

NICKEL MAGAZINE

THE MAGAZINE DEVOTED TO NICKEL AND ITS APPLICATIONS

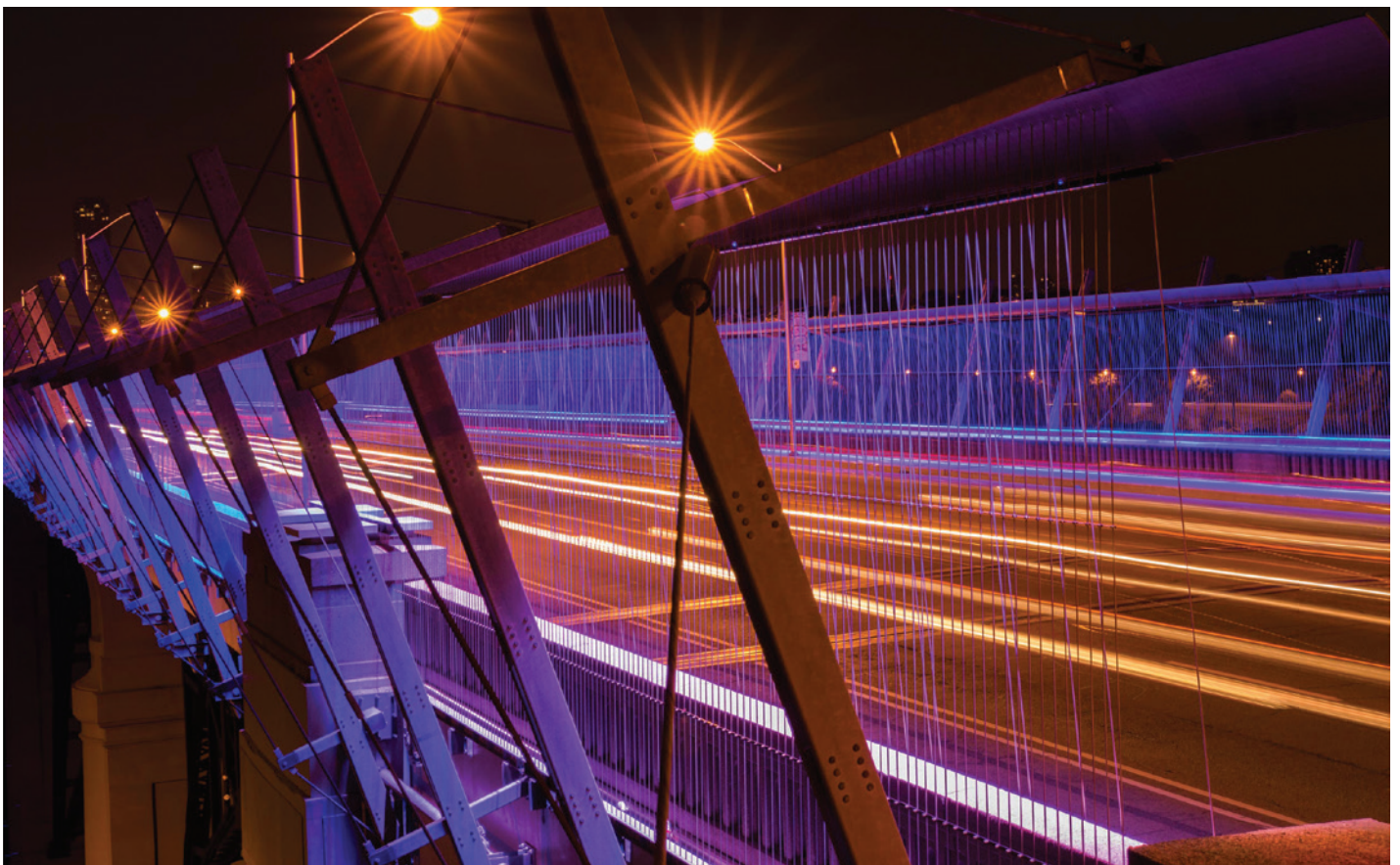
NICKEL, VOL. 33, NO. 3, 2018

Nickel and safety: Beyond 'good enough'

*Stainless steel resilience:
performance under stress*

*Bridge barriers reduce
accidental falls and suicides*

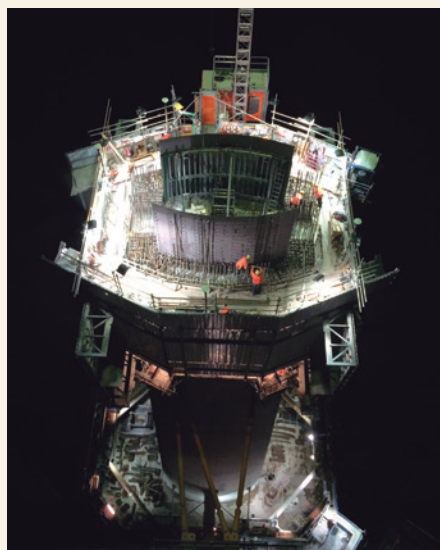
*Stainless steel makes the cut
in food safety*





CASE STUDY 14

QUEENSFERRY CROSSING



SBS (STAINLESS BAR SALES), DIVISION OF FIXING CENTRE LTD.

Duplex stainless steel reinforcing bar with around five percent nickel was used in the construction of the towers.

With a span of 2.7km, the Queensferry Crossing in Scotland is one of the longest cable-stayed bridges in the world and replaces the Forth Road Bridge as the main route for vehicles over the Forth Estuary between Edinburgh and Fife. It was opened to traffic on 30 August 2017.


The superstructure is supported by three 207m tall towers made of reinforced concrete with post tensioning ducts to provide additional strength. Wind shielding was built into the design to enable use of the bridge in high winds. This had regularly led to restrictions on the existing road bridge.

To ensure that the bridge had sufficient durability in its challenging coastal environment, duplex stainless steel containing 4-5% nickel, was used for reinforcing the concrete of the towers and piers. Type 2304 duplex stainless steel (UNS S32304) was selected for the reinforcing bar, supplied by Roldan S.A (Acerinox Group). The bars are connected and anchored by



TRANSPORT SCOTLAND

couplers and headed anchors, all made of Type 2205 (S32205) duplex stainless steel.

Over 21km of 8mm diameter stainless steel Type 316 (S31600) cable assemblies, containing about 10% nickel, were also used in the barrier, edge protection and wind deflector system for the crossing. 

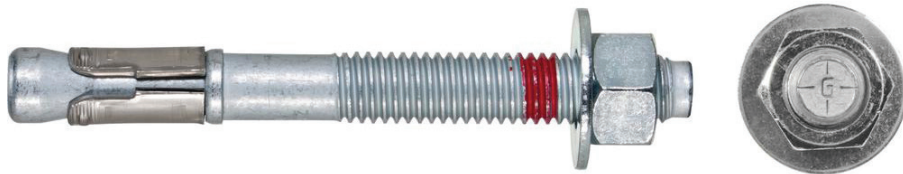
EDITORIAL: WHEN 'GOOD ENOUGH' ISN'T

'Good enough' can sometimes be the only option: floods, fires, earthquakes, wars and more are destructive and demand immediate action to provide shelter, water, transport, communications. A 'good enough' solution can be justified when time is of the essence and there isn't enough time to do it properly.

But if in non-emergency circumstances corners are cut – when sub-optimal material choices are made – a 'good enough' product or structural design puts both buildings and lives at risk.

That's when the appropriate choice and use of nickel-containing stainless steels will change 'good enough' to 'good, safe, reliable, enduring'. Something you can trust with your life. And in terms of return on investment – structural or human or both – they pay for themselves many times over.

HILTI QUICK BOLT TZ



Type 304 stainless steel expansion bolt for cracked concrete

At *Nickel*, we're focused on the performance of nickel-containing materials and the special attributes that they can bring to products and processes. And indeed, you will find examples of that in this issue.

But we realised that safety deserved more attention. Performance remains key, however here we are drawing attention to the additional and vital benefit where lives, limbs and digits are preserved and protected by nickel-containing materials.

For rock climbers, for window washers on their platforms, for pedestrians walking by curtain walls, for abattoir workers: millions of pieces of nickel-containing stainless steel are quietly and effectively changing 'good enough' to 'the best' (and safest) solutions.

Clare Richardson
Editor, Nickel Magazine



Stages require roof anchors and the workers need strong clips when they tie-off (tether themselves to the stage). In both cases, window washers trust nickel-containing stainless steels with their lives.

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NICKEL

NOTABLES



Unworldly resources

The mining of asteroids has been a staple of science fiction writing for more than a century and could become true in the coming decades. Asteroids are generally classed either as 'rocky' or as 'nickel-iron'. While far more common, 'rocky' asteroids are estimated to make up only 10% of the mass of all asteroids, with the very dense nickel-iron asteroids accounting for the other 90%. The nickel-iron asteroids can vary in nickel content from 5 to 25%. Commercial nickel deposits on Earth typically contain 1 to 3% nickel. The largest known on Earth is the Hoba asteroid (pictured below) found in Namibia. It weighs approximately 60 tonnes and is 15% nickel by composition.

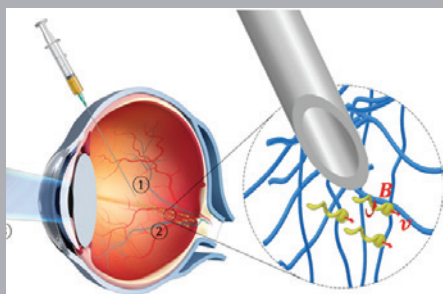




Painting with stainless steel

For the first time, a book has won the Japan Stainless Steel Association's Distinguished Service Award. Renowned artist, Naoya Sakagami, won the award for *An Egg of a Pterosaur – Painting with stainless steel in architecture*.

The award, established in 1993, has historically been awarded to stainless steel products and art. The book was recognised by the JSSA for showcasing the beautiful collection of Mr. Sakagami's stainless steel art which uses various finishing techniques including the INCO method which can colour stainless steel in a rainbow of hues. It also provides useful technical descriptions of the range of techniques employed.



Eye spy

Tiny propeller-shaped nanorobots are poised to make big advances in ocular medicine. Researchers at the Max Planck Institute for Intelligent Systems in Stuttgart have developed nanorobot propellers that can steer through dense tissue without damaging the sensitive biological tissue around them. Only 500nm wide, these 'drills' are 200 times smaller than the diameter of a human hair. Their shape and coating enable them to move relatively unhindered through an eye. Uncoated silicon dioxide-nickel microhelices play a role in the fabrication of the micropropellers. The objective is to use nanopropellers as tools in minimally-invasive treatment of diseases and delivering medication where it's needed.



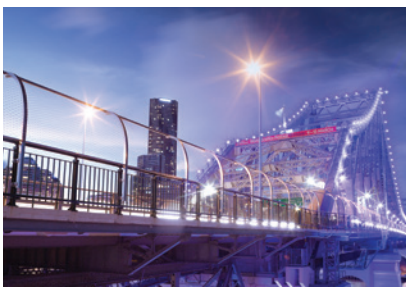
A very grand opening

The Hong Kong-Zhuhai-Macau Bridge, the longest sea crossing and the longest fixed link on earth, officially opened to the public on 24 October 2018. One of the world's major infrastructure projects, this 55km bridge-tunnel system includes a series of three cable-stayed bridges, an undersea tunnel, and four artificial islands. Built using ten thousand tonnes of nickel-containing duplex stainless steel Type 2304 (UNS S32304) rebar, rod and wire, this was the first time duplex stainless steel has been used in bridge construction in China. Designed to last for 120 years, and connecting mainland China to Hong Kong and Macau, the bridge cuts travel time down from as much as three hours to as little as 30 minutes, putting them all within an hour's commute of each other.

SCREENS, NOT WALLS

A STRUCTURAL APPROACH TO PREVENTING TRAGEDIES

ATLAS STEELS



STEFAN MESAROS FOR GVA LIGHTING INC



Evening views of the Story Bridge (upper) and the Bloor Street Viaduct (lower). In addition to their utilitarian functions, bridges are prominent elements of the urban environment.

We are preoccupied with safety. For ourselves, our families, our communities. Sadly, however, there are sometimes moments in people's lives when safety is the last thing on their minds.

There are limits to what can be done to prevent attempts by determined individuals seeking to end their lives. There are, however, passive measures that have succeeded in reducing attempts in places where impulse can exploit opportunity: bridges.

The Story Bridge in Brisbane, Australia, was such a destination bridge. In the period 1975-2015 130 people fell to their death. That led to the suicide prevention measure installed in 2015.

The Bloor Street Viaduct in Toronto, Canada, had experienced over 500 suicides by 2003. In 2012, the last year before the barrier was installed, 19 of 32 Toronto bridge suicides occurred from the Viaduct.

The barriers

Story Bridge: A 777m cantilever bridge that opened in 1940. The suicide barrier was completed in 2013 by Freissinet as designer and lead contractor. It is composed of 530 posts and tubes of Type 316 (UNS S31600) stainless steel with a blackened stainless steel mesh, all of Type 316, to maximise the visual perspective when viewing the city as a pedestrian on the bridge.

Bloor Street Viaduct: A 494m double-decked (rail/subway line on the lower deck) arch bridge that opened in 1918. The barrier, called Luminous Veil (pictured on the cover), was designed by Dereck Revington and produced by Mariani Metal Fabricators. The Veil is made up of over 9,000 nickel-containing stainless steel rods, each 12.7cm apart and 5m high, supported by stays, all Type 316. The visual interest is maximised by the height of the viaduct and the openness of the vista.

Why stainless steel

Retrofitting a safety element to a prominent physical aspect of an urban environment is a challenge. Yet the design, aesthetic and engineering possibilities provided by nickel-containing stainless steels make it a natural choice. That is reinforced in the Brisbane example (a marine environment) and in Toronto (use of salt for melting seasonal ice and snow) because of the enhanced corrosion resistance to chlorides. In addition, the open nature of the safety solutions maximised the valued view perspectives of and from the bridges.



The outcomes justify the investment

There is extensive literature on suicide prevention. The results are dramatic and show that jump bridges become destinations for individuals thinking of ending their pain. When such a bridge gets an effective barrier, successful suicides at that bridge decline and are not just displaced to other bridges.

Australian research shows an 87% decline in successful suicides from another Brisbane bridge with barriers. Ten years after the Bloor Viaduct Veil, there were seven bridge suicides in Toronto (compared to 32 in 2012), none of which occurred from the viaduct.

A social need combines with the performance and aesthetic potentials of nickel-containing stainless steels to the benefit of society. Again. Ni

Functionality with a view: Brisbane's city centre and, in Toronto, the Don Valley, both achieved with nickel-containing stainless steel.

STAINLESS STEEL RESILIENCE PROVIDES LONGEVITY AND SAFETY



South Ferry Station, New York

Resilience planning is part of sustainable development, prioritising both human health, safety and welfare and providing resource preservation. While the definitions of resilience vary, all describe the ability to resist or provide rapid recovery from natural and human-induced events that are outside of the normal demands placed on a system or material.

Planning for resilience requires an assessment of the potential individual and combined threats – for example a seismic event may also trigger a tsunami or fire. Resilient materials and systems can protect human life and reduce the recovery time. The selection of appropriate materials and systems is critical and nickel-containing stainless steels can contribute to more sustainable and resilient design.

Corrosion resistance

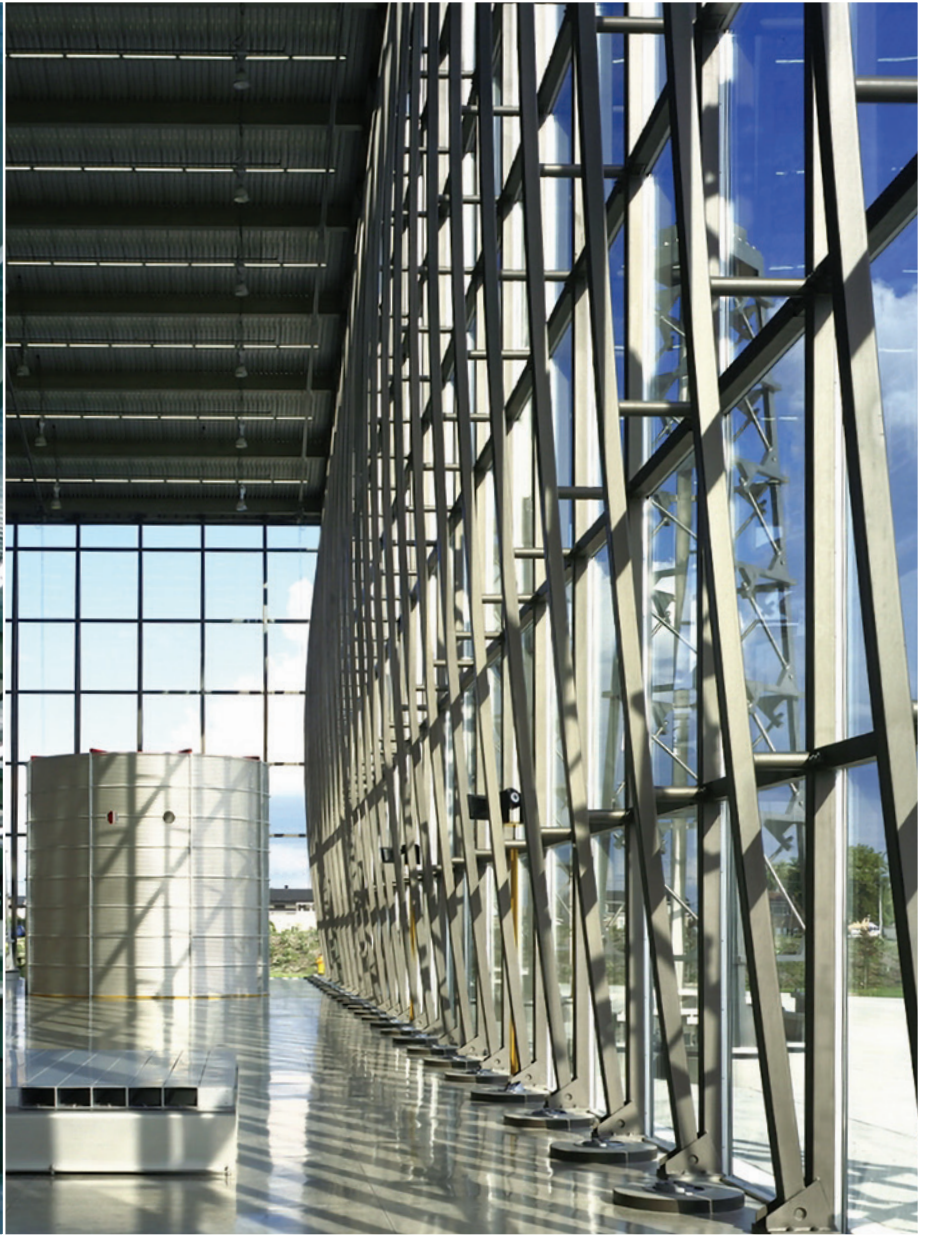
Corrosion performance is critical to system performance. A material or system designed to withstand a seismic event, blast, accidental impact or provide a barrier to fire when new, may not be effective if parts have corroded.

Australia began mandating the use of stainless steel masonry anchors after it was found that, after an earthquake, galvanised carbon steel anchors in coastal walls had failed due to corrosion, leading to widespread collapses. Resilience planning necessitates the use of materials that function according to design many decades later.

A coastal flood surge barrier system must be capable of withstanding years of direct exposure to brackish or salt water and impact. Highly corrosion-resistant and high strength duplex Type 2205 (UNS S32205) stainless steel was selected for the new entrances of South Ferry Station on Manhattan Island, New York City. They are able to withstand the seawater and the impact from floating garbage scows and other objects. These recently completed sealable waterproof structures protect the subway system from water infiltration, such as what occurred during Hurricane Sandy in 2012.

Sustainability, resilience and safety

Long service life, low maintenance requirements, and high recyclability contribute to the targets of sustainable development, by satisfying “the needs of the present without compromising the ability of future generations to meet their own needs”. The impact toughness, strength, corrosion resistance, seismic performance, resistance to fire and to high wind



LIBRARY AND ARCHIVES CANADA

and other characteristics of stainless steel contribute to making it a resilient and safe material for demanding environments.

Impact, blast and stress resistance

Design guidance for stainless steel in seismic, impact and blast-resistant structures is based on almost 30 years of research on austenitic and duplex stainless steels. Stainless steel's combination of high strength, good energy absorption characteristics and high ductility mean that the material provides excellent performance under these

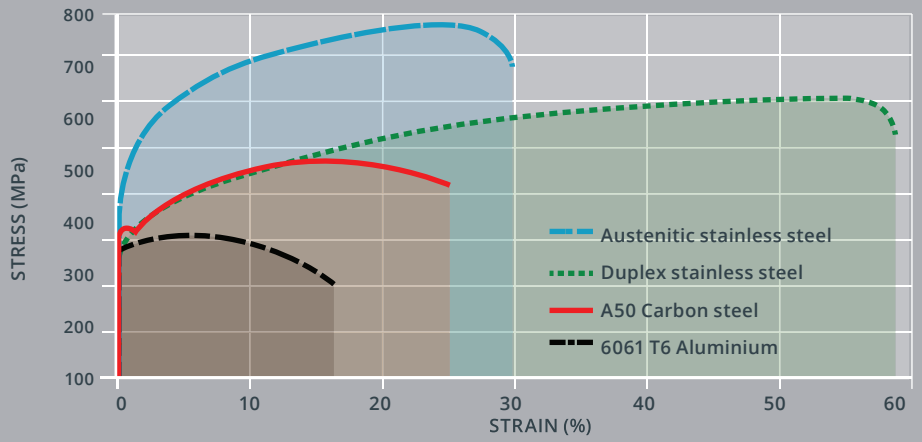
adverse conditions. Different materials behave differently under loading.

The ability of a building component, such as roofing or a structure, to withstand wind loading is integrally tied to its design, corrosion resistance, strength, performance under cyclic loading and resistance to impact damage from wind-blown debris. These are all known, tested and quantified metrics that can be applied for resilience planning (see following page). The characteristics of stainless steel explain its excellent performance.

The National Archives of Canada in Gatineau, Québec, were designed to withstand flooding, seismic events and other threats and utilised the characteristics of nickel-containing Types 304L (UNS S30403) and 316L (S31603) stainless steel. Housing the country's most precious historical documents, it was designed for a 500-year life.

Figure 1

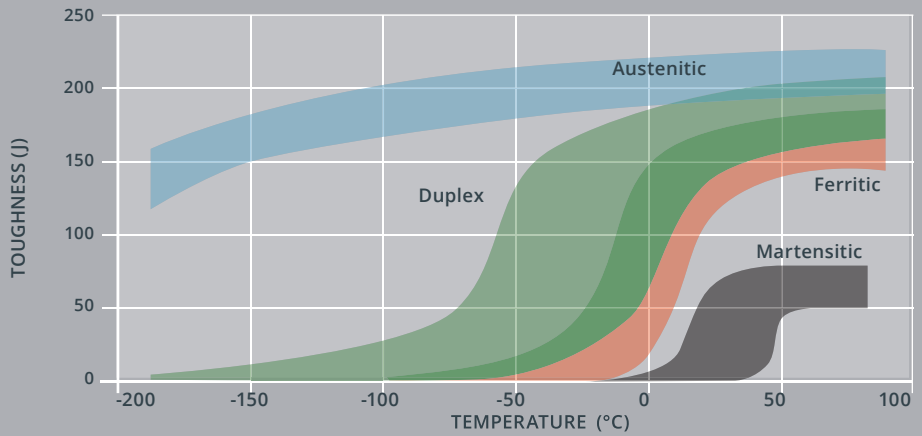
Typical stress-strain curves to failure for stainless and carbon steel and aluminium to failure.



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Figure 2

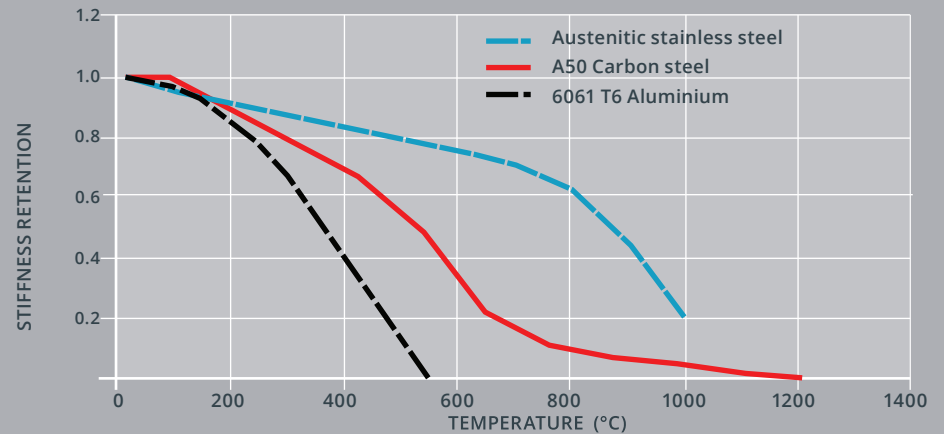
Weld impact toughness for four stainless steel families for temperatures ranging from ambient to cryogenic.



OUTOKUMPU

Figure 3

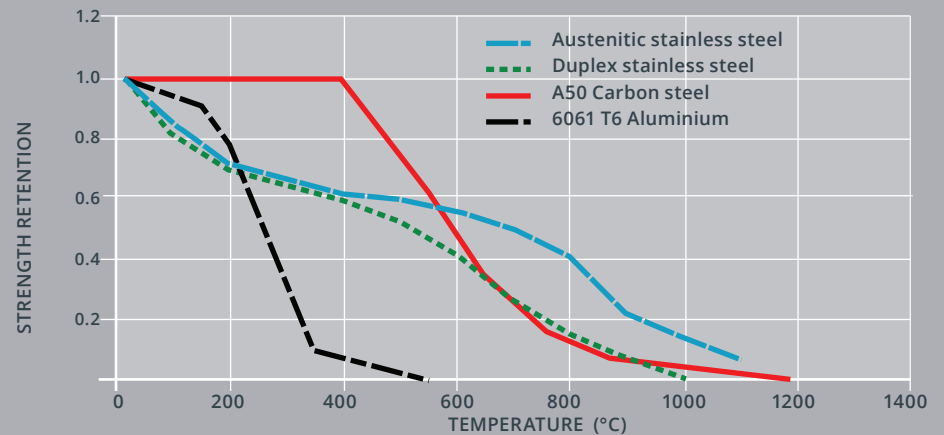
Comparison of stainless and carbon steel and aluminium stiffness retention at elevated temperature.



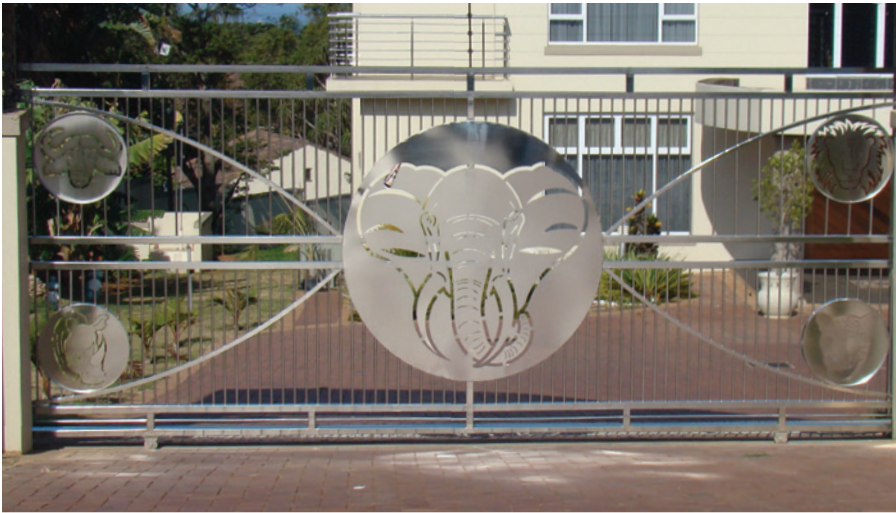
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Figure 4

Comparison of stainless and carbon steel and aluminium strength retention factors.



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The area under the stress-strain curve when taken to failure is in direct proportion to the amount of energy that can be absorbed by a metal. As can be seen in *Figure 1*, the areas under the duplex and austenitic stainless steel curves are much larger than those under the carbon steel and aluminium curves, illustrating stainless steel's superior ability to withstand high levels of impact, blast and stress.

This performance is critical for security barriers, concrete reinforced piers, avalanche and sea walls, highway barriers and guardrails and many other critical safety-related applications.

Security and safety

Terrorism and industrial accidents present blast and other high impact force risks. Structural welded austenitic and duplex stainless steels provide excellent impact toughness at ambient temperatures. Austenitic stainless steels in particular retain high impact toughness down to cryogenic temperatures (*Figure 2*) and perform much better in these applications than carbon steels. They will, in most cases, bend and deform but not shear or break upon impact.

Specific design guidance is contained in *AISC Design Guide 27: Structural Stainless Steel 14*, and in *Eurocode 3, Design of Steel Structures, Supplementary Rules for Stainless Steels, Part 1–4*.

Strength and stiffness

The fire performance (*see Figures 3 and 4*) of Types 304/304L (S30400/S30403) and 316/316L (S31600/S31603) austenitic and Types 2101 (S32101), 2304 (S32304) and 2205 (S32205) have been extensively studied. The stiffness retention of austenitic stainless steels containing both nickel and molybdenum is over six times that of carbon steel at 800 °C. The austenitics also provide superior strength retention above 600 °C.

When both factors are considered, stainless steel columns and beams generally perform better in a fire. In sheet and strip applications, aluminium, copper, and other low melting point materials fail quickly and are a far less effective safety barrier than stainless steel.

Designing a building for resilience and safety over its lifetime involves understanding how materials behave in extreme circumstances years after they have been installed. Nickel-containing stainless steels are able to contribute to the goals of both high resilience and sustainability. NI



Decorative gates are examples of property security that displays the resilience, versatility and artistry possible with nickel-containing stainless steels.

Bollards that provide functional crash security while presenting an attractive appearance.



The Type 302 stainless steel roof of the Chrysler Building has withstood many hurricanes since installation in 1930 with only a few small panel replacements.

FOOD SAFETY

FROM CUTTING TO CLEANING, STAINLESS STEEL IS AN IMPORTANT INGREDIENT



Small interlocking stainless steel rings, made from nickel-containing stainless steel, allow for both comfort and flexibility while providing protection.

Whether you need superior hand protection or are exploring sanitary food handling applications, food-grade stainless steel has the characteristics that make it a material of choice.

Making a mesh

An idea borne in ancient times, when knights in armour could be cut down with the slash of a sword, metal mesh gloves have woven their way into modern food safety protocols. Fast forward to the early 1980s, when manufacturers began using stainless steel almost exclusively to fabricate safety gloves, sleeves and aprons that are used by butchers, food processors and the food service industry.

Small interlocking stainless steel rings, made from Type 304 (UNS S30400) or 316 (S31600) stainless steel wire, allow for both comfort and flexibility needed to move the fingers, while providing superior cut protection, corrosion resistance, ease of cleaning and sanitisation. With tightening food safety standards, innovation in the 1990s led some companies to come up with a 100% stainless steel solution, eliminating fabric parts that could easily be contaminated.

Now widely used around the world, stainless steel mesh gloves are ideal for anyone in the food industry who works with a hand knife or cleans a slicer blade.

While stainless steel wire alone is used to produce metal-mesh gloves providing the highest cut resistance available, innovations in engineered yarn constructed of a nickel-containing stainless steel wire core wrapped with a high strength fibre, such as Kevlar®, offer improved dexterity as well as superior cut protection. Like adding rebar to concrete, it makes a strong material even stronger.

Ideal for CIP

When it comes to food, dairy, and beverage production, as well as pharmaceuticals and cosmetics, hygiene is an essential factor in the processing of anything that may be consumed or come in contact with the human body. The materials used in processing must not react with the product in ways which might endanger human health.

In many cases, these processes use equipment designed for Clean in Place (CIP) systems. CIP refers to the use of a mix of chemicals, heat, pressure and turbulent flow to clean machinery, vessels or pipe work without dismantling the equipment.

What makes nickel-containing stainless steels, such as Type 304 and 316 popular choices? Not only can food-grade stainless steel stand up to high temperatures, its protective oxide layer helps prevent the formation of rust that could cause contamination. The finish of the food-grade stainless steel must be resistant to bacterial growth while being easy to clean and sanitise using CIP processes.

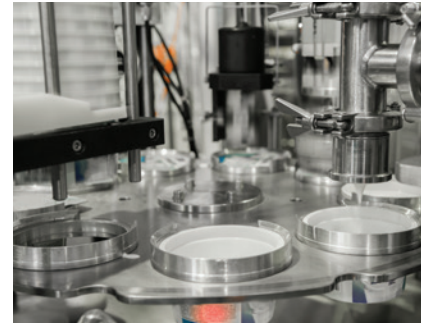
CIP is principally concerned with soil removal, meaning anything that should not be present in a clean vessel and can contaminate the product. It may be visible (scale, foreign bodies) or invisible in the form of bacteria, such as E. coli or yeast spores.

Commonly used chemicals for soil removal include caustic soda, phosphoric and nitric acids. Caustic soda is not effective for removing scale

while phosphoric and nitric acids are used in detergent formulations for scale removal. They are often used in dairies to remove milk scale and frequently used as part of commissioning to remove installation debris.

Effective sanitisers are sodium hypochlorite (commonly known as bleach) and peracetic acid (PAA), which is an equilibrium mixture of acetic acid and hydrogen peroxide. Sodium hypochlorite can cause localised corrosion of stainless steel if not adequately rinsed after its prescribed contact time. Otherwise stainless steels are unaffected.

Overall benefits of CIP to the food, pharmaceutical and cosmetics industries include faster, less labour-intensive and more repeatable cleaning. It also can be easily documented, which may be a requirement for local food safety authorities.



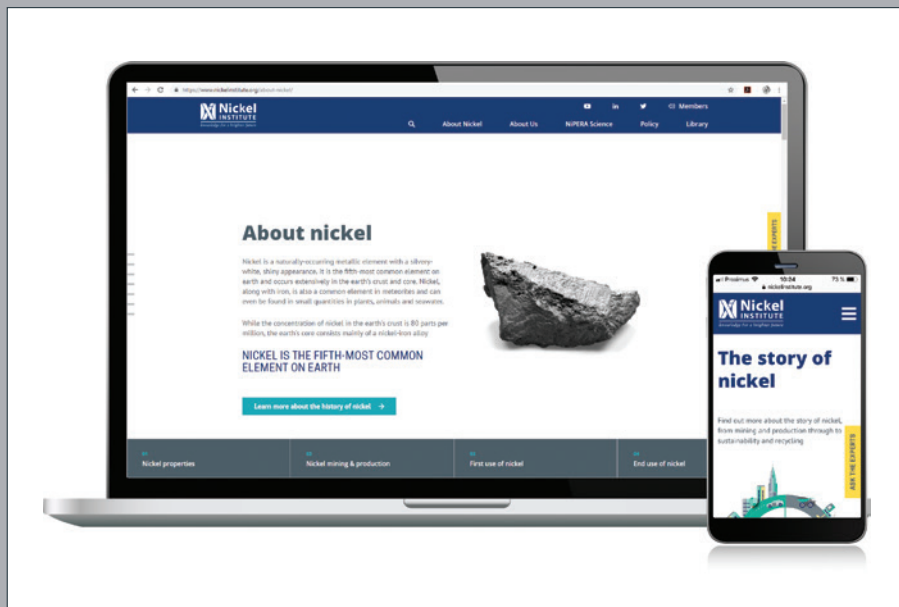
Nickel-containing stainless steel resists the harsh chemicals required to keep dairy equipment safe.

NI



NICKEL INSTITUTE NEW WEBSITE

The go-to site for a wide range of nickel-related knowledge.



The Nickel Institute has unveiled its new website. With significantly updated content, interactive features, as well as a NiPERA science section, the site also contains an extensive searchable library of technical and general nickel-related publications.

The new website is highly visual, showcasing just why nickel is essential in so many vital applications, in a multitude of sectors. And for those

who need to know more, it provides easy access to the Nickel Institute's free Technical Inquiry Service.

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SAFE BOXES FOR SAFE SHARPS

Sharps are hollow needles of all types used in medical practice and for personal use. More than 16 billion annually are made of nickel-containing stainless steel Type 304 (UNS S30400).

It is reported (WHO/2016) that the reuse of syringes and needles leads to more than two million people being infected with diseases such as HIV and hepatitis. The human and economic cost of this far exceeds the savings from reusing syringes and their needles.

These are not trivial consequences and for drug users an increasing number of jurisdictions provide safe injection sites, provide needle/

syringe packets without cost and safe deposit boxes for the disposal of used needles and syringes.

While the focus must be on all who are on the receiving end of needles, for all the usual reasons, there are tens of millions who use needles because of addiction or mental health issues. However, the use of nickel-containing stainless steel means that at least the needles are safe for all. NI



NICK BRANCACCIO

Hospitals and doctors' offices have bio-waste containers for used needles. Increasingly, the reality of non-medical use of needles for drug use is being recognised, as well as the need for the safe disposal of the used needles.



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STEEL YOUR WALLET

With the increased popularity of various tap-and-go payment systems, there has been a rise in the risk of digital thieves using handheld devices to pickpocket data with a mobile RFID reader.

The solution? Innovators have developed woven stainless steel wallets that prevent anyone passing by from connecting up with critical information to access credit cards, smartcards, key fobs, etc. One lightweight privacy wallet is “literally woven from over 20

thousand super-fine strands of stainless steel into a flexible fabric that feels like silk” while others are lined with a nickel and copper fabric. A smart way to enjoy the convenience of contactless payment without the worry of an invisible thief. 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
S30200 p. 11	0.15 max.	17.0-19.0	-	bal.	2.00 max.	-	0.10 max.	8.0-10.0	0.045 max.	0.030 max.	0.75 max.
S30400 p. 6, 11, 12, 13, 15	0.08 max.	18.0-20.0	-	bal.	2.00 max.	-	0.10 max.	8.0-10.0	0.045 max.	0.030 max.	0.75 max.
S30403 p. 9, 11	0.03 max.	18.0-20.0	-	bal.	2.00 max.	-	0.10 max.	8.0-12.0	0.045 max.	0.030 max.	0.75 max.
S31600 p. 2, 6, 11, 12, 13	0.08 max.	16.0-18.0	-	bal.	2.00 max.	2.00-3.00	0.10 max.	10.0-14.0	0.045 max.	0.030 max.	0.75 max.
S31603 p. 9, 11, 16	0.03 max.	16.0-18.0	-	bal.	2.00 max.	2.00-3.00	0.10 max.	10.0-14.0	0.045 max.	0.030 max.	0.75 max.
S32101 p. 11	0.04 max.	21.0-22.0	0.10-0.80	bal.	4.00-6.00	0.10-0.80	0.20-0.25	1.35-1.70	0.040 max.	0.030 max.	1.00 max.
S32304 p. 2, 5, 11	0.03 max.	21.5-24.5	0.05-0.60	bal.	2.50 max.	0.05-0.60	0.05-0.20	3.0-5.5	0.040 max.	0.030 max.	1.00 max.
S32205 p. 2, 8, 11	0.03 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.

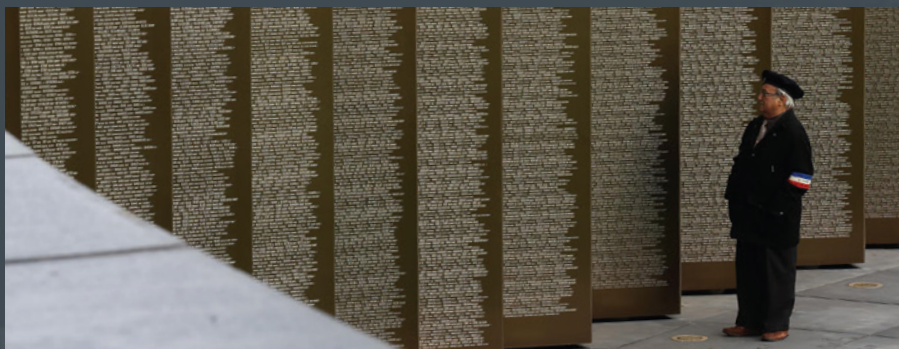


PHILIPPE PROST ARCHITECT / AAPP © ADAGP - 2016
YANN TOMA © ADAGP 2014, © AITOR ORTIZ

A TIMELESS REMEMBRANCE



© PHILIPPE PROST ARCHITECT / AAPP © ADAGP - 2014 © PIERRE DI SCIULLO, GRAPHISTE © AITOR ORTIZ



© PASCAL ROSSIGNOL

World War I memorial honours each of the 579,606 fallen soldiers from 40 different nationalities.

November 11, 2018, marked the one hundredth anniversary of the end of the First World War. The Ring of Remembrance, an international memorial and commemorative landmark at Notre-Dame-de-Lorette in France, gives visitors a lasting and emotional impression of the human cost of the battles of Flanders and Artois. Designed by French architect Philippe Prost, the memorial was opened in 2014 to mark the centenary of the start of hostilities. Panel after panel is meticulously engraved with the 579,606 names of those who fell, in alphabetical order, without reference to nationality, rank or religion.

Stainless steel was chosen for its corrosion resistance and long service life. Supplied by Aperam in Type 316L (UNS S31603), in bright annealed sheets with a 2mm thickness, it was designed to ensure that each panel would remain flat and rigid, and withstand pressure from visitors tracing the names of their ancestors on paper.

Cut from 35-tonne coils produced in the Genk factory in Belgium, the panels were micro-blasted and given their bronze tone at Rimex Metals in England before being sent to Alès in the south of France where Citynox used a laser machine to engrave the names into the 500 panels, each a virtual page in this historic record in the form of a giant loop. A circle of solidarity.

