NICKEL MAGAZINE

THE MAGAZINE DEVOTED TO NICKEL AND ITS APPLICATIONS

NICKEL, VOL. 38, Nº 1, 2023

The power of nickel

Ni catalyst helps turn oils and fats into renewable diesel

A VIP solution to transporting liquefied natural gas

The power of green hydrogen using stainless steel

CASE STUDY 27 **ENTRANCE CANOPY ELIZABETH LINE, PADDINGTON STATION**

The stainless steel mirror-polished grid appears to float above the platforms.

***Location**: Entrance to Elizabeth Line at Paddington Railway Station, London*
***Manufacturer of stainless steel purlins:** Montanstahl*
***Structural engineer**: Ramboll*
***Architect:** Weston Williamson + Partners*
***Weight of stainless steel:** 56 tonnes*
***Dimension of purlins:** 300 mm tall, 100 mm wide, 8 mm thick*

In the most significant transformation since the completion of the original building in 1853, Paddington Station features a stunning glass canopy that stands 8 metres above ground and extends over a length of 120 metres.

One of London's largest ever artworks, the canopy structure consists of painted carbon steel frames spaced at around 6 metres, with 180 Type 316L (UNS S31603) stainless steel purlins spanning between the carbon steel beams. The mirror-polished stainless steel purlins support 220 bespoke glass panels, each weighing over a tonne. The polished finish was critical for their selection as it blended in beautifully with the renowned artist Spencer Finch's *A Cloud Index* printed onto the glazed roof.

The architectural needs imposed a high demand on the fabrication of the purlins in terms of geometrical tolerances, surface finish and weld quality. Consisting of laser-welded custom-made box sections, with the webs overhanging the lower flange by 25 mm, the top and bottom flanges of the purlins were cut short by 80 mm at each end to facilitate the connection to the carbon steel beams. The purlins were bolted to the carbon steel beams through fin plates connected to each web with countersunk bolts. 10 mm thick stainless steel reinforcing plates were welded to the inner side of the box section webs to strengthen the connection to the carbon steel beams.

The canopy provides natural light 25 metres below ground, as well as a unique collage of clouds that delight transit riders as it appears to change according to the light, weather, and the time of day. Ni

EDITORIAL:
THE POWER OF NICKEL

The Oxford English dictionary defines power as "the ability or capacity to do something or act in a particular way." In this edition of Nickel *we look at the power of the unique properties of nickel to act at the heart of technologies that are critical to reducing carbon emissions.*

Green hydrogen is one such promising technology for the future. The specific properties of hydrogen place tough demands on the materials used for its generation, storage, transportation and use. We look at how nickel-containing stainless steels are up to the task and discover the power of nickel catalysts for the production of renewable diesel. Nickel catalysts are an indispensable part of the technology which produces renewable diesel with much lower carbon emissions than petroleum-based alternatives. We also examine the power of nickel to transport liquefied gases at extremely low temperatures to deliver lower-emissions energy.

The Nickel Institute's extensive collection of technical guides covers properties, performance manufacturing technologies and use in almost all nickel-containing materials and sectors and are available without cost. The collection has been substantially updated over the past three years to enable engineers, other specifiers and users to harness the power of nickel with confidence and success. We recently published a second edition of one of our most popular guides, the *Nickel Plating Handbook* – details are on page 15.

The Nickel Institute is all about sharing the knowledge, and it's well known, knowledge is power!

Clare Richardson
Editor, *Nickel*

The power of nickel in many applications is explained in the Nickel Institute's extensive library of technical guides. Check out our free publications at www.nickelinstitute.org

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NICKEL NOTABLES

Seizing sea power

RMIT

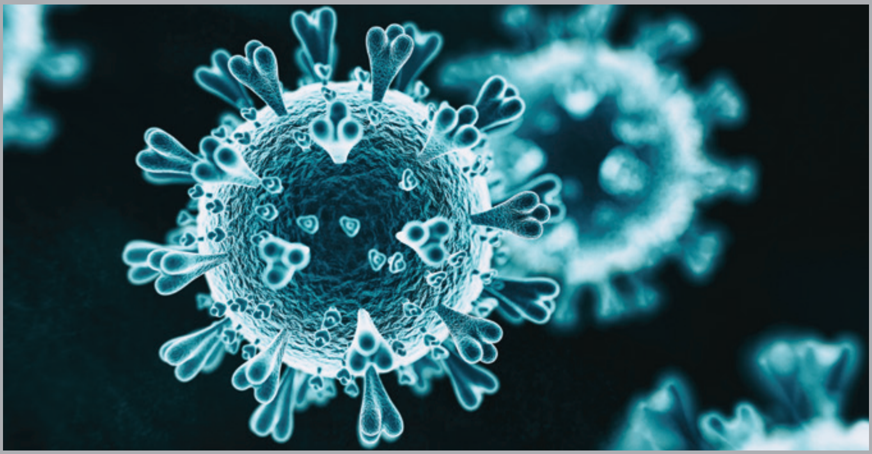
With the push for highly efficient, low-cost green hydrogen generation from seawater, scientists at Australia's RMIT have demonstrated a new method with great potential. The RMIT device uses a novel catalyst made from sheets of nitrogen-doped nickel molybdenum phosphide ($NiMo_3P$). This new catalyst splits seawater and generates hydrogen extremely efficiently in the lab, while resisting corrosion and suppressing chlorine production. When the hydrogen is run through a fuel cell locally, desalinated water is emitted. The research team says it'll be easy to manufacture at scale and should be economical at commercial scale. Why seawater? It is more plentiful than fresh water and it's free.

Faster virus detection

The COVID-19 pandemic has inspired a research group in Japan to engineer a self sustaining batteryless device that not only detects viruses in the air more quickly, but it also transmits that information wirelessly.

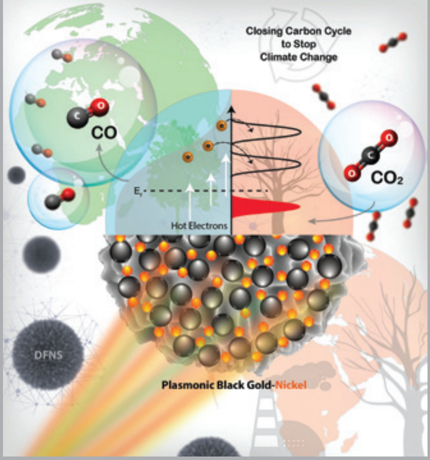
Fumio Narita, at Tohoku University explains that "the device uses a magnetostrictive clad plate composed of iron, cobalt and nickel, generating power via alternative magnetisation caused by vibration." The team modified a 0.2 mm thick Fe-Co/Ni plate with a rectifier/storage circuit that harvested bending vibration energy and enabled the wireless transmission of information. They then created the biorecognition layer, choosing to focus on human coronavirus 229E (HCoV-229E).

"In future, with modifications to the biorecognition layer, we hope to further develop our device and see if it applies to other viruses, such as MERS, SARS and COVID-19," said Narita.



A golden solution

With climate change top of mind, one of the most effective methods to help address the challenge could prove to be CO_2 hydrogenation. Scientists at the Tata Institute of Fundamental Research (TIFR) in Mumbai recently demonstrated a process whereby nickel-laden black gold converted CO_2 into a useful fuel source, using solar energy and green hydrogen. The study validated the exceptional catalytic performance of plasmonic black gold nickel and could lead to the development of a sustainable CO_2 hydrogenation path and help in the development of technologies to reduce greenhouse gas emissions.



MR. RISHI VERMA AND PROF. VIVEK POLSHETTIWAR

Nano building blocks fuel greater efficiency

UNSW SYDNEY

Scientists from UNSW Sydney have developed a new method for designing tiny 3D materials that could make fuel cells more efficient. Researchers demonstrated a novel technique using chemical synthesis, to construct complex compounds from simpler ones. By growing hexagonal crystal–structured nickel branches on cubic crystal–structured cores, they created 3D hierarchical structures with dimensions of around 10–20 nanometres. Authors of the study Professor Richard Tilley and Dr. Lucy Gloag note "these new 3D nanostructures are engineered to expose more atoms to the reaction environment, which can facilitate more efficient and effective catalysis for energy conversion." Used in a fuel cell or battery, the higher surface area for the catalyst means the reaction will be more efficient when converting hydrogen into electricity. As less of the material needs to be used for the reaction, it will decrease the costs. Published in *Science Advances*, the study is a step towards making energy production more sustainable, shifting dependence further away from fossil fuels.

RENEWABLE DIESEL
A PROMISING NICKEL CATALYST TURNS FATS INTO FUEL

According to the International Energy Agency, renewable fuel demand is expected to grow rapidly over the next few years. Steve Deutsch from The Catalyst Group explains the role of nickel catalysts and the potential of renewable fuels.

Renewable diesel (RD) is made by hydroprocessing vegetable oil, and waste fats and greases, in a process very similar to the processes used to make diesel in a conventional refinery.

The increased use of green diesel to combat climate change and the depletion of fossil fuels, is creating more intensive investigation into cost-effective catalysts such as nickel-alumina playing a key part in the process.

The vast majority of renewable fuels today are either ethanol (corn-based in the US and sugar-based in Brazil) or biodiesel, which is made by transesterification of vegetable oils. Both ethanol and biodiesel suffer from blending constraints limiting their use as well as lower energy content compared to either gasoline or petroleum-derived diesel. Renewable diesel (RD) is made by hydroprocessing vegetable oil, and waste fats and greases, in a process very similar to those used to make diesel in a conventional refinery. Renewable diesel's close chemical relative, sustainable aviation fuel (SAF), can be made by different processes, including hydrotreating vegetable oils, if the oil feedstock has the appropriate chemical composition. Renewable diesel meets all the conventional specifications for diesel fuels, so it can be used without blending, unlike biodiesel.

Lower carbon intensity

Different oils are used in making renewable diesel, most commonly rapeseed, soybean, and palm oil. Beef tallow and waste greases can also be used. Due to concerns over replacement of food sources for fuel, non-traditional oils like camelina and jatropha are also considered. Depending on the source and the exact processing methods, its carbon intensity varies, but renewable diesels are considered to have about 30% of the carbon intensity of petroleum-based diesel. While the main driver for renewable diesel is to lower CO_2 emissions, there are other benefits. Renewable diesel typically has only about 1 ppm sulphur, compared to 10–15 ppm (depending on the more common regional fuel standards), so it can be used to lower the sulphur content of petroleum diesel by blending. The cetane number of renewable diesel ranges from 70–90, compared to a minimum cetane value of 40 in the US and 49 in Europe. Higher cetane fuels burn cleaner, making regeneration of soot filters easier and less frequent, saving fuel and reducing maintenance costs.

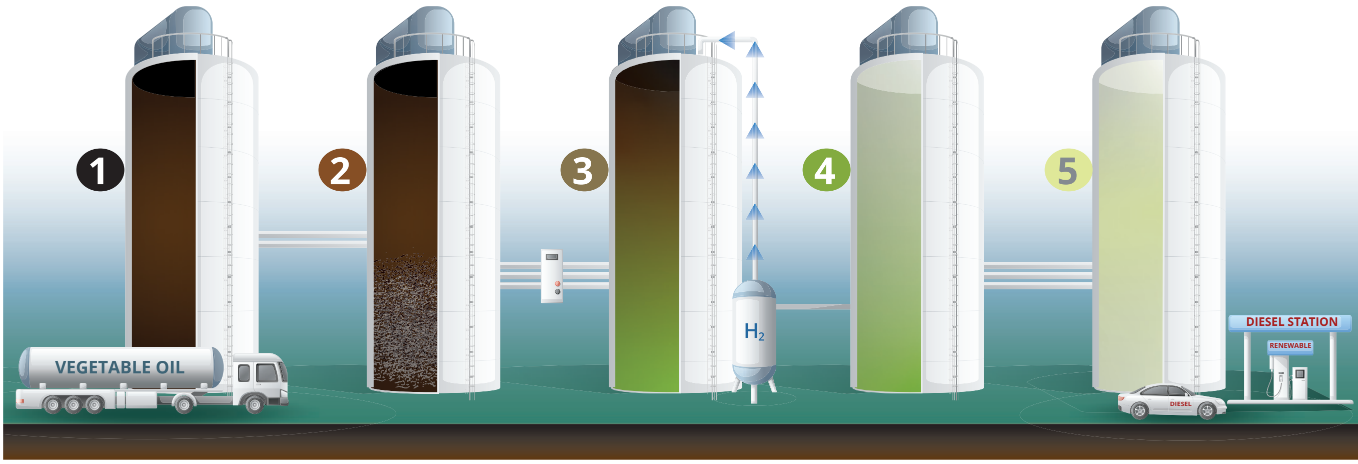


Figure 1. Renewable diesel process flow diagram

1. **Vegetable oils and waste fats/ greases** are brought to the refinery.
2. **Pretreatment** removes unwanted contaminants.
3. **Hydrocracking and deoxygenation** are processes similar to those used at fossil fuel refineries.
4. **Isomerisation** is the final step to obtain fuel quality diesel.
5. **Renewable diesel** is a high quality advanced biofuel suitable for all diesel engines.

Renewable diesel is made by first pre-treating oils to remove metallic contaminants that may be present and acid from rancidification of oils. The oil is then sent to a hydrotreater (similar to petroleum) to break the triglyceride and remove oxygen. Hydrogenation of unsaturated bonds also occurs as well as some cracking of larger molecules to smaller molecules. Finally, the hydrotreated oil is isomerised to improve the cold flow properties of the diesel to meet fuel specifications (*Figure 1*). The main products from this process are renewable diesel and propane, with heavier fractions becoming sustainable aviation fuel (SAF) and lighter fractions converted to renewable gasoline (*Figure 2*).

Nickel catalysts

The catalysts used for hydrotreating vegetable oil are Ni or NiMo supported on alumina. Ni provides good functionality for saturating double bonds as well as promoting the activity for the removal of oxygen. Ni impregnated in zeolites and other molecular sieves are also used in the isomerisation step, replacing more expensive catalysts based on platinum or palladium.

Dynamic growth

According to IEA, global renewable diesel production in 2021 was only 170,000 barrels/day but is forecasted to grow to between 420,000 and 600,000 barrels/day by 2027. Similarly, SAF production was only 2,500 barrels/day in 2021 but expected to grow to 1–2% of global demand by 2027, equivalent to 75,000–150,000 barrels/day. Governments have mandated the use of renewable fuels, so as the demand for renewable fuels increases so will the demand for nickel catalysts, which are an indispensable part of renewable fuel technologies. Ni

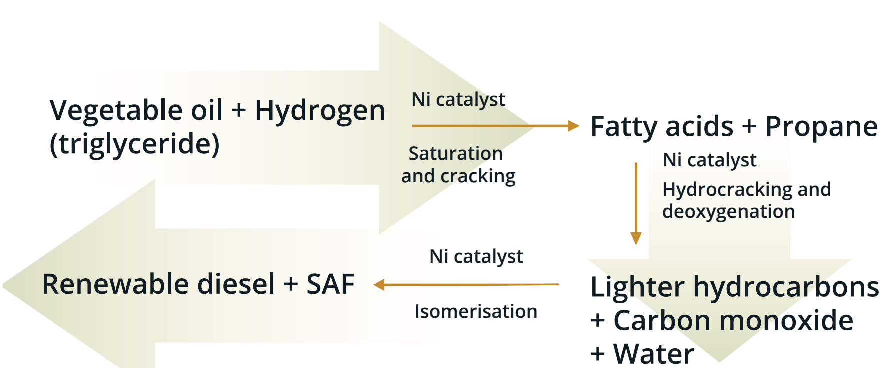


Figure 2. Chemical steps in the hydrotreating of vegetable oils to make renewable diesel.

Please note that the Nickel Institute (NI) does not endorse any particular forecast or forward-looking statement including, but not limited to, which particular use will grow or develop in the future. If the reader would like to utilise or refer to this publicly available information from the third party please cite the original source and not the NI.

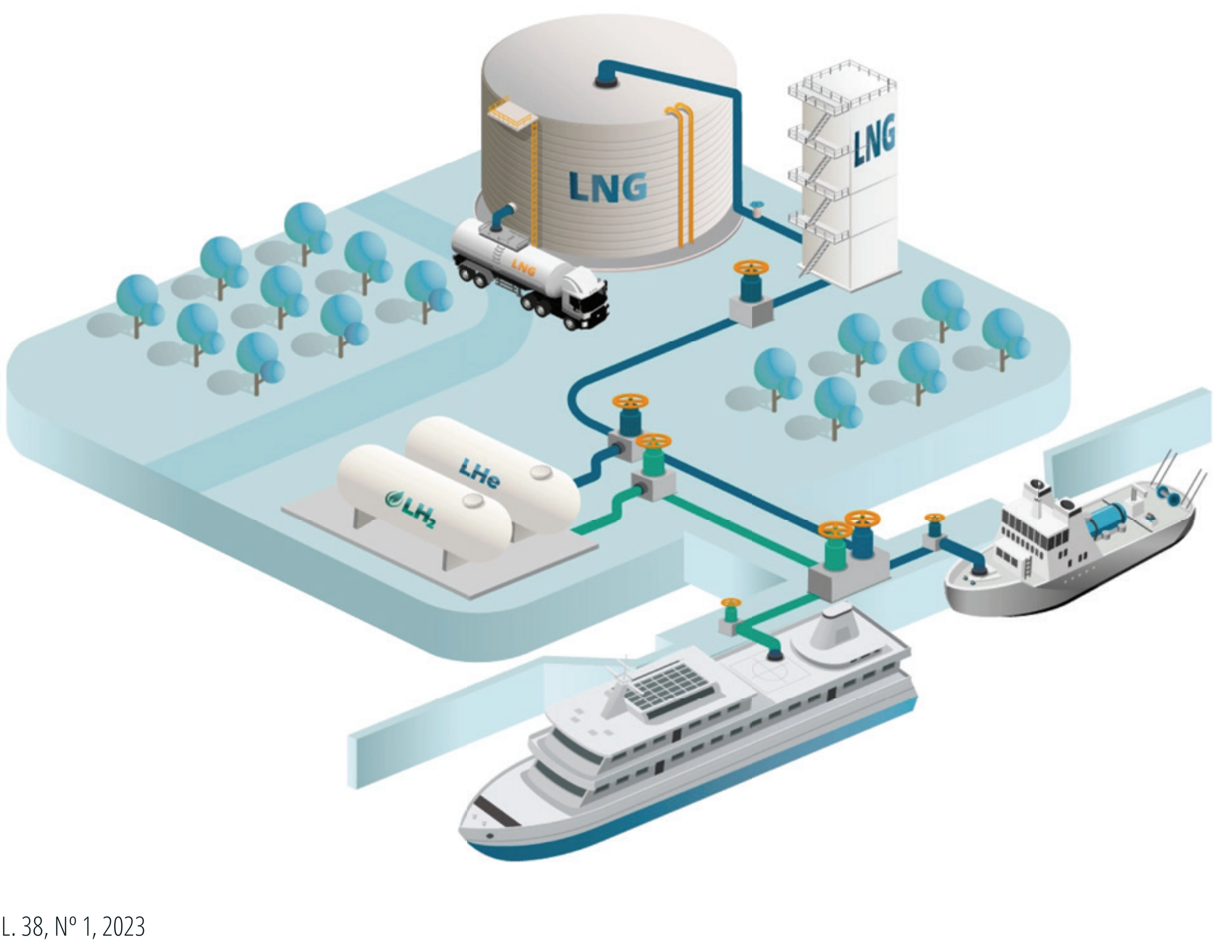
NICKEL – A VIP SOLUTION
TO LIQUID GAS TRANSPORTATION

Vacuum insulated piping (VIP) makes it possible to transport liquefied gases at temperatures well below 0°C to facilitate the energy transition.

LNG bunkering is the process of supplying liquefied natural gas to a vessel for use as fuel. In a pipe-to-ship layout, it starts with LNG from an onshore terminal which stores it ready for bunkering when needed. LNG is then transferred to the vessel through vacuum insulated piping.

VIP and nickel

Climate change is making us strive to reduce our carbon emissions. Non-carbon dioxide emitting fuels such as hydrogen and ammonia provide alternatives and liquefied natural gas (LNG) has proven to be a lower emissons alternative to oil as an energy source to produce electricity or heating. The production, transportation and use of these alternative energy carriers however requires liquefying them. In the case of LNG, this happens at very low temperatures. Care must be taken to ensure that the cooled



CRYOSPAIN

SCHWANNER GMBH

and liquefied gases stay liquid as long as required to store and supply them. For this to work, insulation of the liquefied gases from the environment is required.

This is where nickel comes into the picture. Nickel-containing stainless steels have many attractive properties. They are ductile and resilient even at low temperatures, making them an ideal choice in piping networks for the transportation of liquefied gases.

How does vacuum insulation work?
Think of a pipe-in-pipe layout that carries the liquefied gas on the inside. A vacuum between the two pipes prevents any loss of heat through conduction because the air (which is a conductor) is sucked out of the space between the inner and outer pipe. Translated into industrial applications, nickel-containing stainless steels are used for both inner and outer pipes as well as for the necessary spacers, valves and compensation bellows, which allow the cooling equipment to operate across a range of temperatures.

VIP can be used to transfer liquid hydrogen, argon, nitrogen, oxygen, helium and LNG. The benefits of VIP (as opposed to traditional insulation using, e.g. foam) are many. Firstly, there is the cooling efficiency, which keeps operating costs lower than those of traditional insulating methods. Secondly, vacuum insulated transfer lines take up less space than conventional insulation piping. The double-wall system with a vacuum in between offers an insulation value that is so high that it can only be matched by applying many layers of foam-like

Vacuum insulated pipes are manufactured from two concentric pipes, mostly made of nickel-containing stainless steel: an inner pipe or process pipe, which transports the liquefied gas; and an outer pipe or jacket, which maintains the vacuum. The pipes are separated from each other by pipe supports made of materials with very low thermal conductivity. VIP using double-wall stainless steel tubes can be pre-assembled in the factory which saves time and cost.

VIP can be used to transfer liquid hydrogen, argon, nitrogen, oxygen, helium and LNG.

materials, thus increasing the system's outer diameter. Also, when safety requires a double-containment system, the outer pipe provides just that. If the inner tube were to leak, the double-containment mitigates the risk. Foam insulated transfer pipes don't offer such a safety feature and require a concrete safety trench, which increases costs. VIP using double-wall stainless steel tubes can be pre-assembled in the factory. Traditional insulation solutions require the piping to be mounted on site and special care is needed to keep the insulation layer intact. This explains why VIP solutions can be mounted in half the time that would be required for pipes with traditional insulation. Finally, whereas foam-like insulation has a life span of only ten years, vacuum insulated piping using stainless steel is expected to last at least 20 years.

VIP is an essential part of LNG bunkering and reloading systems

The former refers to the process of supplying LNG (from onshore, from a bunkering vessel or from trucks) to a vessel for use as fuel. The latter concerns transferring LNG from onshore storage to either vessels (bulk reloading) or to trucks (through ISO containers), for use of the LNG for power generation or industrial use. With both LNG bunkering and reloading infrastructure, vacuum insulated piping connects the source of LNG to its destination. The technology also enables regasification of liquefied gas during transfer thanks to the high insulation efficiency.
Nickel: a VIP solution. How "cool" is that? Ni

Double-walled vacuum-sealed stainless steel bottle

The use of nickel-containing stainless steels for vacuum insulation is not limited to industrial solutions. In fact, drinking water bottles make use of the same principle. Vacuum-sealed bottles are double-walled too (whereas double-walled doesn't necessarily mean "vacuum sealed"). A stainless steel bottle that has been "vacuum-sealed" has two walls with a gap in between, which, due to the absence of any molecules doesn't transfer heat. A gap as small as 1mm can insulate food or drink inside your container.

ARSLO STAINLESS STEEL DOUBLE-WALL INSULATED WATER BOTTLE

NICKEL-BASED SUPERALLOYS
THE POWER TO PROPEL

The term "superalloy" was first used in the 1940s to describe a group of alloys developed for high-temperature applications such as turbosupercharger and aircraft engines. Superalloys are metallic materials which can withstand extreme temperatures because they possess microstructural stability, are resistant to high-temperature oxidation and, most importantly, resist high-temperature creep (elongation at high temperature). These alloys have found extensive use in many high-temperature applications, such as automotive exhaust valves, furnace structural parts, heat treatment equipment, nuclear plant components, rocket engines and, most significantly, in the hot zones of gas and jet turbines for electricity generation or to power aircraft.

Superalloys can be based on iron, cobalt or nickel, but nickel-based alloys are by far the dominant type. Nickel-based superalloys typically consist of more than 50% nickel and about 20% chromium. Their strength can be increased by "solid-solution strengthening" by adding elements such as cobalt and molybdenum, or by "precipitation hardening" where aluminium and/or titanium is added to produce alloys with the highest resistance to creep.

These alloys are used for critical components in gas turbines, such as turbine blades and exhaust nozzles, where pressure and heat are extreme.

Turbine fuel efficiency has been increased by controlling the crystal structure of the superalloy turbine blades, initially by making the crystals grown in the same longitudinal direction and then producing the blades as a single crystal which improves creep resistance, meaning resistance to elongation during operation. In addition, cooling passages to reduce surface metal temperatures and application of coatings to reduce oxidation allows turbines to operate at even higher temperatures.

The wonders of flying never cease to amaze with the increased power made possible, in part, because of the strength of nickel-based superalloys. Ni

Nominal composition of common nickel-based superalloys

	UNS/DIN	Ni%	Cr%	Co%	Mo%	Al%	Ti%
Alloy 75	N06075	bal	20	-	-	-	-
Alloy 80A	N07080	bal	20	1	-	1.5	2.2
Alloy 90	N07090	bal	20	18	-	1.5	2.5
105	2.4634	bal	20	20	5	4.7	1.2
115	2.4636	bal	15	14	4	4.7	4
263	N07263	bal	20	20	5.8	-	2.2

OLIVIER CLEYNEN

Nickel-based superalloys typically consist of more than 50% nickel and about 20% chromium. They are used where pressure and heat are extreme.

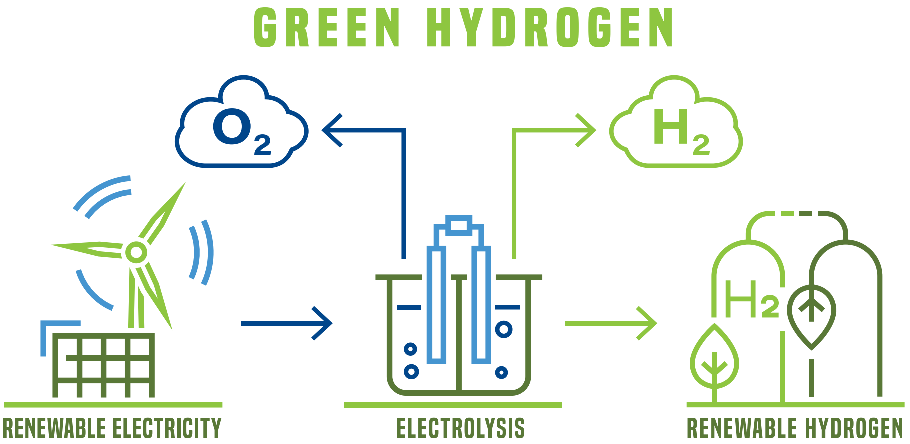
THE POWER OF GREEN HYDROGEN
USING NICKEL-CONTAINING STAINLESS STEEL

Green hydrogen has almost unlimited potential as a replacement for fossil fuels and will be an essential contributor to getting to net-zero. Nickel-containing stainless steel is a sustainable companion on the path to a climate neutral future.

Hydrogen is 14 times lighter than air, non-toxic, colourless and odourless, does not self-ignite and burns without residue with a colourless flame. It is gaseous down to -253 °C, after which it liquefies. It is a very reactive element that only occurs in a bound form, for example as a hydrogen molecule, in water with oxygen or in methane with carbon.

Hydrogen itself is energy intensive to produce. Worldwide annually, 30 million tonnes of "grey" hydrogen are produced from fossil fuels such as natural gas or oil, mostly by steam reforming. This is a process that converts water and methane into hydrogen and carbon dioxide (CO_2). And every tonne of hydrogen produces ten tonnes of CO_2.

LINDE HYDROGEN CENTER UNTERSCHLEISSHEIM, GERMANY © LINDE PLC



Going green

The more climate-friendly alternative is "green" hydrogen, produced in a climate neutral manner from 100% renewable energies. The most common production process for green hydrogen is electrolysis of water where hydrogen is separated from the oxygen.

Hydrogen is an important raw material for the chemical and petrochemical industries to produce basic chemicals such as green ammonia or green methanol. More than half of hydrogen production is processed into ammonia for the manufacture of fertilisers. Hydrogen can also be used directly for building heating, industrial furnaces and in fuel cells to drive electric motors for transportation. It is so attractive because its only exhaust emission is water.

The specific properties of hydrogen place the highest demands on the materials used for its generation, cryogenic storage, transport and use of electrolysers, high-pressure compressors, tanks, valves, pipes and fittings. The high diffusibility of hydrogen requires reliable gas tightness of all components to avoid losses and mitigate the risk of explosion or fire due to escaping hydrogen.

Strength & resistance

With many metals, hydrogen atoms can penetrate the material (permeation) and significantly impair their mechanical properties. Even at a hydrogen concentration of a few ppm, in susceptible material, degradation can occur resulting in the formation of cracks and brittle fracture and therefore represents an unacceptable safety risk. Components made of nickel-containing stainless steel, on the other hand, permanently resist both permeation and degradation thanks to their microstructure. Thus, they prevent gradual escape of gas and protect the components from embrittlement, maintaining consistently high strength, ductility and homogeneity.

For components that come into contact with hydrogen, austenitic stainless steel Types 316L (UNS S31603) and 304L (S30403) are used as standard. Types 317LMN (S31726), 2205 (S32205) and 2507 (S32750) are tried and tested for particularly critical applications.

Looking forward to a sustainable future, ways and means of producing, using and distributing green hydrogen are being expanded around the world. Many grades of stainless steel will play a key role in the process, from start to finish.

Adapted from an article by Ursula Herrling-Tusch on behalf of Warenzeichenverband Edelstahl Rostfrei e.V., https://www.wzv-rostfrei.de/

Hydrogen colour coding

Hydrogen is an element that exists primarily in molecular forms such as water and organic compounds. Hydrogen gas can be produced from various sources or processes. To identify these different sources or processes the hydrogen is identified by a colour-code. The most significant are the following:

Green hydrogen is produced through water electrolysis, which uses renewable electricity to split water into hydrogen and oxygen gas. The reason it is called green is that there is no CO_2 emission during the production process.

Grey, brown and black hydrogen is produced using fossil fuel, natural gas, lignite coal and bituminous coal, respectively. However, these options all emit CO_2 to differing degrees.

Blue hydrogen is derived from natural gas. However, the CO_2 is captured and stored underground (carbon sequestration). As no CO_2 is emitted, the blue hydrogen production process is categorised as carbon neutral.

Pink, purple and red hydrogen. Hypothetically, hydrogen can be produced by use of nuclear power. Pink hydrogen is generated through electrolysis of water by using electricity from a nuclear power plant. Purple hydrogen is made though using nuclear power and heat through combined chemo thermal electrolysis splitting of water. Red hydrogen is produced through the high-temperature catalytic splitting of water using nuclear power thermal as an energy source.

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: What is the maximum recommended flow velocity for stainless steel piping when using it for water applications?

A: Nickel-containing stainless steel does not have a recommended limit for flow velocity. *Table 1* shows the metal loss rate for various metals at velocities up to 8.2 m/s (27 ft/s), demonstrating that 316L (S31603) has the lowest metal loss rate at the higher velocity. In fact, this metal loss is less than the definition of corrosion resistance which is a metal loss rate equal to or less than 0.1 mm/y.

We also see the beneficial effect of increasing nickel content in nickel-containing metals which are not a stainless steel. The nickel content of 316L however is lower than these other nickel-containing materials but benefits from its corrosion resistant passive layer. In fact, 300 series stainless steels have been tested up to 40 m/s (125 ft/s) without any increase in metal loss, *Table 2*. Ni

Table 1: Metal loss rate in seawater at different velocities

		Metal loss mm/y at different velocities	
	Ni%	**0.3 m/s (1 ft/s)**	**8.2 m/s (27 ft/s)**
Carbon steel	-	0.16	1.17
Cast iron	-	0.23	1.36
Silicon bronze	-	0.004	1.46
Al bronze	<1%	0.023	1.10
90/10 CuNi	10	0.020	0.40
70/30 CuNi	30	<0.004	0.16
Alloy 400	65	<0.004	0.016
316L	10	0.005	<0.005

Table 2: Upper velocity limit for CuNi and 300 series stainless steel in seawater and potable water

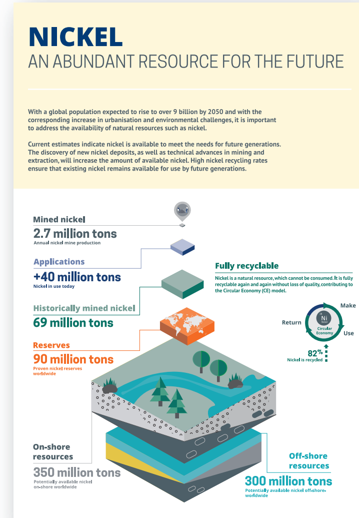
	Velocity limit m/s (ft/s)	
	Seawater	**Potable water**
90/10 Cu/Ni	2.4-3 (8-10)	3.7-4.6 (12-15)
70/30 Cu/Ni	3-3.7 (10-12)	4.6-5.5 (15-18)
300 series SS	>40 (125)	>40 (125)

NEW PUBLICATIONS

Is there enough nickel? The short answer is "yes"!

The terms "resources" and "reserves" are used when we refer to the availability of nickel. "Resources" describe potential future ore deposits which still need to be explored. "Reserves" occur when the exploration quantifies and assesses that the ore deposit can be mined economically. Today, there are 95 million tonnes of known nickel reserves, as well as 350 million tonnes of on-shore nickel resources and 300 million tonnes of potential off-shore resources. Companies are continuously adding new ore deposits to both resources and reserves. To this can be added around 40 million tonnes of nickel which is currently in use and which will eventually become available for recycling. At current production levels of 2.7 million tonnes per year we can say that there's enough nickel for current and future generations.

The Nickel Institute has updated its nickel resources and reserves fact sheet with the latest data. Download from *www.nickelinstitute.org* Ni



Nickel Plating Handbook

The Nickel Institute has published the second edition of the popular *Nickel Plating Handbook*. This free 104-page comprehensive guide to electroplating has been revised and updated by plating industry specialist, Dr William Lo.

The *Nickel Plating Handbook* reviews modern industrial nickel plating practice against a background of fundamental electrochemistry. It covers electrolyte composition, specifications for decorative coatings, engineering coatings, testing procedures, troubleshooting, practical tips, waste minimisation and advice on occupational and environmental health aspects of nickel plating. This edition includes new health and safety information and introduces a section on the prevention of nickel release from nickel plated and alloyed articles. The *Nickel Plating Handbook* is a high quality guide to electroplating and provides practical information for the operation and control of nickel plating processes. Download from *www.nickelinstitute.org* Ni

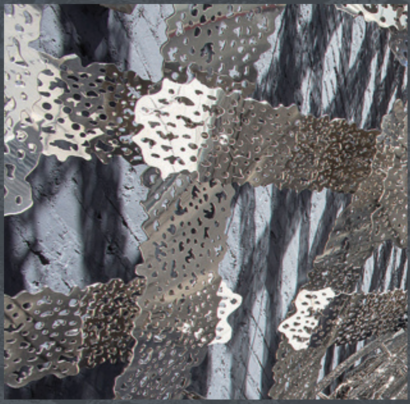
UNS DETAILS

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

UNS	C	Cr	Fe	Mn	Mo	N	Ni	P	S	Si
S30403 pg 13	0.03 max	18.0-20.0	bal	2.00 max	-	-	8.0-12.0	0.045 max	0.030 max	1.00 max
S31603 pg 2,13,14,16	0.030 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
S31726 pg 13	0.030 max	17.0 20.0	bal	2.00 max	4.00-6.00	0.10-0.20	13.5-17.5	0.045 max	0.030 max	1.00 max
S32205 pg 13	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 13	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

GLIMMERING WALLED GARDEN

DANIEL KUKLA



A complex structure and engineering feat, the "foliage" ribbons are laser-cut out of 11-gauge (3 mm) 316L alloy (UNS S31603) stainless steel and polished with a #4 non-directional finish on the back and a #7 mirror finish on the front.

It's a stunning and massive piece of art composed of 900 linear metres of perforated stainless steel, cut with an irregular "foliage" pattern, designed to reflect the ivy-covered walls and green spaces that surround the Brooklyn Academy of Music's (BAM) Harvey Theater.

Called *Paradise Parados*, its award-winning creator, Teresita Fernández worked with Camber Studio in Brooklyn, choosing mirror-polished stainless steel, fabricated in varied interwoven layers. The artist envisioned an immersive, coherent experience where viewers are "surrounded by the artwork, walk underneath it, and see their own reflections in the myriad foliage weave patterns."

Camber Studio developed a detailed digital model from the artist's initial sketches, systematising the artwork geometry to limit the number of unique parts while maintaining its organic character. They worked with licensed engineers "to analyse the geometry for structural performance and develop the connection details, both within the weave and to the masonry wall."

Since its unveiling in 2022, the installation is not only turning heads, but it has also received esteemed recognition including an NYC Public Design Commission Excellence in Design Award. Ni