Stainless steel

Stainless steel cladding is used on the Walt Disney Concert Hall

In metallurgy, **stainless steel**, also known as **inox steel** or **inox** from French *inoxydable*, is a steel alloy with a minimum of 10.5%[1] chromium content by mass.

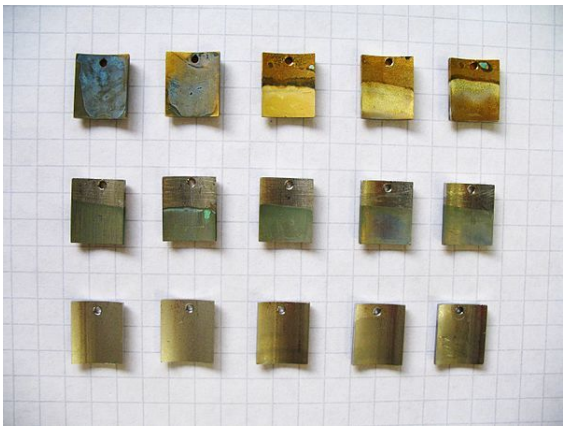
1 Description

Stainless steel is used for corrosion-resistant tools such as this nutcracker

Stainless steel does not readily corrode, rust or stain with water as ordinary steel does. However, it is not fully stainproof in low-oxygen, high-salinity, or poor air-circulation environments.[2] There are different grades and surface finishes of stainless steel to suit the environment the alloy must endure. Stainless steel is used where both the properties of steel and corrosion resistance are required.

Stainless steel differs from carbon steel by the amount of chromium present. Unprotected carbon steel rusts readily when exposed to air and moisture. This iron oxide film (the rust) is active and accelerates corrosion by forming more iron oxide; and, because of the greater volume of the iron oxide, this tends to flake and fall away. Stainless steels contain sufficient chromium to form a passive film of chromium oxide, which prevents further surface corrosion by blocking oxygen diffusion to the steel surface and blocks corrosion from spreading into the metal's internal structure.[3] Passivation occurs only if the proportion of chromium is high enough and oxygen is present.

2 Properties



Stainless steel (row 3) resists salt-water corrosion better than aluminum-bronze (row 1) or copper-nickel alloys (row 2)

Stainless steel is not completely immune to corrosion in this desalination equipment

2.1 Oxidation

High oxidation resistance in air at ambient temperature is normally achieved with addition of a minimum of 13% (by weight) chromium, and up to 26% is used for

harsh environments.[4] The chromium forms a passivation layer of chromium(III) oxide (Cr_2O_3) when exposed to oxygen. The layer is too thin to be visible, and the metal remains lustrous and smooth. The layer is impervious to water and air, protecting the metal beneath, and this layer quickly reforms when the surface is scratched. This phenomenon is called passivation and is seen in other metals, such as aluminium and titanium. Corrosion resistance can be adversely affected if the component is used in a non-oxygenated environment, a typical example being underwater keel bolts buried in timber.

When stainless steel parts such as nuts and bolts are forced together, the oxide layer can be scraped off, allowing the parts to weld together. When forcibly disassembled, the welded material may be torn and pitted, an effect known as galling. This destructive galling can be avoided by the use of dissimilar materials for the parts forced together, for example bronze and stainless steel, or even different types of stainless steels (martensitic against austenitic). However, two different alloys electrically connected in a humid environment may act as a voltaic pile and corrode faster. Nitronic alloys made by selective alloying with manganese and nitrogen may have a reduced tendency to gall. Additionally, threaded joints may be lubricated to prevent galling. Low-temperature carburizing is another option that virtually eliminates galling and allows the use of similar materials without the risk of corrosion and the need for lubrication.

2.2 Acids

Stainless steel is generally highly resistant to attack from acids, but this quality depends on the kind and concentration of the acid, the surrounding temperature, and the type of steel. Type 904 is resistant to sulfuric acid at room temperature, even in high concentrations; type 316 and 317 are resistant below 10%, and 304 should not be used in the presence of sulfuric acid at any concentration. All types of stainless steel resist attack from phosphoric acid, 316 and 317 more so than 304; types 304L and 430 have been successfully used with nitric acid. Hydrochloric acid will damage any kind of stainless steel, and should be avoided.[5]

2.3 Bases

The 300 series of stainless steel grades is unaffected by any of the weak bases such as ammonium hydroxide, even in high concentrations and at high temperatures. The same grades of stainless exposed to stronger bases such as sodium hydroxide at high concentrations and high temperatures will likely experience some etching and cracking, especially with solutions containing chlorides such as sodium hypochlorite.[5]

2.4 Organics

Types 316 and 317 are both useful for storing and handling acetic acid, especially in solutions where it is combined with formic acid and when aeration is not present (oxygen helps protect stainless steel under such conditions), though 317 provides the greatest level of resistance to corrosion. Type 304 is also commonly used with formic acid though it will tend to discolor the solution. All grades resist damage from aldehydes and amines, though in the latter case grade 316 is preferable to 304; cellulose acetate will damage 304 unless the temperature is kept low. Fats and fatty acids only affect grade 304 at temperatures above 150 °C (302 °F), and grade 316 above 260 °C (500 °F), while 317 is unaffected at all temperatures. Type 316L is required for processing of urea.[5]

2.5 Electricity and magnetism

Poor selection of materials can cause galvanic corrosion to other metals in contact with stainless steel

Like steel, stainless steel is a relatively poor conductor of electricity, with lower electrical conductivity than copper. Other metals in contact with stainless steel in a damp environment may suffer galvanic corrosion even though the stainless metal may be unaffected.

Ferritic and martensitic stainless steels are magnetic. Annealed austenitic stainless steels are non-magnetic. Work hardening can make austenitic stainless steels slightly magnetic.

2.6 3D printing

Some 3D printing providers have developed proprietary stainless steel sintering blends for use in rapid prototyping. One of the more popular stainless steel grades used in 3D printing is 316L stainless steel. Due to the high temperature gradient and fast rate of solidification, stainless steel products manufactured via 3D printing tend to have a more refined microstructure; this in turn results in better mechanical properties. However, stainless steel is not used as much as materials like Ti6Al4V in the 3D printing industry, this is because stainless steel products, manufactured via the traditional methods, is currently much more economically competitive.

3 Types

Main article: SAE steel grades

There are different types of stainless steels: when nickel

Pipes and fittings made of stainless steel

is added, for instance, the austenite structure of iron is stabilized. This crystal structure makes such steels virtually non-magnetic and less brittle at low temperatures. For greater hardness and strength, more carbon is added. With proper heat treatment, these steels are used for such products as razor blades, cutlery, and tools.

Significant quantities of manganese have been used in many stainless steel compositions. Manganese preserves an austenitic structure in the steel, similar to nickel, but at a lower cost.

Stainless steels are also classified by their crystalline structure:

- *Austenitic*, or 200 and 300 series, stainless steels have an austenitic crystalline structure, which is a face-centered cubic crystal structure. Austenite steels make up over 70% of total stainless steel production. They contain a maximum of 0.15% carbon, a minimum of 16% chromium, and sufficient nickel and/or manganese to retain an austenitic structure at all temperatures from the cryogenic region to the melting point of the alloy.

  - 200 Series—austenitic chromium-nickel-manganese alloys. Type 201 is hardenable through cold working; Type 202 is a general purpose stainless steel. Decreasing nickel content and increasing manganese results in weak corrosion resistance.[6]

  - 300 Series. The most widely used austenite steel is the 304, also known as *18/8* for its composition of 18% chromium and 8% nickel.[7] 304 may be referred to as A2 stainless (not to be confused with AISI grade A2 *air hardening* alloy tool steel containing about 5% chromium). The second most common austenite steel is the 316 grade, also referred to as A4 stainless and called marine grade stainless, used primarily for its increased resistance to corrosion. A typical composition of 18% chromium and 10% nickel, commonly known as *18/10 stainless*, is often used in cutlery and high-quality cookware. *18/0* is also available.

  Superaustenitic stainless steels, such as Allegheny Ludlum alloy AL-6XN and 254SMO, exhibit great resistance to chloride pitting and crevice corrosion because of high molybdenum content (>6%) and nitrogen additions, and the higher nickel content ensures better resistance to stress-corrosion cracking versus the 300 series. The higher alloy content of superaustenitic steels makes them more expensive. Other steels can offer similar performance at lower cost and are preferred in certain applications. For example ASTM A387 is used in pressure vessels but is a low-alloy carbon steel with a chromium content of 0.5% to 9%.[8] Low-carbon versions, for example 316L or 304L, are used to avoid corrosion problems caused by welding. Grade 316LVM is preferred where biocompatibility is required (such as body implants and piercings).[9] The "L" means that the carbon content of the alloy is below 0.03%, which reduces the sensitization effect (precipitation of chromium carbides at grain boundaries) caused by the high temperatures involved in welding.

- *Ferritic* stainless steels generally have better engineering properties than austenitic grades, but have reduced corrosion resistance, because of the lower chromium and nickel content. They are also usually less expensive. Ferritic stainless steels have a body-centered cubic crystal system and contain between 10.5% and 27% chromium with very little nickel, if any, but some types can contain lead. Most compositions include molybdenum; some, aluminium or titanium. Common ferritic grades include 18Cr-2Mo, 26Cr-1Mo, 29Cr-4Mo, and 29Cr-4Mo-2Ni. These alloys can be degraded by the presence of σ chromium, an intermetallic phase which can precipitate upon welding.

- *Martensitic* stainless steels are not as corrosion-resistant as the other two classes but are extremely strong and tough, as well as highly machinable, and can be hardened by heat treatment. Martensitic stainless steel contains chromium (12–14%),

Swiss Army knives are made of martensitic stainless steel.

molybdenum (0.2–1%), nickel (less than 2%), and carbon (about 0.1–1%) (giving it more hardness but making the material a bit more brittle). It is quenched and magnetic.

- *Duplex steel* stainless steels have a mixed microstructure of austenite and ferrite, the aim usually being to produce a 50/50 mix, although in commercial alloys the ratio may be 40/60. Duplex stainless steels have roughly twice the strength compared to austenitic stainless steels and also improved resistance to localized corrosion, particularly pitting, crevice corrosion and stress corrosion cracking. They are characterized by high chromium (19–32%) and molybdenum (up to 5%) and lower nickel contents than austenitic stainless steels.

  The properties of duplex stainless steels are achieved with an overall lower alloy content than similar-performing super-austenitic grades, making their use cost-effective for many applications. Duplex grades are characterized into groups based on their alloy content and corrosion resistance.

  - *Lean duplex* refers to grades such as UNS S32101 (LDX 2101), S32202 (UR2202), S32304, and S32003.
  - *Standard duplex* refers to grades with 22% chromium, such as UNS S31803/S32205, with 2205 being the most widely used.
  - *Super duplex* is by definition a duplex stainless steel with a Pitting Resistance Equivalent Number (PREN) > 40, where PREN = %Cr + 3.3x(%Mo + 0.5x%W) + 16x%N. Usually super duplex grades have 25% or more chromium. Some common examples are S32760 (Zeron 100 via Rolled Alloys), S32750 (2507), and S32550 (Ferralium).
  - *Hyper duplex* refers to duplex grades with a PRE > 48. UNS S32707 and S33207 are the only grades currently available on the market.

- *Precipitation-hardening martensitic* stainless steels have corrosion resistance comparable to austenitic varieties, but can be precipitation hardened to even higher strengths than the other martensitic grades. The most common, 17-4PH, uses about 17% chromium and 4% nickel.

3.1 Grades

See also: Steel grades and SAE steel grades

There are over 150 grades of stainless steel, of which 15 are most commonly used. There are a number of systems for grading stainless and other steels, including US SAE steel grades.

3.2 Comparison of standardized steels

4 Standard finishes

Main article: Brushed metal

Standard mill finishes can be applied to flat rolled stainless steel directly by the rollers and by mechanical abrasives. Steel is first rolled to size and thickness and then

316L stainless steel, with an unpolished, mill finish

annealed to change the properties of the final material. Any oxidation that forms on the surface (mill scale) is removed by pickling, and a passivation layer is created on the surface. A final finish can then be applied to achieve the desired aesthetic appearance.

- No. 0: Hot rolled, annealed, thicker plates
- No. 1: Hot rolled, annealed and passivated
- No. 2D: Cold rolled, annealed, pickled and passivated
- No. 2B: Same as above with additional pass through highly polished rollers
- No. 2BA: Bright annealed (BA or 2R) same as above then bright annealed under oxygen-free atmospheric condition
- No. 3: Coarse abrasive finish applied mechanically
- No. 4: Brushed finish
- No. 5: Satin finish
- No. 6: Matte finish (brushed but smoother than #4)
- No. 7: Reflective finish
- No. 8: Mirror finish
- No. 9: Bead blast finish
- No. 10: Heat colored finish—offering a wide range of electropolished and heat colored surfaces

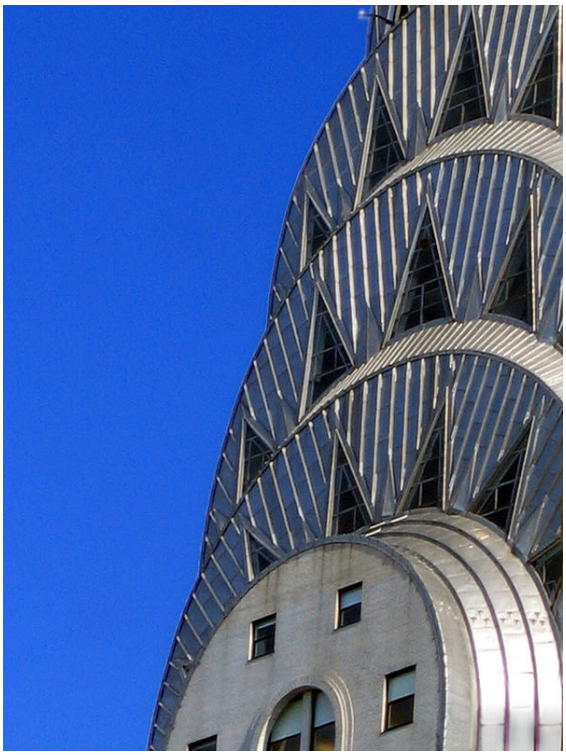
5 Applications

Stainless steel's resistance to corrosion and staining, low maintenance, and familiar lustre make it an ideal material for many applications. The alloy is milled into coils, sheets, plates, bars, wire, and tubing to be used in cookware, cutlery, household hardware, surgical instruments, major appliances, industrial equipment (for example, in sugar refineries) and as an automotive and aerospace structural alloy and construction material in large buildings. Storage tanks and tankers used to transport orange juice and other food are often made of stainless steel, because of its corrosion resistance. This also influences its use in commercial kitchens and food processing plants, as it can be steam-cleaned and sterilized and does not need paint or other surface finishes.

Stainless steel is used for jewelry and watches, with 316L being the type commonly used for such applications. It can be re-finished by any jeweler and will not oxidize or turn black.

Some firearms incorporate stainless steel components as an alternative to blued or parkerized steel. Some handgun models, such as the Smith & Wesson Model 60 and the

The 630-foot-high (190 m), stainless-clad (type 304) Gateway Arch defines St. Louis's skyline



The pinnacle of New York's Chrysler Building is clad with Nirosta *stainless steel, a form of Type 302*[11][12]

An art deco sculpture on the Niagara-Mohawk Power building in Syracuse, New York

Colt M1911 pistol, can be made entirely from stainless steel. This gives a high-luster finish similar in appearance to nickel plating. Unlike plating, the finish is not subject to flaking, peeling, wear-off from rubbing (as when repeatedly removed from a holster), or rust when scratched.

Some automotive manufacturers use stainless steel as decorative highlights in their vehicles.

5.1 Architecture

Main article: Architectural steel

Stainless steel is used for buildings for both practical and aesthetic reasons. Stainless steel was in vogue during the art deco period. The most famous example of this is the upper portion of the Chrysler Building (pictured). Some diners and fast-food restaurants use large ornamental panels and stainless fixtures and furniture. Because of the durability of the material, many of these buildings still retain their original appearance. Stainless steel is used today in building construction because of its durability and because it is a weldable building metal that can be made into aesthetically pleasing shapes. An example of a building in which these properties are exploited is the Art Gallery of Alberta in Edmonton, which is wrapped in stainless steel.

Type 316 stainless is used on the exterior of both the Petronas Twin Towers and the Jin Mao Building, two of the world's tallest skyscrapers.[12]

The Parliament House of Australia in Canberra has a stainless steel flagpole weighing over 220 tonnes (240 short tons).

The aeration building in the Edmonton Composting Facility, the size of 14 hockey rinks, is the largest stainless steel building in North America.

5.2 Bridges

- The Helix Bridge is a pedestrian bridge linking Marina Centre with Marina South in the Marina Bay area in Singapore.
- Cala Galdana Bridge in Minorca (Spain) was the first stainless steel road bridge.
- Sant Fruitos Pedestrian Bridge (Catalonia, Spain), arch pedestrian bridge.
- Padre Arrupe Bridge (Bilbao, Spain) links the Guggenheim museum to the University of Deusto.[13]

5.3 Monuments and sculptures

- Unisphere, constructed as the theme symbol of the 1964 New York World's Fair, is constructed of Type 304L stainless steel as a spherical framework with a diameter of 120 feet (37 m) (New York City)
- Gateway Arch (pictured) is clad entirely in stainless steel: 886 tons (804 metric tonnes) of 0.25 in (6.4 mm) plate, #3 finish, type 304 stainless steel.[14] (St. Louis, Missouri)
- United States Air Force Memorial has an austenitic stainless steel structural skin (Arlington, Virginia)
- Atomium was renovated with stainless-steel cladding in a renovation completed in 2006; previously the spheres and tubes of the structure were clad in aluminium (Brussels, Belgium)
- Cloud Gate sculpture by Anish Kapoor (Chicago, Illinois)
- Sibelius Monument is made entirely of stainless steel tubes (Helsinki, Finland)
- The Kelpies (Falkirk, Scotland)
- Man of Steel (sculpture) under construction (Rotherham, England)
- Juraj Jánošík monument (Terchova, Slovakia)

Surgical tools, such as these hemostats, are commonly made of stainless steel

Stainless steel is often used for everyday kitchen sinks, appliances, and cookware

Stainless steel is often used for cookware

5.4 Other

Automotive bodies

The Allegheny Ludlum Corporation worked with Ford on various concept cars with stainless steel bodies from the 1930s through the 1970s to demonstrate the material's potential. The 1957 and 1958 Cadillac Eldorado Brougham had a stainless steel roof. In 1981 and 1982, the DeLorean DMC-12 production automobile used Type-304 stainless steel body panels over a glass-reinforced plastic monocoque. Intercity buses made by Motor Coach Industries are partially made of stainless steel. The aft body panel of the Porsche Cayman model

Stainless steel is used for industrial equipment when durability and cleanability are important

(2-door coupe hatchback) is made of stainless steel. It was discovered during early body prototyping that conventional steel could not be formed without cracking (due to the many curves and angles in that automobile). Thus, Porsche was forced to use stainless steel on the Cayman.

Passenger rail cars

Rail cars have commonly been manufactured using corrugated stainless steel panels (for additional structural strength). This was particularly popular during the 1960s and 1970s, but has since declined. One notable example was the early Pioneer Zephyr. Notable former manufacturers of stainless steel rolling stock included the Budd Company (USA), which has been licensed to Japan's Tokyu Car Corporation, and the Portuguese company Sorefame. Many railcars in the United States are still manufactured with stainless steel, unlike other countries who have shifted away.

Aircraft

Budd also built an airplane, the Budd BB-1 Pioneer, of stainless steel tube and sheet, which is on display at the Franklin Institute.

The American Fleetwings Sea Bird amphibious aircraft of 1936 was also built using a spot-welded stainless steel hull.

The Bristol Aeroplane Company built the all-stainless steel Bristol 188 high-speed research aircraft, which first flew in 1963.

The use of stainless steel in mainstream aircraft is hindered by its excessive weight compared to other materials, such as aluminum.

Airports

Stainless steel is a modern trend for roofing material for airports due to its low glare reflectance to keep pilots from being blinded, also for its properties that allow thermal reflectance in order to keep the surface of the roof close to ambient temperature. The Hamad International Airport in Qatar was built with all stainless steel roofing for these reasons, as well as the Sacramento International Airport in California.

Jewelry

Valadium, a stainless steel and 12% nickel alloy is used to make class and military rings. Valadium is usually silver-toned, but can be electro-plated to give it a gold tone. The gold tone variety is known as Sun-lite Valadium.[15] Other "Valadium" types of alloy are trade-named differently, with such names as "Siladium" and "White Lazon."

Surgery and dentistry

Surgical tools and medical equipment are usually made of stainless steel, because of its durability and ability to be sterilized in an autoclave. In addition, surgical implants such as bone reinforcements and replacements (e.g. hip sockets and cranial plates) are made with special alloys formulated to resist corrosion, mechanical wear, and biological reactions *in vivo*.

Stainless steel is used in a variety of applications in dentistry. It is common to use stainless steel in many instruments that need to be sterilized, such as needles,[16] endodontic files in root canal therapy, metal posts in root canal–treated teeth, temporary crowns and crowns for deciduous teeth, and arch wires and brackets in orthodontics.[17] The surgical stainless steel alloys (e.g., 316 low-carbon steel) have also been used in some of the early dental implants.[18]

Kitchens

Stainless steel is often preferred for kitchen sinks because of its ruggedness, durability, heat resistance, and ease of cleaning. In better models, acoustic noise is controlled by applying resilient undercoating to dampen vibrations. The material is also used for cladding of surfaces such as appliances and backsplashes.

Cookware and bakeware may be clad in stainless steels, to enhance their cleanability and durability. Because stainless steel is a poor conductor of heat, it is often used as a thin surface cladding over a core of copper or aluminum, which conduct heat more readily.

6 Maintenance

If treated or stored incorrectly, any grade of stainless steel may discolor or stain. To maintain optimum appearance, the surface should be cared for regularly.

6.1 During installation

The quality of installation affects the durability and lifespan of stainless steel.[19] Therefore, it is important to make sure stainless steel is in good condition before installation. Normally, giving it a quick clean is enough prior to installation. However, if surface contamination is present, more attention is required. In fields such as aerospace, pharmaceuticals and food handling, an extremely high standard of cleanliness may be required, so extra care should be taken.

6.2 Routine maintenance

Maintenance is required to maintain the quality and appearance of steel. Depending on the environment, it is carried out between one and ten times per year. A proper maintenance routine significantly prolongs the life of stainless steel.[20]

6.3 Maintenance tools

Abrasive cleaning tools should be avoided to prevent alteration of stainless steel finishes. Chloride-containing solutions, such as bleach, should also be avoided.

- Soft cloth and water: suitable for cosmetic issues and general cleaning
- Mild detergent: needed if stains cannot be easily lifted with water
- Glass cleaner: useful for removing fingerprints and similar stains

6.4 Corrosion[21]

Despite its design and use, stainless steel can still be susceptible to corrosion, some grades more than others, and especially in corrosive environments. Challenging environments include saline environments, such as coastal areas where regular exposure to sea salt is common and areas where de-icing salts are common during winter. Manufacturing environments, especially in chemical and food industries, may also be subject to corrosive substances.

Stainless steel may also corrode if surfaces come into direct contact with iron or carbon steel. Trace particles from iron or carbon steel will rust on stainless steel surfaces. If left unattended, rust spots may compromise surface passivation and may spread internally. Contamination is common when stainless steel is subject to sparks from nearby welding, cutting, drilling, or grinding of carbon steel.

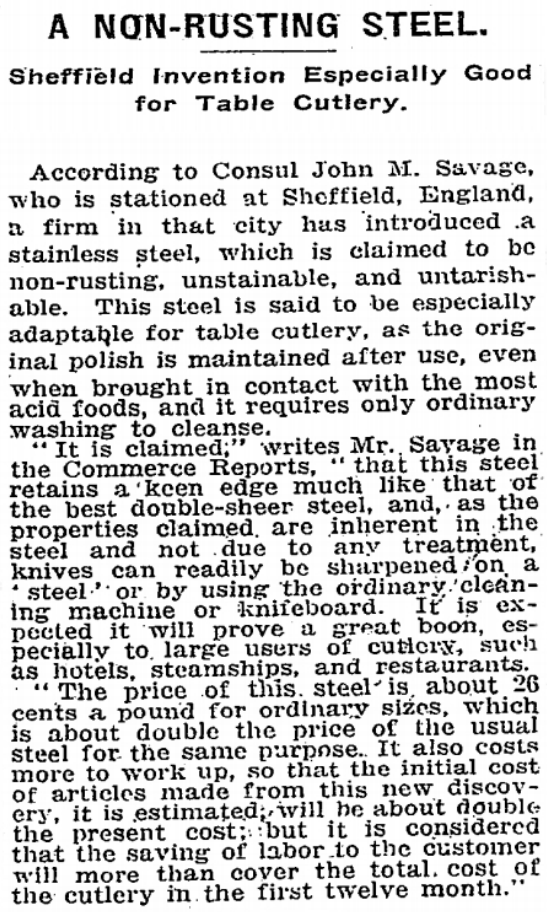
6.5 Treating stainless steel corrosion[22]

- Light rust: all-purpose lubricant or domestic stainless steel cleaners (typically containing calcium carbonate or citric acid)
- Moderate rust: phosphorus acid solutions
- Severe rust: hydrofluoric acid bath (typically performed by professional service providers due to the hazardous nature of chemicals)

7 Recycling and reuse

Stainless steel is 100% recyclable. An average stainless steel object is composed of about 60% recycled material of which approximately 40% originates from end-of-life products and about 60% comes from manufacturing processes.[23] According to the International Resource Panel's Metal Stocks in Society report, the per capita stock of stainless steel in use in society is 80–180 kg in more developed countries and 15 kg in less-developed countries.

There is a secondary market that recycles usable scrap for many stainless steel markets. The product is mostly coil, sheet, and blanks. This material is purchased at a less-than-prime price and sold to commercial quality stampers and sheet metal houses. The material may have scratches, pits, and dents but is made to the current specifications.



A NON-RUSTING STEEL.

Sheffield Invention Especially Good for Table Cutlery.

According to Consul John M. Savage, who is stationed at Sheffield, England, a firm in that city has introduced a stainless steel, which is claimed to be non-rusting, unstainable, and untarishable. This steel is said to be especially adaptable for table cutlery, as the original polish is maintained after use, even when brought in contact with the most acid foods, and it requires only ordinary washing to cleanse.

"It is claimed," writes Mr. Savage in the Commerce Reports, "that this steel retains a keen edge much like that of the best double-sheer steel, and, as the properties claimed are inherent in the steel and not due to any treatment, knives can readily be sharpened on a 'steel' or by using the ordinary cleaning machine or knifeboard. It is expected it will prove a great boon, especially to large users of cutlery, such as hotels, steamships, and restaurants.

"The price of this steel is about 26 cents a pound for ordinary sizes, which is about double the price of the usual steel for the same purpose. It also costs more to work up, so that the initial cost of articles made from this new discovery, it is estimated, will be about double the present cost; but it is considered that the saving of labor to the customer will more than cover the total cost of the cutlery in the first twelve month."

An announcement, as it appeared in the 1915 New York Times, *of the development of stainless steel*[24]

8 Health effects

Stainless steel is generally considered to be biologically inert, but some sensitive individuals develop a skin irritation due to a nickel allergy caused by certain alloys.

9 History

The corrosion resistance of iron-chromium alloys was first recognized in 1821 by French metallurgist Pierre Berthier, who noted their resistance against attack by some acids and suggested their use in cutlery. Metallurgists of the 19th century were unable to produce the combination of low carbon and high chromium found in most modern stainless steels, and the high-chromium alloys they could produce were too brittle to be practical.

In 1872, the Englishmen Clark and Woods patented an alloy that would today be considered a stainless steel.[25]

In the late 1890s Hans Goldschmidt of Germany developed an aluminothermic (thermite) process for producing carbon-free chromium. Between 1904 and 1911 several researchers, particularly Leon Guillet of France, prepared alloys that would today be considered stainless steel.[26]

Friedrich Krupp Germaniawerft built the 366-ton sailing yacht *Germania* featuring a chrome-nickel steel hull in Germany in 1908.[27] In 1911, Philip Monnartz reported on the relationship between chromium content and corrosion resistance. On 17 October 1912, Krupp engineers Benno Strauss and Eduard Maurer patented austenitic stainless steel as Nirosta.[28][29][30]

Similar developments were taking place contemporaneously in the United States, where Christian Dantsizen and Frederick Becket were industrializing ferritic stainless steel. In 1912, Elwood Haynes applied for a US patent on a martensitic stainless steel alloy, which was not granted until 1919.[31]

Also in 1912, Harry Brearley of the Brown-Firth research laboratory in Sheffield, England, while seeking a corrosion-resistant alloy for gun barrels, discovered and subsequently industrialized a martensitic stainless steel alloy. The discovery was announced two years later in a January 1915 newspaper article in *The New York Times*.[24] The metal was later marketed under the "Staybrite" brand by Firth Vickers in England and was used for the new entrance canopy for the Savoy Hotel in

London in 1929.[32] Brearley applied for a US patent during 1915 only to find that Haynes had already registered a patent. Brearley and Haynes pooled their funding and with a group of investors formed the American Stainless Steel Corporation, with headquarters in Pittsburgh, Pennsylvania.[33]

In the beginning stainless steel was sold in the US under different brand names like "Allegheny metal" and "Nirosta steel". Even within the metallurgy industry the eventual name remained unsettled; in 1921 one trade journal was calling it "unstainable steel."[34] In 1929, before the Great Depression hit, over 25,000 tons of stainless steel were manufactured and sold in the US.[35]

10 See also

- Argon oxygen decarburization
- Crucible Industries
- List of blade materials
- List of steel producers
- Panel edge staining
- Pitting Resistance Equivalent Number
- Marine grade stainless
- Rouging
- Stainless steel fiber
- Stainless steel soap

11 References

[1] "The Stainless Steel Family" (PDF). Retrieved 8 December 2012.

[2] "Why is Stainless Steel Stainless?". Retrieved 6 September 2013.

[3] Jianhai Qiu. "Stainless Steels and Alloys: Why They Resist Corrosion and How They Fail". Corrosionclinic.com. Retrieved on 29 June 2012.

[4] Ashby, Michael F.; David R. H. Jones (1992) [1986]. "Chapter 12". *Engineering Materials 2* (with corrections ed.). Oxford: Pergamon Press. p. 119. ISBN 0-08-032532-7.

[5] Davis (1994), *Stainless Steels, Joseph R.*, ASM International, p. 118, ISBN 978-0-87170-503-7

[6] Habara, Yasuhiro. Stainless Steel 200 Series: An Opportunity for Mn. Technical Development Dept., Nippon Metal Industry, Co., Ltd.

[7] Stainless Steel – Grade 304 (UNS S30400). azom.com

[8] ASTM A 387/ A387M – 06a Standard Specification for Pressure Vessel Plates, Alloy Steel, Chromium-Molybdenum

[9] Material Properties Data: Marine Grade Stainless Steel. Makeitfrom.com. Retrieved on 29 June 2012.

[10] "310 310S Stainless Steel". TubingChina.com Stainless Steel Directory.

[11] Start of production: First coil on new mill at the Wayback Machine (archived 30 May 2013). thyssenkrupp-nirosta.de

[12] What is Stainless Steel? at the Wayback Machine (archived 24 September 2006) nickelinstitute.org

[13] "Stainless steel bridge" "Stainless Steel Bridge in Bilbao" Check |url= value (help). *Outokumpu*.

[14] Gateway Arch Fact Sheet. Nps.gov. Retrieved on 29 June 2012.

[15] "What is Valadium?".

[16] Malamed, Stanley (2004). *Handbook of Local Anesthesia*, 5th Edition. Mosby. ISBN 0323024491. p. 99

[17] Anusavice, Kenneth J. (2003) *Phillips' Science of Dental Materials*, 11th Edition. W.B. Saunders Company. ISBN 0721693873. p. 639

[18] Misch, Carl E. (2008) *Contemporary Implant Dentistry*. Mosby. ISBN 0323043739. pp. 277–278

[19] "Maintenance of Stainless Steel Products". 2013. Retrieved 11 October 2013.

[20] Kopecki, E. (1937). *Cleaning Stainless Steel*. ASTM International.

[21] "Article: Cleaning methods for stainless steel". *www.bssa.org.uk*. Retrieved 2016-05-06.

[22] "Article: Care and maintenance of stainless steel". *www.bssa.org.uk*. Retrieved 2016-05-06.

[23] "The Recycling of Stainless Steel ("Recycled Content" and "Input Composition" slides)" (Flash). International Stainless Steel Forum. 2006. Retrieved 19 November 2006.

[24] "A non-rusting steel". *New York Times*. 31 January 1915.

[25] http://www.airedalesprings.co.uk/its-complicated-the-discovery-of-stainless-steel/

[26] http://www.bssa.org.uk/about_stainless_steel.php?id=31

[27] "A Proposal to Establish the Shipwreck Half Moon as a State Underwater Archaeological Preserve" (PDF). Bureau of Archaeological Research, Division of Historical Resources, Florida Department of State. May 2000.

[28] "ThyssenKrupp Nirosta: History". Retrieved 13 August 2007.

[29] German Patent Office: Deutsches Reichspatent Nr. 304126, erteilt am 18. Oktober 1912

[30] German Patent Office: Deutsches Reichspatent Nr. 304159, erteilt am 21. Dezember 1912

[31] Carlisle, Rodney P. (2004) Scientific American Inventions and Discoveries, p. 380, John Wiley and Sons, ISBN 0-471-24410-4

[32] Howse, Geoffrey (2011) *A Photographic History of Sheffield Steel*, History Press, ISBN 0752459856

[33] Cobb, Harold M. (2010). *The History of Stainless Steel*. ASM International. p. 360. ISBN 1-61503-010-7.

[34] Moneypenny, J.H.G. (1921). "Unstainable Steel". *Mining and Scientific Press*. Retrieved 17 February 2013.

[35] Bonnier Corporation (1930). *Popular Science*. Bonnier Corporation. pp. 31–. ISSN 0161-7370.

12 External links

- Comprehensive Information About Stainless Steel by The Stainless Steel Information Center

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