Stainless steel

stainless steel n. Any of various steels alloyed with at least 10 **percent** chromium and **...** Austenitic **stainless** steels contain at least 6 **percent nickel** and

Background

Stainless steel is an iron-containing alloy—a substance made up of two or more chemical elements—used in a wide range of applications. It has excellent resistance to stain or rust due to its chromium content, usually from 12 to 20 percent of the alloy. There are more than 57 stainless steels recognized as standard alloys, in addition to many proprietary alloys produced by different stainless steel producers. These many types of steels are used in an almost endless number of applications and industries: bulk materials handling equipment, building exteriors and roofing, automobile components (exhaust, trim/decorative, engine, chassis, fasteners, tubing for fuel lines), chemical processing plants (scrubbers and heat exchangers), pulp and paper manufacturing, petroleum refining, water supply piping, consumer products, marine and shipbuilding, pollution control, sporting goods (snow skis), and transportation (rail cars), to name just a few.

About 200,000 tons of nickel-containing stainless steel is used each year by the food processing industry in North America. It is used in a variety of food handling, storing, cooking, and serving equipment—from the beginning of the food collection process through to the end. Beverages such as milk, wine, beer, soft drinks and fruit juice are processed in stainless steel equipment. Stainless steel is also used in commercial cookers, pasteurizers, transfer bins, and other specialized equipment. Advantages include easy cleaning, good corrosion resistance, durability, economy, food flavor protection, and sanitary design. According to the U.S. Department of Commerce, 1992 shipments of all stainless steel totaled 1,514,222 tons.

Stainless steels come in several types depending on their microstructure. Austenitic stainless steels contain at least 6 percent nickel and austenite—carbon-containing iron with a face-centered cubic structure—and have good corrosion resistance and high ductility (the ability of the material to bend without breaking). Ferritic stainless steels (ferrite has a body-centered cubic structure) have better resistance to stress corrosion than austenitic, but they are difficult to weld. Martensitic stainless steels contain iron having a needle-like structure.

Duplex stainless steels, which generally contain equal amounts of ferrite and austenite, provide better resistance to pitting and crevice corrosion in most environments. They also have superior resistance to cracking due to chloride stress corrosion, and they are about twice as strong as the common austenitics. Therefore, duplex stainless steels are widely used in the chemical industry in refineries, gas-processing plants, pulp and paper plants, and sea water piping installations.

Raw Materials

Stainless steels are made of some of the basic elements found in the earth: iron ore, chromium, silicon, nickel, carbon, nitrogen, and manganese. Properties of the final alloy are tailored by varying the amounts of these elements. Nitrogen, for instance, improves tensile properties like ductility. It also improves corrosion resistance, which makes it valuable for use in duplex stainless steels.

The Manufacturing Process

The manufacture of stainless steel involves a series of processes. First, the steel is melted, and then it is cast into solid form. After various forming steps, the steel is heat treated and then cleaned and polished to give it the desired finish. Next, it is packaged and sent to manufacturers, who weld and join the steel to produce the desired shapes.

Melting and casting

- The raw materials are first melted together in an electric furnace. This step usually requires 8 to 12 hours of intense heat. When the melting is finished, the molten steel is cast into semi-finished forms. These include blooms (rectangular shapes), billets (round or square shapes 1.5 inches or 3.8 centimeters in thickness), slabs, rods, and tube rounds.

Forming

- Next, the semi-finished steel goes through forming operations, beginning with hot rolling, in which the steel is heated and passed through huge rolls. Blooms and billets are formed into bar and wire, while slabs are formed into plate, strip, and sheet. Bars are available in all grades and come in rounds, squares, octagons, or hexagons 0.25 inch (.63 centimeter) in size. Wire is usually available up to 0.5 inch (1.27 centimeters) in diameter or size. Plate is more than 0.1875 inch (.47 centimeter) thick and over 10 inches (25.4 centimeters) wide. Strip is less than 0.185 inch (.47 centimeter) thick and less than 24 inches (61 centimeters) wide. Sheet is less than 0.1875 (.47 centimeter) thick and more than 24 (61 centimeters) wide.

Heat treatment

- After the stainless steel is formed, most types must go through an annealing step. Annealing is a heat treatment in which the steel is heated and cooled under controlled conditions to relieve internal stresses and soften the metal. Some steels are heat treated for higher strength. However, such a heat treatment—also known as *age hardening*—requires careful control, for even small changes from the recommended temperature, time, or cooling rate can seriously affect the properties. Lower aging temperatures produce high strength with low fracture toughness, while higher-temperature aging produces a lower strength, tougher material.

Though the heating rate to reach the aging temperature (900 to 1000 degrees Fahrenheit or 482 to 537 degrees Celsius) does not effect the properties, the cooling rate does. A post-aging quenching (rapid cooling) treatment can increase the toughness without a significant loss in strength. One such process involves water quenching the material in a 35-degree Fahrenheit (1.6-degree Celsius) ice-water bath for a minimum of two hours.

The type of heat treatment depends on the type of steel; in other words, whether it is austenitic, ferritic, or martensitic. Austenitic steels are heated to above 1900 degrees Fahrenheit (1037 degrees Celsius) for a time depending on the thickness. Water quenching is used for thick sections, whereas air cooling or air blasting is used for thin sections. If cooled too slowly, carbide precipitation can occur. This buildup can be eliminated by thermal stabilization. In this method, the steel is held for several hours at 1500 to 1600 degrees Fahrenheit (815 to 871 degrees Celsius). Cleaning part surfaces of contaminants before heat treatment is sometimes also necessary to achieve proper heat treatment.

Descaling

- Annealing causes a scale or build-up to form on the steel. The scale can be removed using several processes. One of the most common methods, pickling, uses a nitric-hydrofluoric acid bath to descale the steel. In another method, electrocleaning, an electric current is applied to the surface using a cathode and phosphoric acid, and the scale is removed. The annealing and descaling steps occur at different stages depending on the type of steel being worked. Bar and wire, for instance, go through further forming steps (more hot rolling, forging, or extruding) after the initial hot rolling before being annealed and descaled. Sheet and strip, on the other hand, go through an initial annealing and descaling step immediately after hot rolling. After cold rolling (passing through rolls at a relatively low temperature), which produces a further reduction in thickness, sheet and strip are annealed and descaled again. A final cold rolling step then prepares the steel for final processing.

Cutting

- Cutting operations are usually necessary to obtain the desired blank shape or size to trim the part to final size. Mechanical cutting is accomplished by a variety of methods, including straight shearing using guillotine knives, circle shearing using circular knives horizontally and vertically positioned, sawing using high speed steel blades, blanking, and nibbling. Blanking uses metal punches and dies to punch out the shape by shearing. Nibbling is a process of cutting by blanking out a series of overlapping holes and is ideally suited for irregular shapes.

Stainless steel can also be cut using flame cutting, which involves a flame-fired torch using oxygen and propane in conjunction with iron powder. This method is clean and fast. Another cutting method is known as *plasma jet cutting*, in which an ionized gas column in conjunction with an electric arc through a small orifice makes the cut. The gas produces extremely high temperatures to melt the metal.

Finishing

- Surface finish is an important specification for stainless steel products and is critical in applications where appearance is also important. Certain surface finishes also make stainless steel easier to clean, which is obviously important for sanitary applications. A smooth surface as obtained by polishing also provides better corrosion resistance. On the other hand, rough finishes are often required for lubrication applications, as well as to facilitate further manufacturing steps.

  Surface finishes are the result of processes used in fabricating the various forms or are the result of further processing. There are a variety of methods used for finishing. A dull finish is produced by hot rolling, annealing, and descaling. A bright finish is obtained by first hot rolling and then cold rolling on polished rolls. A highly reflective finish is produced by cold rolling in combination with annealing in a controlled atmosphere furnace, by grinding with abrasives, or by buffing a finely ground surface. A mirror finish is produced by polishing with progressively finer abrasives, followed by extensive buffing. For grinding or polishing, grinding wheels or abrasive belts are normally used. Buffing uses cloth wheels in combination with cutting compounds containing very fine abrasive particles in bar or stick forms. Other finishing methods include tumbling, which forces movement of a tumbling material against surfaces of parts, dry etching (sandblasting), wet etching using acid solutions, and surface dulling. The latter uses sandblasting, wire brushing, or pickling techniques.

Manufacturing at the fabricator or end user

- After the stainless steel in its various forms are packed and shipped to the fabricator or end user, a variety of other processes are needed. Further shaping is accomplished using a variety of methods, such as roll forming, press forming, forging, press drawing, and extrusion. Additional heat treating (annealing), machining, and cleaning processes are also often required.

  There are a variety of methods for joining stainless steel, with welding being the most common. Fusion and resistance welding are the two basic methods generally used with many variations for both. In fusion welding, heat is provided by an electric arc struck between an electrode and the metal to be welded. In resistance welding, bonding is the result of heat and pressure. Heat is produced by the resistance to the flow of electric current through the parts to be welded, and pressure is applied by the electrodes. After parts are welded together, they must be cleaned around the joined area.

Quality Control

In addition to in-process control during manufacture and fabrication, stainless steels must meet specifications developed by the American Society for Testing and Materials (ASTM) with regard to mechanical properties such as toughness and corrosion resistance. Metallography can sometimes be correlated to corrosion tests to help monitor quality.

The Future

Use of stainless and super stainless steels is expanding in a variety of markets. To meet the requirements of the new Clean Air Act, coal-fired power plants are installing stainless steel stack liners. Other new industrial applications include secondary heat exchangers for high-efficiency home furnaces, service-water piping in nuclear power plants, ballast tanks and fire-suppression systems for offshore drilling platforms, flexible pipe for oil and gas distribution systems, and heliostats for solar-energy plants.

Environmental legislation is also forcing the petrochemical and refinery industries to recycle secondary cooling water in closed systems rather than simply discharge it. Reuse results in cooling water with elevated levels of chloride, resulting in pitting-corrosion problems. Duplex stainless steel tubing will play an increasingly important role in solving such industrial corrosion problems, since it costs less than other materials. Manufacturers are developing highly corrosion-resistant steels in respond to this demand.

In the automotive industry, one steel manufacturer has estimated that stainless-steel usage per vehicle will increase from 55 to 66 pounds (25 to 30 kilograms) to more than 100 pounds (45 kilograms) by the turn of the century. New applications include metallic substrates for catalytic converters, air bag components, composite bumpers, fuel line and other fuel-system parts compatible with alternate fuels, brake lines, and long-life exhaust systems.

With improvements in process technology, superaustenitic stainless steels (with nitrogen contents up to 0.5 percent) are being developed. These steels are used in pulp-mill bleach plants, sea water and phosphoric-acid handling systems, scrubbers, offshore platforms, and other highly corrosive applications. A number of manufacturers have begun marketing such materials in sheet, plate, and other forms. Other new compositions are being developed: ferritic iron-base alloys containing 8 and 12 percent Cr for magnetic applications, and austenitic stainless with extra low sulfur content for parts used in the manufacture of semiconductors and pharmaceuticals.

Research will continue to develop improved and unique materials. For instance, Japanese researchers have recently developed several. One is a corrosion-resistant stainless steel that displays the shape-memory effect. This type of material returns to its original shape upon heating after being plastically deformed. Potential applications include assembly components (pipe fittings, clips, fasteners, clamps), temperature sensing (circuit breakers and fire alarms), and springs. An improved martensitic stainless steel has also been developed for precision miniature and instrument rolling-contact bearings, which has reduced vibration levels, improved life expectancy, and better surface finish compared to conventional materials.

http://www.answers.com/topic/stainless-steel

In metallurgy, **stainless steel** is defined as a steel alloy with a minimum of 10% chromium content by mass.[1] Stainless steel does not stain, corrode or rust as easily as ordinary steel (it "stains less"), but it is not stain-proof. It is also called **corrosion resistant steel** when the alloy type and grade are not detailed, particularly in the aviation industry. There are different grades and surface finishes of stainless steel to suit the environment to which the material will be subjected in its lifetime. Common uses of stainless steel are cutlery and watch straps.

Stainless steel differs from carbon steel by amount of chromium present. Carbon steel rusts when exposed to air and moisture. This iron oxide film is active and accelerates corrosion by forming more iron oxide. Stainless steels have sufficient amount of chromium present so that a passive film of chromium oxide forms which prevents further corrosion.

[edit] History

An announcement, as it appeared in the 1915 *New York Times*, of the discovery of stainless steel.[2]

A few corrosion-resistant iron artifacts survive from antiquity. A famous (and very large) example is the Iron Pillar of Delhi, erected by order of Kumara Gupta I around the year AD 400. Unlike stainless steel, however, these artifacts owe their durability not to chromium, but to their high phosphorus content, which, together with favorable local weather conditions, promotes the formation of a solid protective passivation layer of iron oxides and phosphates, rather than the non-protective, cracked rust layer that develops on most ironwork.

The corrosion resistance of iron-chromium alloys was first recognized in 1821 by the French metallurgist Pierre Berthier, who noted their resistance against attack by some acids and suggested their use in cutlery. Metallurgists of the 19th century, however, 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 the late 1890s, Hans Goldschmidt of Germany developed an aluminothermic (thermite) process for producing carbon-free chromium. In the years 1904–1911 several researchers, particularly Leon Guillet of France, prepared alloys that would today be considered stainless steel.

Friedrich Krupp Germaniawerft built the 366-ton sailing yacht *Germania* featuring a chrome-nickel steel hull in Germany in 1908.[3] In 1911, Philip Monnartz reported on the relationship between the chromium content and corrosion resistance. On October 17, 1912, Krupp engineers Benno Strauss and Eduard Maurer patented austenitic stainless steel.[4]

Similar developments were taking place contemporaneously in the United States, where Christian Dantsizen and Frederick Becket were industrializing ferritic stainless.

Harry Brearley of the Brown-Firth research laboratory in Sheffield, England is commonly credited as the inventor of stainless steel. In 1913, while seeking an erosion-resistant alloy for gun barrels, he 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*.[2] This 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 1929 in London.[5]

[edit] Properties

High oxidation-resistance in air at ambient temperature are normally achieved with additions of a minimum of 13% (by weight) chromium, and up to 26% is used for harsh environments.[6] 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. It is impervious to water and air, protecting the metal beneath. Also, 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. When stainless steel parts such as nuts and bolts are forced together, the oxide layer can be scraped off causing the parts to weld together. When disassembled, the welded material may be torn and pitted, an effect that is known as galling. This destructive galling can be best avoided by the use of dissimilar materials, e.g. bronze to stainless steel, or even different types of stainless steels (martensitic against austenitic, etc.), when metal-to-metal wear is a concern. In addition, Nitronic alloys (trademark of Armco, Inc.) reduce the tendency to gall through selective alloying with manganese and nitrogen.

Nickel also contributes to passivation, as do other less commonly used ingredients such as molybdenum and vanadium.

[edit] Applications

Stainless steel's resistance to corrosion and staining, low maintenance, relative inexpense, and familiar luster make it an ideal base material for a host of commercial applications. There are over 150 grades of stainless steel, of which fifteen are most common. The alloy is milled into coils, sheets, plates, bars, wire, and tubing to be used in cookware, cutlery, hardware, surgical instruments, major appliances, industrial equipment, and as an automotive and aerospace structural alloy and construction material in large buildings. Orange juice and other food transport and storage tankers are often made of stainless steel, due to its corrosion resistance and antibacterial properties. This also influences its use in commercial catering kitchens and food processing plants, as it can be steam cleaned, sterilized, and does not need painting or application of other surface finishes.

Stainless steel is also used for jewellery and watches. The most common stainless steel alloy used for this is 316L. It can be re-finished by any jeweller and will not oxidize or turn black. Not all manufacturers use this type; Rolex for instance use type 904L for their stainless steel watches.[8]

[edit] Recycling & reuse

Stainless steel is 100% recyclable. In fact, an average stainless steel object is composed of about 60% recycled material, 25% originating from end-of-life products and 35% coming from manufacturing processes.[9]

[edit] Types of stainless steel

There are different types of stainless steels: when nickel is added, for instance, the austenite structure of iron is stabilized. This crystal structure makes such steels non-magnetic and less brittle at low temperatures. For greater hardness and strength, carbon is added. When subjected to adequate heat treatment, these steels are used as razor blades, cutlery, tools, etc.

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

Stainless steels are also classified by their crystalline structure:

- Austenitic, or 300 series, stainless steels comprise 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. A typical composition of 18% chromium and 10% nickel, commonly known as **18/10 stainless**, is often used in flatware. Similarly, **18/0** and **18/8** are also available. Superaustenitic stainless steels, such as alloy AL-6XN and 254SMO, exhibit great resistance to chloride pitting and crevice corrosion due to 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.[citation needed]

The low carbon version of the Austenitic Stainless Steel, for example 316L or 304L, are used to avoid corrosion problem caused by welding. The "L" means that the carbon content of the Stainless Steel is below 0.03%, this will reduce the sensitization effect, precipitation of Chromium Carbides, due to the high temperature produced by welding operation.

- Ferritic stainless steels are highly corrosion-resistant, but less durable than austenitic grades. They contain between 10.5% and 27% chromium and 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.

- Martensitic stainless steels are not as corrosion-resistant as the other two classes but are extremely strong and tough, as well as highly machineable, and can be hardened by heat treatment. Martensitic stainless steel contains chromium (12-14%), molybdenum (0.2-1%), nickel (0-<2%), and carbon (about 0.1-1%) (giving it more hardness but making the material a bit more brittle). It is quenched and magnetic.

- 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. There is a rising trend in defense budgets to opt for an ultra-high-strength stainless steel when possible in new projects, as it is estimated that 2% of the US GDP is spent dealing with corrosion. The Lockheed-Martin Joint Strike Fighter is the first aircraft to use a precipitation-hardenable stainless steel—Carpenter Custom 465—in its airframe.

- Duplex stainless steels have a mixed microstructure of austenite and ferrite, the aim being to produce a 50/50 mix, although in commercial alloys, the mix may be 40/60 respectively. Duplex steels have improved strength over austenitic stainless steels and also improved resistance to localised corrosion, particularly pitting, crevice corrosion and stress corrosion cracking. They are characterised by high chromium (19–28%) and molybdenum (up to 5%) and lower nickel contents than austenitic stainless steels. The most used Duplex Stainless Steel are the 2205 (22% Chromium, 5% Nickel) and 2507 (25% Chromium, 7% Nickel) sometimes the 2507 is also called "SuperDuplex" due to the higher Corrosion resistance.

[edit] Comparison of standardized steels

It has been suggested that this article or section be merged into *SAE steel grades*. (Discuss)

EN-standard Steel no. k.h.s DIN	EN-standard Steel name	SAE grade	UNS
		440A	S44002
1.4112		440B	S44003
1.4125		440C	S44004
		440F	S44020
1.4016	X6Cr17	430	S43000
1.4512	X6CrTi12	409	S40900
		410	S41000
1.4310	X10CrNi18-8	301	S30100
1.4318	X2CrNiN18-7	301LN	N/A
1.4307	X2CrNi18-9	304L	S30403
1.4306	X2CrNi19-11	304L	S30403
1.4311	X2CrNiN18-10	304LN	S30453
1.4301	X5CrNi18-10	304	S30400
1.4948	X6CrNi18-11	304H	S30409
1.4303	X5CrNi18 12	305	S30500
1.4541	X6CrNiTi18-10	321	S32100
1.4878	X12CrNiTi18-9	321H	S32109
1.4404	X2CrNiMo17-12-2	316L	S31603
1.4401	X5CrNiMo17-12-2	316	S31600
1.4406	X2CrNiMoN17-12-2	316LN	S31653
1.4432	X2CrNiMo17-12-3	316L	S31603
1.4435	X2CrNiMo18-14-3	316L	S31603
1.4436	X3CrNiMo17-13-3	316	S31600
1.4571	X6CrNiMoTi17-12-2	316Ti	S31635
1.4429	X2CrNiMoN17-13-3	316LN	S31653
1.4438	X2CrNiMo18-15-4	317L	S31703
1.4539	X1NiCrMoCu25-20-5	904L	N08904
1.4547	X1CrNiMoCuN20-18-7	N/A	S31254

[edit] Stainless steel grades

It has been suggested that this article or section be merged into *SAE steel grades*. (Discuss)

This list is incomplete; you can help by expanding it.

See also: SAE steel grades

- 100 Series—austenitic chromium-nickel-manganese alloys
  - Type 101—austenitic that is hardenable through cold working for furniture
  - Type 102—austenitic general purpose stainless steel working for furniture
- 200 Series—austenitic chromium-nickel-manganese alloys
  - Type 201—austenitic that is hardenable through cold working
  - Type 202—austenitic general purpose stainless steel
- 300 Series—austenitic chromium-nickel alloys
  - Type 301—highly ductile, for formed products. Also hardens rapidly during mechanical working. Good weldability. Better wear resistance and fatigue strength than 304.
  - Type 302—same corrosion resistance as 304, with slightly higher strength due to additional carbon.
  - Type 303—free machining version of 304 via addition of sulfur and phosphorus. Also referred to as "A1" in accordance with ISO 3506.[10]
  - Type 304—the most common grade; the classic 18/8 stainless steel. Also referred to as "A2" in accordance with ISO 3506.[10]
  - Type 304L— same as the 304 grade but contains less carbon to increase weldability. Is slightly weaker than 304.
  - Type 304LN—same as 304L, but also nitrogen is added to obtain a much higher yield and tensile strength than 304L.
  - Type 308—used as the filler metal when welding 304
  - Type 309—better temperature resistance than 304, also sometimes used as filler metal when welding dissimilar steels, along with inconel.
  - Type 316—the second most common grade (after 304); for food and surgical stainless steel uses; alloy addition of molybdenum prevents specific forms of corrosion. It is also known as marine grade stainless steel due to its increased resistance to chloride corrosion compared to type 304. 316 is often used for building nuclear reprocessing plants. 316L is an extra low carbon grade of 316, generally used in stainless steel watches and marine applications due to its high resistance to corrosion. Also referred to as "A4" in accordance with ISO 3506.[10] 316Ti includes titanium for heat resistance, therefore it is used in flexible chimney liners.
  - Type 321—similar to 304 but lower risk of weld decay due to addition of titanium. See also 347 with addition of niobium for desensitization during welding.
- 400 Series—ferritic and martensitic chromium alloys
  - Type 405— ferritic for welding applications
  - Type 408—heat-resistant; poor corrosion resistance; 11% chromium, 8% nickel.

    - Type 409—cheapest type; used for automobile exhausts; ferritic (iron/chromium only).
    - Type 410—martensitic (high-strength iron/chromium). Wear-resistant, but less corrosion-resistant.
    - Type 416—easy to machine due to additional sulfur
    - Type 420—Cutlery Grade martensitic; similar to the Brearley's original rustless steel. Excellent polishability.
    - Type 430—decorative, e.g., for automotive trim; ferritic. Good formability, but with reduced temperature and corrosion resistance.
    - Type 440—a higher grade of cutlery steel, with more carbon, allowing for much better edge retention when properly heat-treated. It can be hardened to approximately Rockwell 58 hardness, making it one of the hardest stainless steels. Due to its toughness and relatively low cost, most display-only and replica swords or knives are made of 440 stainless. Also known as razor blade steel. Available in four grades: 440A, 440B, 440C, and the uncommon 440F (free machinable). 440A, having the least amount of carbon in it, is the most stain-resistant; 440C, having the most, is the strongest and is usually considered more desirable in knifemaking than 440A, except for diving or other salt-water applications.
    - Type 446—For elevated temperature service
- 500 Series—heat-resisting chromium alloys

- 600 Series—martensitic precipitation hardening alloys
    - 601 through 604: Martensitic low-alloy steels.
    - 610 through 613: Martensitic secondary hardening steels.
    - 614 through 619: Martensitic chromium steels.
    - 630 through 635: Semiaustenitic and martensitic precipitation-hardening stainless steels.
        - Type 630 is most common PH stainless, better known as 17-4; 17% chromium, 4% nickel.
    - 650 through 653: Austenitic steels strengthened by hot/cold work.
    - 660 through 665: Austenitic superalloys; all grades except alloy 661 are strengthened by second-phase precipitation.
- Type 2205— the most widely used duplex (ferritic/austenitic) stainless steel grade. It has both excellent corrosion resistance and high strength.

[edit] Stainless steel finishes

316L stainless steel, with an unpolished, mill finish.

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 annealed to change the properties of the final material. Any oxidation that forms on the surface (scale) is removed by pickling, and the 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 conditions
- No. 3 - Coarse abrasive finish applied mechanically
- No. 4 - Brushed finish
- No. 5 - Satin finish
- No. 6 - Matte finish
- No. 7 - Reflective finish
- No. 8 - Mirror finish
- No. 9 - Bead blast finish
- No. 10 - heat colored finish-wide range of electropolished & heat colored surfaces

[edit] See also

- SAE steel grades
- Architectural steel
- Budd Company – Historically notable user of stainless steel
- Edmonton Composting Facility
- Surface finishing

http://en.wikipedia.org/wiki/Stainless_Steel

SAE steel grades

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Iron alloy phases v · d · e
Ferrite (α-iron, δ-iron; soft) Austenite (γ-iron; harder) Spheroidite Pearlite (88% ferrite, 12% cementite) Bainite Martensite Ledeburite (ferrite-cementite eutectic, 4.3% carbon) Cementite (iron carbide, Fe_3C; hardest)
Steel classes
Carbon steel (≤2.1% carbon; low alloy) Stainless steel (+chromium) Maraging steel (+nickel) Alloy steel (hard) Tool steel (harder)
Other iron-based materials
Cast iron (>2.1% carbon) Ductile iron Wrought iron (contains slag)

The Society of Automotive Engineers (SAE) designates **SAE steel grades**. These are four digit numbers which represent standards for steel specifications. Prior to 1995 the American Iron and Steel Institute (AISI) was also involved, and the standard was designated the **AISI/SAE steel grades**. The AISI stopped being involved because it never wrote any of the specifications.[1]

[edit] Carbon and alloy steel

Main articles: Carbon steel and Alloy steel

Carbon steels and alloy steels are designated by a four digit number, where the first two digits indicate the alloying elements and the last two digits indicate the amount of carbon, in hundredths of a percent by weight. For example, a 1060 steel is a plain carbon steel containing 0.60 wt% C.

Carbon and alloy steel grades[2]	
SAE designation	**Type**
Carbon steels	
10xx	Plain carbon (Mn 1.00% max)
11xx	Resulfurized
12xx	Resulfurized and rephosphorized
15xx	Plain carbon (Mn 1.00% to 1.65%)
Manganese steels	
13xx	Mn 1.75%
Nickel steels	
23xx	Ni 3.50%
25xx	Ni 5.00%
Nickel-chromium steels	
31xx	Ni 1.25%, Cr 0.65% or 0.80%

32xx	Ni 1.25%, Cr 1.07%
33xx	Ni 3.50%, Cr 1.50% or 1.57%
34xx	Ni 3.00%, Cr 0.77%
Molybdenum steels	
40xx	Mo 0.20% or 0.25% or 0.25% Mo & 0.042 S[1]
44xx	Mo 0.40% or 0.52%
Chromium-molybdenum (Chromoly) steels	
41xx	Cr 0.50% or 0.80% or 0.95%, Mo 0.12% or 0.20% or 0.25% or 0.30%
Nickel-chromium-molybdenum steels	
43xx	Ni 1.82%, Cr 0.50% to 0.80%, Mo 0.25%
43BVxx	Ni 1.82%, Cr 0.50%, Mo 0.12% or 0.35%, V 0.03% min
47xx	Ni 1.05%, Cr 0.45%, Mo 0.20% or 0.35%
81xx	Ni 0.30%, Cr 0.40%, Mo 0.12%
81Bxx	Ni 0.30%, Cr 0.45%, Mo 0.12%[1]

86xx	Ni 0.55%, Cr 0.50%, Mo 0.20%
87xx	Ni 0.55%, Cr 0.50%, Mo 0.25%
88xx	Ni 0.55%, Cr 0.50%, Mo 0.35%
93xx	Ni 3.25%, Cr 1.20%, Mo 0.12%
94xx	Ni 0.45%, Cr 0.40%, Mo 0.12%
97xx	Ni 0.55%, Cr 0.20%, Mo 0.20%
98xx	Ni 1.00%, Cr 0.80%, Mo 0.25%
Nickel-molybdenum steels	
46xx	Ni 0.85% or 1.82%, Mo 0.20% or 0.25%
48xx	Ni 3.50%, Mo 0.25%
Chromium steels	
50xx	Cr 0.27% or 0.40% or 0.50% or 0.65%
50xxx	Cr 0.50%, C 1.00% min
50Bxx	Cr 0.28% or 0.50%[1]

51xx	Cr 0.80% or 0.87% or 0.92% or 1.00% or 1.05%
51xxx	Cr 1.02%, C 1.00% min
51Bxx	Cr 0.80%[1]
52xxx	Cr 1.45%, C 1.00% min
Chromium-vanadium steels	
61xx	Cr 0.60% or 0.80% or 0.95%, V 0.10% or 0.15% min
Tungsten-chromium steels	
72xx	W 1.75%, Cr 0.75%
Silicon-manganese steels	
92xx	Si 1.40% or 2.00%, Mn 0.65% or 0.82% or 0.85%, Cr 0.00% or 0.65%
High-strength low-alloy steels	
9xx	Various SAE grades
xxBxx	Boron steels
xxLxx	Leaded steels

[edit] Stainless steel

It has been suggested that multiple sections of *Stainless steel* be merged into this article or section. (Discuss)

Main article: Stainless steel

- 200 Series: austenitic chromium-nickel-manganese alloys
- 300 Series: austenitic chromium-nickel alloys
  - Type 301: highly ductile, for formed products. Also hardens rapidly during mechanical working.
  - Type 303: free machining version of 304 via addition of sulfur
  - Type 304: the most common; the classic 18/8 stainless steel.
  - Type 316: the next most common; for food and surgical stainless steel uses; alloy addition of molybdenum prevents specific forms of corrosion. 316 steel is more resistant to corrosion than 18-8 stainless steels. 316 steel is used in the handling of certain food and pharmaceutical products where it is often required in order to minimize metallic contamination. 316 steel is also known as "marine grade" stainless steel due to its increased ability to resist saltwater corrosion compared to type 304. SS316 is often used for building nuclear reprocessing plants.
- 400 Series: ferritic and martensitic chromium alloys
  - Type 408: heat-resistant; poor corrosion resistance; 11% chromium, 8% nickel.
  - Type 409: cheapest type; used for automobile exhausts; ferritic (iron/chromium only).
  - Type 410: martensitic (high-strength iron/chromium).
  - Type 416: the most machinable stainless steel; achieved by the addition of extra sulfur which reduces corrosion resistance. Often used for "stainless" rifle barrels
  - Type 420: "Cutlery grade" martensitic; similar to the Brearley's original "rustless steel". Also known as "surgical steel".
  - Type 430: decorative, e.g., for automotive trim; ferritic.
  - Type 440: a higher grade of cutlery steel, with more carbon in it, which allows for much better edge retention when the steel is heat treated properly.
- 500 Series: heat resisting chromium alloys
- 600 Series: martensitic precipitation hardening alloys
  - Type 630: most common PH stainless, better known as 17-4; 17% chromium, 4% nickel

Stainless steel designations[3]

SAE designation	UNS designation	% Cr	% Ni	% C	% Mn	% Si	% P	% S	% N	Other
Austenitic										
201	S20100	16–18	3.5–5.5	0.15	5.5–7.5	0.75	0.06	0.03	0.25	-
202	S20200	17–19	4–6	0.15	7.5–10.0	0.75	0.06	0.03	0.25	-
205	S20500	16.5–18	1–1.75	0.12–0.25	14–15.5	0.75	0.06	0.03	0.32–0.40	-
301	S30100	16–18	6–8	0.15	2	0.75	0.045	0.03	-	-
302	S30200	17–19	8–10	0.15	2	0.75	0.045	0.03	0.1	-
302B	S30215	17–19	8–10	0.15	2	2.0–3.0	0.045	0.03	-	-
303	S30300	17–19	8–10	0.15	2	1	0.2	0.15 min	-	Mo 0.60 (optional)
303Se	S30323	17–19	8–10	0.15	2	1	0.2	0.06	-	0.15 Se min
304	S30400	18–20	8–10.50	0.08	2	0.75	0.045	0.03	0.1	-

304L	S30403	18–20	8–12	0.03	2	0.75	0.045	0.03	0.1	-
304Cu	S30430	17–19	8–10	0.08	2	0.75	0.045	0.03	-	3–4 Cu
304N	S30451	18–20	8–10.50	0.08	2	0.75	0.045	0.03	0.10–0.16	-
305	S30500	17–19	10.50–13	0.12	2	0.75	0.045	0.03	-	-
308	S30800	19–21	10–12	0.08	2	1	0.045	0.03	-	-
309	S30900	22–24	12–15	0.2	2	1	0.045	0.03	-	-
309S	S30908	22–24	12–15	0.08	2	1	0.045	0.03	-	-
310	S31000	24–26	19–22	0.25	2	1.5	0.045	0.03	-	-
310S	S31008	24–26	19–22	0.08	2	1.5	0.045	0.03	-	-
314	S31400	23–26	19–22	0.25	2	1.5–3.0	0.045	0.03	-	-
316	S31600	16–18	10–14	0.08	2	0.75	0.045	0.03	0.10	2.0–3.0 Mo

316L	S31603	16–18	10–14	0.03	2	0.75	0.045	0.03	0.10	2.0–3.0 Mo
316F	S31620	16–18	10–14	0.08	2	1	0.2	0.10 min	-	1.75–2.50 Mo
316N	S31651	16–18	10–14	0.08	2	0.75	0.045	0.03	0.10–0.16	2.0–3.0 Mo
317	S31700	18–20	11–15	0.08	2	0.75	0.045	0.03	0.10 max	3.0–4.0 Mo
317L	S31703	18–20	11–15	0.03	2	0.75	0.045	0.03	0.10 max	3.0–4.0 Mo
321	S32100	17–19	9–12	0.08	2	0.75	0.045	0.03	0.10 max	Ti 5(C+N) min, 0.70 max
329	S32900	23–28	2.5–5	0.08	2	0.75	0.04	0.03	-	1–2 Mo
330	N08330	17–20	34–37	0.08	2	0.75–1.50	0.04	0.03	-	-
347	S34700	17–19	9–13	0.08	2	0.75	0.045	0.030	-	Nb + Ta, 10 x C min, 1 max
348	S34800	17–19	9–13	0.08	2	0.75	0.045	0.030	-	Nb + Ta, 10 x C min, 1 max, but

										0.10 Ta max; 0.20 Ca
384	S38400	15–17	17–19	0.08	2	1	0.045	0.03	-	-
Ferritic										
405	S40500	11.5–14.5	-	0.08	1	1	0.04	0.03	-	0.1–0.3 Al, 0.60 max
409	S40900	10.5–11.75	0.05	0.08	1	1	0.045	0.03	-	Ti 6 x C, but 0.75 max
429	S42900	14–16	0.75	0.12	1	1	0.04	0.03	-	-
430	S43000	16–18	0.75	0.12	1	1	0.04	0.03	-	-
430F	S43020	16–18	-	0.12	1.25	1	0.06	0.15 min	-	0.60 Mo (optional)
430FSe	S43023	16–18	-	0.12	1.25	1	0.06	0.06	-	0.15 Se min
434	S43400	16–18	-	0.12	1	1	0.04	0.03	-	0.75–1.25 Mo
436	S43600	16–18	-	0.12	1	1	0.04	0.03	-	0.75–1.25 Mo; Nb+Ta 5

										x C min, 0.70 max
442	S44200	18–23	-	0.2	1	1	0.04	0.03	-	-
446	S44600	23–27	0.25	0.2	1.5	1	0.04	0.03	-	-
Martensitic										
403	S40300	11.5–13.0	0.60	0.15	1	0.5	0.04	0.03	-	-
410	S41000	11.5–13.5	0.75	0.15	1	1	0.04	0.03	-	-
414	S41400	11.5–13.5	1.25–2.50	0.15	1	1	0.04	0.03	-	-
416	S41600	12–14	-	0.15	1.25	1	0.06	0.15 min	-	0.060 Mo (optional)
416Se	S41623	12–14	-	0.15	1.25	1	0.06	0.06	-	0.15 Se min
420	S42000	12–14	-	0.15 min	1	1	0.04	0.03	-	-
420F	S42020	12–14	-	0.15 min	1.25	1	0.06	0.15 min	-	0.60 Mo max (optional)

422	S42200	11.0–12.5	0.50–1.0	0.20–0.25	0.5–1.0	0.5	0.025	0.025	-	0.90–1.25 Mo; 0.20–0.30 V; 0.90–1.25 W
431	S41623	15–17	1.25–2.50	0.2	1	1	0.04	0.03	-	-
440A	S44002	16–18	-	0.60–0.75	1	1	0.04	0.03	-	0.75 Mo
440B	S44003	16–18	-	0.75–0.95	1	1	0.04	0.03	-	0.75 Mo
440C	S44004	16–18	-	0.95–1.20	1	1	0.04	0.03	-	0.75 Mo
Heat resisting										
501	S50100	4–6	-	0.10 min	1	1	0.04	0.03	-	0.40–0.65 Mo
502	S50200	4–6	-	0.1	1	1	0.04	0.03	-	0.40–0.65 Mo