-coated copper nanowires for the intended application.*





◁ *Bottom left (C) - EDAX image of nanowire showing copper core and nickel coating.*

◁ *Picture bottom right (E) - Nickel coated nanowires, about 75 nm in width and 30 µm in length. Inset shows cross-section of a wire.*

BENJAMIN J. WILEY, ASSISTANT PROFESSOR, DEPARTMENT OF CHEMISTRY, DUKE UNIVERSITY

PHOTOGRAPHS BY SHAI GILL

△ *The Terrence Donnelly Health Sciences complex, a shining example of nickel-containing stainless steel in architecture and energy efficiency.*

Stainless adds shine to **University of Toronto's Health Sciences Complex**

The Mississauga campus of the University of Toronto has added an important teaching and research facility to its 90-hectare facility and the use of nickel-containing stainless steel will help it qualify for gold LEED (Leadership in Energy and Environmental Design) certification.

The four-storey Terrence Donnelly Health Sciences complex houses the Mississauga Academy of Medicine in addition to the university's renowned biomedical communications program, Department of Anthropology offices and research laboratories, lecture theatres and medical teaching classrooms. The Mississauga Academy of Medicine, which welcomed 54 students in its first-year class this past August, is a partnership together with University of Toronto's Faculty of Medicine and two local hospitals.

PMX Inc. was the project manager for the building designed by Kongats Architects, Harbridge + Cross was the general contractor while Semple Gooder carried out the installation. The 5,960-square-metre building will incorporate energy-efficient lighting and use rainwater to serve interior functions and water its green roof.

The external surface of the building has seven panel designs with 18- and 20-gauge (1.2 and 1.0 mm respectively) Type 304 (S30400) stainless steel panels supplied by Ryerson Canada with a Blend "S" finish from Excelsior Steel. The first level has single 750-mm-wide flat panels. Levels 2 to 5 employ six different panel designs. Three are V-shaped at solid walls and three are louvre panels where glazing occurs. The louvre panels are placed at angles of 15, 30, 60 and 90 degrees to capture the multi-colouration of the natural landscape setting.

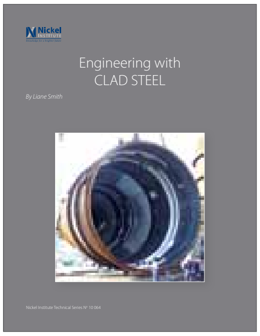
In addition to their reflective properties, the stainless panels enhance the bioclimatic properties to reflect solar heat in the summer, and trap warm air as an insulating blanket in the winter.

The wall assembly is a tried and tested rain screen assembly - exterior stainless steel panels on metal "Z" girts, air space, moisture barrier, insulation, air and vapour barrier membrane on a structural liner on metal studs. The rain screen wall assembly allowed the building to be rapidly protected and insulated against the elements during construction, reducing heating costs and associated carbon release into the atmosphere. This also allowed for the required time for quality workmanship needed for the fabrication and installation of the custom stainless steel panels.

The stainless steel panels themselves are fabricated as three dimensional hollow units, closed on all sides and hollow in the centre. The air trapped within the units is typically warmer than the outside air, most notably on sunny winter days, forming an insulating bubble wrap around the building. During the summer the rain screen construction of the exterior wall assembly allows both sides of the panels to be ventilated with minimum contact to the insulated wall assembly ensuring there is minimal solar gain on the insulated portion of the wall assembly. Ni

New NI publication **"Engineering with Clad Steel"** now available

The Nickel Institute is pleased to announce a new publication: Engineering with Clad Steel, 2nd Edition (10 064) is now available.



Corrosion resistant alloy clad and lined steel has been available in various forms for over 50 years and is widely applied in the oil and gas production industries. In the context of the specific requirements of this industrial sector, methods of manufacturing clad plate, pipe and fittings are given along with welding details and information on some field applications of clad and lined products.

Written by Liane Smith, this publication aims to address the concerns relating to clad steel in order that it can be applied with confidence.

To download the PDF please click here <http://www.nickelinstitute.org/MediaCentre/News/~/media/Files/TechnicalLiterature/10064_EngineeringWithCladSteel2ndEd.ashx> . Ni

NI speaks at **Indian Stainless Steel Development Association (ISSDA)** Celebration of 100 Years of Stainless Steel

NI Promotion Director, Dr. Peter Cutler gave an invited talk "Stainless steel and nickel—still partners after 100 years" to 160 attendees at this event in Delhi on 9 October. Topics covered were the history, role of nickel today and the importance of nickel-containing grades in future applications.

The event was co-sponsored by the Federation of Indian Chambers of Commerce and Industry (FICCI). Each speaker had a grove of 10 trees planted in his name as a symbol of the green credentials of stainless steel! Ni

PHOTO COURTESY OF ISSDA

UNS details

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

UNS No.	C	Co	Cr	Cu	Fe	Mn	Mo	N	Nb+Ta	Ni	P	S	Si	V	W
J91150 p.5	0.15 max.	-	11.5-14.0	-	-	1.00 max.	0.50 max.	-	-	1.00 max.	0.040 max.	0.040	1.50 max.	-	-
J91540 p.5	0.06 max.	-	11.5-14.0	-	-	1.00 max.	0.40-1.00	-	-	3.5-4.5	0.04 max.	0.03 max.	1.00 max.	-	-
J92900 p.10	0.08 max.	-	18.0-21.0	-	-	1.50 max.	2.0-3.0	-	-	9.0-12.0	0.04 max.	0.04 max.	2.00 max.	-	-
J93404 p.10	0.03 max.	-	24.0-26.0	-	-	1.50 max.	4.0-5.0	0.10-0.30	-	6.0-8.0	0.04 max.	0.04 max.	1.00 max.	-	-
N08007 p.10	0.07 max.	-	19.0-22.0	3.00-4.00	rem.	1.50 max.	2.00-3.00	-	-	27.5-30.5	0.04 max.	0.04 max.	1.50 max.	-	-
N08020 p.10	0.07 max.	-	19.00-21.00	3.00-4.00	rem.	2.00 max.	2.00-3.00	-	8x%C-1.00	32.00-38.00	0.045 max.	0.035 max.	1.00 max.	-	-
N08367 p.15	0.030 max.	-	20.0-22.0	-	rem.	2.00 max.	6.00-7.00	0.18-0.25	-	23.5-25.5	0.040 max.	0.030 max.	1.00 max.	-	-
N10276 p.10	0.02 max.	2.5 max.	14.5-16.5	-	4.0-7.0	1.0 max.	15.0-17.0	-	-	rem.	0.030 max.	0.030 max.	0.08 max.	0.35 max.	3.0-4.5
S30400 p.5,13,16	0.08 max.	-	18.00-20.00	-	-	2.00 max.	-	-	-	8.00-10.50	0.045 max.	0.030 max.	1.00 max.	-	-
S30403 p.6,8,9	0.030 max.	-	18.00-20.00	-	-	2.00 max.	-	-	-	8.00-12.00	0.045 max.	0.030 max.	1.00 max.	-	-
S31254 p.10	0.020 max.	-	19.5-20.5	-	-	1.00 max.	6.00-6.50	0.180-0.220	-	17.5-18.5	0.030 max.	0.010 max.	0.80 max.	-	-
S31600 p.5,6,7,15	0.08 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.	-	-
S31603 p.6,7,10	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.	-	-
S32205 p.6,10	0.030 max.	-	22.0-23.0	-	-	2.00 max.	3.00-3.50	0.14-0.20	-	4.50-6.50	0.030 max.	0.020 max.	1.00 max.	-	-
S32750 p.10	0.030 max.	-	24.0-26.0	-	-	1.20 max.	3.0-5.0	0.24-0.32	-	6.0-8.0	0.035 max.	0.020 max.	0.8 max.	-	-
S32760 p.10	0.03 max.	-	24.0-26.0	0.5-1.0	-	1.0 max.	3.0-4.0	0.2-0.3	-	6.0-8.0	0.03 max.	0.01 max.	1.0 max.	-	0.5-1.0
S41003 p.16	0.030 max.	-	10.5-12.5	-	-	1.50 max.	-	0.030 max.	-	1.50 max.	0.040 max.	0.030 max.	1.00 max.	-	-
S41500 p.5	0.050 max.	-	11.5-14.0	-	-	0.50-1.00	0.50-1.00	-	-	3.50-5.50	0.030 max.	0.030 max.	0.60 max.	-	-
EN 1.4418 p.5	0.06 max.	-	15.0-17.0	-	-	1.50 max.	0.80-1.50	0.020 min.	-	4.00-6.00	0.040 max.	0.015 max.	0.70 max.	-	-

ISTOCK PHOTO @ LARYSA DODZ

Super Austenitic Stainless

The solution to personal care corrosion problem

The personal care industry makes products such as deodorant, shampoo, toothpaste, body wash, detergent, and more. Manufacturers may use aggressive chemicals to develop new formulas for improved products. Many of these formulas include chlorides (salt) as a major ingredient. The chemicals produce the desired end result, but they can sometimes damage the equipment used in the process.

Type 316L (UNS S31603) stainless steel is often the material of choice for the construction of piping systems used in manufacturing of personal care products. However, in November 2008, Unilever Brazil encountered some problems in the form of pitting corrosion in the Type 316L transfer piping at its Vinhedo factory which makes their Galileo product. The picture below shows the through-wall pitting of the piping. Poor quality material and poor fabrication practices were blamed, and the piping system was replaced with new Type 316L.

Unfortunately the replacement was not the answer, as six months later pitting again occurred in the piping system. A corrosion investigation was initiated to determine a suitable replacement material. The Galileo Formula was tested to have a pH of 4.08, with a chloride content of 2.63%, which is higher than that of sea water.

Cyclic polarization electrochemical testing indicated that Type 316L had very low resistance to pitting corrosion in the Galileo Formulation. An alternative material of construction was recommended during the investigation process. AL-6XN® (N08367), a super austenitic stainless steel with 6% molybdenum, was similarly tested and found to have very high pitting resistance, more than ever expected in the manufacturing of the product. An alternative piping material considered was CPVC (chlorinated polyvinyl chloride), but it was rejected because of interference in both the appearance and odor of the finished product.

The replacement program was initiated in June 2010. The supplier selected was Central States Industrial (CSI) of Springfield, Missouri, U.S.A., the sole producer of AL-6XN® material in the forms (tubing and fittings) required by the sanitary market. The service experience with the N08367 material indicates that it was an excellent choice of replacement material. Ni

Through-wall pitting on the 316L pipe.

The line retrofitted with AL-6XN.

UNILEVER BRAZIL

Stainless Steel Cabs

ensure durability in the trucking industry

For truckers, ruggedness and durability are essential. To help meet those and other demands, LoadStar has unveiled an international line of trucks which feature cabs made of nickel-containing stainless steel.

The severe-service work trucks were designed with input from designers and fleet managers, who know a thing or two about serving customer needs in the waste, concrete pumping and airplane refueling markets, among others.

"We talked to drivers to better understand their needs and what's missing from the trucks they drive," says James Hebe, senior vice-president, North American sales operations, for Navistar (LoadStar's owner). To ensure ruggedness and other driver needs, the company opted for a cab made of stainless steel.

The cab is mostly made of a low alloyed stainless steel, UNS S41003, which has about 11.5% chromium and a small nickel addition for improved weldability. The more difficult-to-form panels use Type 304 (UNS S30400) with a minimum of 8.0% nickel. The austenitic structure of Type 304 has the highest formability. "Navistar selected S41003 stainless steel as a primary material because of its higher yield strength (345 MPa typical) but also because of its excellent weldability, toughness and manufacturability," says Raymond Baggett, a chief engineer at Navistar. He adds that the door structure is composed mainly of aluminum.

LoadStar: fitted with the industry's first stainless steel cab-over design, creating a high-strength, long-lasting and corrosion-resistant cab.

"Navistar has experience working with stainless steel, but this is the first time we've used it in an overall cab structure application."

The trucks have a "Class A" exterior surface, well-suited to mass production. The LoadStar cab is painted in a similar fashion to Navistar's other cabs. Special processes are in place for the pre-treat and priming of the stainless steel.

The cab panels are primarily stamped. Navistar has worked closely with its die supplier to develop panel designs that form well in stainless steel. Developing the designs, prototyping the panels and releasing design concessions have all proved challenging. Simple panels are laser-trimmed and break-pressed. The primary joining method for the cab is spot welds.

"Our customers value the stainless steel cab chiefly for its corrosion-resistance benefits and long service life," Baggett explains, adding that stainless cabs are available in all of Navistar's LoadStar applications. "While the primary applications for LoadStar to date are waste/refuse, concrete pumping and refueling, stainless steel cabs are also common in the fire truck industry."

LoadStar trucks are available through International dealers in the United States and Canada.

Navistar International Corp. is a holding company whose subsidiaries and affiliates produce trucks and assorted other vehicles.