THE NAMING AND NUMBERING OF STAINLESS STEELS

The variety of numbering and naming systems for stainless steels is based on the fact that the alloys were developed by companies all over the world.

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Back in 1935, *Allegheny Ludlum proposed building a stainless steel car to Ford Motor Co. The idea took shape in the form of this* 1936 *Ford Deluxe Sedan. That car became the centerpiece of a campaign to show the public the wonders of stainless steel. Image courtesy Allegheny Technologies Inc.*

The stainless steel industry had its beginnings around the year 1912, when metallurgists in three countries quite accidentally performed a bit of alchemy when they turned iron into alloys that did not rust. Theoretical studies were conducted on iron-chromium and iron-chromium-nickel corrosion-resistant alloys in Europe between 1904 and 1911. However, it is generally accepted that the commercial development of stainless steels began with the work of Harry Brearley at the Brown Firth Research Laboratories in Sheffield, England, and with the work of Eduard Maurer and Benno Strauss at the Krupp Laboratories in Essen, Germany, both in 1912. Christian Dantsizen of the General Electric Research Laboratory at Schenectady, New York, was the developer in 1911 of a third class of alloys that became known as "stainless irons."

The Brown Firth martensitic iron-chromium alloy, the Krupp austenitic iron-chromium nickel alloy, and the Dantsizen stainless iron alloy are described in this article, which also discusses the development of the names and the systems of numbering the alloys that are now generally called "stainless steels" in English, "Nichtrostende Stahle" in German, and "aciers inoxydable" in French.

The martensitic alloys

The Brown Firth alloy produced in 1912 was an alloy steel with approximately 13% chromium and 0.24% carbon, a composition falling within the limits of what became known in America as Type 420 stainless steel. By 1914, the alloy was being made into table knives by George Ibberson & Co., a Sheffield cutler. The blades were stamped with the manufacturer's name and the words "Stainless Knife." This is the first known use of the word "stainless" to describe the alloy. Also in 1914, the steel was being sold for the production of aircraft engine valves under the name "Firths Aeroplane Steel" (FAS). In fact, the entire output of FAS was destined for this purpose throughout the 1914–1918 war. In 1917, the Firth-Brearley Stainless Steel Syndicate was formed to foster the worldwide production of stainless cutlery steel.

The austenitic alloys

The Krupp alloy that was developed in 1912 was austenitic and had a chemical composition that was virtually the 18% chromium, 8% nickel composition of "18-8," or what became known as Type 304 stainless steel. Krupp named the alloy "V.2.A" and referred to the material as a corrosion-resistant iron-chromium-nickel alloy. The alloy was a new metal very different from steel. It could not be hardened by heat treatment, it had a different crystal structure, it had vastly different physical properties, it remained ductile at sub-zero temperatures, it was nonmagnetic unless work hardened, and it did not rust. Krupp marketed the alloy under the trade name Nirosta

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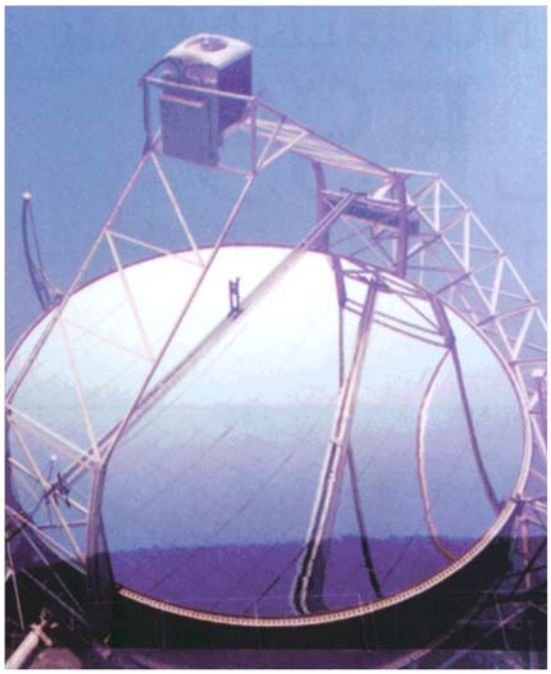

The parabolic mirror made of ThyssenKrupp Nirosta stainless steel at the Almeria, Spain, research facility converts solar energy into electricity. Image courtesy of ThyssenKrupp.

KA2, with Nirosta being an abbreviation of Nichtrostende Stahle (non-rusting steel).

The ferritic alloys

Dantsizen's alloy contained 14 to 16% chromium and 0.07 to 0.15% carbon. This ferritic alloy was only slightly hardenable by heat treatment and was at that time called stainless iron because of its relative softness and ductility. The alloy was initially used for leading-in wires for incandescent lamps. It is interesting to note also that there was once a Rustless Iron and Steel Company that was established in Baltimore in 1920. The classic book written by the English metallurgist, J.H.G. Monypenny in 1926, was entitled *Stainless Iron and Steel.* The terms "stainless iron" and "rustless iron" referred to certain iron-chromium-carbon alloys that were predominantly ferritic and not hardenable by heat treatment, or only slightly hardenable. However, the terms were never adequately defined and are no longer in general use.

For many years the term "stainless steel" was applied only to those alloys that were hardenable by heat treatment, the martensitic alloys. This was logical since the martensitic alloys had all of the characteristics of alloy steel except that they did not rust.

"Stainless steel" as a generic name

When Ernest E. Thum, editor of the American Society for Metal's *Metal Progress,* published the first American book on iron-chromium-carbon and iron-chromium-nickel alloys in 1933, he called it *The Book of Stainless Steels.* This book became a classic in the stainless steel industry and undoubtedly paved the way for the acceptance of "stainless steel" as a generic name for all of these high-chromium, stain-resisting alloys.

Trade names

Some of the earliest trade names, around the year 1915, for various stainless steel alloys were Anka (Brown, Bayley's Steel Works, Ltd.), Staybrite (Thos. Firth & Sons, Ltd.), V.2.A (Krupp Works), Jessop Hi-Gloss (Jessop Steel Co.), and Sterling Nirosta KA-2 S (Firth Sterling Steel Co.).

By 1923, the Firth Sterling Steel Company at McKeesport, Pennsylvania, was marketing three types of chromium stainless steels which were called Stainless Steel Annealed, Stainless Steel Particularly Annealed and Stainless Iron. They were "sold on Brand and Performance and not to Carbon Content or Chemical Analysis." Four years later, Firth Sterling changed its marketing practice, offering five types — Type A, Type T, Type B, Type M and Type H. For each type the carbon and chromium contents were listed. Type A, for example, was listed as having 0.35% carbon and 132% chromium, a composition that meets the requirements of what became generally known as Type 420 stainless steel.

By the early 1930s, almost 100 companies in the United States produced or fabricated stainless steels, marketing them with almost 1,000 trade names, such as Defistain (Rustless Iron Company), Allegheny Metal B (Allegheny Steel Co.), Industrial No. 35 (Industrial Steels Co.), Ship Brand Orange Label (Webb Wire Works), and Corrosion Resisting Circle L (Lebanon Steel Foundry). However, some companies broke away from this practice of giving their products mysterious names and started using meaningful names such as Armco 18-8, USS 19-9 and Enduro 20-10, where the numbers indicated the approximate percentages of chromium and nickel in the alloys. Although AISI numbers had been developed, they were not yet in general use.

Modern producers continue to name their alloys in various ways, including the custom of using established standard numbers, such AISI, UNS, DIN or EN numbers, following their company names or trade names, as in the case of AL 410S, AK Steel 41003, Cronifer 3718 and Outokumpu 4372.

AISI standards

No standardization of the chemical compositions of alloys produced in the stainless steel industry was established until the early 1930's. The American Iron and Steel Institute (AISI) had developed the now-familiar four-digit numbering system for carbon and alloy steels. They decided on a three-digit numbering system for stainless steels. However, it important to note that AISI classed the 4–6% chromium steels as stainless steels, because

these alloys showed a resistance to sulfides four to 10 times that of ordinary steel. Due to this classification, the dictionary definition of stainless steel was "an alloy of iron and at least four percent chromium."

The AISI numbering system for stainless steels consisted of a 300 series for chromium-nickel austenitic alloys, a 400 series for high-chromium ferritic and martensitic alloys, and a 500 series for 4–6% chromium alloys. Examples in each series include 304, 410 and 501.

Forty-six AISI numbers and their corresponding chemical compositions were published in 1932, 28 of which are still in use. Many new AISI numbers were added that were primarily modifications, using suffix letters, such as 304L, 304H, 304N and 420F. AISI 329 was the only duplex (austenitic-ferritic) alloy to have been assigned an AISI number.

In the 1960s, AISI established the 200 series of numbers for the high-manganese austenitic alloys and a 600 series to cover proprietary alloys such as Allegheny Ludlum's A286 alloy. This alloy was designated as Grade 660, and Armco's 17-4PH was designated as Grade 630. Although these 600 numbers still appear in ASTM specifications and elsewhere, they were never officially adopted by AISI.

By 1957 there were 39 AISI numbers for stainless steels, including the 4–6% chromium Types 501 and 502. These 39 alloys are those that have often been referred to as standard stainless steels, whereas all of the remaining alloys have been referred to as nonstandard stainless steels simply because they were not included among those alloys having assigned AISI numbers.

In the mid-1960s, AISI discontinued the practice of assigning numbers because of questions concerning the legality of a trade association being in the business of writing standards (i.e., establishing chemical composition limits for stainless steel alloys). However, the AISI numbering system is still the basic system in the United States for designating alloys standardized by AISI prior to 1960. In fact, AISI requested that the usage of AISI should be discontinued, but that was easier said than done. The AISI numbers still serve as the primary stainless numbering system in many countries, including Canada, Mexico, Brazil, South Africa, India, Australia, New Zealand, and in a modified form in the British, Japanese, and Korean numbering systems. In addition, the AISI numbers are widely recognized throughout the world and are often referenced or adopted by stainless steel producers.

SAE standards

The Society of Automotive Engineers introduced a modification of the AISI stainless steel numbers for SAE standards. SAE embedded most of the AISI three-digit stainless steel numbers into a five-digit system in which the two digits "30" preceded the AISI 300 series numbers and "51" preceded the AISI three-digit 400 series numbers. AISI 304 became SAE 30303 and AISI 410 became SAE 51410.

SAE also developed a series of special EV designations, such as EV-4 and EV-13, for proprietary high-chromium, heat-resisting, aircraft engine valve steels.

ASTM standards

In the 1960s, the American Society for Testing and Materials (ASTM) Committee A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys introduced a series of 34 XM numbers (XM-1 through XM-34) to designate certain proprietary stainless steel alloys. This scheme was adopted so that the proprietary alloys could be included in specifications without using trade names which are generally not accepted in ASTM specifications. The precipitation hardening alloys were given XM numbers and Armco's 15-5PH alloy, for example, was assigned the designation XM-12.

Alloy Casting Institute

The Alloy Casting Institute, a former division of the Steel Founders Society, developed a system for designating stainless and heat-resistant casting alloys. Casting designations within this system begin with either the letter C for corrosion-resistant alloys, or H for heat-resistant alloys. Typical examples are CA-15 and HK-40. This is the most common designation system for stainless steel casting alloys in the United States. Although the ACI organization no longer exists, the system is maintained by ASTM Subcommittee A01.17 on Steel Castings.

British Standards Institution

During the Second World War, the British Standards Institution (BSI) introduced EN Numbers (Emergency Numbers) which was the first standard numbering system for steels in Great Britain. Stainless steels were assigned En numbers 56–61 with letter suffixes. An alloy similar to AISI 304, for example, received the designation En 58E. The En numbers, which should not be confused with the modern EN (Euronorm Numbers), were superseded around 1960, but they continue to be used and are often seen in reference books.

Around 1960, the BSI adopted a new numbering system that incorporated the AISI system in most cases, but not all. The first three digits in the British system are the AISI numbers, followed by the letter S, for stainless, and two digits to indicate modifications. 304S18 and 410S21 are examples of the British Standard numbers for Types 304 and 410 stainless steels. Exceptions include numbers such as 301S81, which is not equivalent to AISI 301, but is a designation for the 17-7PH alloy, and 284S16, which has a composition similar to that of AISI 202.

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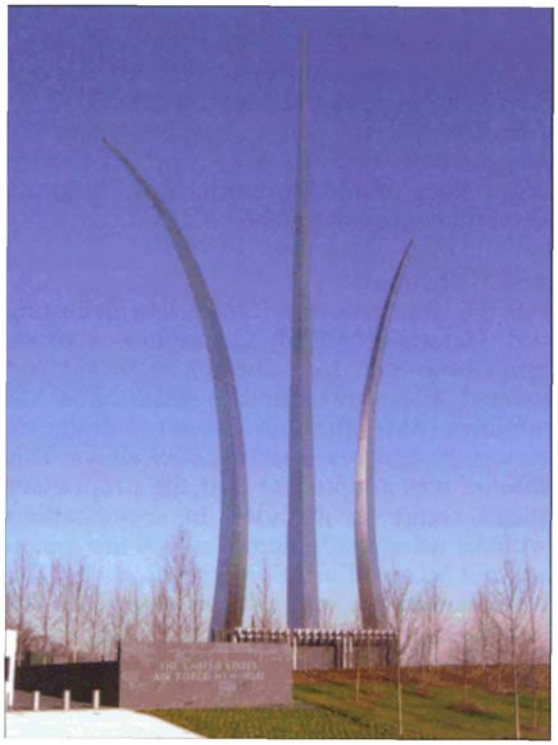

The Air Force Memorial in Washington, D.C., ranks as one of the world's largest structural applications of stainless steel. It consists of three stainless steel spires reaching 64 m into the sky. Each spire has a 19-mm-thick skin of 531600 stainless steel covering a core of reinforced concrete. Image © 2008, Jon Rochetti, www.TheDCTraveler.com.

There are also British Aerospace numbers for stainless steels. These include HR numbers such as HR 3, S numbers such as 2S.130, and T numbers such as T.69.

Deutsches Institut fur Normung (DIN)

In Germany, DIN developed the Werkstoff numbering system for steel in 1959, reserving the 1.4000–1.4999 series of numbers for stainless steels. The Werkstoff number 1.4301 is for a stainless steel composition that is similar to Type 304. In addition to developing Werkstoff numbers, DIN also developed name designations for each alloy. These consist of chemical symbols and numbers that indicate the approximate percentages of the elements. The name associated with the 1.4301 designation is X5CrNi18-10. The DIN five-digit numbering system has been generally adopted for the Euronorm EN numbers. Various forms of this name designation system have been adopted by the national standards organizations of most European countries and ISO, as well as by Russia and China.

Stainless steel in eleven languages

English	Stainless steel
Czech	Nerezová ocel
Dutch	In roestvast staal
French	Acier inoxydable
German	Nichtrostende Stäl
Italian	Acciaio inossidabile
Polish	Gatunków stali
Portuguese	Aço inox
Russian	Nerzhaveiushchei stali
Spanish	Acero inoxidable
Swedish	Rostfritt stål

AFNOR (France)

In France, a dual designation system consists of steel names and a numerical system. The names are based on a mixture of abbreviations for chemical symbols and other names. The names start with the letter Z. The abbreviations include C for chromium, N for nickel and F for free machining. The name for Type 304 stainless steel is Z6CN18.09, and for Type 410F it is Z30CF13.

The numerical system consists of the AISI number followed by the letter F and two digits, such as 304F01.

SIS (Swedish Institute for Standards)

In 1947, SIS developed a four-digit numbering system for metals, reserving the 23xx series for stainless steels. For example, the number 2332 was established for an alloy having a composition similar to that of Type 304.

JIS (Japan Industrial Standards)

Japan has generally adopted the AISI numbering system for stainless steels, with some modifications. In the Japanese system, SUS 304 corresponds to Type 304 stainless steel. SUH numbers serve to designate the heat-resistant alloys such as SUH 310. SCS and SCH numbers are used for stainless steel castings.

ISC (People's Republic of China)

China has a dual system of designating stainless steel, similar to that used in the DIN and EN systems. It consists of the alpha-numerical ISC system and a steel name system based on chemical symbols and numbers indicating percentages.

ISC is the Iron and Steel Code: Unified Numbering System for Iron, Steel and Alloys. This ISC system resembles the American UNS system in many respects. It uses a letter followed by five digits, and for stainless steels the initial letter is S. Some of the entries in the ISC system, such as S31603, S31653 and S41008, are the same as those in the UNS system, and in such cases the chemical compositions for the alloys are identical in each system. The ISC system for stainless steel groups the alloys into five categories: Slxxxx (Ferritic), S2xxxx (Austenitic-Ferritic), S3xxxx (Austenitic), S4xxxx (Martensitic) and S5xxxx (Precipitation Hardening).

In the steel naming system, 00Cr17Ni13Mo2N is the designation for the 316LN alloy which is S31653 in both the ISC and UNS systems.

KS (Republic of Korea)

Korea has adopted a numbering system which appears to be consistent with the Japanese system for stainless steel. The prefix letters STS are used for corrosion-resisting steels, STR for heat-resisting alloys and SSC for stainless steel castings. STS 304 corresponds to Type 304.

GOST (Russia)

Steel names standardized by GOST use chemical symbols and abbreviations of chemical symbols. Ch and K are used for chromium, N for nickel and T for titanium. The name for Type 304 is 08Ch18N10.

UNE (Spain)

In Spain there are three numbering systems for stainless steel. The steel names use chemical symbols and numbers such as X6CrNi19-10, which also corresponds to the F number F.3804.

AISI numbers are also used with the prefix E, such as E305.

UNI (Italy)

Steel names standardized by UNI use chemical symbols and numbers. The name for Type 304 is X8CrNi18-10.

UNS (Unified Numbering System for Metals and Alloys)

The ASTM/SAE UNS system of numbering metals and alloys is widely used for the designation and cataloguing of stainless steels in America and abroad.

The Unified Numbering System for Metals was developed in 1970 by the American Society for Testing and Materials (ASTM) and the Society of Automotive Engineers (SAE) with the cooperation of the Aluminum Association (AA), the American Iron & Steel Institute (AISI), the Copper Development Association, the Steel Founders' Society of America (SFSA), representatives from the metals industry, and the U.S. government. The goal was to develop a numbering system for metals and alloys that could be applied throughout the metals industry. Furthermore, it was to be a system with sufficient capacity to accommodate the possible development of hundreds of new alloys without the need to add suffix letters as in the case of the AISI numbers for carbon, alloy and stainless steels. The existing numbers in the aluminum, copper and steel industries were to become a part of the new system. For stainless steels, the system consists of the letter S followed by five digits. For Type 304 stainless steel, the UNS number is S30400 and for Type 304L the UNS equivalent is S30403. The system also permits the numbering of stainless steel alloys for which there is no AISI designation, such as S35500 for stainless alloy AM 355. For Ferralium 255, the UNS designation is S32550.

The letter N also designates certain stainless alloys that contain less than 50% iron and high nickel contents. The UNS designation for alloy 20Cb-3 is N08020.

For steel casting alloys in the UNS system, a Jxxxxx series of numbers was established. This J series is based on the total alloy content. For stainless steel casting alloys, the numbers fall in a J9xxxx series. ACI alloy CA-15 has the UNS designation J91150. The second, third and fourth digits of J91150 indicate that the alloy has a minimum alloy content of 11.5%, which happens to be the minimum chromium content for this alloy.

Comparable designations for Type 304 stainless steel

USA	304; 30304; S30400
Hungary	AoX; 7CrNi 18-9; KO 33
European	EN 1.4301; X5CrNi 18-10
India	04Cr18Ni 11
International	ISO X5CrNi 18-10
Italy	X8CrNi 19-10
Australia	304; S30400
Japan	SUS 304
Austria	X5CrNi 18-10 KKW
Korea	STS 304
Brazil	E304
Mexico	MT304
Bulgaria	0Ch18N10
Poland	0H8N
Canada	304; S30400
PRC China	0Cr19Ni9; S30408
Czech Republic	240
Rumania	T6NiCr180
France	Z6CN18-09; 304F01
Spain	X6CrNi 19-10; F.3504; E-304
Germany	1.4301; X5CrNi 18-10
Sweden	2332
Great Britain	En 58E; S30418
Russia	08Ch18N11

ISO (International Standards Organization)

Around 1960, the International Standards Organization established ISO Committee TC17 on Steel, and Subcommittee SC4 on Heat Treated and Alloy Steel, which developed ISO 683/XIII, covering stainless steel chemical compositions. Type 304 stainless steel was designated as Type 11 in that document. In 1987 the Type Numbers for stainless steels were changed to the identical steel names used by DIN. The former Type 11 stainless steel is now designated by ISO as X5CrNi 18-10. An exception to this rule is that stainless steels for surgical implants are designated by letters of the alphabet, since these alloys are not included in the DIN system.

In 1980, a group within ISO wanted to develop an International Numbering System for Metals. The proposal was to use the basic format of the UNS system with an initial letter and five digits. The initial letters were the

same as those in the UNS system in some cases, such as A for Aluminum and C for Copper and Copper Alloys. The letter S, however, was to designate Steel Alloys rather than Stainless Steels as in the UNS system. It was obvious to the developers of the UNS system that two systems that looked alike, but in fact were different, would lead to a great deal of confusion. The ISO numbering system never got beyond the planning stage.

EN (Europaischen Normen)

Beginning in 1988, a new series of mandatory European standards (Euronorms) were created to replace national standards, such as British Standards, DIN, Swedish Standards, and French Standards, throughout 18 countries of Western Europe. In 1995, three parts of EN 10088 were published. Part 1 listed the chemical compositions of 83 stainless steels. In addition, EN 10027-1, Part 1, Designation Systems for Steels; Steel Names and EN 10027-2, Part 2, Designation Systems for Steels: Numerical System, were also published in 1995.

The designation system for steel names generally adopted the DIN steel names, such as X5CrNi 18-10 for AISI 304 stainless steel. EN 1.4301 was also adopted from the DIN Werkstoff number DIN 1.4301 for the AISI 304 alloy. ✦

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