

NICKEL MAGAZINE

THE MAGAZINE DEVOTED TO NICKEL AND ITS APPLICATIONS

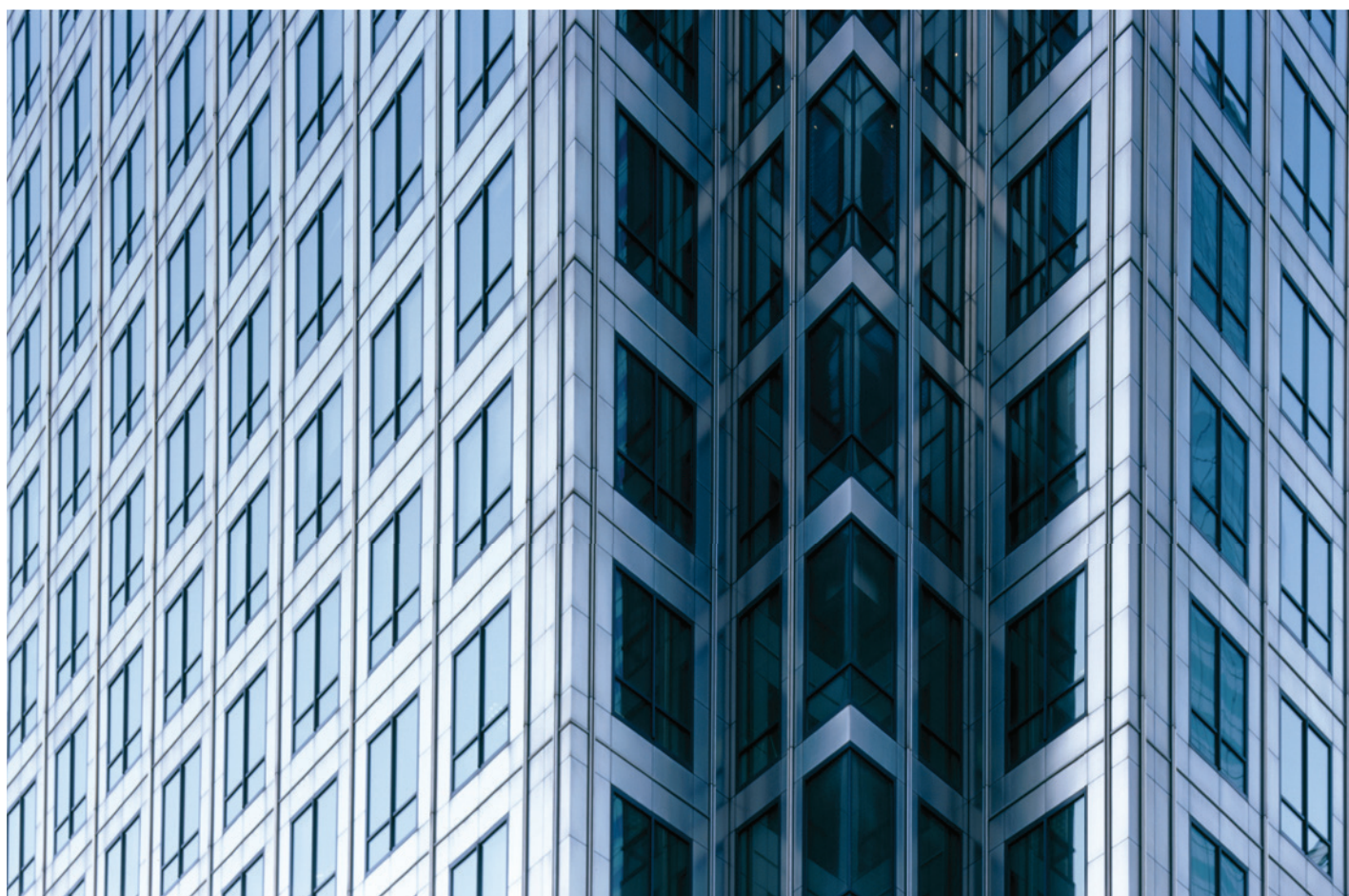
NICKEL, VOL. 35, N° 1, 2020

Architecture, building and construction Nickel's supporting role

*Design standards for
structural stainless steel*

*Stainless steel
for curtain walls*

*Wind Tree
rebirth of a sculpture*





CASE STUDY 18

BANK OF COMMUNICATIONS, SUZHOU



XIONG DUOKUI, ZHANG JUN, SUZHOU GOLD MANTIS CURTAIN WALL CO., LTD.

Designers on this project believe that among all materials used in building curtain walls, stainless steel is the decorative material with the longest useful life, the highest value and the best end-of-life recovery rate.

Curtain walls give external stability and internal elegance to buildings. China's Suzhou branch building of the Bank of Communications takes full advantage of the unique properties of stainless steel, delivering long-term value in cost and maintenance while providing a beautiful exterior reflecting the image of rigour, safety and reliability required of a bank.

Curtain wall designers and engineers for the Bank of Communications project, Zhang Jun and Xiong Duokui of Suzhou Gold Mantis Curtain Wall Co., looked to examples like the Chrysler Building in the U.S. built in 1930, the Burj Khalifa Tower in Dubai and the Ping International Finance Centre in China. All have used nickel-containing Type 316L (UNS S31603) stainless steel to great effect, without wear or replacement.

The Type 316L stainless steel selected for extensive use in the 25 storey building has a design life of over 100 years. A stainless steel curtain wall rises to over 106m and mirror-finish stainless steel decorative round tubes, 2.0mm thick with a diameter of 150mm, are used in all the façade unit systems of the tower. Inter-floor

claddings are fabricated from 2.0mm thick brush pattern stainless steel and the awning system is suspended with stainless steel cables. The primary and secondary joists of the awning are clad with 1.5mm stainless steel sheets, with the bottom of the awning decorated with 30 x 50mm stainless steel rectangular tubes. And 1.5mm thick mirror stainless steel clad columns used at the roof balconies rise to 3.3m.

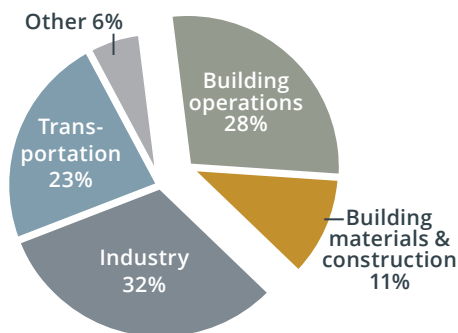
Inspired by traditional Suzhou gardens, the concept of "Suzhou garden gate" is introduced into the overall layout of the building. The end result is an intelligent and striking-looking office building, and an important landmark in Suzhou Industrial Park.



EDITORIAL: FORM AND FUNCTION

Beautiful stainless steel façades adorn the most iconic high-rise buildings in the world, and have done so for more than 90 years. But underlying the elegant exteriors is serious technology and advantages to improve efficiency, appearance and sustainability.

Global CO₂ emissions by sector



GLOBAL ALLIANCE FOR BUILDINGS AND CONSTRUCTION

Buildings and their construction generate 36% of global energy use and almost 40% of greenhouse gas emissions. Urbanisation of much of the world's population will see 230 billion square metres (equivalent to the entire current stock of buildings) added by 2060.

Careful materials selection and design can make all the difference in environmental burden. And

incorporating functional façades like curtain walls is a smart approach. Curtain walls protect the building and its inhabitants from weather, heat, noise, light and glare and have a big impact on energy efficiency. Unsurprisingly they are growing in appeal.

Architects have choices for curtain wall materials. Nickel-containing stainless steel offers low thermal conductivity and is an ideal material for structures in corrosive environments or for architecturally exposed structural steel applications. And they have an excellent life-cycle cost track record.

This edition of *Nickel* features beautiful examples of façades which add to the catalogue of iconic stainless steel clad buildings. Think of the Chrysler Building, a feature of the New York skyline since 1930. Proof that nickel-containing stainless steel is more than just a pretty façade.

Clare Richardson
Editor, *Nickel* magazine



CATHERINE HOUSKA

Globally, constructing high-performance buildings and performing deep energy renovations of existing building envelopes, which include curtain walls, represent a huge energy savings potential. The International Energy Agency estimates this to be more than all the final energy consumed by the G20 countries in 2015, or around 330 EJ (one exajoule = 10¹⁸ joules) in cumulative energy savings to 2060.
www.iea.org/etp/

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NICKEL

NOTABLES



Tesla's stellar Cybertruck

Tesla's futuristic electric Cybertruck looks more like a space rover than a truck. The eye-catching exoskeleton is made from ultra-hard 30X cold-rolled stainless steel for superior strength and endurance. The Cybertruck – available in 2022 – will be made from the same stainless steel alloy Type 301 (UNS S30100) that Elon Musk's other company SpaceX is using on its Starship spaceship. Type 301 was chosen for its cost and effectiveness, and its ability to withstand and shed high heat. For driving on Earth, it resists dents, damage and long-term corrosion while providing passengers with maximum protection. The tri-motor version of the truck can accelerate to 60 mph (96.6 km/hr) in 2.9 seconds. It is also able to tow up to 6,500 kgs.

TESLA



Elastocaloric cooling material

The cooling technology used in the multi-billion dollar a year refrigeration and HVAC industry is about to take a big leap forward thanks to a novel elastocaloric cooling material – a shape memory alloy that is highly efficient, eco-friendly and can be easily scaled-up for use in large devices. Developed by an international team led by Professor Ichiro Takeuchi and the University of Maryland, the new cooling material is a nickel-titanium alloy that was sculpted using additive technology (3-D printing). It has the potential to be more efficient than vapour compression cooling, which has dominated the market for over 150 years and uses chemical refrigerants which impact global-warming. The new cooling material is entirely green. Professor Takeuchi has been working on this innovative technology for nearly a decade, and it is now on the verge of commercialisation.



ICHIRO TAKEUCHI, UNIVERSITY OF MARYLAND

Greener, cheaper hydrogen fuel



In a study published in *Nature Communications*, scientists in Australia demonstrated that it's possible to use only water, iron, and nickel to create hydrogen fuel. It's less expensive and more ecologically friendly than traditional 'water-splitting' methods. The team from Swinburne University of Technology (UNSW) and Griffith University, was able to split hydrogen from oxygen in water, speed up the chemical reaction process while requiring less energy to do so. UNSW School of Chemistry's Professor Chuan Zha says, we "coat the electrodes with our catalyst to reduce energy consumption. On this catalyst, there is a tiny nano-scale interface where the iron and nickel meet at the atomic level, which becomes an active site for splitting water. This is where hydrogen can be split from oxygen and captured as fuel, and the oxygen can be released as an environmentally-friendly waste."



MANSION YACHTS

A floating first

It's the world's first yacht to be made entirely out of stainless steel. Named Mansion Yacht, its sharp design and striking alloy finish created a buzz at the 60th annual Fort Lauderdale International Boat Show. Measuring 25.6 m in length and 12.2 m across, the 840 m² base model can accommodate 149 people. Four 5.5 m hydraulic legs that have a lifting capacity of 500,000 kg each, enable it to stand up in the water giving it a futuristic overwater bungalow look. Seventy-two solar panels provide green power. The stainless steel advantage? "It is actually 25% of the maintenance cost of a fibreglass boat," Bruno Edwards from Mansion Yachts says.

DEVELOPING AND UPDATING DESIGN STANDARDS FOR STRUCTURAL STAINLESS STEEL



STANTON WILLIAMS CSE/ELLE

New revised design standards are being developed to help engineers harness the benefits of structural stainless steel with confidence.

Engineers use design standards to verify the adequacy of a structure before it's built and hence demonstrate compliance with national building regulations. As interest grows in the use of stainless steel for structure, the need for comprehensive and economic structural design rules increases and this year sees an unprecedented surge of activity in writing international design standards. Stainless steel design standards are closely aligned to the existing carbon steel design standards, which vary around the world in terms of philosophy, design models, organisation, and presentation.

In Europe, all construction must comply with the design rules in the Eurocodes. The Second Generation version of the stainless steel Eurocode is under preparation, and will contain a number of significant developments, including rules which exploit the benefit of strain hardening and the introduction of two strength classes to simplify the process of grade selection. In addition, the design rules for stainless steel in fire have been comprehensively revised.

The Nickel Institute has played a key role in supporting standards development work for stainless steel in the U.S. The American Institute of Steel Construction (AISC) decided that the interest in structural stainless steel in the U.S. merited the preparation of a full standalone design standard with work starting on AISC 370, *Specification for Structural Stainless Steel Buildings*, due for issue in 2021.

The UK's Steel Construction Institute has been responsible for preparing the drafts, based on contributions from researchers and practitioners in Europe, China and the U.S.

At the same time, the American Society of Civil Engineers' ASCE 8-02: *Specification for the Design of Cold-Formed Stainless Steel Structural Members* is also undergoing an extensive revision – the scope is being broadened to include duplex stainless steels and the design rules being updated. The new version is expected to be published in 2021.

There is also activity on standards writing in China – in 2015, the first Chinese design standard for structural stainless steel was published as *CECS 410*. A revision is now underway focussing on developing more comprehensive design rules for welded and bolted joints, and also seismic design rules.



Raising the standards on the London Underground

An example of recent stainless steel structures are the two crystal-like entrances to the redeveloped Tottenham Court Road and new Crossrail underground stations.

The larger south entrance is 15m tall and was completed in 2015, with the 9.5m tall north entrance being opened two years later. Structural engineers, Expedition, worked closely with specialist glass contractor Seele to develop the design with primary framing of glass and stainless steel composite beams and columns. The structures include 1,100m² of laminated safety glass, supported by 650m of stainless steel structural



sections. In selecting the stainless steel alloy, structural strength requirements, weldability and the ability to fabricate minimum radius edges were all-important considerations. Duplex Type 2205 (UNS S32205) was used for the structural members in the taller entrance due to its superior strength, which is twice that of Type 316L (S31603). Type 316L was used for the north entrance because its strength was sufficient for the applied loading and fabrication is easier. The flashings to both entrances were Type 316L. **NI**



Designed by architects Stanton Williams, the glass structures draw daylight into the station below and are illuminated at night, creating a dramatic and secure environment. The two entrance structures are separated by a diagonal strip of glazing in the pavement, which also allows daylight to reach the ticket hall below.

STAINLESS STEELS TRANSFORMING BUILDING FAÇADES



One Canada Square pioneered the use of embossed finishes on a super high-rise building façade.

Among the materials applied extensively to building façades, stainless steel is a relative newcomer. Nickel-containing stainless steels have been used from the beginning – think of the Chrysler Building in New York (1930) using Type 302 (UNS S30200) – and have been performing exceptionally well ever since.

Leading architects, Pelli Clarke Pelli Architects, Inc. (PCPA) has been designing stainless steel into building façades for the past 30 years. “Stainless steel building façades are full of visual impact and add an exciting luster, remaining like new over time,” explains architect Jie Zhang, who leads PCPA’s Shanghai office. “However, the successful application of stainless steel in building façades relies on having an adequate budget, rigorous detailing and specification selection, as well as refined manufacturing and construction quality.” A range of PCPA’s projects, having employed different applications of stainless steel in building façades reflecting on the opportunities and challenges in working with stainless steel are presented here.

London’s first skyscraper at 235 m and the centerpiece of Canary Wharf, **One Canada Square** stands as a simple square prism terminating with a pyramidal top. Completed in 1992, this tower has a clear and powerful form, and is the founding landmark of the new urban area which has

become London’s new financial centre. The design team selected Type 316L (S31603) stainless steel with an embossed linen finish, later known as Cambric. One Canada Square pioneered the use of embossed finishes on a super high-rise building. Cambric has ensured a highly stable flatness, gloss and reflection directionality of panels to reinforce the architectural design. Beyond the curtain walls, stainless steel is also applied to the tower lobby, awnings, overhangs and other public spaces. Today, after nearly 30 years, the tower has become one of London’s best-known landmarks.

The **Petronas Towers** in Kuala Lumpur, built in the same period, were once the tallest twin towers in the world. This building is the core element of the city centre. In order to create a uniquely Malaysian design, the team drew inspiration from Islamic culture, Kuala Lumpur’s climate and traditional Malaysian arts. The plan of the twin towers is generated from two overlapping squares that form an eight-pointed star, a

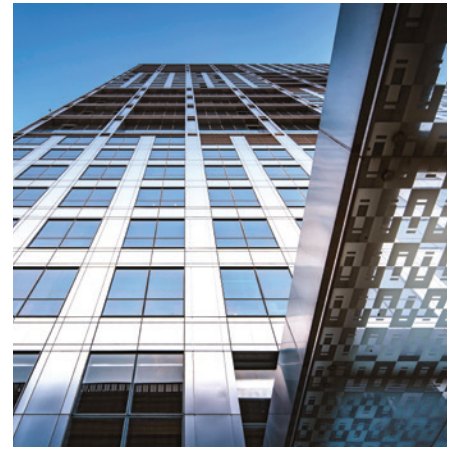
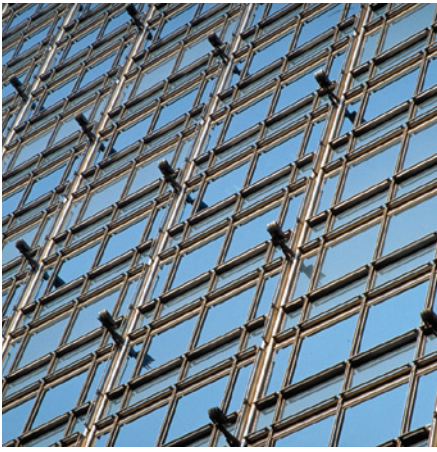


The design of the Petronas Towers in Kuala Lumpur pays tribute to traditional Malaysian architectural style.

pattern frequently found in Islamic crafts. As the buildings rise, they step back six times, and at each setback the walls tip outward slightly. This complex technique is used to pay tribute to the traditional Malaysian architectural style. The façade design needed to show both modernity and an enduring charm. The body of the twin towers is wrapped by glass curtain walls and Type 316 (S31600) stainless steel panels and members, which softly reflect sunlight. Stainless steel is used in the sunshade devices as part of the sustainable design to

mitigate the large sun angle of the region. In addition, stainless steel is applied in the spandrel panel, as structural column enclosures at the tower top, providing enduring luster and vitality to the building.

The **Cheung Kong Center** completed in 1999 illustrates a wonderful dialogue between architectural massing (shape, form and size) and detailing. The building stands out from its neighbours, taking the simple form of a tall and well-proportioned square prism. The curtain wall is reflective



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Left to right:

The Cheung Kong Centre – The curtain wall is reflective glass modulated by a wrapping grid of stainless steel.

The new headquarters of Baowu Steel Group – wrapped in Type 316L panels with high performance glass and sunscreens.

The Baodi Plaza Tower – Polished and embossed stainless steel is used extensively on the façades to provide both luster and high durability.

glass modulated by a wrapping grid of stainless steel. A dense pattern of integrated light fixtures on the façade allows the pattern of the stainless steel grid to glow softly at night, with changing colour and design during times of festivities. Three different finishes on Type 316L stainless steel were used, Cambric, a fine No. 4, and glass bead blasted.

The new headquarters of **Baowu Steel Group**, located at the former site of the Shanghai World Expo, is one of the tallest buildings in this area. The building had a key role in the redevelopment of this area and needed to illustrate the corporate characteristics of Baowu Steel Group. The enclosure systems for each building feature two types of curtain walls. The street edge of all the buildings is wrapped in a “hard shell” of linen Type 316L panels with high-performance glass and sun screens. Special features, amenities and the rounded corners of the buildings have a more open, glassy “soft shell” of high-performance glass. The stainless steel raw material for the panels was produced by Baosteel in China, a first architectural application for the Group.

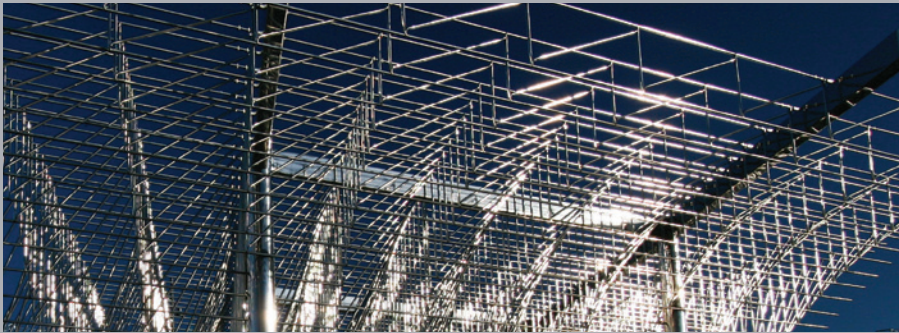
The **Baodi Plaza** tower – the Guangzhou headquarters of Baosteel – emphasises simplicity and elegance. As with its Shanghai headquarters building, this project features Type 316L stainless

steel façades, reflecting the status of Baosteel as one of the largest steel producers in the world. Through use of a different façade design, diversity in expression is added. Polished and embossed stainless steel is used extensively on the façades to provide both luster and high durability. The vertical and horizontal grid, two detail treatment methods, and the flat and concise façades brought tremendous challenges for panel production and construction. The design team worked closely with the client, suppliers and the contractor to develop solutions for details such as nuances in grain directionality, extreme fillet radius at folds and fixation methods using backing joists.

PCPA believes that great design should not be constrained by a signature style, but rather born of the close cooperation with the client, and a deep respect for a project’s environmental, economic and social content. Jie Zhang adds. “In the practice of applying stainless steel to building façade design, all steps from conceptual design to material implementation are complementary to each other in ensuring project success. Timeless architecture arises from a deep understanding of the past combined with a bold aspiration for the future.” And nickel-containing stainless steels ensure the long life of the building. **Ni**

WIND TREE

REBIRTH OF A SCULPTURE




Michio Ihara's Wind Tree was installed in Queen Elizabeth Park, in Auckland, New Zealand in 1977 and was moved to a new home in Wynyard Quarter, by Auckland harbour in 2011. Its trusses once again swung in the wind while the pool below reflected light up through the sculpture.

In 2014 an inspection showed a corrosion cracking problem on several of the welded truss joints fabricated from Type 316 (S31600).

Further examination of the corroded fracture face revealed the presence of fatigue striations, corrosion damage and residual weld heat tinting, which are factors associated with corrosion-assisted fatigue. Wind Tree's waterfront location is classified as a severe marine environment, which provided the corrosive chloride ions that aided the corrosion-assisted fatigue.

The weld cracking and corrosion were serious and temporary weld repairs were carried out on several truss joints. Auckland Council decided that Wind Tree should be restored, and public safety ensured.

Various joint designs were assessed, and the selected design was reviewed by sculptor Ihara to ensure it did not change the artistic characteristics of the sculpture. The TIG (tungsten inert gas) welds on the new joint design were fabricated to weld Category FA in AS/NZS 1554:6:2012. The welds were chemically cleaned to remove heat tint and mechanically polished to a 600 grit surface finish.

The most severely attacked truss was replaced in 2018 with the new design fabricated from Type 316L (S31603). After six months of service the redesigned truss was examined and no cracking or corrosion was found. The remaining 39 trusses were replaced in 2019. Ihara has described it as a "rebirth for the sculpture". 



In 1977 it was not common to use low-carbon Type 316L stainless steel in structures. Advancements in steelmaking has made 'L' grade stainless steel commonly available. Type 316L will similarly ensure the artwork will remain sound and corrosion-free into the future.

NI-RESIST

SUPERIOR CORROSION RESISTANCE FOR SPECIALISED APPLICATIONS



Only 9% of nickel production is used in alloy steels and castings but these materials are significant in delivering specific characteristics for specialised and often critical applications.

One such material is Ni-Resist cast irons, with up to 36% nickel. Their superior corrosion resistance and toughness, in comparison to grey cast iron, makes them an important material in various types of pumps, and their superior oxidation resistance and high temperature strength makes them an ideal material as piston ring inserts.

Nickel is responsible for producing a stable austenitic microstructure like that of austenitic stainless steel.

The austenitic structure provides improved heat and corrosion-resistant properties in comparison to unalloyed and low-alloy grey and ductile cast irons. Castability of Ni-Resists are comparable to that of grey and ductile cast irons and they are readily machined and welded. These benefits are described in further detail in *Table 1*. The family is divided into two types – flake graphite (FG) alloys and the ductile spheroidal graphite (SG) alloys. Both types are similar in composition

Table 1: Beneficial properties of Ni-Resist alloys

Corrosion resistance	In salt solutions, seawater, mild acid, alkalis and oil field liquids, both sweet and sour, Ni-Resist alloys possess corrosion resistance superior to that of normal and low alloy cast irons.
Wear resistance	Cylinder liners, pistons, wear rings and sleeves, bearings, glands and other metal-to-metal rubbing parts are cast in Ni-Resist alloys. Their galling resistance is excellent.
Erosion resistance	Fluids with entrained solids, such as slurries, are extremely erosive to most metals. Ni-Resist alloys offer a combination of corrosion-erosion resistance which is superior to grey cast iron, ductile irons and steel.
Toughness	Ni-Resist alloys are much superior to grey cast iron, particularly at low temperatures.
Heat resistance	SG alloys are used up to 1050 °C (1930 °F) because of superior elevated properties relative to FG alloys. FG alloys are seldom used above 315 °C (600 °F). All Ni-Resist alloys have relatively low rates of oxidation in air. The resulting oxides adhere tenaciously, further reducing oxidation with time.

Table 2: Nominal composition of some notable Ni-Resist alloys

Type	UNS	Ni	Cr	Si	Cu	Mn	C max	Tensile strength MPa (ksi)	Compressive strength MPa (ksi)	Elongation %
Flake graphite Ni-Resist alloys (ASTM A436)										
1	F41000	15.5	2	2	6.5	1	3.0	170-210 (24-30)	700-840 (100-120)	2
2	F41002	20	2	2	0.5 max	1	3.0	170-210 (24-30)	700-840 (100-120)	2
5	F41006	35	0.1 max	2	0.5 max	1	3.0	120-180 (17-26)	560-700 (80-100)	2
Type	UNS	Ni	Cr	Si	Cu max	Mn	C max	Tensile strength MPa (ksi)	Yield strength MPa (ksi)	Elongation %
Spheroidal graphite Ni-Resist alloys (ASTM A439)										
D-2B	F43001	20	3	2	0.5	1	3.0	370-480 (53-69)	210-250 (30-36)	7-20
D-2M	-	21	0.1	2	0.5	4	2.6	440-480 (63-69)	210-240 (30-34)	13-18
D-5S	-	36	2	5.2	0.5	1.0 max	3.0	370-500 (53-71)	200-290 (29-41)	10-20

except for a small magnesium addition, which converts the graphite to the spheroidal form in the SG alloys, providing higher strength, ductility and elevated temperature properties. However, the flake grades with lower cost, fewer foundry problems and better machinability still find application. Typical microstructures are

shown in *Figures 1 and 2*.

The composition of some of the most notable grades are shown in *Table 2* and specific beneficial properties are identified in *Table 3*.

As their name suggests, Ni-Resist alloys are excellent performers in the most demanding applications.

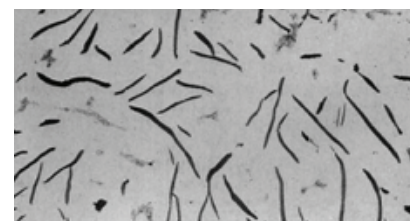


Figure 1 Typical microstructure of flake graphite Ni-Resist alloys

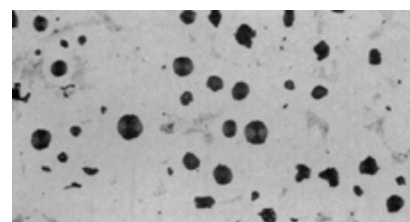


Figure 2 Typical microstructure of spheroidal graphite Ni-Resist alloys

Discharge elbow for triple-effect evaporators for the potash industry made from ASTM A436 Grade 2b (2900 kg)



Table 3: Notable Ni-Resist alloys

Ni-Resist 1	Good corrosion resistance with good moderate temperature and wear resistance. Used in pumps, valves and particularly piston ring inserts and products where wear resistance is required.
Ni-Resist 2	Higher nickel content makes this alloy more corrosion resistant in alkaline environments for applications handling soap, rayon and plastics.
Ni-Resist 5	Lowest coefficient of thermal expansion of Ni-Resist alloys. Provides dimensional stability for machine tool parts, forming dies, instruments and expansion joints.
D-2B	Good resistance to corrosion, corrosion-erosion and frictional wear and used at temperatures up to 760 °C (1400 °F). Applications include pumps, compressors, turbocharger housings and exhaust gas manifolds.
D-2M	Maintains ambient temperature mechanical properties down to -170 °C (-275 °F). This is achieved by its manganese addition. Major uses are for refrigeration and cryogenic equipment.
D-5S	Low coefficient of thermal expansion with good thermal shock resistance with excellent resistance to growth and oxidation resistance up to 1050 °C (1925 °F). Used in gas turbines, turbocharger housings and exhaust manifolds.

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/>

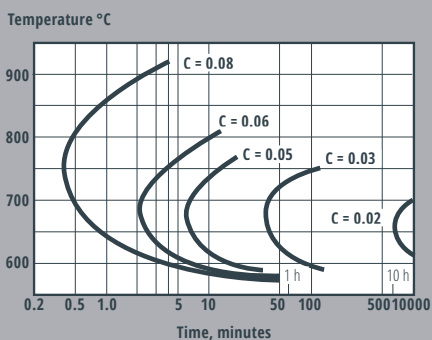


Figure 1: The time needed to form detrimental amounts of chromium carbides is much longer for the “L” grades, which contain 0.03% C.

Q: Does the low carbon present in “L” grade austenitic stainless steels, such as 304L or 316L, improve weldability?

A: No, the low carbon in “L” grade (<0.03%) is to prevent the formation of a detrimental amount of chromium carbides during welding. These carbides can bind considerable quantities of chromium, thereby depleting chromium along the grain boundaries, potentially impairing corrosion resistance, which can result in intergranular corrosion (IGC), as indicated in *Figure 1*. Low carbon contents are typical of all stainless steels for corrosion service and thus IGC of stainless steel, due to welding, is rarely observed. Whether the carbon content is above or below 0.03% has no impact on weldability.

In contrast, carbon steel weldability is influenced by carbon content. Carbon steel experiences a microstructural change with temperature. At temperatures above ~727 °C (1340 °F) the equilibrium microstructure is austenite, while below this temperature the equilibrium microstructure is ferrite. However, if austenite is cooled rapidly a less ductile microstructure called martensite is created. Carbon content >0.30% in carbon steels are especially problematic requiring preheat to lower the cooling rate to mitigate martensite formation. It is this concern with carbon steel welding that

leads to the assumption that the low carbon of “L” grade also influences the weldability of nickel-containing austenitic stainless steel. The nickel in austenitic stainless steels stabilises the microstructure at all temperatures, thus there is no microstructural change in the weld area as a result of welding.

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NEW PUBLICATIONS

Alloy selection for service in nitric acid (10075) reviews the corrosive effect of nitric acid at all concentrations. It discusses the most common process for nitric acid production, the corrosion resistance of various nickel-containing metals and other metals to nitric acid, as well as some industrial applications.

About 75% of nitric acid produced is used in the production of nitrate fertiliser.

This fully revised technical publication from the Nickel Institute provides a useful guide for materials engineers.

Available to download free from www.nickelinstitute.org

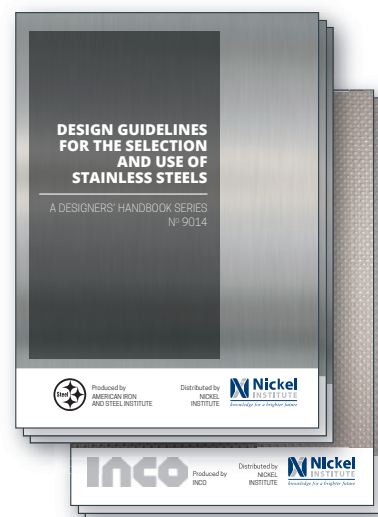


UPDATED PUBLICATIONS

Updated technical publications
The Nickel Institute has updated 30 significant historical technical publications originally produced by INCO and American Iron and Steel Institute (AISI). Popular titles, such as INCO's *The Corrosion Resistance of Nickel-Containing Alloys in Sulphuric Acid and Related*

Compounds and AISI's *Design Guidelines for the Selection and Use of Stainless Steels* provide relevant technical information for engineers and end-users. The digital quality of the guides has been improved and all publications are searchable.

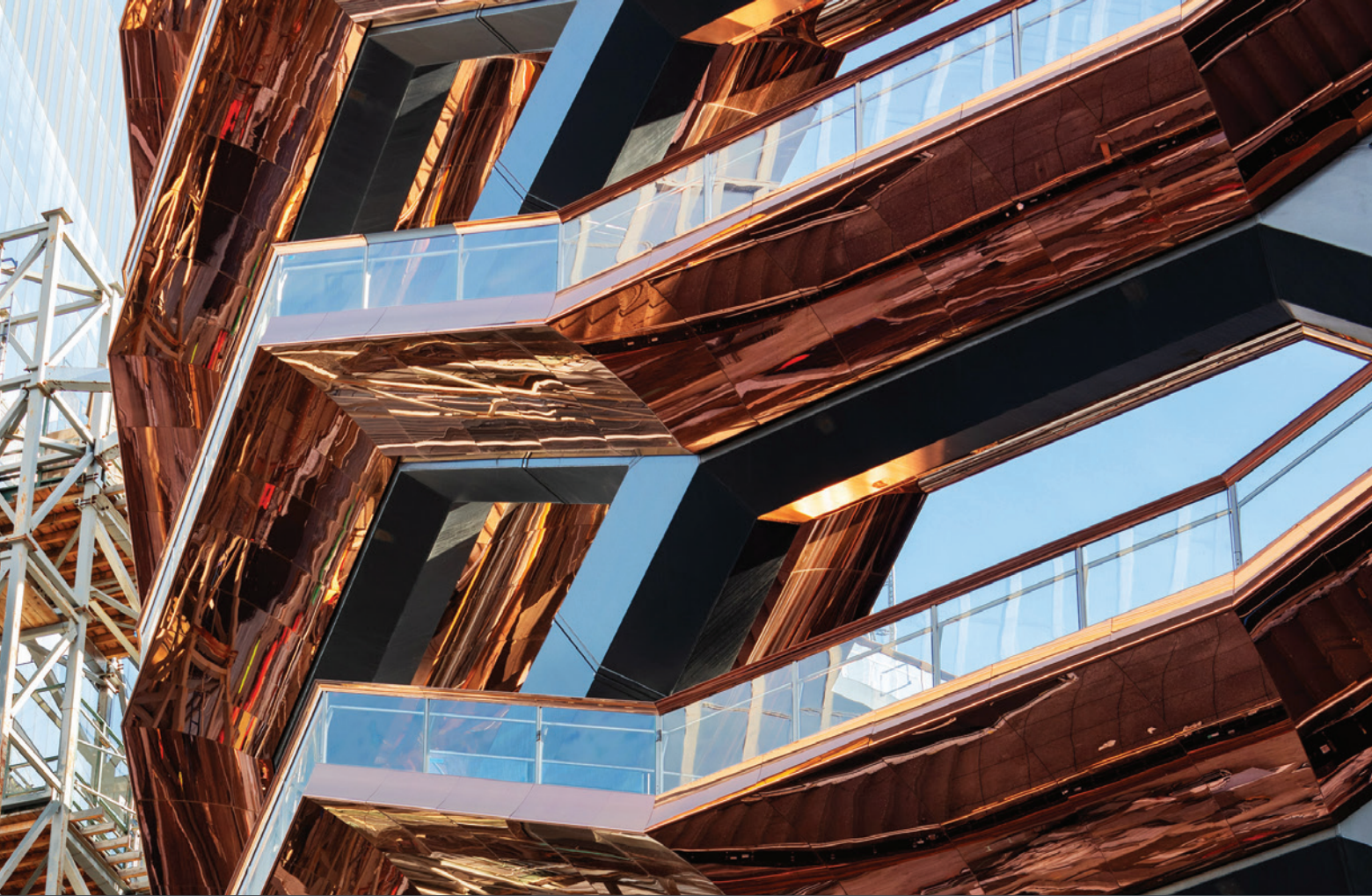
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UNS DETAILS

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

UNS	C	Cr	Fe	Mn	Mo	N	Ni	P	S	Si
S30100 p. 4	0.15 max.	16.0- 18.0	bal.	2.00 max.	-	0.10 max.	6.0- 8.0	0.045 max.	0.030 max.	1.00 max.
S30200 p. 8	0.15 max.	17.0- 19.0	bal.	2.00 max.	-	0.10 max.	8.0- 10.0	0.045 max.	0.030 max.	1.00 max.
S30403 p. 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 p. 9, 11	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 p. 2, 7, 8, 10, 11, 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.
S32205 p. 7, 16	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.



PHOTOGRAPHY IS BY MICHAEL MORAN FOR RELATED COMPANIES.



The Vessel minimises its footprint by being small at the bottom. As it grows vertically its width increases.

THE VESSEL AT HUDSON YARDS

New York City's Hudson Yards is the largest private real estate development in the United States by area. The first phase opened in 2019 with a spectacular interactive sculpture, the Vessel, as its focal point. Designed by Thomas Heatherwick and Heatherwick Studio, this extraordinary 46 m (150 ft) tall new landmark was meant to be climbed and provides fascinating views of the city. The red bronze look of the exterior was obtained by applying a highly customised PVD coating to over 45 tonnes of mirror-polished, Type 316L (S31603) nickel-containing stainless steel.

While the appearance of the sculpture's interior is reminiscent of M.C. Escher's continuous staircase, the Vessel's 154 intricately interconnecting flights of stairs with 80 landings do allow visitors to climb to the top. It was important for the staircase to retain its beauty over time and appear lightweight while meeting structural

requirements. The hollow balusters allow for discreet evening lighting and are made from about 80 tonnes of high-strength nickel-containing Type 2205 (S32205) stainless steel with an abrasive blasted finish. For the mobility impaired, there is a curvilinear stainless steel and glass elevator.

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