NICKEL MAGAZINE

THE MAGAZINE DEVOTED TO NICKEL AND ITS APPLICATIONS

NICKEL, VOL. 36, Nº 1, 2021

Nickel: the solution for water

High-rise secondary water systems deliver water to the top

Overcoming the "yuck factor" of reused water

New technologies for green hydrogen

DAVE BURK, NATIONAL MUSEUM OF THE UNITED STATES ARMY, SOM

CASE STUDY 21
NATIONAL ARMY MUSEUM

***U.S. Green Building Council** – LEED Silver*

AWARDS
***American Institute of Architects New York (AIANY) 2021 Design Awards** – Merit Award*

***Metal Architecture Magazine 2020 Design Awards** – Smooth Metal Wall Panel category*

Wrapped in nickel-containing austenitic stainless steel panels that reflect its surroundings, the new National Museum of the United States Army opened in November 2020. Designed by the international architecture firm SOM, the simple elegant lines and long unbroken polished expanses of stainless steel create a sense of monumental solidity and precision.

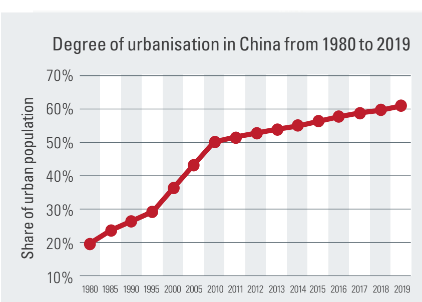
As the symbolic front door to the oldest branch of the US military, the building conveys the core values of discipline, modesty, and rigor, which are inherently part of army life. While the stainless steel panels will remain solidly unchanged in appearance over time, they will also be ever changing as they reflect the shifting light and surrounding forest at Fort Belvoir outside Washington DC.

This substantial appearance was created with composite panels faced in 238 tonnes of 3 mm thick, Type 316L (UNS S31603) stainless steel which was polished with a fine, precisely uniform hairline finish to create the spectacular softly reflective facade.

Selection of high recycled content and longevity of the stainless steel was among the design considerations that resulted in the museum being certified as USGBC LEED Silver. The building has received international attention and despite its recent completion has already garnered numerous awards. Ni

EDITORIAL:
WATER SOLUTIONS

Universal and equitable access to safe and affordable drinking water by 2030 is the United Nations' sixth sustainable development goal. But according to a recent report from UN-Water[1], the consequences of urban growth mean that too many people are still missing out. Since 2000 there has been an estimated 50% increase in urban populations without access to clean water. To secure SDG 6 there will need to be a four-fold increase in effort and investment globally.



NATIONAL BUREAU OF STATISTICS OF CHINA © STATISTA 2021

In China, urban dwellers now account for over 60% of the population, up from just 36% in 2000. And between now and 2050, China is projected to add a further 225 million people to its urban population[2].

The challenge of providing water to a growing urban population is daunting enough but it's exacerbated by the need to renew aging systems from earlier urbanisation campaigns. On top of that, the need to eliminate leaks, reduce waste and improve water quality means a close focus on material performance for the long term.

Housing for the new urban population is often in tower blocks and ensuring a hygienic supply of water to the upper floors is being assured by secondary water systems. In this edition of *Nickel* read about how China is tackling the dual issue of combatting water losses and delivering clean water to high-rise apartments with nickel-containing stainless steel.

Nickel's role in securing safe water for a sustainable future in China and elsewhere is mirrored in technologies for using water in our low carbon transition. Nickel will play a vital role in producing green hydrogen by electrolysis from renewable energy to produce a fuel whose only byproduct is...water. Whether we drink it, use it to make green energy, or transport our goods upon it, water has a story intimately woven with nickel.

Clare Richardson
Editor, *Nickel*

Innovative practices and technologies for water and sanitation will be an important part of achieving SDG 6. Sustainable and affordable success will come with leak-free, resilient and durable systems, like those being introduced in China, with nickel.

[1] UN-Water, 2020: Summary Progress; Update 2021 – SDG 6 – water and sanitation for all. Version: 1 March 2021. Geneva, Switzerland.

[2] https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html

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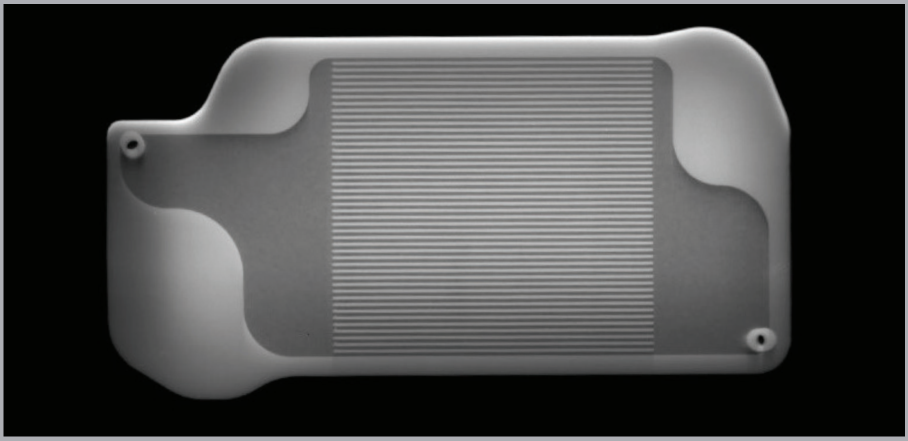
NICKEL NOTABLES

Taking the heat on Mars



NASA/JPL-CALTECH

NASA's Perseverance rover landed on Mars carrying 11 metal parts made with 3D printing. Six of those were palm-size nickel alloy plates – heat exchangers designed to protect key parts of an instrument called the Mars Oxygen In-Situ Resource Utilization Experiment, or MOXIE, from the effects of high temperatures. MOXIE's mission is to test future technology to produce industrial quantities of oxygen needed as rocket propellant to help astronauts launch back to Earth. To create oxygen, MOXIE heats Martian air to nearly 800 °C (1,500 °F). A conventionally machined heat exchanger would need to be made out of two parts welded together. The additive manufacturing process allowed each to be 3D printed as a single piece, making the hardware lighter and stronger. The plates were then treated in a hot isostatic press – a gas crusher – that heats the material to over 1,000 °C (1,832 °F) and adds intense pressure evenly around the part. Last step? Engineers inspect them and perform rigorous mechanical testing to ensure the microstructures are spaceflight-ready.

Clubs with bite

COBRAGOLF.COM

MIM's the word when it comes to an exciting new golf club innovation. Instead of the traditional forged or cast irons, Cobra is using Metal Injection Molding (MIM) technology with the goal to produce a more precise product. Made from a mixture of Type 304 (UNS S30400) stainless steel metal powder that is heated at a super high temperature (1340 °C vs 1200 °C for forged clubs) and injected into a mould, each iron head is fabricated with fewer steps leading to more consistent results. The difference? Cobra says it creates a stronger grain structure and claims that it delivers the super soft feel both pros and regular players yearn for to improve their game. First to market were wedges and now the full set of irons is available, ready to test your "metal" on the golf course.

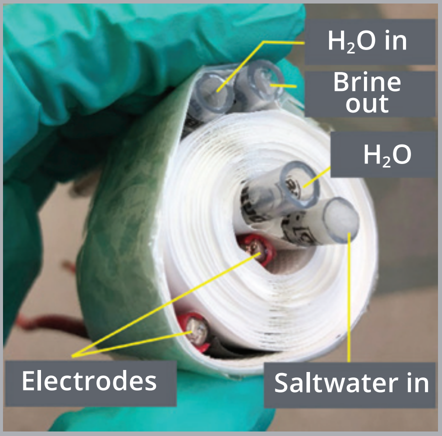
Sunny CO_2 solution

While reducing CO_2 emissions is the ultimate goal, researchers are also exploring innovative, efficient ways to convert CO_2 and hydrogen into useful carbon-based chemical methane (CH_4). The benefit? It counteracts the release of CO_2 when methane is burned as fuel. Recently developed at KAUST in Saudi Arabia, postdoc Diego Mateo explains, "Our approach is based on the synergistic combination of light and heat, known as the photothermal effect. While other industrial approaches require heating from external sources to attain temperatures as high as 500 °C, this research demonstrates that the reaction can be achieved using just the photothermal effect of daylight and a catalyst that is built from nickel nanoparticles on a layer of barium titanate." Says Mateo, "It captures the light in a way that kicks electrons into high energy states, known as 'hot electrons'. These electrons then initiate the chemical reaction that sends CO_2 back into methane. It's a very promising, sustainable way to convert greenhouse gas into valuable fuel."

KING ABDULLAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

Pass the salt

Desalinating hyper saline water, which contains up to ten times more salt than seawater, has become an important global challenge for countries where fresh water is scarce and for industries wanting to close the loop on wastewater. Rice University's Department of Materials Science and NanoEngineering (MSNE) has developed an innovative, efficient, cost-effective technology, by adding a protective coating of the 2D nanomaterial hexagonal boron nitride (hBN) to a commercially available nickel-containing Type 316 (UNS S31600), 25µm diameter stainless steel mesh.



KUICHANG ZUO/RICE UNIVERSITY

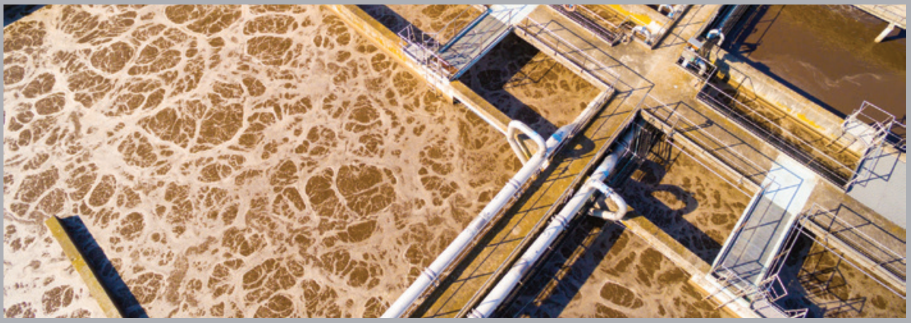
Rice materials scientists Pulickel Ajayan and Jun Lou had proven they could grow this protective hBN coating on curved metal surfaces which was key for the desalination application as the hot, super salty water could exploit gaps, eating away the fine metallic mesh. Building on breakthrough research at the Center for Atomically Thin Multifunctional Coatings, aka ATOMIC, the only National Science Foundation (NSF) centre dedicated to the development of advanced 2D coatings, this resilient heating element for desalinating large volumes of highly corrosive brine will enable decentralised, fit-for-purpose technologies.

REUSE OF WATER
OVERCOMING THE "YUCK FACTOR"

VILLAGEBREWERY.COM

University of Calgary's Advancing Canadian Water Assets (ACWA) has partnered with Village Brewery and Xylem Inc. to produce beer made with reused water, demonstrating how treated wastewater can help address water scarcity.

"There's a mental hurdle to get over of how inherently gross this could be," says Jeremy McLaughlin, head brewer at Village Brewery. "But we know that this water is safe, and we stand by our process."



Would you drink the water coming out of a municipal WWTF (Wastewater Treatment Facility)? The water from a WWTF normally goes into a river, a lake or underground. It is then piped in from another location and treated to make it potable, that is, completely safe to drink. But will people be willing to overcome the "yuck factor"? This term, coined by University of Pennsylvania bioethicist Arthur Caplan, describes the influence of instinctive responses against new technology, such as the reaction of most people to the thought of drinking reclaimed wastewater. Yet for obvious reasons, wastewater reuse is what must be practiced at, for example, the International Space Station.

Reusing wastewater immediately after treatment is being considered not only in areas where water is in short supply now or during reoccurring droughts, but also as a new way to provide sustainable sources of water for future growth.

In some modern buildings, water from sinks is cleaned up slightly and then reused for sanitary purposes, mostly flushing of toilets. But because of concerns for pathogens and other contaminants, it is rarely applied to drinking water which would need more sophisticated treatment to reach the required quality. Techniques include ultrafiltration, reverse osmosis (RO), and use of ozone, ultraviolet light or other standard disinfection chemicals, all of which require the reslience of nickel-containing stainless steels. Most used are Types 304L (UNS S30403) or 316L (S31603), but duplex alloys are often used in RO facilities.

Reusing wastewater is technically possible, but how do we overcome the "yuck factor"? Surprisingly, some craft breweries are helping by promoting special batches of beer made with wastewater. Breweries in Sweden, Germany, the U.S., Canada and other countries have made such batches, which have sold out quickly. While still in its infancy, water reuse is being developed in most parts of the world. We can certainly raise a glass to that! Ni

CHINA'S NEW WATER WAYS
TAPPING INTO STAINLESS STEEL FOR LONG-TERM SOLUTIONS

Leakage in water distribution systems, known as non-revenue water, has long been a big concern for global water authorities. Drinking water hygiene is also a critical challenge, particularly in developing countries and those with centuries-old infrastructure. In addition, rapid urbanisation and high-rise living present additional technical challenges for secondary water systems that need to be designed to ensure an efficient, clean water supply to the highest dwellings.

In China, traditional piping materials are mostly plastic (PE, PPR) or galvanised steel and ductile iron. Water leaks and water contamination are the major issues for the old water supply systems caused by ageing or corroding pipelines made originally of inappropriate materials.

Cutting water losses and reducing health risks caused by poor drinking water quality have become top priorities for the Chinese government and local water authorities. Increasingly, they are turning to the technical solution provided by stainless steel piping and fittings.

Higher quality, less leakage

Tubing made of nickel-containing stainless steel has been successfully used in many water distribution systems around the world. It has proved to be highly effective in resolving water loss and hygiene issues.

Since 2011, China's central government has set ambitious plans to safeguard water quality in its five year plans. Those goals targeted significant improvements from water source-to-tap, and a budget of nearly RMB 700 billion (USD 112 billion) has been earmarked for upgrading water treatment and piping systems. The funds were spread across multiple ministries and government bodies, including the State Council, the National Development and Reform Commission, the Ministry of Water Resources, the Ministry of Environmental Protection, the Ministry of Housing and Urban-Rural Development and the Ministry of Health.

The most promising material

The economic progress of China in recent decades has enabled rapid growth of stainless steel water applications. Over the past five years, growth has been driven by massive investments and substantial favourable policies and regulations rolled out by various levels of government. Increased public awareness of the

Tokyo has led the way in successfully using stainless steel partially corrugated tube (SPCT) in water service systems. Since the 1980s, the Tokyo water authority has replaced ageing water distribution systems with stainless steel piping, resulting in high water quality and a significant reduction of water leakage.

© ZHENGTONG

Renovation of secondary water supply systems is a national project with huge potential and China has committed to making massive investments.

huge benefits of using stainless steel for water piping has also been a driver.

Stainless steel is now being used extensively in large scale applications, from service piping and plumbing to secondary water supply equipment and renovation of total water supply systems. It is now well recognised as the most promising material for a modern water supply system and is becoming the mainstream of piping materials for the water network. The market is growing fast and holds significant potential.

Raising the bar

An additional factor is the national standard for drinking water quality (GB 5749-2006) introduced in 2007, which is in line with most international standards. The government expects all cities across China to meet this national standard eventually. Continuous efforts are needed to attain this goal and stainless steel piping will make an enormous contribution.

Over the past five years, investment in China's stainless steel water industry has grown significantly. The number of stainless steel pipe manufacturers has tripled. Some significant Chinese steel piping companies have also targeted this application and added new stainless steel tubing product lines.

This is not surprising given estimates for the stainless steel piping and fittings needed for both secondary water renovation for old apartment buildings as well as installations for new apartment buildings. A typical community with 1,000 households is likely to need about 10,000–15,000 metres of Type 304 (UNS S30400) tubes with diameters ranging from 15–160 mm, plus various fittings. The total weight of the stainless tube and fitting is estimated at 20–25 metric tonnes for 1,000 households. Add to this other stainless steel facilities, such as water storage tanks and valves, as well as the 200 million households in China that will need secondary water renovation, and the potential use for stainless tube and fittings will be around 4–5 million tonnes in total.

With enormous water projects ongoing across the country, this is a long-term project to achieve the ultimate goal – full supply coverage of premium drinking water to all residential communities in China, utilising stainless steel as the best and most sustainable choice.

Delivering water to the top

In Hangzhou, the Zhejiang province's capital city, renovation of one hundred water supply systems with stainless steel products was underway in 2020. This massive project serves 55,000 households with more than 210,000 residents who previously experienced muddy tap water.

The project started by rebuilding the secondary water supply facilities, which are essential to deliver water to the top of high-rise buildings. Type 304 (UNS S30400) and 316 (S31600) nickel-containing stainless steel tubes, water tanks, valves and pumps are being used. Stainless steel water tanks were installed at secondary water supply stations, connected to the water pump and valves with stainless steel piping, then to a stainless steel water distribution network to enable water to reach upper floors.

The renovation project has been highly successful. The water pressure is more stable than ever, water sanitation is secured, and the whole water supply system is much easier to clean, maintain, and disinfect. Piping and fitting failures and resulting repair cases have been dramatically reduced. Ni

A local stainless pipe manufacturer, Zhejiang Zhengtong Pipe Industry Co., Ltd., was awarded the project to supply a wide range of stainless steel products. The Chairman of the stainless pipe and fitting supplier, Mr. SX Yang, is very proud of these accomplishments. "I am excited about these business opportunities and ambitious to continue investing in this emerging market."

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CLEAN GREEN

NEW TECHNOLOGY GENERATES GREEN HYDROGEN

Countries around the globe are implementing aggressive initiatives to encourage the production and use of green hydrogen. Some forecasts predict that markets for two nickel-containing technologies, electrolysers that produce hydrogen, and fuel cells that use hydrogen to power vehicles, are likely to increase by two orders of magnitude in the next ten years.

Energy is consumed in four major areas: transportation, industry, residential and commercial uses.

What is fueling the shift?

To achieve the Paris Agreement's decarbonisation targets and the subsequent ambitions of individual countries for a carbon-neutral society, fossil fuel combustion must be replaced by carbon-neutral alternatives.

Hydrogen could be a perfect solution as an alternative fuel. It is a gas that, when converted to energy, does not produce CO_2 but rather emits only water vapour. Its adoption would, therefore, significantly reduce greenhouse gas generation.

The role of electrolysis

The most efficient way of producing hydrogen is by electrolysis, which is based on splitting a water molecule into hydrogen and oxygen. The dissociation of the water molecule in an electrical field evolves hydrogen on the cathode (–) and oxygen on the anode (+), where they are both collected off respective terminals. When hydrogen is produced by electrolysis using renewable energy sources, it is also free of CO_2 production. This form of hydrogen is called "green hydrogen".

Liquid Alkaline (LA) electrolysers are the current standard for large-scale electrolysis and are the most widely deployed, proven mature technology and cost-effective solution. In LA electrolysers, the reaction occurs in a solution composed of water and liquid electrolyte (30% potassium hydroxide) between the two electrodes. Both electrodes require intermediate catalytic reaction for conversion efficiency.

This is where nickel plays a key role. Nickel is used on the electrode surface for optimum cost, durability, and efficiency. The quantity of pure nickel used in an alkaline electrolyser is approximately 2 kg/kW of converted energy.

The future of fuel cells

Fuel cells are electrochemical energy generators that convert chemical energy into electrical energy. And when hydrogen is used as a fuel, the only by-product is water.

In the carbon-neutral future, electric vehicles of all types and sizes will be the norm. While most passenger vehicles will use Li-ion batteries, larger vehicles such as trucks, buses, and marine will likely use fuel cells.

How different fuel cells work

Like electrolysers, fuel cells have two electrodes with an electrolyte sandwiched in between. The different types of fuel cells are distinguished by the type of electrolyte they use.

Proton exchange membrane fuel cells (PEMFC) are the most widely used and commonly deployed in mobile applications such as cars, trucks, buses, and forklifts due to their size flexibility, favourable power-to-weight ratio, and fast start up.

This type of fuel cell uses a solid polymer membrane electrolyte that electrochemically reacts with stored hydrogen and oxygen from air to produce power, operating at relatively lower temperatures and pressures, and delivering higher power densities compared to other fuel cells.

Each cell is sandwiched between two bipolar plates, which channels hydrogen fuel to the anode and oxygen to the cathode, as well as transporting the product water away from the electrodes to the exhaust. In general, proton exchange membrane fuel cells use modest amounts of nickel since they operate at low temperatures (~80 °C), but due to the high extent of their deployment, the total quantity of nickel used could be significant.

Solid oxide fuel cells (SOFC) are the second most used, mainly as primary power sources for power plants, micro-grids and large single users. This type of fuel cell uses an ionically conductive ceramic electrolyte and operates at temperatures between 600 °C and 800 °C. Due to this high temperature, the solid oxide fuel cell requires nickel-containing stainless steels to be used extensively in the construction.

Molten carbonate fuel cells (MCFC) are high-temperature fuel cells similar to solid oxide, but they use a molten carbonate in a ceramic matrix as an electrolyte. Although not commonly deployed, this type of fuel cell has the ability to sequester carbon dioxide in their process, making them highly desirable in reducing total GHG in many off-gas applications. Significant amounts of nickel are used in these systems – approximately 5 kg for each kW of electricity produced.

Climate change and resulting environmental degradation is a real threat to the world. The many new and innovative applications of hydrogen as fuel show great promise for a greener future. Ni

Proton exchange membrane fuel cells (PEMFC) are the most widely used and commonly deployed in mobile applications such as cars, trucks, buses, and forklifts due to their size flexibility, favourable power-to-weight ratio, and fast start up.

NICKEL ALLOYS: **NI-HARD**

PENTICTON FOUNDRY

Ferrite is the atomic structure of mild steels that exists below ~727 °C (1,340 °F), while austenite is the atomic structure of steel that exists above this temperature. Austenite is a non-magnetic solid solution of iron and carbon, while ferrite is magnetic with a lower carbon solubility than austenite. When steel is cooled below ~727 °C, excess carbon is tied up as an iron and carbon compound known as cementite. Cementite and ferrite form a multilayered structure called pearlite, which is present as 'islands' within the ferrite matrix.

Alloy steels and castings account for around 9% of nickel production and provide specific characteristics for specialised and often critical applications.

One such material is Ni-Hard. Ni-Hard is a generic name for a family of white cast irons, alloyed with nickel and chromium, suitable for low impact, sliding abrasion for both wet and dry applications.

There are three types of Ni-Hard: Type 1, Type 2 and Type 4. Each has slight variations in composition between ASTM and EN specifications, shown in the table below.

Nickel is vital in optimising hardness and thus wear resistance. Nickel content increases with section size or cooling time of the casting to inhibit pearlitic transformation. For castings of 38–50 mm (1½–2") thick, 3.4% to 4.2% nickel is sufficient to suppress pearlite formation which forms as the casting mold cools.

Heavier sections may require nickel levels up to 5.5% to avoid the formation of pearlite. It is important to limit nickel content to the level needed to control pearlite as excess nickel increases the amount of retained austenite and lowers hardness.

Typical applications:
Ni-Hard Types 1 and 2
- Metal-working rolls
- Grinding mill liners
- Pulveriser rings
- Slurry pump parts
- Grinding media

Ni-Hard Type 4
- Slurry pump parts
- Impact blow bars

Compositions of the Ni-Hard irons

Grade	Chemical composition* (weight %)								
		C	Ni	Cr	Si	Mn	Mo	S	P
	ASTM A532								
Ni-Hard 1	Class 1, Type A	2.8–3.6	3.3–5.0	1.4–4.0	0.8	2.0	1.0	0.15	0.3
Ni-Hard 2	Class 1, Type B	2.4–3.0	3.3–5.0	1.4–4.0	0.8	2.0	1.0	0.15	0.3
Ni-Hard 4	Class 1, Type D	2.5–3.6	4.5–7.0	7.0–11.0	2.0	2.0	1.5	0.15	0.10
	EN 12513								
Ni-Hard 1	EN-JN2039	3.0–3.5	3.0–5.5	1.5–3.0	0.8	0.8	–	0.10	0.10
Ni-Hard 2	EN-JN2029	2.5–3.0	3.0–5.5	1.5–3.0	0.8	0.8	–	0.10	0.10
Ni-Hard 4	EN-JN2049	2.5–3.5	4.5–6.5	8.0–10.0	1.5–2.5	0.3–0.8	–	0.08	0.08

* Single values are maximums

NI EDUCATION
SHARING THE KNOWLEDGE

With the worldwide lockdowns due to Covid-19 in place since early 2020, the planned in-person workshops, conferences, and seminars that the Nickel Institute is known for, ground to an immediate halt.

These educational activities are a key part of our mission to promote and support the proper use of nickel in appropriate applications. An evaluation of the possible delivery methods led to the conclusion that webinars were the quickest and most effective way to deliver the technical information needed by users of nickel-containing products such as nickel alloys and stainless steels. Partners are necessary and the key to provide a suitable audience, just as it was for in-person meetings. Both existing and new partners welcomed the opportunity to work with the Nickel Institute, including various corrosion and welding groups, stainless steel development associations and, in a few cases, large end use companies and for-profit platforms. Where conferences could take place, but travel by non-local speakers was not possible, pre-recorded talks were used to great effectiveness. In 2020, 52 unique presentations were made to about 18,000 participants. This represents more presentations and a greater audience than if we had made the presentations in-person.

In 2021, webinar and pre-recorded presentations will continue. Our goal is to improve upon the visual quality and interest of the presentations.

Upcoming publicly available webinars will be posted on our LinkedIn page, and on the Nickel Institute's website. (Go to Library and select Events.)

Nickel Institute webinar topics:

- *Introduction to corrosion-resistant nickel alloys*
- *Introduction to stainless steels*
- *Properties of high temperature stainless steels*
- *Clad stainless steels and nickel alloys*
- *Pickling, passivation and cleaning of stainless steel*
- *Stainless steel: finishes and specification*
- *Welding and fabrication of corrosion-resistant stainless steels*
- *Welding and fabrication of duplex stainless steels*
- *Welding and fabrication of nickel alloys*

Industry specific webinars include:

- *Batteries*
- *Food processing*
- *Pharmaceutical*
- *Oil and gas*
- *Water and wastewater*
- *Chemical*
- *Architectural*
- *Marine scrubbers*

For more information contact communications@nickelinstitute.org

ASK AN EXPERT FAQ FROM THE NICKEL INSTITUTE TECHNICAL ADVICE LINE

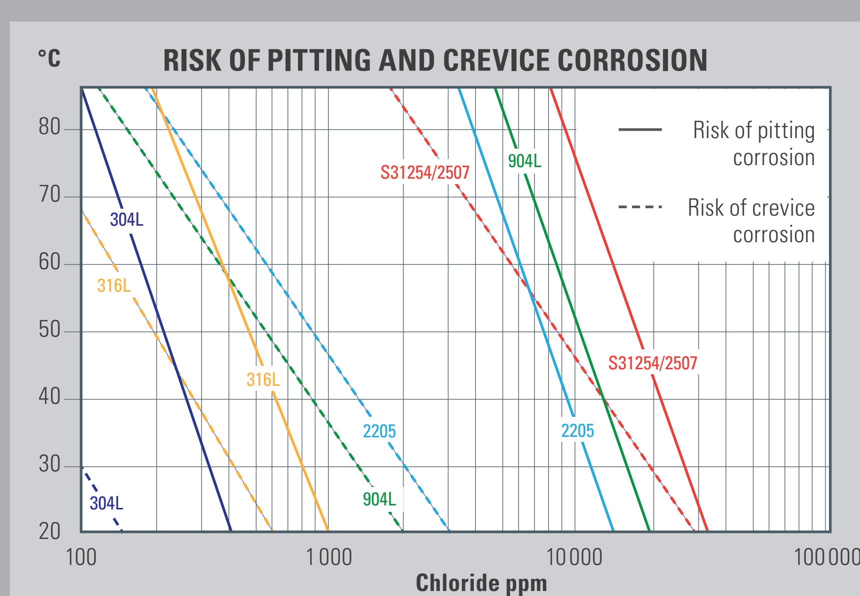
Geir Moe P.Eng. is the Technical Inquiry Service Coordinator at the Nickel Institute. Along with other material specialists situated around the world, Geir helps end-users and specifiers of nickel-containing materials seeking technical support. The team is on hand to provide technical advice free of charge on a wide range of applications such as stainless steel, nickel alloys and nickel plating to enable nickel to be used with confidence.
https://inquiries.nickelinstitute.org/

Q: I know that chloride solutions are a problem for stainless steel. How corrosive is chloride and how do I select a suitable nickel-containing stainless steel?

A: Chlorides are responsible for localised attack, such as pitting and crevice corrosion. Increasing contents of chromium, molybdenum, and nitrogen provide increasing resistance to chloride. The relative resistance to chloride for the grades 304L (UNS S30403), 316L (S31603), 2205 (S32205), 904L (N08904), 6%Mo (S31254) and superduplex 2507 (S32750) is shown below.

This selection chart assesses long-term contact by stainless steel grade, in a neutral chloride solution. The area to the right of each line is conditions of chloride concentration and temperature where there is a risk of attack. However, these curves are for guidance only because there are many other additional factors, which may be beneficial or detrimental and can move the curves to the left or right. These include pH, presence of oxidising species, solution agitation (stagnant conditions are worse), dissolved oxygen content, surface roughness, contact time, inclusion content, presence of heat tint.

This topic will be discussed in greater detail in our upcoming publication **Guidelines for the Use of Stainless Steels and Nickel-containing Alloys in Water (11003)** to be published later this year. Ni



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NEW PUBLICATIONS

Alloy selection in wet-process phosphoric acid (10015) discusses the corrosion resistance of various nickel-containing alloys and other metals in pure and contaminated phosphoric acid. Phosphoric acid is a major industrial chemical utilised in nearly every major industry. Its principal use is the production of fertiliser for agriculture and a mineral supplement in animal feed. This publication provides a useful guide for materials engineers.

High-temperature high-strength nickel-base alloys (No 393) presents mechanical and physical properties at room and elevated temperatures for cast and wrought nickel-base, cobalt-nickel and iron-nickel superalloys. These properties are of interest in gas turbine design, which includes applications for aircraft, automotive and energy generation.

Practical guide to using duplex stainless steels (10044) summarises the different types of duplex stainless steels, their mechanical and physical properties, corrosion resistance, metallurgy, fabrication, and welding. It provides guidance to successfully utilise these stainless steels in a wide variety of industrial applications.

Practical Guidelines for the Fabrication of Austenitic Stainless Steels provides information on the properties, performance and fabrication of the whole range of austenitic stainless steels. It offers clear and practical guidelines on cutting, machining, joining and finishing to ensure fabricators produce high quality installations and equipment, and engineers have the information to effectively use these materials. The Nickel Institute assisted IMOA (International Molybdenum Association) in the production of this publication.

The publications are available for free download from *www.nickelinstitute.org* Ni

UNS DETAILS

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

UNS	C	Cr	Cu	Fe	Mn	Mo	N	Ni	P	S	Si
N08904 Pg 14	0.020 max.	19.0-23.0	1.00-2.00	bal.	2.00 max.	4.00-5.00	-	23.0-28.0	0.045 max.	0.035 max.	1.00 max.
S30400 Pg 5, 8, 9, 16	0.08 max.	18.0-20.0	-	bal.	2.00 max.	-	-	8.0-10.5	0.045 max.	0.030 max.	1.00 max.
S30403 Pg 6, 14	0.03 max.	18.0-20.0	-	bal.	2.00 max.	-	-	8.0-12.0	0.045 max.	0.030 max.	1.00 max.
S31600 Pg 5, 9	0.08 max.	16.0-18.0	-	bal.	2.00 max.	2.00-3.00	-	10.0-14.0	0.045 max.	0.030 max.	1.00 max.
S31603 Pg 2, 6, 14, 16	0.03 max.	16.0-18.0	-	bal.	2.00 max.	2.00-3.00	-	10.0-14.0	0.045 max.	0.030 max.	1.00 max.
S31254 Pg 14	0.020 max.	19.5-20.5	0.50-1.00	bal.	1.00 max.	6.0-6.5	0.18-0.22	17.5-18.5	0.030 max.	0.010 max.	0.80 max.
S32205 Pg 14	0.030 max.	22.0-23.0	-	bal.	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 Pg 14	0.030 max.	24.0-26.0	-	bal.	1.20 max.	3.0-5.0	0.24-0.32	6.0-8.0	0.035 max.	0.020 max.	0.80 max.

BUILDING THE **SHIPBUILDERS**

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John McKenna at the test build. The figures were made in sections in the studio and assembled outdoors with the aid of cranes and elevators.

Port Glasgow on Scotland's River Clyde is celebrating its industrial heritage with a colossal new stainless steel sculpture which has been six years in the making. The artist, John McKenna, is known for his life-size sculptures of people at work and has been commissioned by the local council to produce the Shipbuilders of Port Glasgow as part of a regeneration project for the town.

The sculpture of two hammer-wielding shipbuilders is made from Type 304 (UNS S30400) tube and clad with Type 316L (S31603) with a 2B finish. Each of the various sized sheet facets has been formed separately, the edges folded and then welded together using plug spot welds to give the impression of thousands of rivets. The welds have been meticulously electropolished to remove heat tint and to enhance corrosion resistance. As well as being a work of art, the Shipbuilders has also presented a structural engineering challenge. At 11 m tall and weighing in at around 20 tonnes, the sculpture will have to withstand the winds of the west coast of Scotland when placed in its new home in Coronation Park near the site of the former quays of Port Glasgow.

The Shipbuilders of Port Glasgow is set to be a new visitor attraction when installed later this year. Ni