STAINLESS STEEL

Welding of Stainless Steel

Stainless steels is a group of high alloy steels, which contain at least 12% chromium. In general, these steels are alloyed with a number of other elements which make them resistant to a variety of different environments. In addition, these elements modify the microstructure of the alloy which in turn has a distinct influence on their mechanical properties and weldability.

Stainless steels can be broadly classified into five groups as detailed below:

- Austenitic stainless steels which contain 12 - 27% chromium and 7 - 25% nickel
- Ferritic stainless steels which contain 12 - 30% chromium with a carbon content below 0,1%
- Martensitic stainless steels which have a chromium content of between 12 and 18% with 0,15 - 0,30% carbon
- Ferritic-austenitic stainless steels which contain 18 - 25% chromium, 3 - 5% nickel and up to 3% molybdenum
- Martensitic-austenitic steels which have 13 - 16% chromium, 5 - 6% nickel and 1 - 2% molybdenum. The first four of these groups will be discussed in detail below.

Austenitic Stainless Steels

This is by far the largest and most important group in the stainless steel range. These steels, which exhibit a high level of weldability, are available in a wide range of compositions such as the 19/9 AISI 304 types, 25/20 AISI 310 types and 19/12/2 AISI 316 types, which are used for general stainless steel fabrications, elevated temperature applications and resistance to pitting corrosion respectively.

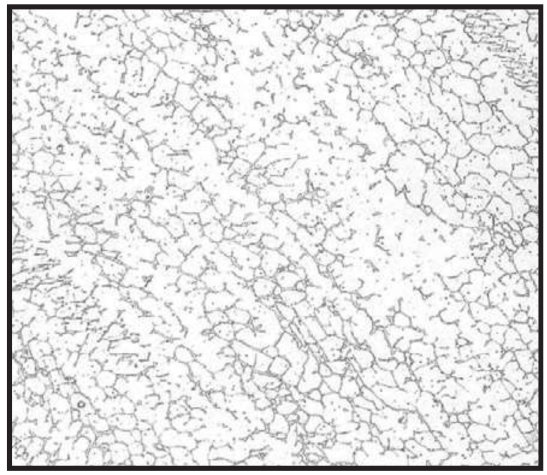
As the name implies, the microstructure of austenitic stainless steel consists entirely of fine grains of austenite in the wrought condition. When subjected to welding, however, a secondary ferrite phase is formed on the austenite grain boundaries, in the heat affected zone and in the weld metal. The extent of the formation of this secondary phase is dependent on the composition of the steel or filler material and the heat input during welding.

While delta ferrite formation can have negative effects on the resistance to corrosion and formation of sigma phase at operating temperatures between 500°C and 900°C, delta ferrite in weld metal is necessary to overcome the possibility of hot cracking.

In general, austenitic welding consumables deposit a weldment containing 4 - 12% delta ferrite. For special applications, i.e. when dissimilar steels are welded under conditions of high restraint, austenitic consumables having weld metal delta ferrite contents as high as 40%, may be required. The delta ferrite can be calculated using the procedure given at the end of this section with the aid of the Schaeffler diagram.

The carbon content of austenitic stainless steels is kept at very low levels to overcome any possibility of carbide precipitation, where chromium combines with available carbon in the vicinity of the grain boundaries to produce an area depleted in chromium, which thus becomes susceptible to intergranular corrosion.

The titanium and niobium stabilised AISI 321 and 347 steels together with ELC (extra low carbon) grades are available to further overcome this problem.



Typical microstructure of Afrox group 1 weld metal showing a structure of delta ferrite in austenite

Ferritic Stainless Steels

These steels which contain 12 - 30% chromium with carbon content below 0,10% do not exhibit the good weldability of the austenitic types. The steels, which become fully ferritic at high temperatures and undergo rapid grain growth, lead to brittle heat affected zones in the fabricated product. No refinement of this coarse structure is possible without cold working and recrystallisation. In addition, austenite formed at elevated temperatures may form martensite upon transformation, which can cause cracking problems. The brittleness and poor ductility of these materials have limited their applications in the as welded condition.

Ferritic stainless steels are also subject to intergranular corrosion as a result of chromium depletion from carbide precipitation. Titanium and niobium stabilised ferritic steels and steels with extra low interstitials (i.e. C, N) are available to overcome this problem.

As this material has a coefficient of expansion lower than that of carbon manganese steels, warpage and distortion during welding is considerably less. They are magnetic, however, and therefore subject to magnetic arc blow. Ferritic stainless steels cannot be hardened by conventional heat treatment processes.

Martensitic Stainless Steels

Martensitic stainless steels contain between 12 - 18% chromium with 0,15 - 0,30% carbon. As a result of their composition, these steels are capable of air hardening and thus special precautions should be taken during welding to overcome possible cracking. Cold cracking, as a result of hydrogen, which is experienced with alloy steels, can also occur in martensitic stainless steels and thus hydrogen-controlled consumables must be used.

Martensitic steels, because of their lower chromium content and responsiveness to heat treatment, have limited applications for corrosion resistance but are successfully used where their high strength and increased hardness can be utilised, e.g. turbine blades, cutlery, shafts, etc.

As in the case of ferritic stainless steels, the martensitic types have a lower coefficient of expansion than mild steels and are magnetic.

Duplex Stainless Steel

These are the most recently developed group of stainless steels and have a mixed metallurgical structure of nearly equal amounts of austenite and ferrite.

The composition ranges from 21 - 25% chromium, 5 - 7% nickel, approximately 3% molybdenum and 0,17% nitrogen.

They have excellent corrosion resistance especially to pitting, crevice and stress corrosion cracking. Their main applications are found in saltwater conditions where pressure and elevated temperatures are present.

Handling of Stainless Steels

To prevent stainless steel sheets and plates from becoming contaminated with grease, oil and carbon steel, all storage areas must be kept clean and free from grinding or welding dust from other operations in the shop. Any oil spills from machinery and equipment must be cleaned and removed as soon as they happen. Lifting straps and grabs that encounter stainless steel either must be made of stainless steel or be covered to protect against contamination. Storage shelves should be made of wood and wood should be used as spacers between sheets and plates also to prevent contamination.

Preparation

All stainless steels need to be prepared without contamination. Any sources of free iron, rust, carbon or hydrogen, etc. can cause welding or corrosion problems. Ideally, all stainless steel fabrication should be done in an area where no other types of steels or materials are processed. The following guidelines should be followed when preparing stainless steels:

- Thermal cutting should be done with the appropriate process (i.e. plasma arc, laser or arc air, not oxy-fuel)
- If machining is performed, it should be done without overheating the base metal, which could cause oxidation
- Grinding should be done with the correct grade of grinding disc and with discs segregated for use only on stainless steel
- All hand tools should be segregated and only used on stainless steel (e.g. files, deburring knives)
- All wire brushes should be made of stainless steel and used only on stainless steel.

Preweld Cleaning

Regardless of the type of stainless steel to be used, it is imperative that the base metal be properly cleaned before welding. In most cases, this involves:

- Wire brush or grind to remove any oxidation (which may be present on hot rolled parts)
- Chemically clean all surfaces that were machine-cut with cutting fluids
- Remove all oil, grease, moisture, etc.
- Wipe all surfaces to be welded with acetone or isopropyl alcohol.

Welding Preparation

- Weld in an area segregated from the welding of other alloys, especially carbon steels and low alloy steels
- Cover welding tables with stainless steel, aluminium or other material to protect the stainless steel parts from contamination
- Use vices, hold-down fixtures and tools, clamps, etc., made of stainless steel or covered with protective material (stainless steel tape).

Re-drying of Electrodes Prior to Welding

Austenitic materials are generally insensitive to the presence of hydrogen, however, since moisture in the electrode coating can lead to porosity in the weld metal, it is recommended that the electrodes be re-baked at 350 - 370°C for 1 - 2 hours prior to use.

Start porosity is generally indicative of damp electrodes. These electrodes should be removed from service immediately and re-dried. Porosity is more common in fillet welds than in butt welds where pores only occur at high moisture contents.

Procedure for Welding Stainless Steels

The procedure for welding stainless steels does not differ greatly from that of welding mild steel. The material being handled, however, is expensive and exacting conditions of service are usually required which necessitate extra precautions and attention to detail.

Stainless steels can be welded using either AC or DC, using as short an arc as possible, to overcome any possibility of alloy loss across the arc. When using AC, a slightly higher current setting may be required.

When welding in the flat position, stringer beads should be used and if weaving is required, this should be limited to two times the electrode diameter. The heat input, which can adversely affect corrosion resistance and lead to excessive distortion, should be limited by using the correct electrode diameter to give the required bead profile and properties at the maximum travel speed. In all cases, the heat input should be limited to 1,5 kJ/mm (MMA and MIG).

Specific points to be noted for the different stainless steel types are given below.

Austenitic Steels

As austenitic stainless steels have a coefficient of expansion 50% greater than carbon manganese steels, distortion and warping can be a problem. Welding currents should therefore be kept as low as possible with high travel speeds. Tacking should be carried out at approximately half the pitch used for mild steel and welding should be balanced and properly distributed. Preheating should not be applied and post weld heat treatment of this material is seldom required after welding. Austenitic stainless steels are normally welded with electrodes of matching composition to the base material.

Ferritic Steels

The need for preheating is determined largely by composition, desired mechanical properties, thickness and conditions of restraint. Preheat, when employed, is normally in the 150 - 250°C range. Some ferritic stainless steels can form chromium carbides at the ferrite grain boundaries during welding. For these types a post weld heat treatment of 700 - 800°C will restore the corrosion properties of the material. For mildly corrosive applications, and where the presence of nickel bearing weld metal can be tolerated, an austenitic steel electrode is recommended. This would tend to alleviate many of the toughness problems of ferritic stainless steel weld metal and could negate the need for post weld heat treatment (i.e.

in many cases the narrow notch sensitive heat affected zone could be tolerated).

Martensitic Steels

These steels require a preheat of 200 - 400°C followed by slow cooling after welding. This should be followed if possible by a post weld heat treatment at 650 - 800°C. Austenitic stainless steel electrodes are normally used for welding this material.

Duplex Stainless Steels

With the ever-increasing demand for duplex stainless steel process equipment, fabricators have developed procedures for the welding and fabrication of these grades. A lot of data on these procedures as well as practical experiences have become available. When fabricating duplex stainless steels, special attention should be paid to heat treatment and welding. Unsuitable heat treatment can result in precipitation of intermetallic phases and deterioration of toughness and corrosion resistance. Although most welding methods can be used to weld duplex steels, they require special procedures for the retention of properties after welding. Below you will find some general guidelines for welding duplex stainless steels.

Duplex stainless steels have good hot cracking resistance, therefore hot cracking of the duplex weld metal is seldom a concern. The problems most typical of duplex stainless steels are associated with the heat affected zone (HAZ), not with the weld metal. The HAZ problems are not hot cracking, but rather a loss of corrosion resistance and toughness, or of post weld cracking. To avoid these problems, the welding procedure should focus on minimising total time at temperature in the 'red hot' 500 - 790°C range for the whole procedure rather than managing the heat input for any one pass. Experience has shown that this approach can lead to procedures that are both technically and economically optimal.

Duplex stainless steels require good joint preparation. For duplex stainless steels, a weld joint design must facilitate full penetration and avoid autogenous regions in the weld solidification. It is best to machine rather than grind the weld edge preparation to provide uniformity of the root face or gap. When grinding must be done, special attention should be given to the uniformity of the weld preparation and the fit-up. Any grinding burr should be removed to maintain complete fusion and penetration. For an austenitic stainless steel, a skilled welder can overcome some deficiencies in joint preparation by manipulation of the welding torch. For a duplex stainless steel, these techniques can cause a longer than expected exposure in the harmful temperature range, leading to results outside of those of the qualified procedure.

Duplex stainless steels can be welded to other duplex stainless steels, to austenitic stainless steels, and to carbon and low alloy steels. Duplex stainless steel filler metals with increased nickel content relative to the base metal are most frequently used to weld duplex stainless steels to other duplex grades. When welding duplex stainless steels to austenitic grades, the austenitic filler metals with low carbon and molybdenum content intermediate between the two steels are typically used. AWS E309LMo/ER309LMo is frequently used for these joints. The same filler metal or AWS E309L/ER309L is commonly used to join duplex stainless steels to carbon and low alloy steels. As austenitic stainless steels have lower strength than duplex grades, welded joints made with austenitic filler metals may not be as strong as the duplex base metal. When welding the highly alloyed austenitic stainless steels, nickel-based fillers are used. The nickel-based filler metals are not normally used for duplex stainless steels, but if they are, they should be free of niobium (columbium). Although not thoroughly documented, there have been suggestions that the ENiCrMo-3 filler (625) has been less than satisfactory, possibly because of interaction of the niobium from the filler with the nitrogen from the duplex base metal.

Table 1 summarises filler metals frequently used to weld duplex stainless steels to dissimilar metals. These examples show the AWS bare wire designation (ER), but depending on the process, joint geometry and other considerations, electrodes (AWS designation E) and flux cored wire may be considered.

Table 1 Welding Consumables used for Dissimilar Metal Welding

	2304	2205	25Cr	Superduplex
2304	2304 ER2209	ER2209	ER2209	ER2209
2205	ER2209	ER2209	25Cr-10Ni-4Mo-N	25Cr-10Ni-4Mo-N
25Cr	ER2209	25Cr-10Ni-4Mo-N	25Cr-10Ni-4Mo-N	25Cr-10Ni-4Mo-N
Superduplex	ER2209	25Cr-10Ni-4Mo-N	25Cr-10Ni-4Mo-N	25Cr-10Ni-4Mo-N
304	ER309LMo ER2209	ER309LMo ER2209	ER309LMo ER2209	ER309LMo
316	ER309LMo ER2209	ER309LMo ER2209	ER309LMo ER2209	ER309LMo ER2209
Carbon steel Low alloy steel	ER309L	ER309L	ER309L	ER309L

Procedure for Welding Clad Steels

The use of a clad material, consisting of a mild or low alloy steel backing faced with stainless steel, usually from 10 - 20% of the total thickness, combines the mechanical properties of an economic backing material with the corrosion resistance of the more expensive stainless steel facing. This facing usually consists of austenitic stainless steel of the 18% chromium, 8% nickel and 18% chromium, 10% nickel type, with or without additions of molybdenum, titanium and niobium, or a martensitic stainless steel of the 13% chromium type.

The backing should be welded first, at the same time making sure that the root run of the mild steel electrode does not come into contact with the alloyed cladding. This can be achieved in two ways, either by cutting the cladding away from both sides of the root, or welding with a close butt preparation and a sufficiently large root face.

After welding the mild steel side, the root run should be back grooved and the stainless clad side welded with a stainless electrode of matching composition. The use of a more highly alloyed electrode (e.g. Afrox 309L) for the initial root run on the clad side is advisable. This applies particularly to preparations in which the backcutting of the cladding makes pick-up from the mild steel difficult to avoid. For the best resistance to corrosion, at least two layers of stainless weld metal on the clad side are recommended.

The welding of material which is clad or lined with 13% Cr (martensitic) steels usually requires a preheat of 250°C and the use of austenitic electrodes of appropriate type. Welding should be followed by a post weld heat treatment, though satisfactory results can be obtained without these precautions if, during welding, heat dissipation is kept to a minimum. This will help to temper the heat affected zone by utilising the heat build-up from adjacent weld runs.

Procedure for Welding Stainless Steels to Mild or Low Alloy Steels

Situations frequently arise when it becomes necessary to weld an austenitic stainless steel to a CMn or low alloy ferritic steel. In selecting a suitable electrode, the effect of dilution of the weld metal by the base material must be considered.

The weld metal may be diluted from 20 - 50% depending on the welding technique used, root runs in butt joints being the most greatly affected since all subsequent runs are only in partial contact with the base material and share dilution with neighbouring runs. If a CMn or low alloy steel electrode is used to weld stainless to CMn steel, the pick-up of chromium and nickel from the stainless steel side of the joint could enrich the weld metal by up to 5% chromium and 4% nickel. This would result in a hardenable crack-sensitive weld.

Austenitic stainless steel electrodes are therefore used for joining dissimilar metal combinations of stainless materials to CMn and low alloy ferritic steels. However, the correct type, which has sufficient alloying to overcome the effects of dilution from the mild or low alloy steel side of the joint, must be selected since if the weld metal does not start with an adequate alloy content the final weld may contain less than 17% chromium and 7% nickel. Weld metal with lower chromium and nickel content is crack sensitive. Also, if as a result of dilution the weld metal is incorrectly balanced with nickel and chromium, there may not be sufficient ferrite present in the weld metal to prevent fissuring and subsequent cracking.

For these reasons, the austenitic stainless steel electrodes such as Afrox 312 or 309LMo, etc. should be used, as their composition has been specially balanced to ensure that the total alloy content is adequate to accommodate dilution effects and their ferrite content is sufficient to provide high resistance to hot cracking.

Post Weld Cleaning of Stainless Steels

Following welding, the weld and surrounding heat affected zone (HAZ) should be properly cleaned, to ensure that the entire weldment has full corrosion resistance.

Depending upon the application, one or more of the following may be necessary:

- Chip or grind to remove all slag, scale and heavy oxide
- Remove all spatter
- Grind any arc strikes
- Wire brush to remove all traces of slag
- Wire brush to remove discolouration
- Grind and/or repair any crevices and pits
- Ensure all wire brushes are stainless steel, and are segregated for use only on stainless steels
- Segregate all tools for use on stainless steel, and do not allow them to become contaminated with carbon steel.

If the weldment is not properly cleaned, slag, entrapped foreign particles, and even discoloured oxides (light blue or straw-coloured or darker) may cause corrosion, depending on the environment.

Further treatments could include:

- Chemical cleaning
- Pickling – use of an acid to attack and remove contamination, oxidised areas, etc.
- Passivation – chemical treatment to form chromium rich passive oxide layer on the surface
- Mechanical polishing – to remove crevices and produce a smooth surface
- Electropolishing (following mechanical polishing) – produces the smoothest surface finish to avoid crevices and pits. This also renders the surface less reactive than chemical passivation.

Effects of Alloying Elements and Impurities in Stainless Steels

Carbon (C)

- A strong austenite former
- Added to some high strength alloys for hardening and strengthening effects.

Manganese (Mn)

- Austenite former.

Silicon (Si)

- A ferrite former
- Used to increase the corrosion resistance of austenitic steels
- Used to improve high temperature scaling resistance
- Used to improve resistance of high temperature steels to carburisation

- Promotes wetting by weld metal at 0,1 - 0,8%.

Chromium (Cr)

- A ferrite former
- Primary contributor to resistance to scaling and corrosion
- In the stainless steels, this element is used with little or no effect on high temperature strength and creep strength
- 12% chromium minimum essential for passivation.

Nickel (Ni)

- An austenite former
- Used to improve the general corrosion resistance against non-oxidising liquids
- Sometimes added in small amounts to straight chromium grades to improve the mechanical properties.

Molybdenum (Mo)

- A ferrite former
- Used to improve high temperature strength and creep resistance
- Used to improve general corrosion resistance of steels in non-oxidising media, and the resistance to pitting corrosion in all media.

Copper (Cu)

- Used to improve corrosion resistance of stainless steel in environments which are reducing rather than oxidising.

Niobium (Nb)

- A strong carbide former, used to stabilise austenitic stainless steels against the harmful precipitation of chromium carbides in the range of 480 - 820°C
- A strong ferrite former
- Added to some high strength alloys for hardening and strengthening effects
- Added to some martensitic straight chromium stainless steels to tie up the carbon and hence reduce the hardening tendency of the steels.

Titanium (Ti)

- A strong carbide former. Used to stabilise austenitic stainless steels against the harmful precipitation of chromium carbides in the range of 480 - 820°C
- A strong ferrite former
- Added to some high strength heat resisting alloys for its hardening and strengthening effects.

Cobalt (Co)

- Added to various alloys to impart strength and creep resistance at high temperatures.

Tungsten (W)

- Improves the high temperature strength and creep resistance of some high temperature alloys.

Nitrogen (N)

- A strong austenite former
- Used to minimise grain grown in high chromium straight chromium steels at high temperatures.

Types of Corrosion

Uniform Surface Corrosion

This occurs when the general corrosion resistance of a steel is inadequate to withstand the attack of the corrosive medium. It is then necessary to choose another steel having higher corrosion resistance, i.e. usually one of higher alloy content.

Pitting Corrosion

Certain chemicals, such as chlorides and some organic acids, cause localised pitting of the steel surface. The presence of molybdenum in the stainless steel has been found to reduce this tendency.

Stress Corrosion

Some stainless steels having high residual stresses remaining after fabrication will, in certain cases, fail very rapidly due to stress corrosion. The most satisfactory method of preventing this is to solution treat the fabrication. Another method involves redesigning to reduce the stress concentration. If neither of these methods is possible or economical, a change to a higher alloy material may provide the solution. The use of duplex austenitic ferritic stainless steels can also be effective in preventing stress corrosion cracking.

Weld Decay/Sensitisation

If unstabilised CrNi steels are heated to 500 - 900°C and allowed to cool slowly, they become more easily prone to corrosion. Such a condition may occur in the heat affected zone of a weld when a band is formed parallel to the weld where corrosion resistance is greatly reduced. This is due to the chromium in the grain boundary areas combining with the carbon. The subsequent precipitation of chromium carbides leaves a chromium depleted alloy in the grain boundaries of much lower corrosion resistance. When the steel is immersed in a corrosive medium, these depleted areas are eaten out and the grains of metal simply fall apart.

Titanium or niobium additions are frequently made to stainless steels to act as ‘stabilisers’. These elements have a greater affinity for carbon than has chromium and combine with it to form harmless titanium or niobium carbides. In this way, the grain boundaries are not depleted of chromium and retain their corrosion resistance.

Unstabilised steel that has been welded may have corrosion resistance restored by quenching from 1 100°C. This method is limited by size considerations and the tendency to distort during the heat treatment.

An even better method of avoiding carbide precipitation is to reduce the carbon content in the steel to such a low level that negligible carbide formation is possible at any temperature. A carbon level of less than 0,03% is effective in achieving this. Such extra low carbon steels are not subject to harmful carbide precipitation during welding and also display superior impact properties at low temperatures.

Welding electrodes are available with either extra low carbon content (L grade, i.e. 308L, 316L) or containing niobium to stabilise the higher carbon weld deposit against weld decay. Titanium, used to stabilise wrought material, i.e. AISI 321, is not suitable for stabilising weld metal since much of it is oxidised during transfer across the arc. It is lost to the slag and is replaced by niobium as a stabiliser in electrodes.

Oxidation

Steels for heat resistance must possess one or both of two properties – resistance to oxidation or scaling, and the retention of correct shape under stress at elevated temperatures, i.e. AISI 310.

The scaling or oxidation resistance of these steels is derived primarily from chromium, which is increasingly effective from 8% upwards. Nickel also improves oxidation resistance but only when present in large amounts. It is, however, more effective in promoting dimensional stability under stress at elevated temperatures, that is, it imparts creep resistance. Other elements contributing to creep resistance are titanium, niobium, molybdenum, cobalt and tungsten.

Sigma Phase Embrittlement

A feature, which occurs when some stainless steels are exposed to temperatures in the range of 450 - 900°C, is the formation of sigma phase. This is a brittle constituent which develops from the ferrite in the 'duplex' austenitic type of stainless steels, and results in loss of ductility and toughness in steel, especially with 312 and 2209.

Sulphur Attack

Sulphidation may occur in nickel bearing steel exposed to high-temperature atmospheres containing sulphurous gases.

The nickel is attacked and forms nickel sulphide causing cracking of the steel. Under such conditions, plain chromium steels must be used.

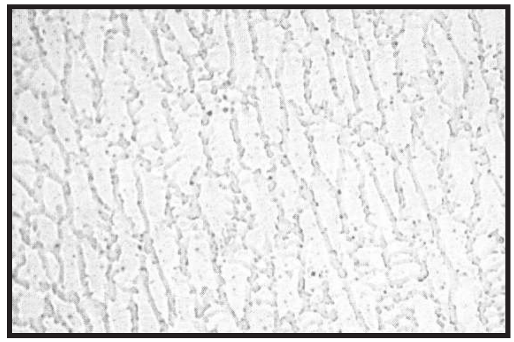
Schaeffler, DeLong and WRC - 1992 Diagrams

A useful method of assessing the general metallurgical characteristics of any stainless steel weld metal is by means of the Schaeffler, DeLong and WRC – 1992 diagrams. The various alloying elements are expressed in terms of nickel or chromium equivalents, i.e. elements such as nickel tend to form austenite and elements like chromium which tend to form ferrite. By plotting the total values for the nickel and chromium equivalents on these diagrams, a point can be found indicating the main phases present in the stainless steel in terms of ferrite percentage and ferrite number, respectively. This provides certain information as to its behaviour during welding.

The Schaeffler diagram indicates that the comparatively low-alloyed steels are hardenable since they contain the martensitic phase in the as welded state. As the alloying elements increase, the austenite and ferrite phases become more stable and the alloy ceases to be quench hardenable. Steels with a relatively high level of carbon, nickel and manganese become fully austenitic (austenite area), while those with more chromium, molybdenum, etc. tend to be fully ferritic (ferrite area).

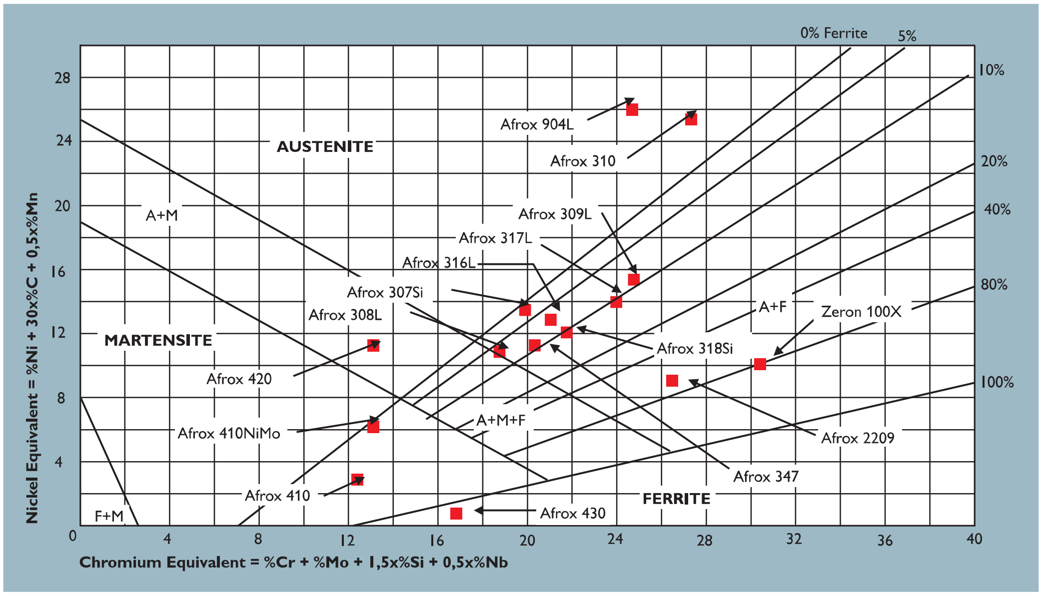
There is also an important intermediate region of 'duplex' compositions indicated as A + F on the diagram. In this region the welds contain both austenite and ferrite. This leads to the general classification of stainless steels into austenitic, ferritic and martensitic, according to which phase is predominant.

The DeLong and WRC diagrams are used to determine the amount of ferrite present in the deposited weld metal. The amount of ferrite is indicated either as the percentage of ferrite present in the microstructure or as a ferrite number. As previously mentioned ferrite, whilst detrimental to corrosion resistance, is necessary in small amounts to prevent hot cracking and is usually present in the range 4-12FN.

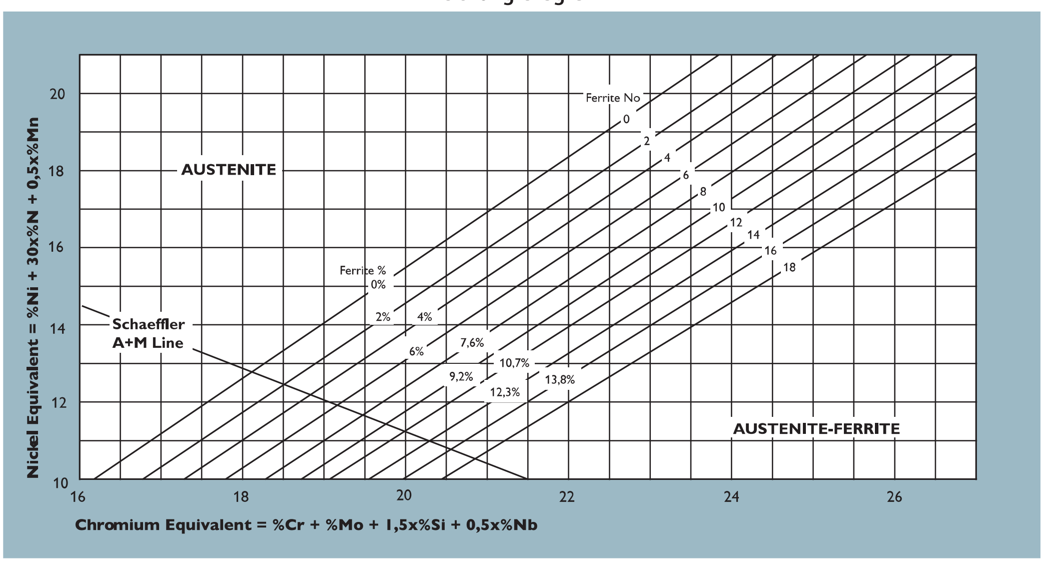


The fully austenitic weld metal of Afrox 904L

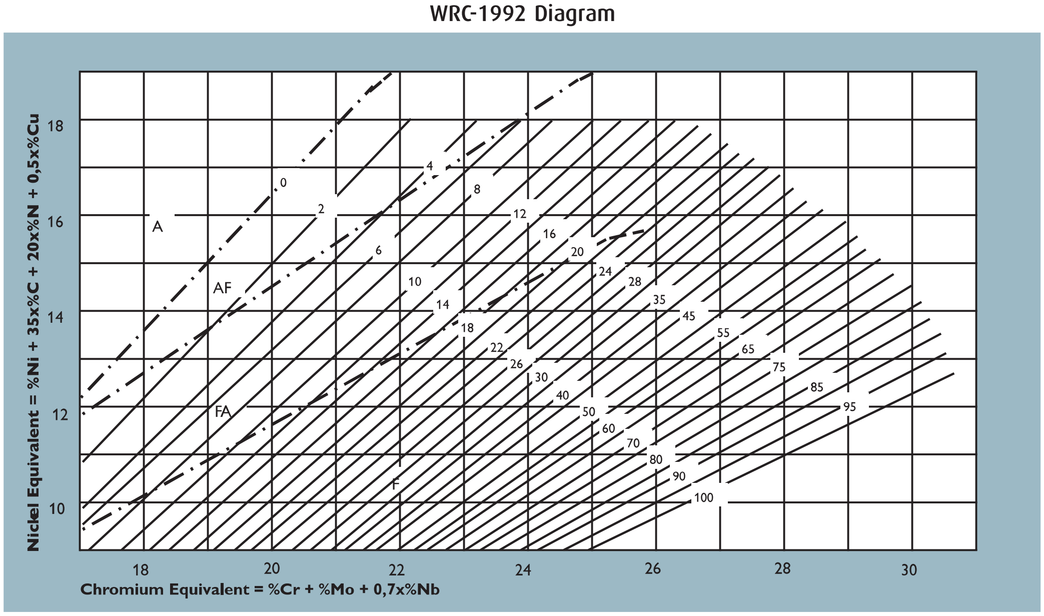
Schaeffler Diagram



DeLong Diagram



WRC-1992 Diagram



Electrode Selection Chart

Suggested Afrox electrodes for fabrication of CrNi and CrNiMo stainless steels:

Chemical Analysis of AISI Stainless Steels

AISI Type Number	Carbon (% max)	Manganese (% max)	Silicon (% max)	Chromium (%)	Nickel (%)	Other Elements (%)	Weld with Electrode Type
201	0,15	5,5 - 7,5	1,0	16,0 - 18,0	3,5 - 5,5	N2 0,25 max	Supranox 308L Afrox 308L
202	0,15	7,5 - 10,0	1,0	17,0 - 19,0	4,0 - 6,0	N2 0,25 max	Supranox 308L Afrox 308L
301	0,15	2,0	1,0	16,0 - 18,0	6,0 - 8,0		Supranox 308L Afrox 308L
302	0,15	2,0	1,0	17,0 - 19,0	8,0 - 10,0		Supranox 308L Afrox 308L
302B	0,15	2,0	3,0	17,0 - 19,0	8,0 - 10,0		Supranox 308L Afrox 308L
303	0,15	2,0	1,0	17,0 - 19,0	8,0 - 10,0	S 0,15 min	Supranox 308L Afrox 308L
303E	0,15	2,0	1,0	17,0 - 19,0	8,0 - 10,0	Se 0,15 min	Supranox 308L Afrox 308L
304	0,08	2,0	1,0	18,0 - 20,0	8,0 - 12,0		Supranox 308L Afrox 308L
304L	0,03	2,0	1,0	18,0 - 20,0	8,0 - 20,0		Supranox 308L Afrox 308L
305	0,12	2,0	1,0	17,0 - 19,0	10,0 - 13,0		Supranox 308L Afrox 308L
308	0,08	2,0	1,0	19,0 - 21,0	10,0 - 12,0		Supranox 308L Afrox 308L
309	0,20	2,0	1,0	22,0 - 24,0	12,0 - 15,0		Supranox 309L Afrox 309L
309S	0,08	2,0	1,0	22,0 - 24,0	12,0 - 15,0		Supranox 309L Afrox 309L
310	0,25	2,0	1,5	24,0 - 26,0	19,0 - 22,0		Inox 310 Afrox 310
310S	0,08	2,0	1,5	24,0 - 26,0	19,0 - 22,0		Inox 310 Afrox 310
314	0,25	2,0	3,0	23,0 - 26,0	19,0 - 22,0		Inox 310 Afrox 310
316	0,08	2,0	1,0	16,0 - 18,0	10,0 - 14,0	Mo 2,0 - 3,0	Supranox 316L Afrox 316L
316L	0,03	2,0	1,0	16,0 - 18,0	10,0 - 14,0	Mo 2,0 - 3,0	Supranox 316L Afrox 316L
317	0,08	2,0	1,0	18,0 - 20,0	11,0 - 15,0	Mo 3,0 - 4,0	Supranox 317
321	0,08	2,0	1,0	17,0 - 19,0	9,0 - 12,0	Ti 5 x C min	Inox 347
347	0,08	2,0	1,0	17,0 - 19,0	9,0 - 13,0	Nb + Ta 10 x C min	Inox 347
904	0,025	2,5	0,5	19,5 - 21,5	24,0 - 26,0	Mo 4,5 - 5,2, Cu 1,2 - 2,0	Afrox 904L
2209	0,03	2,0	0,9	21,5 - 23,5	7,5 - 9,5	Mo 2,5 - 3,5, N 0,08 - 0,2, Cu 0,75 max	Inox 4462
2507	0,03	2,0	1,0	24,0 - 26,0	8,5 - 10,5	Mo 3,5 - 4,5, N 0,2 - 0,3, Cu 0,5 max	TBA
2553	0,04	1,5	1,0	24,0 - 27,0	7,5 - 8,5	Mo 2,9 - 3,9, N 0,18 - 0,25, Cu 1,5 - 2,5 max	TBA
Zeron® 100	0,04	1,0	1,0	24,5 - 26,0	9,0 - 10,0	Mo 3,5 - 4,0, W 0,5 - 1,0, N 0,2 - 0,3, Cu 0,5 - 1,0	TBA

Columbus Steel 3CR12 can be welded with any of the following consumables: Afrox 308L, 309L, 316L, Afrox E3CR12

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AWS Classifications for Stainless Steel Welding Consumables

Stainless steel welding consumables may be classified according to the American Welding Society (AWS) as follows:

- AWS A5.4 SMAW/MMA electrodes
- AWS A5.9 GMAW/MIG, GTAW/TIG and SAW wires and rods
- AWS A5.22 FCAW electrodes.

AWS 5.4 for Covered Electrodes

Generally, the electrodes are designated by an 'E' for electrode and then by a series of numbers to designate the alloy type. These numbers generally follow the same numbering system as the base metals such as 309 or 316. These numbers are followed by a suffix indicating current polarity and positions. Therefore, the designation for a 308 electrode will be as follows:

AWS A5.4 E308L-17

There may be other designators, which indicate specific alloying elements such as L which indicates a low carbon grade, H, which indicates a high carbon grade, Si, which indicates higher silicon content, and Mo, which indicates the addition of molybdenum to the alloy. The final two digits indicating polarity and position are as follows:

AWS Classification	Welding Current	Welding Position
EXXX(X)-I5	DCEP	All
EXXX(X)-25	DCEP	H, F
EXXX(X)-16	DCEP or AC	All
EXXX(X)-17	DCEP or AC	All
EXXX(X)-26	DCEP or AC	H, F

AWS A5.9 for Solid Wires

Wire or rods for welding stainless steels are designated by the letters 'ER' for electrode rod followed by the same alloy designators as in AWS A5.4. Thus, a low carbon 308 wire with higher silicon levels will have the following designation:

AWS A5.9 ER.308LSi

AWS A5.22 for Flux Cored Electrodes

The designations indicate the chemical composition of the undiluted deposited weld metal, position of welding, external shielding medium and type of current. The 'E' designator is used for the FCAW process - both for gas shielded and self-shielded - whilst the 'R' designator is used for the GTAW/TIG process. These filler materials are generally used for root pass welding of stainless steel pipes, without the use of back shielding gas. Thus, a 308 flux cored electrode will have the following designation:

AWS A5.22 E308LT 1-4

The 'T' designator indicates a tubular wire and the digit following the 'T' indicates the position of welding, with 1 indicating all-position and 0 for flat and horizontal only. The final digit indicates the type of shielding medium as follows:

1 indicates 100% carbon dioxide

3 indicates non- or self-shielded

4 indicates 75 - 80% argon 20 - 25% CO_2

5 indicates 100% argon

AWS A5.0 1 Filler Material Procurement Guidelines

The specification covers the testing and classification of welding consumables from a procurement point of view and outlines how customers should specify what product testing and quality control they require. The first section covers the classification of 'lots' or batch sizes and testing. The second section covers product testing. In all instances, when a customer orders product, they should state on the order the lot classification and testing schedule they require.

Lot Classification

This covers electrodes, solid wires and tubular wires with the suffix 'C' for covered electrodes, 'S' for solid wires, 'F' for submerged arc welding, brazing and braze welding and 'T' for tubular wires. See table overleaf for details.

AWS Lot and Testing Schedules for Welding Consumbles

Lot Classification	Requirements
Covered Electrodes	
C1	Manufacturer's standard lot as defined in its quality system
C2	A lot of one size not exceeding 45 350 kg of any size produced in 24 hr of consecutively scheduled production
C3	A lot of one size not exceeding 45 350 kg produced in 24 hr of consecutively scheduled production. The flux to be identified by wet mix or controlled chemical. Composition and core wire identified by heat number or controlled chemical composition
C4	A lot of any one size produced from one wet mix and one heat of core wire
C5	A lot of one size produced from one dry blend of flux and one heat of core wire
Solid Wire	
S1	A lot as defined in the manufacturer's quality assurance programme
S2	A lot not exceeding 45 350 kg of one size, form and temper produced in 24 hr of consecutively scheduled production from one heat or from material identified by controlled chemical composition
S3	A lot of one size produced from one heat in one production cycle
S4	A lot not exceeding 45 350 kg of one size, form and temper produced under one production schedule from one heat or from material identified by controlled chemical composition
Tubular Electrodes	
T1	A lot as defined in the manufacturer's quality assurance programme
T2	A lot not exceeding 45 350 kg of one size produced in 24 hr of consecutively scheduled production. The strip to be identified by one heat or from material identified by controlled chemical composition. The core ingredients to be identified by dry blend
T3	A lot of one size produced from one heat and one dry batch or dry blend of core ingredients
T4	A lot not exceeding 45 350 kg of one size produced under one production schedule from tube or strip identified by heat number or controlled chemical composition. The core ingredients to be identified by dry blend or controlled chemical composition
Submerged Arc Fluxes	
F1	A lot as defined in the manufacturer's quality assurance programme
F2	A lot produced from the same combination of raw materials in one production cycle

Testing Schedule

AWS A5.0 1 specifies the level of testing as follows:

Schedule	Requirements
F	The manufacturer's standard testing level
G	Tests of the material from any production run of the product within the 12 months preceding the date of purchase
H	Chemical analysis only for each lot shipped
I	In the case of stainless steel, schedule I calls for chemical analysis only
J	All tests called for in the AWS filler metal specification, for each lot shipped. In all cases, this includes chemical analysis. Covered electrodes 3,2 mm and above require tensile and fillet weld tests
K	All tests specified by the purchaser, for each lot shipped

EN ISO Classifications of Manual Metal Arc (MMA) Stainless Steel Welding Consumables

Covered electrodes for MMA welding are covered by EN ISO 3581 as set out below:

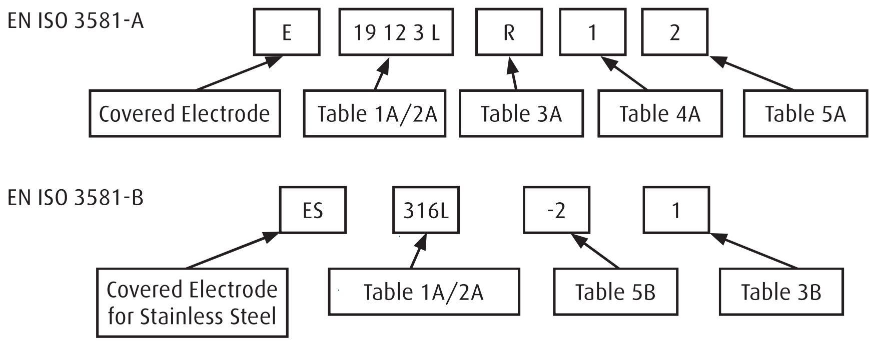

Table 1A Chemical Composition Requirements

Symbol classification by chemical composition a (%)												
Nominal Composition b,c,d (EN ISO 3581-A)	Alloy Type d (EN ISO 3581-B)	C	Si	Mn	P	S	Cr	Ni	Mo	Cu	Nb + Ta	N
—	409Nb	0,12	1,0	1,0	0,04	0,03	11,0 - 14,0	0,6	0,75	0,75	0,5 - 1,5	—
13	(410)	0,12	1,0	1,5	0,03	0,025	11,0 - 14,0	0,6	0,75	0,75	—	—
(13)	410	0,12	0,9	1,0	0,04	0,03	11,0 - 14,0	0,7	0,75	0,75	—	—
13 4	(410NiMo)	0,06	1,0	1,5	0,03	0,025	11,0 - 14,5	3,0 - 5,0	0,4 - 1,0	0,75	—	—
(13 4)	410NiMo	0,06	0,90	1,0	0,04	0,03	11,0 - 12,5	4,0 - 5,0	0,4 - 0,7	0,75	—	—
17	(430)	0,12	1,0	1,5	0,03	0,025	16,0 - 18,0	0,6	0,75	0,75	—	—
(17)	430	0,1	0,9	1,0	0,04	0,03	15,0 - 18,0	0,6	0,75	0,75	—	—
—	430Nb	0,1	1,0	1,0	0,04	0,03	15,0 - 18,0	0,6	0,75	0,75	0,5 - 1,5	—
19 9	(308)	0,08	1,2	2,0	0,03	0,025	18,0 - 21,0	9,0 - 11,0	0,75	0,75	—	—
(19 9)	308	0,08	1,0	0,5 - 2,5	0,04	0,03	18,0 - 21,0	9,0 - 11,0	0,75	0,75	—	—
19 9 H	(308H)	0,04 - 0,08	1,2	2,0	0,03	0,025	18,0 - 21,0	9,0 - 11,0	0,75	0,75	—	—
(19 9 H)	308H	0,04 - 0,08	1,0	0,5 - 2,5	0,04	0,03	18,0 - 21,0	9,0 - 11,0	0,75	0,75	—	—
19 9 L	(308L)	0,04	1,2	2,0	0,03	0,025	18,0 - 21,0	9,0 - 11,0	0,75	0,75	—	—
(19 9 L)	308L	0,04	1,0	0,5 - 2,5	0,04	0,03	18,0 - 21,0	9,0 - 12,0	0,75	0,75	—	—
(20 10 3)	308Mo	0,08	1,0	0,5 - 2,5	0,04	0,03	18,0 - 21,0	9,0 - 12,0	2,0 - 3,0	0,75	—	—
—	308LMo	0,04	1,0	0,5 - 2,5	0,04	0,03	18,0 - 21,0	9,0 - 12,0	2,0 - 3,0	0,75	—	—
—	349	0,13	1,0	0,5 - 2,5		0,04	0,03	18,0 - 21,0	8,0 - 10,0	0,35 - 0,65	0,75	—

Table 1A (continued)

Symbol classification by chemical composition [a] (%)											
Nominal Composition [b,c,d] (EN ISO 3581-A)	Alloy Type [d] (EN ISO 3581-B)	C	Si	Mn	P	S	Cr	Ni	Mo	Cu	Nb + Ta	N
19 9 Nb	(347)	0,08	1,2	2,0	0,03	0,025	18,0 - 21,0	9,0 - 11,0	0,75	0,75	8 x C - 1,1	—
(19 9 Nb)	347	0,08	1,0	0,5 - 2,5	0,04 0,03	18,0 - 21,0	9,0 - 11,0	0,75	0,75	8 x C - 1,0	—	—
—	347L	0,04	1,0	0,5 - 2,5	0,04	0,03	18,0 - 21,0	9,0 - 11,0	0,75	0,75	8 x C - 1,0	—
19 12 2	(316)	0,08	1,2	2,0	0,03	0,025	17,0 - 20,0	10,0 - 13,0	2,0 - 3,0	0,75	—	—
(19 12 2)	316	0,08	1,0	0,5 - 2,5	0,04	0,03	17,0 - 20,0	11,0 - 14,0	2,0 - 3,0	0,75	—	—
(19 12 2)	316H	0,04 - 0,08	1,0	0,5 - 2,5	0,04	0,03	17,0 - 20,0	11,0 - 14,0	2,0 - 3,0	0,75	—	—
(19 12 3 L)	316L	0,04	1,0	0,5 - 2,5	0,04	0,03	17,0 - 20,0	11,0 - 14,0	2,0 - 3,0	0,75	—	—
19 12 3 L	(316L)	0,04	1,2	2,0	0,03	0,025	17,0 - 20,0	10,3 - 13,0	2,5 - 3,0	0,75	—	—
—	316LCu	0,04	1,0	0,5 - 2,5	0,04	0,03	17,0 - 20,0	11,0 - 16,0	1,2 - 2,75	1,0 - 2,5	—	—
—	317	0,08	1,0	0,5 - 2,5	0,04	0,03	18,0 - 21,0	12,0 - 14,0	3,0 - 4,0	0,75	—	—
—	317L	0,04	1,0	0,5 - 2,5	0,04	0,03	18,0 - 21,0	12,0 - 14,0	3,0 - 4,0	0,75	—	—
19 12 3 Nb	(318)	0,08	1,2	2,0	0,03	0,025	17,0 - 20,0	10,0 - 13,0	2,5 - 3,0	0,75	8 x C - 1,1	—
(19 12 3 Nb)	318	0,08	1,0	0,5 - 2,5	0,04	0,03	17,0 - 20,0	11,0 - 14,0	2,0 - 3,0	0,75	6 x C - 1,0	—
19 13 4 N L	—	0,04	1,2	1,0 - 5,0	0,03	0,025	17,0 - 20,0	12,0 - 15,0	3,0 - 4,5	0,75	—	0,02
—	320	0,07	0,6	0,5 - 2,5	0,04	0,03	19,0 - 21,0	32,0 - 36,0	2,0 - 3,0	3,0 - 4,0	8 x C - 1,0	—
—	320LR	0,03	0,3	1,5 - 2,5	0,02	0,015	19,0 - 21,0	32,0 - 36,0	2,0 - 3,0	3,0 - 4,0	8 x C - 0,4	—
22 9 3 N L	(2209)	0,04	1,2	2,5	0,03	0,025	21,0 - 24,0	7,5 - 10,5	2,5 - 4,0	0,75	—	0,08 - 0,2
(22 9 3 N L)	2209	0,04	1,0	0,5 - 2,0	0,04	0,03	21,5 - 23,5	7,5 - 10,5	2,5 - 3,5	0,75	—	0,08 - 0,02
25 7 2 N L [c]	—	0,04	1,2	2,0	0,035	0,025	24,0 - 28,0	6,0 - 8,0	1,0 - 3,0	0,75	—	0,2
25 9 3 Cu N L	(2593)	0,04	1,2	2,5	0,03	0,025	24,0 - 27,0	7,5 - 10,5	2,5 - 4,0	1,5 - 3,5	—	0,1 - 0,25
25 9 4 N L [d]	(2593)	0,04	1,2	2,5	0,03	0,025	24,0 - 27,0	8,0 - 11,0	2,5 - 4,5	1,5	—	0,2 - 0,3
—	2553	0,06	1,2	0,5 - 1,5	0,04	0,03	24,0 - 27,0	6,5 - 8,5	2,9 - 3,9	1,5 - 2,5	—	0,1 - 0,25
(25 9 3 Cu N L)	2593	0,04	1,0	0,5 - 1,5	0,04	0,03	24,0 - 27,0	8,5 - 10,5	2,9 - 3,9	1,5 - 3,0	—	0,08 - 0,25
18 15 3 L	—	0,04	1,2	1,0 - 4,0	0,03	0,025	16,5 - 19,5	14,0 - 17,0	2,5 - 3,5	0,75	—	—
18 16 5 N L [c]	—	0,04	1,2	1,0 - 4,0	0,035	0,025	17,0 - 20,0	15,5 - 19,0	3,5 - 5,0	0,75	—	0,2
20 25 5 Cu N L	(385)	0,04	1,2	1,0 - 4,0	0,03	0,025	19,0 - 22,0	24,0 - 27,0	4,0 - 7,0	1,0 - 2,0	—	0,25

Table 1A (continued)

Symbol classification by chemical composition a (%)												
Nominal Composition b,c,d (EN ISO 3581-A)	Alloy Type d (EN ISO 3581-B)	C	Si	Mn	P	S	Cr	Ni	Mo	Cu	Nb + Ta	N
20 16 Mn N L c	—	0,04	1,2	5,0 - 8,0	0,035	0,025	18,0 - 21,0	15,0 - 18,0	2,5 - 3,5	0,75	—	0,2
25 22 2 N L	—	0,04	1,2	1,0 - 5,0	0,03	0,025	24,0 - 27,0	20,0 - 23,0	2,0 - 3,0	0,75	—	0,2
27 31 4 Cu L	—	0,04	1,2	2,5	0,03	0,025	26,0 - 29,0	30,0 - 33,0	3,0 - 4,5	0,6 - 1,5	—	—
18 8 Mn c	—	0,2	1,2	4,5 - 7,5	0,035	0,025	17,0 - 20,0	7,0 - 10,0	0,75	0,75	—	—
18 9 Mn Mo c	(307)	0,04 - 0,14	1,2	3,0 - 5,0	0,035	0,025	18,0 - 21,5	9,0 - 11,0	0,5 - 1,5	0,75	—	—
(18 9 Mn Mo)	307	0,04 - 0,14	1,0	3,3 - 4,75	0,04	0,03	18,0 - 21,5	9,0 - 10,7	0,5 - 1,5	0,75	—	—
20 10 3	(308Mo)	0,1	1,2	2,5	0,03	0,025	18,0 - 21,0	19,0 - 12,0	1,5 - 3,5	0,75	—	—
23 12 L	(309L)	0,04	1,2	2,5	0,03	0,025	22,0 - 25,0	11,0 - 14,0	0,75	0,75	—	—
(23 12 L)	309L	0,04	1,0	0,5 - 2,5	0,04	0,03	22,0 - 25,0	12,0 - 14,0	0,75	0,75	—	—
(22 12)	309	0,15	1,0	0,5 - 2,5	0,04	0,03	22,0 - 25,0	12,0 - 14,0	0,75	0,75	—	—
23 12 Nb	(309Nb)	0,1	1,2	2,5	0,03	0,25	22,0 - 25,0	11,0 - 14,0	0,75	0,75	8 x C - 1,1	—
—	309LNb	0,04	1,0	0,5 - 2,5	0,04	0,03	22,0 - 25,0	12,0 - 14,0	0,75	0,75	0,7 - 1,0	—
(23 12 Nb)	309Nb	0,12	1,0	0,5 - 2,5	0,04	0,03	22,0 - 25,0	12,0 - 14,0	0,75	0,75	0,7 - 1,0	—
—	309Mo	0,12	1,0	0,5 - 2,5	0,04	0,03	22,0 - 25,0	12,0 - 14,0	2,0 - 3,0	0,75	—	—
23 12 2 L	(309LMo)	0,04	1,2	2,5	0,03	0,025	22,0 - 25,0	11,0 - 14,0	2,0 - 3,0	0,75	—	—
(23 12 2 L)	309LMo	0,04	1,0	0,5 - 2,5	0,04	0,03	22,0 - 25,0	12,0 - 14,0	2,0 - 3,0	0,75	—	—
29 9 c	(312)	0,15	1,2	2,5	0,035	0,025	27,0 - 31,0	8,0 - 12,0	0,75	0,75	—	—
(29 9)	312	0,15	1,0	0,5 - 2,5	0,04	0,03	28,0 - 32,0	8,0 - 10,5	0,75	0,75	—	—
16 8 2	(16-8-2)	0,08	0,06	2,5	0,03	0,025	14,5 - 16,5	7,5 - 9,5	1,5 - 2,5	0,75	—	—
(16 8 2)	16-8-2	0,1	0,6	0,5 - 2,5	0,03	0,03	14,5 - 16,5	7,5 - 9,5	1,0 - 2,0	0,75	—	—
25 4	—	0,15	1,2	2,5	0,03	0,025	24,0 - 27,0	4,0 - 6,0	0,75	0,75	—	—
—	209	0,06	1,0	4,0 - 7,0	0,04	0,03	20,5 - 24,0	9,5 - 12,0	1,5 - 3,0	0,75	—	0,1 - 0,3
—	219	0,06	1,0	8,0 - 10,0	0,04	0,03	19,0 - 21,5	5,5 - 7,0	0,75	0,75	—	0,1 - 0,3
—	240	0,06	1,0	10,5 - 13,5	0,04	0,03	17,0 - 19,0	4,0 - 6,0	0,75	0,75	—	0,1 - 0,3
22 12	(309)	0,15	1,2	2,5	0,03	0,025	20,0 - 23,0	10,0 - 13,0	0,75	0,75	—	—
25 20	(310)	0,06 - 0,2	1,2	1,0 - 5,0	0,03	0,025	23,0 - 27,0	18,0 - 22,0	0,75	0,75	—	—

Table 1A (continued)

Symbol classification by chemical composition a (%)												
Nominal Composition b,c,d (EN ISO 3581-A)	Alloy Type d (EN ISO 3581-B)	C	Si	Mn	P	S	Cr	Ni	Mo	Cu	Nb + Ta	N
(25 20)	310	0,08 - 0,2	0,75	1,0 - 2,5	0,03	0,03	25,0 - 28,0	20,0 - 22,5	0,75	0,75	—	—
25 20 H	(310H)	0,35 - 0,45	1,2	2,5	0,03	0,025	23,0 - 27,0	18,0 - 22,0	0,75	0,75	—	—
(25 20 H)	310H	0,35 - 0,45	0,75	1,0 - 2,5	0,03	0,03	25,0 - 28,0	20,0 - 22,5	0,75	0,75	—	—
—	310Nb	0,12	0,75	1,0 - 2,5	0,03	0,03	25,0 - 28,0	20,0 - 22,0	0,75	0,75	0,70 - 1,0	—
—	310Mo	0,12	0,75	1,0 - 2,5	0,03	0,03	25,0 - 28,0	20,0 - 22,0	2,0 - 3,0	0,75	—	—
18 36	(330)	0,25	1,2	2,5	0,03	0,025	14,0 - 18,0	33,0 - 37,0	0,75	0,75	—	—
(18 36)	330	0,18 - 0,25	1,0	1,0 - 2,5	0,04	0,03	14,0 - 17,0	33,0 - 37,0	0,75	0,75	—	—
—	330H	0,35 - 0,45	1,0	1,0 - 2,5	0,04	0,03	14,0 - 17,0	33,0 - 37,0	0,75	0,75	—	—
—	383	0,03	0,9	0,5 - 2,5	0,02	0,02	26,5 - 29,0	30,0 - 33,0	3,2 - 4,2	0,6 - 1,5	—	—
(20 25 5 Cu N L)	385	0,03	0,9	1,0 - 2,5	0,03	0,02	19,5 - 21,5	24,0 - 26,0	4,2 - 5,2	1,2 - 2,0	—	—
—	630	0,05	0,75	0,25 - 0,75	0,04	0,03	16,0 - 16,75	4,5 - 5,0	0,75	3,25 - 4,0	0,15 - 0,3	—

a Single values shown in this table are maximum values
b Covered electrodes not listed in this table, but those which the user wishes to classify to this system, can be similarly symbolised and prefixed with the letter Z
c The sum of P and S may not exceed 0,05%, except for 25 7 2 N L; 18 16 5 N L; 20 16 3 Mn N L; 18 8 Mn; 18 9 Mn Mo and 29 9
d A designation in parentheses [e.g., (308L) or (19 9 L)] indicates a near match in the other designation system, but not an exact match. The correct designation for a given composition range is the one not in parentheses. A given product, by having a more restricted chemical composition that fulfils both sets of designation requirements, may be assigned both designations independently

Table 2A Mechanical Property Requirements

Nominal Composition (EN ISO 3581-A)	Alloy Symbol (EN ISO 3581-B)	Minimum Proof Strength ($R_{p0,2}$)	Minimum Tensile Strength (R_m MPa)	Minimum Elongation [a] (%)	Post Weld Heat Treatment
—	409Nb	—	450	13	[b]
13	(410)	250	450	15	[c]
(13)	410	—	450	15	[d]
13 4	(410NiMo)	500	750	15	[e]
(13 4)	410NiMo	—	760	10	[f]
17	(430)	300	450	15	[g]
(17)	430	—	450	15	[b]
—	430Nb	—	450	13	[b]
19 9	(308)	350	550	30	
(19 9)	308	—	550	30	
19 9 H	(308H)	350	550	30	
(19 9 H)	308H	—	550	30	
19 9 L	(308L)	320	510	30	
(19 9 L)	308L	—	510	30	
—	308Mo	—	550	30	
—	308LMo	—	520	30	
—	349	—	690	23	
19 9 Nb	(347)	350	550	25	
(19 9 Nb)	347	—	520	25	
—	347L	—	510	25	
19 12 2	(316)	350	550	25	
(19 12 2)	316	—	520	25	
—	316H	—	520	25	
19 12 3 L	(316L)	320	510	25	
(19 12 3 L)	316L	—	490	25	
—	316LCu	—	510	25	none
—	317	—	550	20	
—	317L	—	510	20	
19 12 3 Nb	(318)	350	550	25	
(19 12 3 Nb)	318	—	550	20	
19 13 4 N L	—	350	550	25	
—	320	—	550	28	
—	320LR	—	520	28	
22 9 3 N L	(2209)	450	550	20	
(29 9 3 N L)	2209	—	690	15	
25 7 2 N L	—	500	700	15	
25 9 3 Cu N L	—	550	620	18	
25 9 4 N L	—	550	620	18	
—	2553	—	760	13	
—	2593	—	760	13	
18 15 3 L	—	300	480	25	
18 16 5 N L	—	300	480	25	
20 25 5 Cu N L	—	320	510	25	

Table 2A (continued)

Nominal Composition (EN ISO 3581-A)	Alloy Symbol (EN ISO 3581-B)	Minimum Proof Strength ($R_{p0,2}$)	Minimum Tensile Strength (R_m MPa)	Minimum Elongation [a] (%)	Post Weld Heat Treatment
20 16 3 Mn N L	—	320	510	25	none
25 22 2 N L	—	320	510	25	
27 31 4 Cu L	—	240	500	25	
18 8 Mn	—	350	500	25	
18 9 Mn Mo	(307)	350	500	25	
(18 9 Mn Mo)	307	—	590	25	
20 10 3	—	400	620	20	
—	309	—	550	25	
23 12 L	(309L)	320	510	25	
(23 12 L)	309L	—	510	25	
23 12 Nb	(309Nb)	350	550	25	
(23 12 Nb)	309Nb	—	550	25	
—	309Mo	—	550	25	
23 12 2 L	(309LMo)	350	550	25	
(23 12 2 L)	309LMo	—	510	25	
—	309LNb	—	510	25	
29 9	(312)	450	650	15	
(29 9)	312	—	660	15	
16 8 2	(16-8-2)	320	510	25	
(16 8 2)	16-8-2	—	520	25	
25 4	—	400	600	15	
—	209	—	690	15	
—	219	—	620	15	
—	240	—	690	25	
22 12	—	350	550	25	
25 20	(310)	350	550	20	
(25 20)	310	—	550	25	
25 20 H	(310H)	350	550	10 [h]	
(25 20 H)	310H	—	620	8	
—	310Nb	—	550	23	
—	310Mo	—	550	28	
18 36	(330)	350	510	10 [h]	
(18 36)	330	—	520	23	
—	330H	—	620	8	
—	383	—	520	28	
—	385	—	520	28	
—	630	—	930	6	i

NOTE: All weld metal can have elongation and toughness lower than those of the parent metal
a Gauge length is equal to five times the test specimen diameter
b 760 - 790°C for 2 hr. Furnace cooling at a rate not exceeding 55°C/hr down to 595°C then air cooling to ambient
c 840 - 870°C for 2 hr. Furnace cooling down to 600°C then air cooling
d 730 - 760°C for 1 hr. Furnace cooling at a rate not exceeding 110°C/hr down to 315°C then air cooling to ambient
e 580 - 620°C for 2 hr. Air cooling
f 595 - 620°C for 1 hr. Air cool to ambient
g 760 - 790°C for 2 hr. Furnace cooling down to 600°C then air cooling
h These electrodes have high carbon in the all weld metal for service at high temperatures. Room temperature elongation has little relevance to such applications
i 1 025 - 1 050°C for 1 hr. Air cool to ambient, followed by precipitation hardening at 610 - 630°C for 4 hr then air cool to ambient

Table 3A Symbol for Type of Covering

Symbol	Type of Covering
R	Rutile
B	Basic

Table 3B Symbol for Type of Covering

Symbol	Type of Covering
5	Basic DC
6	Rutile AC+DC (Except 46 -DC only)
7	High silica rutile AC/DC (Except 47 -DC)

Table 4A Symbol for Effective Electrode Efficiency and Type of Current
(Classification according to nominal composition)

Symbol	Effective Electrode Efficiency (%)	Type of Current a
1	≤105	AC and DC
2	≤105	DC
3	>105 but ≤125	AC and DC
4	>105 but ≤125	DC
5	>125 but ≤160	AC and DC
6	>125 but ≤160	DC
7	>160	AC and DC
8	>160	DC

a In order to demonstrate operability on alternating current, tests shall be carried out with load voltages higher than 65 V (AC means alternating current; DC means direct current)

Table 5A Symbol for Welding Position
(Classification according to nominal composition)

Symbol	Welding Positions a
1	PA, PB, PD, PF, PG
2	PA, PB, PD, PF
3	PA, PB
4	PA
5	PA, PB, PG

a Positions are defined in ISO 6947
PA = Flat position
PB = Horizontal-vertical position
PD = Horizontal-overhead position
PF = Vertical-up position
PG = Vertical-down position

Table 5B Symbol for Welding Position (Classification according to alloy type)

Symbol	Welding Positions a
-1	PA, PB, PD, PF
-2	PA, PB
-4	PA, PB, PD, PF, PG

a Positions are defined in ISO 6947
PA = Flat position
PB = Horizontal-vertical position
PD = Horizontal-overhead position
PF = Vertical-up position
PG = Vertical-down position

Classifications of Solid Stainless Steel Wires

Wire electrodes and rods for arc welding are covered by EN ISO 14343 as set out below:

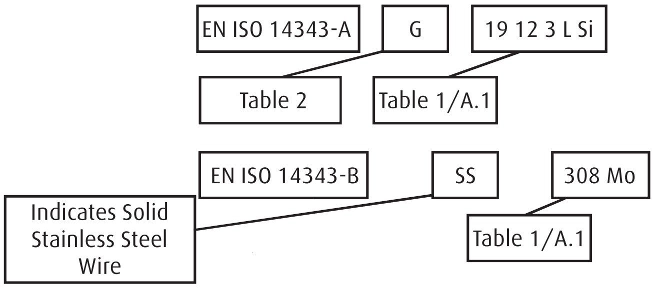

Table 2 Symbol for Type of Covering

Symbol	Type of Covering
G	GMAW
W	GTAW
P	PAW
S	SAW

Table A.1 Expected Minimum Tensile Properties of All Weld Metal

Alloy Symbol		Mechanical Property			
Classification According to Nominal Composition (EN ISO 14343-A)	Classification According to Alloy Type (EN ISO 14343-B)	Proof Strength ($R_{p0,2}$ N/mm²)	Tensile Strength (R_m N/mm²)	Elongation [a] (%)	Post Weld Heat Treatment
	409	180	380	14	none
	409Nb	250	450	15	b
13 [c]	410 [b]	250	450	15	c or b
13L		250	450	15	c
13 4	410NiMo	500	750	15	d
	420	250	450	15	c
17	430	300	450	15	e
	430Nb	250	450	15	e
18LNb	430LNb	220	410	15	none
	308	350	550	30	none
	308Si	350	550	30	
19 9 L	308L	320	510	30	
19 9 L Si	308LSi	320	510	30	
19 9 Nb	347	350	550	25	
19 9 Nb Si	347Si	350	550	25	
	347L	320	510	25	
	316	320	510	25	
	316Si	320	510	25	
19 12 3 L	316L	320	510	25	
19 12 3 L Si	316LSi	320	510	25	
	316LCu	320	510	25	
19 12 3 Nb	318	350	550	25	
	318L	320	510	25	
19 12 3 Nb Si		350	550	25	
	317	350	550	25	
18 15 3 L	317L	300	480	25	
	321	350	550	25	
22 9 3 N L	2209	450	550	20	none
25 7 2 L		500	700	15	
25 9 3 Cu N L		550	620	18	
25 9 4 N L		550	620	18	

Table A.1 (continued)

Alloy Symbol		Mechanical Property			
Classification According to Nominal Composition (EN ISO 14343-A)	**Classification According to Alloy Type (EN ISO 14343-B)**	**Proof Strength ($R_{p0,2}$ N/mm²)**	**Tensile Strength (R_m N/mm²)**	**Elongation [a] (%)**	**Post Weld Heat Treatment**
18 15 3 L		300	480	25	
18 16 5 N L		300	480	25	
19 13 4 N L		350	550	25	
20 25 5 Cu L		350	550	25	
20 25 5 Cu N L	385	320	510	25	
20 16 3 Mn L		320	510	25	none
20 16 3 Mn N L		320	510	25	
25 22 2 N L		320	510	25	
27 31 4 Cu L	383	320	510	25	
	320	240	500	25	
	320LR	320	550	25	
		300	520	25	
	307	350	590	25	
18 8 Mn		350	500	25	
20 10 3	308Mo	400	620	20	
	308LMo	320	510	30	
23 12 L23 12 L Si	309L	320	510	25	
23 12 Nb	309LSi	320	510	25	none
		350	550	25	
	309LNb	320	510	25	
23 12 2 L	309Mo	350	550	25	
29 9	309LMo	350	550	25	
	312	450	650	15	
16 8 2	16-8-2	320	510	25	
19 9 H	19-10H	350	550	30	
	308H	350	550	30	
19 12 3 H	316H	350	550	25	
22 12 H	309	350	550	25	
	309Si	350	550	25	
25 4		450	650	15	none
25 20	310	350	550	20	
	310S	350	550	20	
	310L	320	510	20	
25 20 Mn		350	550	20	
25 20 H		350	550	10[f]	
18 36 H	330	350	550	10[f]	
	630	725	930	5	g

NOTE: Weld metal may have elongation lower than that of the parent metal
a Gauge length is equal to five times the specimen diameter
b 730 - 760°C for 1 hr, furnace cooling down to 600°C, then air cooling
c 840 - 870°C for 2 hr, furnace cooling down to 600°C, then air cooling
d 580 - 620°C for 2 hr, air cooling
e 760 - 790°C for 2 hr, furnace cooling down to 600°C, then air cooling
f These wire electrodes deposit high carbon weld metal for service at high temperatures. Room temperature elongation has little relevance to such applications
g 1 025 - 1 050°C for 1 hr, air cool to ambient, then 610 - 630°C for 4 hr, air cool

Table 1 Chemical Composition Requirements

Alloy Designation a for Classification According to		Chemical Composition (%) (m/m) b,c											
Nominal Composition d (EN ISO 14343-A)	Alloy Type (EN ISO 14343-B)	C	Si	Mn	P	S	Cr	Ni	Mo	N	Cu	Nb e	Other
Martensitic-Ferritic Types													
—	409	0,08	0,8	0,8	0,03	0,03	10,5 - 13,5	0,6	0,50	—	0,75	—	Ti 10 x C - 1,5
—	409Nb	0,12	0,5	0,6	0,03	0,03	10,5 - 13,5	0,6	0,75	0,10 - 0,20	0,75	8 x C - 1,0	—
13	(410)	0,15	1,0	1,0	0,03	0,02	12,0 - 15,0	0,3	0,3	—	0,3	—	—
(13)	410	0,12	0,5	0,6	0,03	0,03	11,5 - 13,5	0,6	0,75	—	0,75	—	—
13L	—	0,05	1,0	1,0	0,03	0,02	12,0 - 15,0	0,3	0,3	—	0,3	—	—
13 4	(410NiMo)	0,05	1,0	1,0	0,03	0,02	11,0 - 14,0	3,0 - 5,0	0,4 - 1,0	—	0,3	—	—
(13 4)	410NiMo	0,06	0,5	0,6	0,03	0,03	11,0 - 12,5	4,0 - 5,0	0,4 - 0,7	—	0,75	—	—
—	420	0,25 - 0,4	0,5	0,6	0,03	0,03	12,0 - 14,0	0,75	0,75	—	0,75	—	—
17	(430)	0,12	1,0	1,0	0,03	0,02	16,0 - 19,0	0,3	0,3	—	0,3	—	—
(17)	430	0,1	0,5	0,6	0,03	0,03	15,5 - 17,0	0,6	0,75	—	0,75	—	—
—	430Nb	0,1	0,5	0,6	0,03	0,03	15,5 - 17,0	0,6	0,75	—	0,75	8 x C - 1,2	—
18LNb	430LNb	0,02	0,5	0,8	0,03	0,02	17,8 - 18,8	0,3	0,3	0,02	0,3	0,05 + 7 (C+N) up to 0,5	—
Austenitic Types													
—	308	0,08	0,65	1,0 - 2,5	0,03	0,03	19,5 - 22,0	9,0 - 11,0	0,75	—	0,75	—	—
—	308Si	0,08	0,65 - 1,0	1,0 - 2,5	0,03	0,03	19,5 - 22,0	9,0 - 11,0	0,75	—	0,75	—	—
19 9 L	(308L)	0,03	0,65	1,0 - 2,5	0,03	0,02	19,0 - 21,0	9,0 - 11,0	0,3	—	0,3	—	—
(19 9 L)	308L	0,03	0,65	1,0 - 2,5	0,03	0,03	19,5 - 22,0	9,0 - 11,0	0,75	—	0,75	—	—
19 9 L Si	(308LSi)	0,03	0,65 - 1,0	1,0 - 2,5	0,03	0,02	19,0 - 21,0	9,0 - 11,0	0,3	—	0,3	—	—
(19 9 L Si)	308LSi	0,03	0,65 - 1,0	1,0 - 2,5	0,03	0,03	19,5 - 22,0	9,0 11,0	0,75	—	0,75	—	—
19 9 Nb	(347)	0,08	0,65	1,0 - 2,5	0,03	0,02	19,0 - 21,0	9,0 - 11,0	0,3	—	0,3	10 x C - 1,0	—
(19 9 Nb)	347	0,08	0,65	1,0 - 2,5	0,03	0,03	19,0 - 21,5	9,0 - 11,0	0,75	—	0,75	10 x C - 1,0	—
19 9 Nb Si	(347Si)	0,08	0,65 - 1,2	1,0 - 2,5	0,03	0,02	19,0 - 21,0	9,0 - 11,0	0,3	—	0,3	10 x C - 1,0	—
(19 9 Nb Si)	347Si	0,08	0,65 - 1,0	1,0 - 2,5	0,03	0,03	19,0 - 21,5	9,0 - 11,0	0,75	—	0,75	10 x C - 1,0	—

Table 1 (continued)

Alloy Designation a for Classification According to		Chemical Composition (%) (m/m) b,c											
Nominal Composition d (EN ISO 14343-A)	Alloy Type (EN ISO 14343-B)	C	Si	Mn	P	S	Cr	Ni	Mo	N	Cu	Nb e	Other
—	347L	0,03	0,65	1,0 - 2,5	0,03	0,03	19,0 - 21,5	9,0 - 11,0	0,75	—	0,75	10 x C - 1,0	—
—	316	0,08	0,65	1,0 - 2,5	0,03	0,03	18,0 - 20,0	11,0 - 14,0	2,0 - 3,0	—	0,75	—	—
—	316Si	0,08	0,65 - 1,0	1,0 - 2,5	0,03	0,03	18,0 - 20,0	11,0 - 14,0	2,0 - 3,0	—	0,75	—	—
19 12 3 L	(316L)	0,03	0,65	1,0 - 2,5	0,03	0,02	18,0 - 20,0	11,0 - 14,0	2,5 - 3,0	—	0,3	—	—
(19 12 3 L)	316L	0,03	0,65	1,0 - 2,5	0,03	0,03	18,0 - 20,0	11,0 - 14,0	2,0 - 3,0	—	0,75	—	—
19 12 3 L Si	(316LSi)	0,03	0,65 - 1,2	1,0 - 2,5	0,03	0,02	18,0 - 20,0	11,0 - 14,0	2,5 - 3,0	—	0,3	—	—
(19 12 3 L Si)	316LSi	0,03	0,65 - 1,0	1,0 - 2,5	0,03	0,03	18,0 - 20,0	11,0 - 14,0	2,0 - 3,0	—	0,75	—	—
—	316LCu	0,03	0,65	1,0 - 2,5	0,03	0,03	18,0 - 20,0	11,0 - 14,0	2,0 - 3,0	—	1,0 - 2,5	—	—
19 12 3 Nb	(318)	0,08	0,65	1,0 - 2,5	0,03	0,02	18,0 - 20,0	11,0 - 14,0	2,5 - 3,0	—	0,3	10 x C - 1,0	—
(19 12 3 Nb)	318	0,08	0,65	1,0 - 2,5	0,03	0,03	18,0 - 20,0	11,0 - 14,0	2,0 - 3,0	—	0,75	8 x C - 1,0	—
—	318L	0,03	0,65	1,0 - 2,5	0,03	0,03	18,0 - 20,0	11,0 - 14,0	2,0 - 3,0	—	0,75	8 x C - 1,0	—
19 12 3 Nb Si	—	0,08	0,65 - 1,2	1,0 - 2,5	0,03	0,02	18,0 - 20,0	11,0 - 14,0	2,5 - 3,0	—	0,3	10 x C - 1,0	—
—	317	0,08	0,65	1,0 - 2,5	0,03	0,03	18,5 - 20,5	13,0 - 15,0	3,0 - 4,0	—	0,75	—	—
(18 15 3 L)	317L	0,03	0,65	1,0 - 2,5	0,03	0,03	18,5 - 20,5	13,0 - 15,0	3,0 - 4,0	—	0,75	—	—
—	321	0,08	0,65	1,0 - 2,5	0,03	0,03	18,5 - 20,5	9,0 - 10,5	0,75	—	0,75	—	Ti 9 x C - 1,0
Ferritic-Austenitic Types (Sometimes referred to as austenitic-ferritic types)													
22 9 3 N L	(2209)	0,03	1,0	2,5	0,03	0,02	21,0 - 24,0	7,0 - 10,0	2,5 - 4,0	0,1 - 0,2	0,3	—	—
(22 9 3 N L)	2209	0,03	0,9	0,5 - 2,0	0,03	0,03	21,5 - 23,5	7,5 - 9,5	2,5 - 3,5	0,08 - 0,2	0,75	—	—
25 7 2 L	—	0,03	1,0	2,5	0,03	0,02	24,0 - 27,0	6,0 - 8,0	1,5 - 2,5	—	0,3	—	—
25 9 3 Cu N L	—	0,03	1,0	2,5	0,03	0,02	24,0 - 27,0	8,0 - 10,5	2,5 - 4,5	0,2 - 0,3	1,5	—	W 1,0

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Table 1 (continued)

Alloy Designation a for Classification According to		Chemical Composition (%) (m/m) b,c											
Nominal Composition d (EN ISO 14343-A)	Alloy Type (EN ISO 14343-B)	C	Si	Mn	P	S	Cr	Ni	Mo	N	Cu	Nb e	Other
Fully Austenitic Types f													
18 15 3 L f	(317L) f	0,03	1,0	1,0 - 4,0	0,03	0,02	17,0 - 20,0	13,0 - 16,0	2,5 - 4,0	—	0,3	—	—
18 16 5 N L f	—	0,03	1,0	1,0 - 4,0	0,03	0,02	17,0 - 20,0	16,0 - 19,0	3,5 - 5,0	0,1 - 0,2	0,3	—	—
19 13 4 L f	(317L) f	0,03	1,0	1,0 - 5,0	0,03	0,02	17,0 - 20,0	12,0 - 15,0	3,0 - 4,5	—	0,3	—	—
19 13 4 N L f	—	0,03	1,0	1,0 5,0	0,03	0,02	17,0 - 20,0	12,0 - 15,0	3,0 - 4,5	0,1 - 0,2	0,3	—	—
20 25 5 Cu L f	(385) f	0,03	1,0	1,0 - 4,0	0,03	0,02	19,0 - 22,0	24,0 - 27,0	4,0 - 6,0	—	1,0 - 2,0	—	—
(20 25 5 Cu L) f	385 f	0,025	0,5	1,0 - 2,5	0,02	0,03	19,5 - 21,5	24,0 - 26,0	4,2 - 5,2	—	1,2 - 2,0	—	—
20 25 5 Cu N L f	—	0,03	1,0	1,0 - 4,0	0,03	0,02	19,0 - 22,0	24,0 - 27,0	4,0 - 6,0	0,1 - 0,2	1,0 - 2,0	—	—
20 16 3 Mn L f	—	0,03	1,0	5,0 - 9,0	0,03	0,02	19,0 - 22,0	15,0 - 18,0	2,5 - 4,5	—	0,3	—	—
20 16 3 Mn N L f	—	0,03	1,0	5,0 - 9,0	0,03	0,02	19,0 - 22,0	15,0 - 18,0	15,0 - 18,0	0,1 - 0,2	0,3	—	—
25 22 2 N L f	—	0,03	1,0	3,5 - 6,5	0,03	0,02	24,0 - 27,0	21,0 - 24,0	1,5 - 3,0	0,1 - 0,2	0,3	—	—
27 31 4 Cu L f	(383) f	0,03	1,0	1,0 - 3,0	0,03	0,02	26,0 - 29,0	30,0 - 33,0	3,0 - 4,5	—	0,7 - 1,5	—	—
(27 31 4 Cu L) f	383 f	0,025	0,5	1,0 - 2,5	0,02	0,03	26,5 - 28,5	30,0 - 33,0	3,2 - 4.2	—	0,7 - 1,5	—	—
—	320 f	0,07	0,6	2,5	0,03	0,03	19,0 - 21,0	32,0 - 36,0	2,0 - 3.0	—	3,0 - 4,0	8 x C - 1,0	—
—	320LR f	0,025	0,15	1,5 - 2,0	0,015	0,02	19,0 - 21,0	32,0 - 36,0	2,0 - 3,0	—	3,0 - 4,0	8 x C - 0,40	—
Special Types (Often used for dissimilar metal joining)													
—	307 f	0,04 - 0,14	0,65	3,3 - 4,8	0,03	0,03	19,5 - 22,0	8,0 - 10,7	0,5 - 1,5	—	0,75	—	—
18 8 Mn f	—	0,2	1,2	5,0 - 8,0	0,03	0,03	17,0 - 20,0	7,0 - 10,0	0,3	—	0,3	—	—
20 10 3	(308Mo)	0,12	1,0	1,0 - 2,5	0,03	0,02	18,0 - 21,0	8,0 - 21,0	—	1,5 - 3,5	—	0,3	—
(20 10 3)	308Mo	0,08	0,65	1,0 - 2,5	0,03	0,03	18,0 - 21,0	9,0 - 12,0	2,0 - 3,0	—	0,75	—	—
—	308LMo	0,03	0,65	1,0 - 2,5	0,03	0,03	18,0 - 21,0	9,0 - 12,0	2,0 - 3,0	—	0,75	—	—

Table 1 (continued)

Alloy Designation a for Classification According to		Chemical Composition (%) (m/m) b,c											
Nominal Composition d (EN ISO 14343-A)	Alloy Type (EN ISO 14343-B)	C	Si	Mn	P	S	Cr	Ni	Mo	N	Cu	Nb e	Other
23 12 L	(309L)	0,03	0,65	1,0 - 2,5	0,03	0,02	22,0 - 25,0	11,0 - 14,0	0,3	—	0,3	—	—
(23 12 L)	309L	0,03	0,65	1,0 - 2,5	0,03	0,03	23,0 - 25,0	12,0 - 14,0	0,75	—	0,75	—	—
23 12 L Si	(309LSi)	0,03	0,65 - 1,2	1,0 - 2,5	0,03	0,02	22,0 - 25,0	11,0 - 14,0	0,3	—	0,3	—	—
(23 12 l Si)	309LSi	0,03	0,65 - 1,0	1,0 - 2,5	0,03	0,03	23,0 - 25,0	12,0 - 14,0	0,75	—	0,75	—	—
23 12 Nb	—	0,08	1,0	1,0 - 2,5	0,03	0,02	22,0 - 25,0	11,0 - 14,0	0,3	—	0,3	10 x C - 1,0	—
—	309LNb	0,03	0,65	1,0 - 2,5	0,03	0,03	23,0 - 25,0	12,0 - 14,0	0,75	—	0,75	10 x C - 1,0	—
—	309Mo	0,12	0,65	1,0 - 2,5	0,03	0,03	23,0 - 25,0	12,0 - 14,0	2,0 - 3,0	—	0,75	—	—
23 12 2 L	(309LMo)	0,03	1,0	1,0 - 2,5	0,03	0,02	21,0 - 25,0	11,0 - 15,5	2,0 - 3,5	—	0,3	—	—
(23 12 2 L)	309LMo	0,03	0,65	1,0 - 2,5	0,03	0,03	23,0 - 25,0	12,0 - 14,0	2,0 - 3,0	—	0,75	—	—
29 9	312	0,15	1,0	1,0 - 2,5	0,03	0,02	28,0 - 32,0	8,0 - 12,0	0,3	—	0,3	—	—
(29 9)	312	0,15	0,65	1,0 - 2,5	0,03	0,03	28,0 - 32,0	8,0 - 10,5	0,75	—	0,75	—	—
Heat Resisting Types													
16 8 2	(16-8-2)	0,1	1,0	1,0 - 2,5	0,03	0,02	14,5 - 16,5	7,5 - 9,5	1,0 - 2,5	—	0,3	-	—
(16-8-2)	16 8 2	0,1	0,65	1,0 - 2,5	0,03	0,03	14,5 - 16,5	7,5 - 9,5	1,0 - 2,0	—	0,75	-	—
19 9 H	(19-10H)	0,04 - 0,08	1,0	1,0 - 2,5	0,03	0,02	18,0 - 21,0	9,0 - 11,0	0,3	—	0,3	-	—
(19 9 H)	19-10H	0,04 - 0,08	0,65	1,0 - 2,0	0,03	0,03	18,5 - 20,0	9,0 - 11,0	0,25	—	0,75	0,05	Ti 0,05
(19 9 H)	308H	0,04	0,65	1,0 - 2,5	0,03	0,03	19,5 - 22,0	9,0 - 11,0	0,50	—	0,75	—	—
19 12 3 H	(316H)	0,04 - 0,08	1,0	1,0 - 2,5	0,03	0,02	18,0 - 20,0	11,0 - 14,0	2,0 - 3,0	—	0,3	—	—
(19 12 3 H)	316H	0,04 - 0,08	0,65	1,0 - 2,5	0,03	0,03	18,0 - 20,0	11,0 - 14,0	2,0 - 3,0	—	0,75	—	—
22 12 H	(309)	0,04 - 0,15	2,0	1,0 - 2,5	0,03	0,02	21,0 - 24,0	11,0 - 14,0	0,3	—	0,3	—	—

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Table 1 (continued)

Alloy Designation [a] for Classification According to		Chemical Composition (%) (m/m) [b,c]											
Nominal Composition [d] (EN ISO 14343-A)	Alloy Type (EN ISO 14343-B)	C	Si	Mn	P	S	Cr	Ni	Mo	N	Cu	Nb [e]	Other
(22 12 H)	309	0,12	0,65	1,0 - 2,5	0,03	0,03	23,0 - 25,0	12,0 - 14,0	0,75	—	0,75	—	—
—	309Si	0,12	0,65 - 1,0	1,0 - 2,5	0,03	0,03	23,0 - 25,0	12,0 - 14,0	0,75	—	0,75	—	—
25 4	—	0,15	2,0	1,0 - 2,5	0,03	0,02	24,0 - 27,0	4,0 - 6,0	0,3	—	0,3	—	—
25 20 [f]	(310) [f]	0,08 - 0,15	2,0	1,0 - 2,5	0,03	0,02	24,0 - 27,0	18,0 - 22,0	0,3	—	0,3	—	—
(25 20) [f]	310 [f]	0,08 - 0,15	0,65	1,0 - 2,5	0,03	0,03	25,0 - 28,0	20,0 - 22,5	0,75	—	0,75	—	—
—	310S [f]	0,08	0,65	1,0 - 2,5	0,03	0,03	25,0 - 28,0	20,0 - 22,5	0,75	—	0,75	—	—
—	310L [f]	0,03	0,65	1,0 - 2,5	0,03	0,03	25,0 - 28,0	20,0 - 22,5	0,75	—	0,75	—	—
25 20 H [f]	—	0,35 - 0,45	2,0	1,0 - 2,5	0,03	0,02	24,0 - 27,0	18,0 - 22,0	0,3	—	0,3	—	—
25 20 Mn [f]	—	0,08 - 0,15	2,0	2,5 - 5,0	0,03	0,02	24,0 - 27,0	18,0 - 22,0	0,3	—	0,3	—	—
18 36 H [f]	(330)	0,18 - 0,25	0,4 - 2,0	1,0 - 2,5	0,03	0,02	15,0 - 19,0	33,0 - 37,0	0,3	—	0,3	—	—
(18 36 H) [f]	330	0,18 - 0,25	0,65	1,0 - 2,5	0,03	0,03	15,0 - 17,0	34,0 - 37,0	0,75	—	0,75	—	—
Precipitation Hardening Type													
—	630	0,05	0,75	0,25 - 0,75	0,03	0,03	16,0 - 16,75	4,5 - 5,0	0,75	—	3,25 - 4,0	0,15 - 0,3	—

a A designation in parentheses, e.g. (308L) or (19 9 L) indicates a near match in the other designation system, but not an exact match. The correct designation for a given composition range is the one not in parentheses. A given product may, by having a more restricted chemical composition which fulfils both sets of designation requirements, be assigned both designations independently

b Single values shown in the table are maximum values. Two values shown indicate minimum and maximum limits for a range

c The results shall be rounded to the same number of significant figures as in the specified value using the rules in according with Annex B, Rule A of ISO 31-0:1992

d Wire electrodes not listed in the table shall be symbolised similarly and prefixed by the letter 'Z'

e Up to 20% of the amount of Nb can be replaced by Ta

f The all weld metal is in most cases fully austenitic and therefore can be susceptible to microfissuring or hot cracking. The occurrence of fissuring/cracking is reduced by increasing the weld metal manganese level and in recognition of this the manganese range is extended for a number of grades

Classifications of Tubular Stainless Steel Welding Consumables

Tubular electrodes for FCW welding are covered by EN ISO 17633 as set out below:

For classification by nominal composition

EN ISO 17633-A	T	19 12 3	R	M	
	Tubular electrode	Table 1A/2A	Table 3A	Table 5A	Table 4A

For classification by alloy type

EN ISO 17633-B	TS	316L	F	M	1
	Tubular electrode	Table 1B - 1, 2, 3, 4 Table 2B	Table 3B	Table 5A	Table 4B

Table 1A Symbols for Chemical Composition Requirements for All Weld Metal (Classification according to nominal composition)

Alloy Designation According to Nominal Composition	Chemical Composition (percentage mass fraction) [a, b, c]												
	Shielding Gas [d]	C	Mn	Si	P [e]	S [e]	Cr	Ni	Mo	Nb + Ta [f]	Cu	N	Ti
13	M, C, N	0,12	1,5	1,0	0,03	0,025	11,0 - 14,0	0,3	0,3	—	0,3	—	—
13 Ti	M, C, N	0,10	0,8	1,0	0,03	0,030	10,5 - 13,0	0,3	0,3	—	0,3	—	10 x C - 1,5
13 4	M, C, N	0,06	1,5	1,0	0,03	0,025	11,0 - 14,5	3,0 - 5,0	0,4 - 1,0	—	0,3	—	—
17	M, C, N	0,12	1,5	1,0	0,03	0,025	16,0 - 18,0	0,3	0,3	—	0,3	—	—
19 9 L	M, C, N	0,04	2,0	1,2	0,03	0,025	18,0 - 21,0	9,0 - 11,0	0,3	—	0,3	—	—
19 9 Nb	M, C, N	0,08	2,0	1,2	0,03	0,025	18,0 - 21,0	9,0 - 11,0	0,3	8 x C - 1,1	0,3	—	—
19 12 3 L	M, C, N	0,04	2,0	1,2	0,03	0,025	17,0 - 20,0	10,0 - 13,0	2,5 - 3,0	—	0,3	—	—
19 12 3 Nb	M, C, N	0,08	2,0	1,2	0,03	0,025	17,0 - 20,0	10,0 - 13,0	2,5 - 3,0	8 x C - 1,1	0,3	—	—
19 13 4 N L	M, C, N	0,04	1,0 - 5,0	1,2	0,03	0,025	17,0 - 20,0	12,0 - 15,0	3,0 - 4,5	—	0,3	0,08 - 0,20	—
22 9 3 N L	M, C, N	0,04	2,5	1,2	0,03	0,025	21,0 - 24,0	7,5 -10,5	2,5 - 4,0	—	0,3	0,08 - 0,20	—
18 16 5 N L	M, C, N	0,04	1,0 - 4,0	1,2	0,035	0,025	17,0 - 20,0	15,5 - 19,0	3,5 - 5,0	—	0,3	0,08 - 0,20	—
18 8 Mn	M, C, N	0,20	4,5 - 7,5	1,2	0,035	0,025	17,0 - 20,0	7,0 - 10,0	0,3	—	0,3	—	—
20 10 3	M, C, N	0,08	2,5	1,2	0,035	0,025	19,5 - 22,0	9,0 - 11,0	2,0 - 4,0	—	0,3	—	—
23 12 L	M, C, N	0,04	2,5	1,2	0,03	0,025	22,0 - 25,0	11,0 - 14,0	0,3	—	0,3	—	—
23 12 2 L	M, C, N	0,04	2,5	1,2	0,03	0,025	22,0 - 25,0	11,0 - 14,0	2,0 - 3,0	—	0,3	—	—
29 9	M, C, N	0,15	2,5	1,2	0,035	0,025	27,0 - 31,0	8,0 - 12,0	0,3	—	0,3	—	—

Table 1A (continued)

Alloy Designation According to Nominal Composition	Chemical Composition (percentage mass fraction) a, b, c											
	Shielding Gas d	C	Mn	Si	P e	S e	Cr	Ni	Mo	Nb + Ta f	Cu	N	Ti
22 12 H	M, C, N	0,15	2,5	1,2	0,03	0,025	20,0 - 23,0	10,0 - 13,0	0,3	—	0,3	—	—
25 20	M, C, N	0,06 - 0,20	1,0 - 5,0	1,2	0,03	0,025	23,0 - 27,0	18,0 - 22,0	0,3	—	0,3	—	—

a Single values shown in the table are maximum values
b Tubular cored electrodes not listed in the table shall be symbolised similarly and prefixed by the letter 'Z'
c The results shall be rounded to the same number of significant figures as in the specified value using the rules in accordance with Annex B, Rule A of ISO 31-0:1992
d The symbol 'N' shall be used for tubular cored electrodes without a gas shield
e The sum of P and S shall not exceed 0,05%, except for 18 16 5 L, 18 8 Mn and 29 9
f Up to 20% of the amount of Nb can be replaced by Ta

Table 2A Tensile Properties of All Weld Metal (Classification according to nominal composition)

Alloy Designation According to Nominal Composition	Minimum Proof Strength (MPa)	Minimum Tensile Strength (MPa)	Minimum Elongation a (%)	Post Weld Heat Treatment
13	250	450	15	b
13 Ti	250	450	15	b
13 4	500	750	15	c
17	300	450	15	d
19 9 L	320	510	30	none
19 9 Nb	350	550	25	
19 12 3 L	320	510	25	
19 12 3 Nb	350	550	25	
19 13 4 N L	350	550	25	
22 9 3 N L	450	550	20	
18 16 5 N L	300	480	25	
18 8 Mn	350	500	25	
20 10 3	400	620	20	
23 12 L	320	510	25	
23 12 2 L	350	550	25	
29 9	450	650	15	
22 12 H	350	550	25	
25 20	350	550	20	

a Gauge length is equal to five times the test specimen diameter
b The weld test assembly (or the blank from it, from which the tensile test specimen is to be machined) shall be heated to a temperature between 840 - 870°C, held for 2 hr, furnace cooled to 600°C, then cooled in air
c The weld test assembly (or the blank from it, from which the tensile test specimen is to be machined) shall be heated to a temperature between 580 - 620°C, held for 2 hr, then cooled in air
d The weld test assembly (or the blank from it, from which the tensile test specimen is to be machined) shall be heated to a temperature between 760 - 790°C, held for 2 hr, furnace cooled to 600°C, then cooled in air

Table 3A Symbols for Type of Electrode Core (Classification according to nominal composition)

Symbol	Characteristics
R	Rutile, slow freezing slag
P	Rutile, fast freezing slag
M	Metal powder
U	Self-shielding
Z	Other types
(See Annex B)	

Table 5A Types of Shielding Gases

Symbol for Shielding Gas	
M	Ar + 20 - 25% CO_2
B	100% CO_2
A	Ar + 0 - 3% O_2
I	100% Ar
G	Unspecified

Table 4A Symbols for Welding Position (Classification according to nominal composition)

Symbol	Welding Positions [a]
1	PA, PB, PC,PD, PE, PF and PG
2	PA, PB, PC, PD, PE and PF
3	PA and PB
4	PA
5	PA, PB and PG
a	PA = Flat position PB = Horizontal-vertical position PC = Horizontal position PD = Horizontal-overhead position PE = Overhead position PF = Vertical-up position PG = Vertical-down position

Table 1B-1 Symbols for Chemical Composition Requirements for All Weld Metal of Gas Shielded Flux Cored Electrodes (Classification according to alloy type)

Alloy Designation According to Alloy Type	Chemical Composition (percentage mass fraction) [a, b, c]											
	Shielding Gas [d]	C	Mn	Si	P	S	Cr	Ni	Mo	Nb + Ta	Cu	N	Ti
307	M, B, C, G	0,13	3,30 - 4,75	1,0	0,04	0,03	18,0 - 20,5	9,0 - 10,5	0,5 - 1,5	—	0,5	—	—
308	M, B, C, G	0,08	0,5 - 2,5	1,0	0,04	0,03	18,0 - 21,0	9,0 - 11,0	0,5	—	0,5	—	—
308L	M, B, C, G	0,04	0,5 - 2,5	1,0	0,04	0,03	18,0 - 21,0	9,0 - 12,0	0,5	—	0,5	—	—
308H	M, B, C, G	0,04 - 0,08	0,5 - 2,5	1,0	0,04	0,03	18,0 - 21,0	9,0 - 11,0	0,5	—	0,5	—	—
308Mo	M, B, C, G	0,08	0,5 - 2,5	1,0	0,04	0,03	18,0 - 21,0	9,0 - 11,0	2,0 - 3,0	—	0,5	—	—
308LMo	M, B, C, G	0,04	0,5 - 2,5	1,0	0,04	0,03	18,0 - 21,0	9,0 - 12,0	2,0 - 3,0	—	0,5	—	—
309	M, B, C, G	0,10	0,5 - 2,5	1,0	0,04	0,03	22,0 - 25,0	12,0 - 14,0	0,5	—	0,5	—	—
309L	M, B, C, G	0,04	0,5 - 2,5	1,0	0,04	0,03	22,0 - 25,0	12,0 - 14,0	0,5	—	0,5	—	—
309Mo	M, B, C, G	0,12	0,5 - 2,5	1,0	0,04	0,03	21,0 - 25,0	12,0 - 16,0	2,0 - 3,0	—	0,5	—	—
309LMo	M, B, C, G	0,04	0,5 - 2,5	1,0	0,04	0,03	21,0 - 25,0	12,0 - 16,0	2,0 - 3,0	—	0,5	—	—
309LNb	M, B, C, G	0,04	0,5 - 2,5	1,0	0,04	0,03	22,0 - 25,0	12,0 - 14,0	0,5	0,7 - 1,0	0,5	—	—
310	M, B, C, G	0,20	1,0 - 2,5	1,0	0,035	0,03	25,0 - 28,0	20,0 - 22,5	0,5	—	0,5	—	—
312	M, B, C, G	0,15	0,5 - 2,5	1,0	0,04	0,03	28,0 - 32,0	8,0 - 10,5	0,5	—	0,5	—	—
316	M, B, C, G	0,08	0,5 - 2,5	1,0	0,04	0,03	17,0 - 20,0	11,0 - 14,0	2,0 - 3,0	—	0,5	—	—

Table 1B-1 (continued)

Alloy Designation According to Alloy Type	Chemical Composition (percentage mass fraction) a, b, c											
	Shielding Gas d	C	Mn	Si	P	S	Cr	Ni	Mo	Nb + Ta	Cu	N	Ti
316L	M, B, C, G	0,04	0,5 - 2,5	1,0	0,04	0,03	17,0 - 20,0	11,0 - 14,0	2,0 - 3,0	—	0,5	—	—
316H	M, B, C, G	0,04 - 0,08	0,5 - 2,5	1,0	0,04	0,03	17,0 - 20,0	11,0 - 14,0	2,0 - 3,0	—	0,5	—	—
316LCu	M, B, C, G	0,04	0,5 - 2,5	1,0	0,04	0,03	17,0 - 20,0	11,0 - 16,0	1,25 - 2,75	—	1,0 - 2,5	—	—
317	M, B, C, G	0,08	0,5 - 2,5	1,0	0,04	0,03	18,0 - 21,0	12,0 - 14,0	3,0 - 4,0	—	0,5	—	—
317L	M, B, C, G	0,04	0,5 - 2,5	1,0	0,04	0,03	18,0 - 21,0	12,0 - 16,0	3,0 - 4,0	—	0,5	—	—
318	M, B, C, G	0,08	0,5 - 2,5	1,0	0,04	0,03	17,0 - 20,0	11,0 - 14,0	2,0 - 3,0	8 x C - 1,0	0,5	—	—
347	M, B, C, G	0,08	0,5 - 2,5	1,0	0,04	0,03	18,0 - 21,0	9,0 - 11,0	0,5	8 x C - 1,0	0,5	—	—
347L	M, B, C, G	0,04	0,5 - 2,5	1,0	0,04	0,03	18,0 - 21,0	9,0 - 11,0	0,5	8 x C - 1,0	0,5	—	—
409	M, B, C, G	0,10	0,8	1,0	0,04	0,03	10,5 - 13,5	0,6	0,5	—	0,5	—	10 x C - 1,5
409Nb	M, B, C, G	0,12	1,2	1,0	0,04	0,03	10,5 - 14,0	0,6	0,5	8 x C - 1,5	0,5	—	—
410	M, B, C, G	0,12	1,2	1,0	0,04	0,03	11,0 - 13,5	0,6	0,5	—	0,5	—	—
410NiMo	M, B, C, G	0,06	1,0	1,0	0,04	0,03	11,0 - 12,5	4,0 - 5,0	0,4 - 0,7	—	0,5	—	—
430	M, B, C, G	0,10	1,2	1,0	0,04	0,03	15,0 - 18,0	0,6	0,5	—	0,5	—	—
430Nb	M, B, C, G	0,10	1,2	1,0	0,04	0,03	15,0 - 18,0	0,6	0,5	0,5 - 1,5	0,5	—	—
16-8-2	M, B, C, G	0,10	0,5 - 2,5	0,75	0,04	0,03	14,5 - 16,5	7,5 - 9,5	1,0 - 2,0	—	0,5	—	—
2209	M, B, C, G	0,04	0,5 - 2,5	1,0	0,04	0,03	21,0 - 24,0	7,5 - 10,0	2,5 - 4,0	—	0,5	0,08 - 0,20	—
2553	M, B, C, G	0,04	0,5 - 2,5	0,75	0,04	0,03	24,0 - 27,0	8,5 - 10,5	2,9 - 3,9	—	1,0 - 2,5	0,10 - 0,20	—

a ‘–’ signs in the table are used to indicate that these elements are not required to be analysed
b Single values shown in the table are maximum values
c The results shall be rounded to the same number of significant figures as in the specified value using the rules in accordance with Annex B, Rule A of ISO 31-0:1992

Table 1B-2 Symbols for Chemical Composition Requirements for All Weld Metal of Self-Shielded Flux Cored Electrodes (Classification according to alloy type)

Alloy Designation According to Alloy Type	Chemical Composition (percentage mass fraction) a, b, c											
	Shielding Gas d	C	Mn	Si	P	S	Cr	Ni	Mo	Nb + Ta	Cu	N	Ti
307	N	0,13	3,30 - 4,75	1,0	0,04	0,03	19,5 - 22,0	9,0 - 10,5	0,5 - 1,5	—	0,5	—	—
308	N	0,08	0,5 - 2,5	1,0	0,04	0,03	19,5 - 22,0	9,0 - 11,0	0,5	—	0,5	—	—
308L	N	0,03	0,5 - 2,5	1,0	0,04	0,03	19,5 - 22,0	9,0 - 12,0	0,5	—	0,5	—	—
308H	N	0,04 - 0,08	0,5 - 2,5	1,0	0,04	0,03	19,5 - 22,0	9,0 - 11,0	0,5	—	0,5	—	—
308Mo	N	0,08	0,5 - 2,5	1,0	0,04	0,03	18,0 - 21,0	9,0 - 11,0	2,0 - 3,0	—	0,5	—	—
308LMo	N	0,03	0,5 - 2,5	1,0	0,04	0,03	18,0 - 21,0	9,0 - 12,0	2,0 - 3,0	—	0,5	—	—
308HMo	N	0,07 - 0,12	1,25 - 2,25	0,25 - 0,80	0,04	0,03	19,0 - 21,5	9,0 - 10,7	1,8 - 2,4	—	0,5	—	—
309	N	0,10	0,5 - 2,5	1,0	0,04	0,03	23,0 - 25,5	12,0 - 14,0	0,5	—	0,5	—	—
309L	N	0,03	0,5 - 2,5	1,0	0,04	0,03	23,0 - 25,5	12,0 - 14,0	0,5	—	0,5	—	—
309Mo	N	0,12	0,5 - 2,5	1,0	0,04	0,03	21,0 - 25,0	12,0 - 16,0	2,0 - 3,0	—	0,5	—	—
309LMo	N	0,04	0,5 - 2,5	1,0	0,04	0,03	21,0 - 25,0	12,0 - 16,0	2,0 - 3,0	—	0,5	—	—
309LNb	N	0,03	0,5 - 2,5	1,0	0,04	0,03	23,0 - 25,5	12,0 - 14,0	0,5	0,7 - 1,0	0,5	—	—
310	N	0,20	0,5 - 2,5	1,0	0,03	0,03	25,0 - 28,0	20,0 - 22,5	0,5	—	0,5	—	—
312	N	0,15	0,5 - 2,5	1,0	0,04	0,03	28,0 - 32,0	8,0 - 10,5	0,5	—	0,5	—	—
316	N	0,08	0,5 - 2,5	1,0	0,04	0,03	18,0 - 20,5	11,0 - 14,0	2,0 - 3,0	—	0,5	—	—
316L	N	0,03	0,5 - 2,5	1,0	0,04	0,03	18,0 - 20,5	11,0 - 14,0	2,0 - 3,0	—	0,5	—	—
316H	N	0,04 - 0,08	0,5 - 2,5	1,0	0,04	0,03	18,0 - 20,5	11,0 - 14,0	2,0 - 3,0	—	0,5	—	—
316LCu	N	0,03	0,5 - 2,5	1,0	0,04	0,03	18,0 - 20,5	11,0 - 16,0	1,25 - 2,75	—	1,0 - 2,5	—	—
317	N	0,08	0,5 - 2,5	1,0	0,04	0,03	18,5 - 21,0	13,0 - 15,0	3,0 - 4,0	—	0,5	—	—
317L	N	0,03	0,5 - 2,5	1,0	0,04	0,03	18,5 - 21,0	13,0 - 15,0	3,0 - 4,0	—	0,5	—	—
318	N	0,08	0,5 - 2,5	1,0	0,04	0,03	18,0 - 20,5	11,0 - 14,0	2,0 - 3,0	8 x C - 1,0	0,5	—	—
347	N	0,08	0,5 - 2,5	1,0	0,04	0,03	19,0 - 21,5	9,0 - 11,0	0,5	8 x C - 1,0	0,5	—	—
347L	N	0,04	0,5 - 2,5	1,0	0,04	0,03	19,0 - 21,5	9,0 - 11,0	0,5	8 x C - 1,0	0,5	—	—
409	N	0,1	0,8	1,0	0,04	0,03	10,5 - 13,5	0,6	0,5	—	0,5	—	10 x C - 1,5

Table 1B-2 (continued)

Alloy Designation According to Alloy Type	Chemical Composition (percentage mass fraction) a, b, c											
	Shielding Gas d	C	Mn	Si	P	S	Cr	Ni	Mo	Nb + Ta	Cu	N	Ti
409Nb	N	0,12	1,0	1,0	0,04	0,03	10,5 - 14,0	0,6	0,5	8 x C - 1,5	0,5	—	—
410	N	0,12	1,0	1,0	0,04	0,03	11,0 - 13,5	0,6	0,5	—	0,5	—	—
410NiMo	N	0,06	1,0	1,0	0,04	0,03	11,0 - 12,5	4,0 - 5,0	0,4 - 0,7	—	0,5	—	—
430	N	0,10	1,0	1,0	0,04	0,03	15,0 - 18,0	0,6	0,5	—	0,5	—	—
430Nb	N	0,10	1,0	1,0	0,04	0,03	15,0 - 18,0	0,6	0,5	0,5 - 1,5	0,5	—	—
16-8-2	N	0,10	0,5 - 2,5	0,75	0,04	0,03	14,5 - 16,5	7,5 - 9,5	1,0 - 2,0	—	0,5	—	—
2209	N	0,04	0,5 - 2,0	1,0	0,04	0,03	21,0 - 24,0	7,5 - 10,0	2,5 - 4,0	—	0,5	0,08 - 0,20	—
2553	N	0,04	0,5 - 1,5	0,75	0,04	0,03	24,0 - 27,0	8,5 - 10,5	2,9 - 3,9	—	1,5 - 2,5	0,10 - 0,20	—

a ‘–’ signs in the table are used to indicate that these elements are not required to be analysed
b Single values shown in the table are maximum values
c The results shall be rounded to the same number of significant figures as in the specified value using the rules in accordance with Annex B, Rule A of ISO 31-0:1992

Table 1B-3 Symbols for Chemical Composition Requirements for All Weld Metal of Gas Shielded Metal Cored Electrodes (Classification according to alloy type)

Alloy Designation According to Alloy Type	Chemical composition (percentage mass fraction) a, b, c											
	Shielding Gas d	C	Mn	Si	P	S	Cr	Ni	Mo	Nb + Ta	Cu	N	Ti
308L	A M	0,03 0,04	1,0 - 2,5 0,5 - 2,5	0,30 - 0,65 1,0	0,03 0,04	0,03	19,5 - 22,0 18,0 - 21,0	9,0 - 11,0 9,0 - 12,0	0,75	—	0,75	—	—
308Mo	A, M	0,08	1,0 - 2,5	0,30 - 0,65	0,03	0,03	18,0 - 21,0	9,0 - 12,0	2,0 - 3,0	—	0,75	—	—
309L	A M	0,03 0,04	1,0 - 2,5 0,5 - 2,5	0,30 - 0,65 1,0	0,03 0,04	0,03	23,0 - 25,5 22,0 - 25,0	12,0 - 14,0	0,75	—	0,75	—	—
309LMo	A M	0,03 0,04	1,0 - 2,5 0,5 - 2,5	0,30 - 0,65 1,0	0,03 0,04	0,03	23,0 - 25,5 21,0 - 25,0	12,0 - 14,0 12,0 - 16,0	2,0 - 3,0	—	0,75	—	—
316L	A M	0,03 0,04	1,0 - 2,5 0,5 - 2,5	0,30 - 0,65 1,0	0,03 0,04	0,03	18,0 - 20,5 17,0 - 20,0	11,0 - 14,0	2,0 - 3,0	—	0,75	—	—
347	A M	0,08	1,0 - 2,5 0,5 - 2,5	0,30 - 0,65 1,0	0,04	0,03	19,0 - 21,5 18,0 - 21,0	9,0 - 11,0	0,75	10 x C - 1,0 8 x C - 1,0	0,75	—	—
409	A	0,08	0,8	0,8	0,03	0,03	10,5 - 13,5	0,6	0,75	—	0,75	—	10 x C - 1,5
409Nb	A, M	0,12	1,2	1,0	0,04	0,03	10,5 - 14,0	0,6	0,75	8 x C - 1,5	0,75	—	—

Table 1B-3 (continued)

Alloy Designation According to Alloy Type	Chemical composition (percentage mass fraction) a, b, c											
	Shielding Gas d	C	Mn	Si	P	S	Cr	Ni	Mo	Nb + Ta	Cu	N	Ti
410	A M	0,12	0,6 1,2	0,5 1,0	0,03 0,04	0,03	11,5 - 13,5 11,0 - 13,5	0,6	0,75	—	0,75	—	—
410NiMo	A M	0,06	0,6 1,0	0,5 1,0	0,03 0,04	0,03	11,0 - 12,5	4,0 - 5,0	0,4 - 0,7	—	0,75	—	—
430	A M	0,10	0,6 1,2	0,5 1,0	0,03 0,04	0,03	15,0 - 17,0 15,0 - 18,0	0,6	0,75	—	0,75	—	—
430Nb	A, M	0,10	1,2	1,0	0,04	0,03	15,0 - 18,0	0,6	0,75	0,5 - 1,5	0,75	—	—

a '–' signs in the table are used to indicate that these elements are not required to be analysed
b Single values shown in the table are maximum values
c The results shall be rounded to the same number of significant figures as in the specified value using the rules in accordance with Annex B, Rule A of ISO 31-0:1992

Table 1B-4 Symbols for Chemical Composition Requirements for All Weld Metal of Cored Rods for Gas Tungsten Arc Welding (Classification according to alloy type)

Alloy Designation According to Alloy Type	Chemical composition (percentage mass fraction) a, b, c											
	Shielding Gas d	C	Mn	Si	P	S	Cr	Ni	Mo	Nb + Ta	Cu	N	Ti
308L	I	0,03	0,5 - 2,5	1,2	0,04	0,03	18,0 - 21,0	9,0 - 11,0	0,5	—	0,5	—	—
309L	I	0,03	0,5 - 2,5	1,2	0,04	0,03	22,0 - 25,0	12,0 - 14,0	0,5	—	0,5	—	—
316L	I	0,03	0,5 - 2,5	1,2	0,04	0,03	17,0 - 20,0	11,0 - 14,0	2,0 - 3,0	—	0,5	—	—
347	I	0,08	0,5 - 2,5	1,2	0,04	0,03	18,0 - 21,0	9,0 - 11,0	0,5	8 x C - 1,0	0,5	—	—

a '–' signs in the table are used to indicate that these elements are not required to be analysed
b Single values shown in the table are maximum values
c The results shall be rounded to the same number of significant figures as in the specified value using the rules in accordance with Annex B, Rule A of ISO 31-0:1992

Table 2B Tensile Properties of All Weld Metal (Classification according to alloy type)

Alloy Designation According to Alloy Type	Minimum Tensile Strength (MPa)	Minimum Elongation a (%)	Post Weld Heat Treatment
307	590	25	none
308	550	30	
308L	520	30	
308H	550	30	
308Mo	550	30	
308LMo	520	30	
308HMo	550	30	
309	550	25	
309L	520	25	
309Mo	550	15	
309LMo	520	15	
309LNb	520	25	
310	550	25	
312	660	15	
316	520	25	
316L	485	25	
316H	520	25	
316LCu	485	25	
317	550	20	
317L	520	20	
318	520	20	
347	520	25	
347L	520	25	
409	450	15	
409Nb	450	15	b
410	480	15	b
410NiMo	760	10	c
430	450	15	d
430Nb	450	13	d
16-8-2	520	25	none
2209	690	15	
2553	760	13	

a Gauge length is equal to five times the test specimen diameter

b The weld test assembly (or the blank from it, from which the tensile test specimen is to be machined) shall be heated to a temperature between 730 - 760°C, held for 1 hr, furnace cooled to 315°C, then cooled in air

c The weld test assembly (or the blank from it, from which the tensile test specimen is to be machined) shall be heated to a temperature between 590 - 620°C, held for 1 hr, then cooled in air

d The weld test assembly (or the blank from it, from which the tensile test specimen is to be machined) shall be heated to a temperature between 760 - 790°C, held for 2 hr, furnace cooled to 600°C, then cooled in air

Table 3B Symbol for Type of Tubular Cored Electrode and Rod (Classification according to alloy type)

Symbol	Characteristics
F	Flux cored electrodes
M	Metal cored electrodes
R	Cored rods for gas tungsten arc welding

Table 4B Symbol for Welding Position (Classification according to alloy type)

Symbol	Welding Positions a
0	PA and PB
1	PA, PB, PC, PD, PE, PF or PG, or PF + PG
a	PA = Flat position PB = Horizontal-vertical position PC = Horizontal position PD = Horizontal-overhead position PE = Overhead position PF = Vertical-up position PG = Vertical-down position

10204 Metallic Products Types Inspection Documents

This Euro-norm document covers the types of documentation required for material certification. It does not specify what tests must be done but does differentiate between actual test results and typical or statistical test results. Customers must specify on their purchase order the tests required and the test method required.

The relevant sections are Type 2.1, 2.2, 3.1 and 3.2 as shown in the table below.

Table 1 Inspection Document Content

Document Type	Document Content
2.1	Statement of compliance with order. Validated by the manufacturer
2.2	Statement of compliance with order, with indication of results of non-specific inspection. Validated by the manufacturer
3.1	Statement of compliance with order, with indication of results of specific inspection. Validated by the manufacturer's authorised inspection representative independent of the manufacturing department
3.2	Statement of compliance with order, with indication of results of specific inspection. Validated by the manufacturer's authorised inspection representative independent of the manufacturing department and either the purchaser's authorised inspection representative or the inspector designated by the official regulations

Stainless Steel Dissimilar Welding Chart

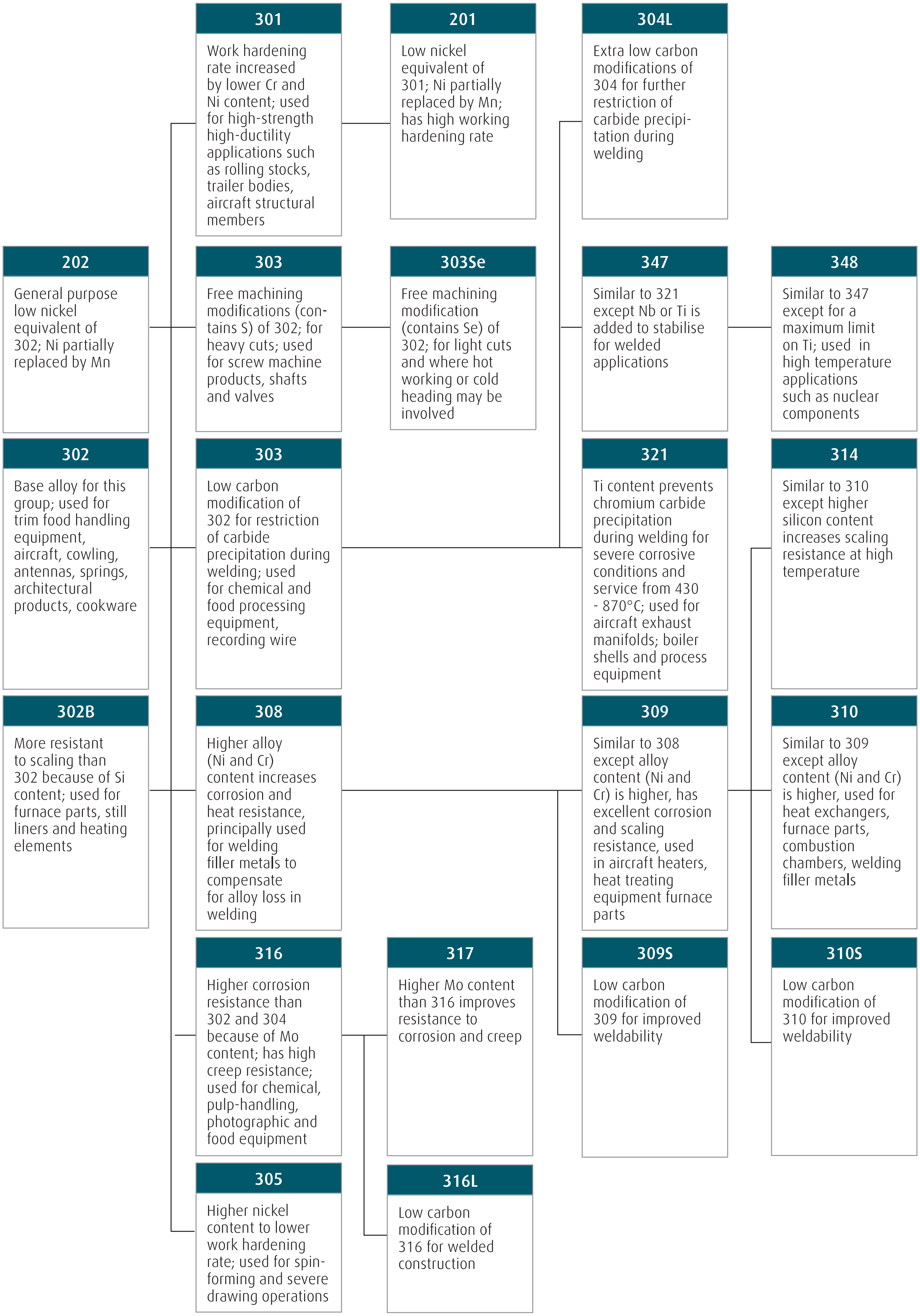
201	202	301	302	302B	303	304	304L	305	308	309	309S	310	310S	314	316	316L	317	317L	321	330	347	318	403	405	410	414	416	420	430	430F	431	440A	440E	440C	446	Base Metal
308	308	308	308	308	308/312	308	308	308	308	308	308	308	308	308/312	308	308	308	308	308	312/309	308	308	309	309	309	309	309	309	309	309	309	309	309	309	310	201
	308	308	308	308	308/312	308	308	308	308	308	308	308	308	308/312	308	308	308	308	308	312/309	308	308	309	309	309	309	309	309	309	309	309	309	309	309	310	202
		308	308	308	308/312	308	308	308	308	308	308	308	308	308/312	308	308	308	308	308	312/309	308	308	309	309	309	309	309	309	309	309	309	309	309	309	310	301
			308	308	308/312	308	308	308	308	308	308	308	308	308/312	308	308	308	308	308	312/309	308	308	309	309	309	309	309	309	309	309	309	309	309	309	310	302
				309	308/312	308	308	308	308	308	308	308	308	308/312	308	308	308	308	308	312/309	308	308	309	309	309	309	309	309	309	309	309	309	309	309	310	302B
					308/312	308/312	308/312	308/312	308/312	308/312	308/312	312	312	312	308/312	308/312	308/312	308/312	308/312	312/309	308/312	308/312	309	309	309	309	309	309	309	309	309	309	309	309	312	303
						308	308	308	308	308	308	308	308	308/312	308	308	308	308	308	312/309	308	308	309	309	309	309	309	309	309	309	309	309	309	309	310	304
							308L	308	308	308	308	308	308	308/312	308L	308L	308L	308L	308L	312/309	308L	308L	309	309	309	309	309	309	309	309	309	309	309	309	310	04L
								308/310	308	308	308	308/310	310/308	312	308	308	308	308	308	312/309	308	308	309	309	309	309	309	309	309	309	309	309	309	309	310	305
									308	308	308	308	308	308/312	308	308	308	308	308	312/309	308	308	309	309	309	309	309	309	309	309	309	309	309	309	310	308
										309	309	309	309	309/312	309	309/316	309	309	308/347	312/309	308/347	308/347	309	309	309	309	309	309	309	309	309	309	309	309	310	309
											309	309	309	309/312	309/316	316	316	316	308/347	312/309	308/347	308/347	309	309	309	309	309	309	309	309	309	309	309	309	310	309S
												310	310	310/312	316	316	317	317	308	312/309	308/347	308/347	309	309	309	309	309	309	309	309	309	309	309	309	310	310
													310	310/312	316	316	317	317	308	312/309	308/347	308/347	309	309	309	309	309	309	309	309	309	309	309	309	309/310	310S
														310/312	316	316	317	317	308	312/309	308/347	308/347	309	309	309	309	309	309	309	309	309	309	309	309	309/310	314
															316/16.8.2	316	316	316	308	312/309	308/16.8.2	308/316	309	309	309	309	309	309	309	309	309	309	309	309	310	316
																316	316	316L	308L	312/309	316L	316L	309	309	309	309	309	309	309	309	309	309	309	309	310	316L
																	317	317	308	312/309	308L/16.8.2	308L/16.8.2	309	309	309	309	309	309	309	309	309	309	309	309	310	317
																		317L	308L/347	312/309	308L	308L	309	309	309	309	309	309	309	309	309	309	309	309	310	317L
																			347	312/309	347	347	309	309	309	309	309	309	309	309	309	309	309	309	310	321
																				330	312/309	312/309	312	312	312	312	312	312	312	312	312	312	312	312	312	330
																					347	347	309	309	309	309	309	309	309	309	309	309	309	309	310	347
																						347	309	309	309	309	309	309	309	309	309	309	309	309	310	348
																							410	410	410	410	312/309	410	430	309	410	410	410	410	410	403
																								410	410	410	312/309	410	430	309	410	410	410	410	410	405
																									410	410	312/309	410	430	309	410	410	410	410	410	410
																										309	312/309	410	430	309	410	410	410	410	410	414
																											410/309	309	410/309	309	410/309	309	309	309	309/310	416
																												420/410	410	309	410	420	420	420	430	420
																													430	309	430	430	430	430	430	430
																														309	309	309	309	309	309/310	430F
																															309	309	309	309	309/310	431
																																309	309	309	309/310	440A
																																	309	309	309/310	440B
																																		309	309/310	440C
																																			312/310	446

Note

- This chart is only a suggestion of which filler materials should be adequate for joining of stainless steels. This does not mean that other filler metal alloys are not recommended or are of a lesser quality. In all instances, the chart should be used as a reference only. Actual application should dictate the proper alloy choice.
- The shaded sections of the chart indicate 'free machining' alloys, which are considered not weldable. This is due to the high percentage of sulphur or other low melting point elements that cause hot cracking. If high quality joints are required, welding is not generally recommended.
- This chart does not indicate welding procedure. Some stainless steels require preheat while others should not have a preheat. Some welds require a buttering layer or rather more rigid procedures. Please contact Afrox regarding procedure recommendation.

Figure 1

The interrelationship and applications of the austenitic stainless steels.
Machine Design Reference Issue, The Penton Publishing Co., Cleveland, Ohio, 1967.



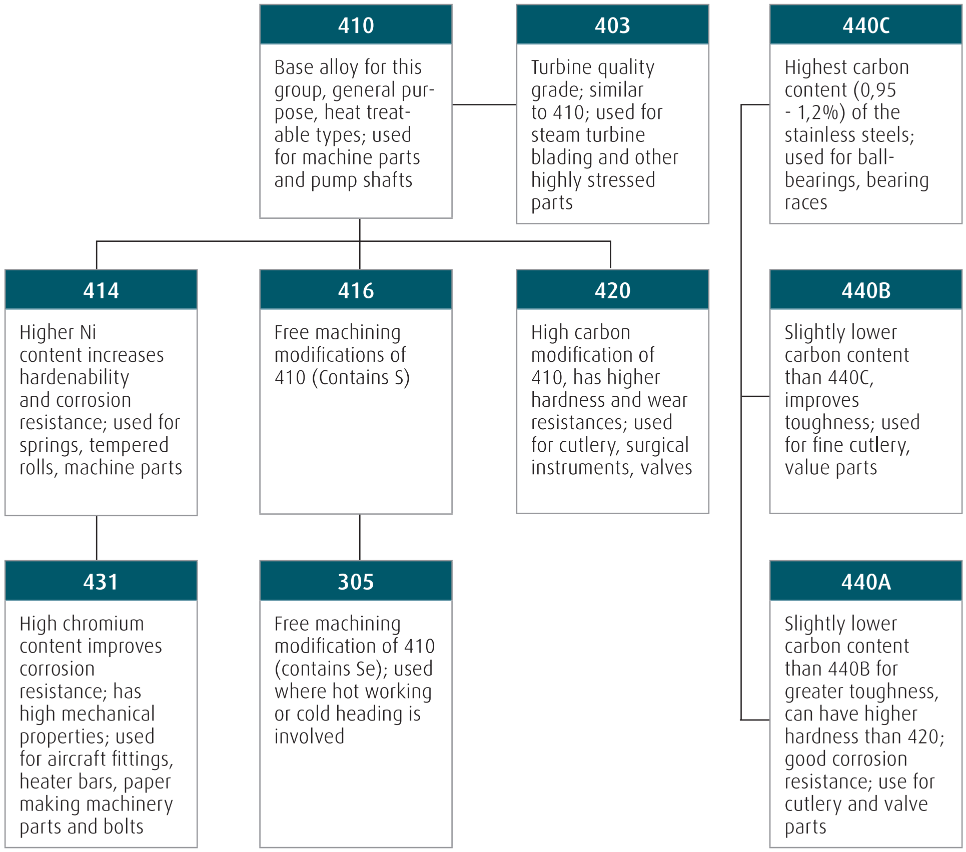
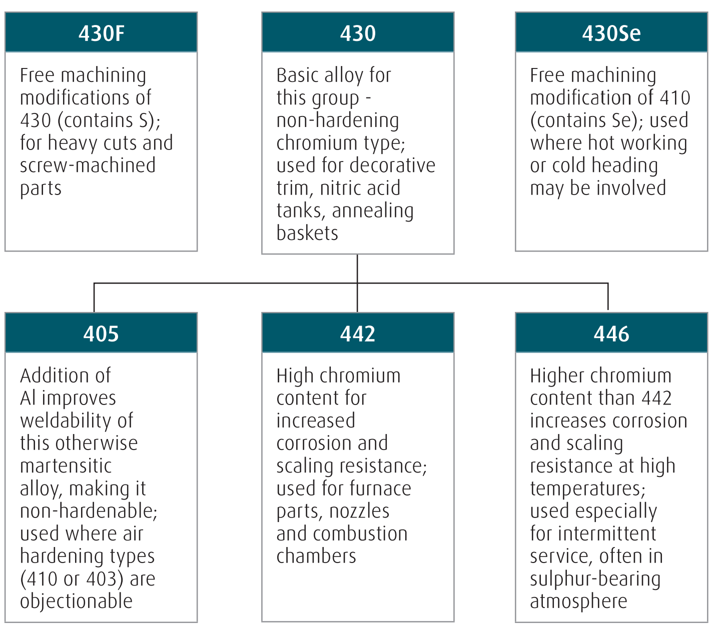


Figure 2

The interrelationship and applications of the martenistic stainless steels.
Machine Design Reference Issue, The Penton Publishing Co., Cleveland, Ohio, 1967.



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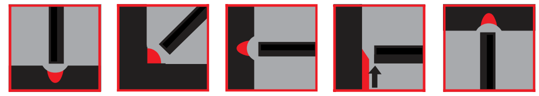
Stainless Steel Electrodes

Afrox 308L



Afrox 308L is a rutile basic coated low carbon electrode for the high quality welding of stainless steel of the 19% chromium and 9% nickel type. It is recommended for welding AISI 302, 304, 304L, 321 and 347 stainless steels, which may be used in the following applications: brewing equipment, steam piping, vacuum pump parts, dairy equipment, textile drying equipment, chemical handling equipment, pharmaceutical and food processing.

Re-baking
Dry electrodes at 300°C for 2 hours.

Approvals
TÜV, EN 13479, CE (C880-CPD-0035), BV

Classifications		
AWS	A5.4	E308L-17
EN ISO	3581-A	E 19 9 L R 12

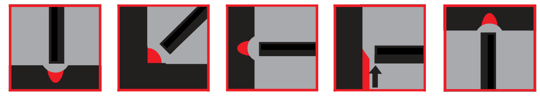
Typical Chemical Analysis			
% Carbon	0,03 max	**% Nickel**	9,0 - 11,0
% Manganese	0,5 - 2,5	**% Sulphur**	0,025 max
% Silicon	0,9 max	**% Phosphorous**	0,025 max
% Chromium	18,0 - 21,0		

Typical Mechanical Properties (All weld metal)	
0,2% Proof Stress	400 MPa min
Tensile Strength	520 - 630 MPa
% Elongation on 4d	35 min
Charpy V-Notch at +20°C	50 J min
Charpy V-Notch at -70°C	40 J min
Hardness VPN	180 - 220

Packing Data
(DC+ AC 70 OCV min)

Diameter (mm)	Electrode Length (mm)	Current (A)	Pack Mass (kg)	Item Number (multi-kg pack)
2,5	300	45 - 80	3 x 5,0	W075702
3,25	350	70 - 120	3 x 5,0	W075703
4,0	350	100 - 150	3 x 5,0	W075704

Afrox 309L



Afrox 309L is a rutile basic coated low carbon grade electrode of the 23% chromium and 12% nickel type. It is recommended for welding corrosion resistant and heat resistant steels of the AISI 309 type, which is often used for furnace parts, aircraft components, heat exchangers and chemical processing equipment.

Afrox 309L can also be used for welding dissimilar carbon manganese steels and low alloy steels, welding stainless steels to mild steels and as a buffer for hardfacing applications.

Re-baking

Dry electrodes at 300°C for 2 hours.

Approvals
TÜV

Classifications		
AWS	A5.4	E309L-17
EN ISO	3581-A	E 23 12 L R 12

Typical Chemical Analysis			
% Carbon	0,03 max	**% Nickel**	12,0 - 14,0
% Manganese	0,5 - 2,5	**% Sulphur**	0,025 max
% Silicon	0,9 max	**% Phosphorous**	0,025 max
% Chromium	22,0 - 25,0		

Typical Mechanical Properties (All weld metal)	
0,2% Proof Stress	400 MPa min
Tensile Strength	550 - 650 MPa
% Elongation on 5d	30 min
Charpy V-Notch at +20°C	>60 J min
Charpy V-Notch at -70°C	40 J min
Hardness VPN	170 - 200
Ferrite Number WRC (1992)	20FN

Packing Data (DC+ AC 70 OCV min)

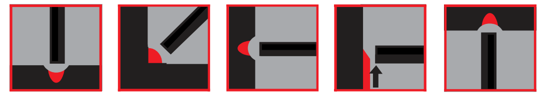
Diameter (mm)	Electrode Length (mm)	Current (A)	Item Number (1 kg electrode pack)	Pack Mass (kg)	Item Number (multi-kg pack)
2,5	300	40 - 80	W072772	3 x 4,0	W075772
3,25	350	70 - 105	W072773	3 x 4,0	W075773
4,0	350	90 - 145	-	3 x 4,0	W075774
5,0	350	140 - 190	-	3 x 4,0	W075775

DriPac Range

Packing Data (DC+ AC 70 OCV min)

Diameter (mm)	Electrode Length (mm)	Current (A)	Pack Mass (kg)	Item Number (multi-kg pack)
2,5	300	40 - 80	2 x 6,0	W075776
3,25	350	70 - 105	2 x 6,0	W075777

Afrox 310



Afrox 310 is an all-position rutile basic coated electrode of the 25% chromium and 20% nickel type. It is suitable for welding AISI 310 grade materials and resists scaling in oxidising atmospheres at temperatures up to 1 100°C while maintaining adequate joint strength.

Re-baking

Dry electrodes at 300°C for 2 hours.

Classifications		
AWS	A5.4	E310-16
EN ISO	3581-A	E 25 20 R 26

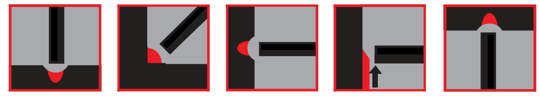
Typical Chemical Analysis			
% Carbon	0,08 - 0,15	**% Nickel**	20,0 - 22,5
% Manganese	1,5 - 2,5	**% Molybdenum**	0,20 max
% Silicon	0,75 max	**% Sulphur**	0,025 max
% Chromium	25,0 - 28,0	**% Phosphorous**	0,025 max

Typical Mechanical Properties (All weld metal)	
0,2% Proof Stress	370 MPa min
Tensile Strength	550 - 650 MPa
% Elongation on 4d	30 min
Charpy V-Notch at +20°C	65 J min
Charpy V-Notch at -70°C	45 J min
Charpy V-Notch at -196°C	35 J min

Packing Data (DC+ AC 70 OCV min)

Diameter (mm)	Electrode Length (mm)	Current (A)	Pack Mass (kg)	Item Number (multi-kg pack)
2,5	300	50 - 70	3 x 4,0	W075732
3,25	350	80 - 95	3 x 4,0	W075733
4,0	350	95 - 130	3 x 4,0	W075734

Afrox 316L



Afrox 316L is a low carbon 19% chromium, 12% nickel and 3% molybdenum rutile basic coated electrode. It is recommended for welding of low carbon molybdenum bearing steels of the AISI 316L type which may be used for applications such as pulp handling equipment, high temperature equipment, heat exchangers, chemical storage and transportation tanks, oil refining equipment and pharmaceutical equipment.

Re-baking

Dry electrodes at 300°C for 2 hours.

Approvals
TÜV, EN 13479, CE (C880-CPD-0035), BV

Classifications		
AWS	A5.4	E316L-17
EN ISO	3581-A	E 19 12 3 L 12

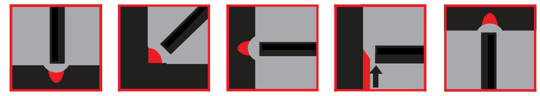
Typical Chemical Analysis			
% Carbon	0,03 max	**% Nickel**	11,0 - 14,0
% Manganese	0,5 - 2,5	**% Molybdenum**	2,5 - 3,0
% Silicon	0,90 max	**% Sulphur**	0,02 max
% Chromium	17,0 - 20,0	**% Phosphorous**	0,025 max

Typical Mechanical Properties (All weld metal)	
0,2% Proof Stress	430 MPa min
Tensile Strength	520 - 650 MPa
% Elongation on 4d	35 min
Charpy V-Notch at +20°C	50 J min
Charpy V-Notch at -70°C	35 J min

Packing Data (DC+ AC 70 OCV min)

Diameter (mm)	Electrode Length (mm)	Current (A)	Item Number (4 electrode sleeve)	Item Number (1 kg electrode pack)	Pack Mass (kg)	Item Number (multi-kg pack)
2,0	300	30 - 60	-	-	3 x 3,0	W075751
2,5	300	40 - 80	W072752	W072782	3 x 4,0	W075752
3,25	350	70 - 105	W072753	W072783	3 x 4,0	W075753
4,0	350	90 - 145	-	-	3 x 4,0	W075754
5,0	350	140 - 190	-	-	3 x 4,0	W075755
2,5 (DriPac)	300	40 - 80	-	-	3 x 2,0	W075756
3,25 (DriPac)	350	70 - 105	-	-	3 x 2,0	W075757

Afrox E3CR12



Afrox E3CR12 is a heavily coated 13% chromium alloyed electrode suitable for all-position welding of 13% chromium ferritic steels. The deposited weld metal is sound with a low inclusion content and exhibits good toughness at temperatures down to -20ºC. The electrode features a smooth, stable, low spatter arc on DC+. Weld bead appearance is good with a smooth uniform ripple. The slag is readily removed from the weld surface in all positions. Afrox E3CR12 has been especially developed for the welding of 3CR12 material. The weld metal has similar corrosion properties to that of 3CR12 without over alloying, i.e. in contrast to the 300 series electrodes.

Classifications		
AWS	A5.4	E410NiMo
EN ISO	3581-A	E13 4 R 26
EN ISO	3581-B	ES 410 NiMo-26

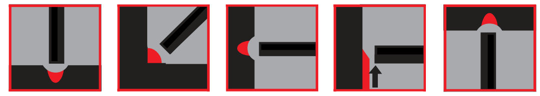
Typical Chemical Analysis			
% Carbon	0,03	**% Nickel**	4,8
% Manganese	0,16	**% Molybdenum**	0,48
% Silicon	0,4	**% Sulphur**	0,01
% Chromium	12,0	**% Phosphorous**	0,03

Typical Mechanical Properties (All weld metal)	
PWHT 605ºC x 1 hr	
Yield Strength	850 MPa
Tensile Strength	920 MPa
% Elongation on 5d	18
Charpy V-Notch at +20°C	40 - 55 J
Charpy V-Notch at -20°C	25 - 35 J

Packing Data (DC+ AC 70 OCV min)

Diameter (mm)	Current (A)	Pack Mass (kg)	Item Number
3,2	70 - 130	3 x 5,0	W075843
4,0	100 - 170	3 x 5,0	W075844

Afrox 904L



Afrox 904L gives a fully austenitic low carbon weld metal with molybdenum and copper, with good resistance to corrosion in sulphuric, phosphoric and other inorganic and organic acids. It is not normally chosen for resistance to corrosion in concentrated nitric acid. For service in severe chloride pitting media, overmatching nickel-based weld metal is recommended. It is the preferred weld metal for some lower alloy austenitics such as Creusot UHB 34L and UHB 734L for wet process phosphoric acid service. Applications include tanks and process vessels, piping systems, agitators, rotors, cast pumps and valves for use in the fertiliser, phosphoric and sulphuric environments. It is also used in some offshore applications, including overlays on mild and low alloy steels.

Re-baking

Re-dry electrodes at 300 - 350°C for 2 hours.

Classifications		
AWS	A5.4	E385-16

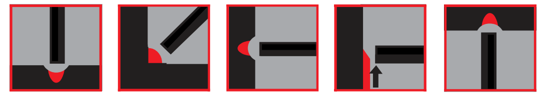
Typical Chemical Analysis			
% Carbon	0,03 max	**% Nickel**	24,0
% Manganese	1,0	**% Molybdenum**	4,0
% Silicon	0,8	**% Copper**	1,3
% Sulphur	0,005	**% Niobium**	0,1
% Phosphorous	0,02	**% Nitrogen**	0,08
% Chromium	21,0		

Typical Mechanical Properties (All weld metal)	
Tensile Strength	580 MPa min
0,2% Proof Stress	375 MPa min
% Elongation on 5d	32 min
Impact Energy at -196°C	35 J min
Microstructure	In the as welded condition the weld metal microstructure is fully austenitic

Packing Data (DC+ AC OCV 70 V min)

Diameter (mm)	Current (A)	Pack Mass (kg)	Item Number
2,5	50 - 75	5,0	W078104
3,2	65 - 105	5,0	W078106
4,0	85 - 150	5,0	W078108

Afrox 2209



Inox 2209 is a rutile coated electrode designed for the welding of austenitic-ferritic duplex steels. The weld deposit has a ferrite content of 25 - 30% providing resistance to stress corrosion cracking and pitting in chloride and hydrogen sulphide environments at service temperatures up to 300°C. The electrode has good re-strike characteristics with excellent bead profile and overall ease of operation. Suitable for use on AC and DC and welding transformers with low OCV. Suitable for welding SAF 2205 and LDX 2101.

Re-baking

Re-dry electrodes at 300°C for 2 hours.

Classifications		
AWS	A5.4	E2209-17
EN ISO	3581-A	E 2293 N L R
EN ISO	3581-B	ES 2209-17

Typical Chemical Analysis			
% Carbon	<0,04	**% Nickel**	9,0
% Silicon	0,8	**% Molybdenum**	3,0
% Manganese	0,9	**% Nitrogen**	0,1
% Chromium	22,0		

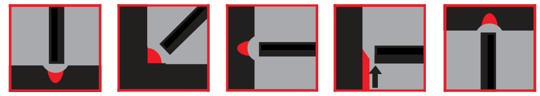
Typical Mechanical Properties (All weld metal)	
Tensile Strength	>760 MPa
0,2% Proof Stress	>620 MPa
% Elongation on 4d	>25
Impact Energy at +20°C	>55 J

Packing Data
(DC+ AC OCV 42 V min)

Diameter (mm)	Current (A)	Pack Mass (kg)	Item Number
2,5	50 - 80	3 x 5,0	W075742
3,2	70 - 120	3 x 5,0	W075743
4,0	90 - 150	3 x 5,0	W075744

Stainless Steel Wires for MIG & TIG Welding

Afrox MIG 307Si



Afrox MIG 307Si is a bright drawn, stainless steel welding wire suitable for the joining of armour plate, austenitic manganese steels, ferritic chromium stainless steels and dissimilar steels. The wire is also suitable for buffer layering prior to hardfacing. The weld deposit is work hardenable and heat resistant up to 850°C.

Classifications		
EN ISO	14343-A	G 18 8 Mn
EN ISO	14343-B	SS 307 Si (nearest)

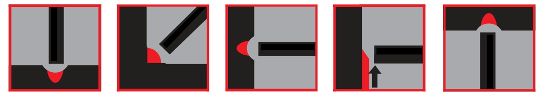
Typical Chemical Analysis			
% Carbon	0,2 max	**% Manganese**	5,0 - 8,0
% Silicon	1,5 max	**% Chromium**	17,0 - 20,0
% Nickel	7,0 - 10,0	**% Sulphur**	0,025 max
% Phosphorous	0,035 max		

Typical Mechanical Properties (All weld metal)	
0,2% Proof Stress	390 MPa
Tensile Strength	590 - 740 MPa
% Elongation on 4d	30 min
Charpy V-Notch at +20°C	60 J min
Microstructure	Fully austenitic

Packing Data		
Diameter (mm)	**Pack Mass (kg)**	**Item Number**
1,0	15,0 (spool)	W033244
1,2	15,0 (spool)	W033242
1,0	15,0 (spool)	W033003
1,0	120,0 (drum)	W033457
1,0	220,0 (drum)	W033467

Suggested shielding gas: Stainshield®, Stainshield® Plus

Afrox TIG 307Si



TIG 307Si is for use on dissimilar combinations of CMn, stainless, hardenable, wear resistant and armour steels. Also suitable for 13% Mn manganese (Hadfield) steel and mixed welding applications. Can be used as buffer layers and a surfacing consumable.

Classifications		
AWS	A5.9	Similar to ER307
EN ISO	14343	W 18 8 Mn
EN ISO	14343	SS 307 nearest

Typical Chemical Analysis			
% Carbon	0,08	**% Chromium**	19,0
% Manganese	6,0	**% Nickel**	8,5
% Silicon	0,8	**% Molybdenum**	0,2
% Sulphur	0,01	**% Copper**	0,1
% Phosphorous	0,015		

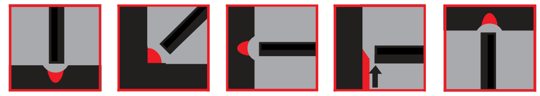
Typical Mechanical Properties (All weld metal)	
Tensile Strength	605 MPa
0,2% Proof Stress	414 MPa
% Elongation on 4d	42
Charpy V-Notch at +20°C	105 J
Charpy V-Notch at -50°C	65 J
Microstructure	In the as welded condition the weld metal microstructure is fully austenitic

Packing Data
TIG (DC-)

Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
1,6	100	12	5,0	W030405
2,4	100	12	5,0	W030407

Suggested shielding gas: Argon

Afrox Exhaust F1 1,00 mm



Exhaust F1 (MIG/GMAW) is a ferritic stainless steel wire developed and customised for the automotive industry and exhaust manufacturers. Welds of ferritic stainless steel sheets obtained with Exhaust F1 wire exhibit far better thermal fatigue cycles due to unique chemical composition.

Classifications	
ISO	14343.2: 18LNb
AISI	430Cb
DIN	85561.4511

Typical Chemical Analysis			
% Carbon	0,05	**% Chromium**	17,5 - 19,0
% Manganese	0,3 - 0,8	**% Nickel**	0,56
% Silicon	0,3 - 1,0	**% Molybdenum**	0,50
% Sulphur	0,030	**% Copper**	0,50
% Phosphorous	0,030	**Nb**	10xC - 0,7

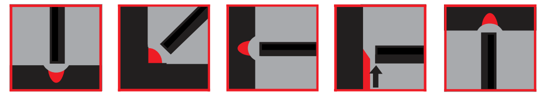
Typical Mechanical Properties (All weld metal)	
Tensile Strength	520 MPa
0,2% Proof Stress	360 MPa
% Elongation on 5d	23

Packing Data
TIG (DC-)

Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
1,0	200	26	220,0	W033466

Suggested shielding gas: Stainshield®

Afrox MIG/TIG 308LSi



MIG/TIG 308LSi is used to weld 18/8 stainless steels including 301, 302, 303, nitrogen bearing 304LN and similar. Service temperatures are typically -100°C to about 400°C. Applications can be found in the brewery, food, architectural and general fabrication industries.

Classifications		
AWS	A5.9	ER308LSi
EN ISO	14343-A	G/W 19 9 LSi
EN ISO	14343-B	SS 308 LSi

Typical Chemical Analysis			
% Carbon	0,01	**% Chromium**	20,0
% Manganese	1,7	**% Nickel**	10,0
% Silicon	0,8	**% Molybdenum**	0,1
% Sulphur	0,01	**% Copper**	0,15
% Phosphorous	0,015	**Ferrite Number**	10,0

Typical Mechanical Properties (All weld metal)	MIG	TIG
Tensile Strength	570 MPa	605 MPa
0,2% Proof Stress	435 MPa	465 MPa
% Elongation on 4d	42	35
Impact Energy at -20°C	30 - 60 J	80 J
Microstructure	Austenite with a controlled level of ferrite, normally in the range 2 - 10FN	

Packing Data
MIG (DC+)

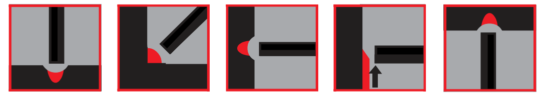
Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
0,9	160	23	15,0	W033014
1,0	200	26	15,0	W033224
1,2	260	26	15,0	W033222

TIG (DC-)

Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
1,6	100	12	5,0	W030413

Suggested gas for welding: Stainshield®, Stainshield® Plus (MIG), Argon (TIG)

Afrox MIG/TIG 308L



MIG/TIG 308L is used to weld 18/8 stainless steels including 301, 302, 303, nitrogen bearing 304LN and similar. Service temperatures are typically -100°C to about 400°C. Applications can be found in the brewery, food, architectural and general fabrication industries.

Classifications		
AWS	A5.9	ER308L
EN ISO	14343-A	G/W 19 9 L
EN ISO	14343-B	SS 308L

Typical Chemical Analysis			
% Carbon	0,03 max	**% Phosphorous**	0,03 max
% Manganese	1,0 - 2,5	**% Chromium**	19,5 - 22,0
% Silicon	0,3 - 0,65	**% Nickel**	9,0 - 11,0
% Sulphur	0,03 max	**Ferrite Number**	10,0

Typical Mechanical Properties (All weld metal)		
	MIG	**TIG**
Tensile Strength	570 MPa	605 MPa
0,2% Proof Stress	435 MPa	465 MPa
% Elongation on 4d	42	35
Impact Energy at -196°C	30 - 60 J	80 J
Hardness	200/220 HV	200/220 HV
Microstructure	Austenite with a controlled level of ferrite, normally in the range 2 - 10FN	

Packing Data
MIG (DC+)

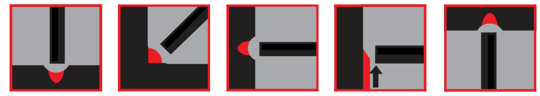
Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
1,2	260	26	15,0	W033010
1,0	260	26	220,0	W033447
1,2	260	26	220,0	W033448

TIG (DC-)

Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
1,6	100	12	5,0	W030560
2,0	100	12	5,0	W030562
2,4	100	12	5,0	W030561

Suggested gas for welding: Stainshield®, Stainshield® Plus (MIG), Argon (TIG)

Afrox MIG/TIG 308H



MIG/TIG 308H consumables are designed to match unstabilised 18% Cr, 10% Ni austenitic stainless steels for elevated temperature strength and oxidation resistance. These steels and the weld metal have carbon content controlled to 0,04 - 0,08%. The 308H consumables should also be considered for welding thick (>12 mm) stabilised grades 321H or 347H to avoid in-service HAZ cracking and low creep rupture ductility associated with 347 weld metal.

Materials to be Welded	
ASTM / UNS	304 H, S30409, CF 10, CF 8
DIN	1.4948
BS	304S51, 302C25, 304C15

Classifications		
AWS	A5.9	ER308H
EN ISO	14343 - A	G/W 19 9 H
EN ISO	14343 - B	SS 308H

Typical Chemical Analysis			
% Carbon	0,05	**% Chromium**	19,9
% Manganese	1,8	**% Nickel**	9,5
% Silicon	0,4	**% Molybdenum**	0,1
% Sulphur	0,002	**% Copper**	0,1
% Phosphorous	0,015		

Typical Mechanical Properties (All weld metal)		
	MIG	**TIG**
Tensile Strength	550 MPa min	630 MPa
0,2% Proof Stress	350 MPa min	450 MPa
% Elongation on 4d	30	43
Impact Energy -20°C	-	100 J
Microstructure	Austenite with delta ferrite controlled 3 - 8FN	

Packing Data
MIG (DC+)

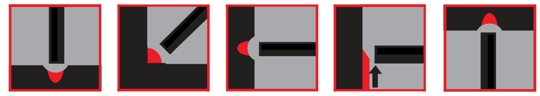
Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
1,2	260	28	15,0	W033026

TIG (DC-)

Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
1,6	100	12	5,0	W030417
2,0	100	12	5,0	W030418
2,4	100	12	5,0	W030419

Suggested gas for welding: Stainshield®, Stainshield Plus® (MIG), Argon (TIG)

Afrox MIG 309LSi



MIG 309LSi is mainly used under high dilution conditions, particularly dissimilar welds between stainless and CMn steels. There are three main areas of application: buffer layers and clad steels, dissimilar joints and similar metal joints.

Classifications		
AWS	A5.9	ER309L Si
EN ISO	14343 - A	23 12 L Si
EN ISO	14343 - B	309L Si

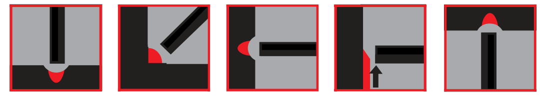
Typical Chemical Analysis			
% Carbon	0,015	**% Chromium**	23,5
% Manganese	1,7	**% Nickel**	13,0
% Silicon	0,8	**% Molybdenum**	0,1
% Sulphur	0,005	**% Copper**	1,15
% Phosphorous	0,015	**Ferrite Number**	12,0

Typical Mechanical Properties (All weld metal)	
Tensile Strength	560 MPa
0,2% Proof Stress	430 MPa
% Elongation on 4d	42
% Elongation on 5d	39
Impact Energy at -20°C	80 J
Impact Energy at +20°C	100 J
Microstructure	Austenite with ferrite in the range 8 - 20FN

Packing Data
MIG (DC+)

Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
0,8	120	19	15,0	W033035
0,9	160	23	15,0	W033036
1,0	200	26	15,0	W033228
1,2	260	26	15,0	W033227
1,6	280	28	15,0	W033039

Afrox MIG/TIG 309L



MIG/TIG 309L is mainly used under high dilution conditions, particularly dissimilar welds between stainless and CMn steels. There are three main areas of application: buffer layers and clad steels, dissimilar joints and similar metal joints.

Classifications		
AWS	A5.9	ER309L
EN ISO	14343-A	G/W 23 12 L
EN ISO	14343-B	SS 309L

Typical Chemical Analysis			
% Carbon	0,03 max	**% Phosphorous**	0,02 max
% Manganese	1,0 - 2,5	**% Nickel**	12,0 - 14,0
% Silicon	0,3 - 0,65	**% Chromium**	23,0 - 25,0
% Sulphur	0,02 max	**Ferrite Number**	6,0 - 12,0

Typical Mechanical Properties (All weld metal)		
	MIG	**TIG**
Tensile Strength	560 MPa	590 MPa
0,2% Proof Stress	430 MPa	450 MPa
% Elongation on 4d	42	43
% Elongation on 5d	39	41
Impact Energy at +20°C	100 J	>200 J
Hardness	175 - 215 HV	205 - 2 250 HV
Microstructure	Austenite with ferrite in the range 6 - 12FN	

Packing Data
MIG (DC+)

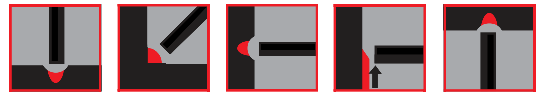
Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
1,0	220	25	15,0	W033455
1,2	260	26	15,0	W033127
1,2	260	26	120,0	W033108

TIG (DC-)

Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
1,6	100	12	5,0	W030570
2,0	100	12	5,0	W030572
2,4	100	12	5,0	W030571

Suggested gas for welding: Argon (TIG)

Afrox MIG/TIG 310



MIG/TIG 310 consumables are used primarily for welding similar wrought or cast 25% Cr, 20% Ni (310) parent alloys with up to 0,25% carbon. Parent metal and weld metal are fully austenitic. The high alloy content of type 310 gives useful oxidation resistance up to peak temperatures of about 1 200°C for heat shields, furnace parts and ducting. Can be used for mixed welding, dissimilar joints, buffer layers and surfacing, as well as specialised applications requiring low magnetic permeability and for cryogenic installations.

Classifications		
AWS	A5.9	ER310
EN ISO	14343-A	G/W 25 20
EN ISO	14343-B	SS 310

Typical Chemical Analysis			
% Carbon	0,11	**% Chromium**	26,0
% Manganese	1,8	**% Nickel**	21,0
% Silicon	0,4	**% Molybdenum**	0,1
% Sulphur	0,005	**% Copper**	1,1
% Phosphorous	0,02		

Typical Mechanical Properties (All weld metal)	MIG	TIG
Tensile Strength	540 MPa	560 MPa
0,2% Proof Stress	355 MPa	370 MPa
% Elongation on 4d	27	25
Impact Energy at -196°C	70 J	-
Hardness cap/mid	185 HV	185 HV
Microstructure	Fully austenitic	

Packing Data
MIG (DC+)

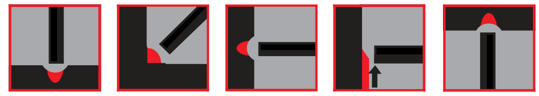
Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
1,2	220	29	15,0	W033054

TIG (DC-)

Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
1,6	100	12	5,0	W030433
2,0	100	12	5,0	W030434
2,4	100	12	5,0	W030435

Suggested gas for welding: Stainshield®, Stainshield® Plus (MIG), Argon (TIG)

Afrox MIG/TIG 316LSi



MIG/TIG 316LSi consumables are used for Mo bearing austenitic stainless steels with 1,5 - 3% Mo. Type 316/316L steels are widely used for their good resistance to pitting, many acids and general corrosion.

Classifications		
AWS	A5.9	ER316LSi
EN ISO	14343-A	G/W 19 12 3 L Si
EN ISO	14343-B	SS 316L Si

Typical Chemical Analysis			
% Carbon	0,01	**% Chromium**	18,5
% Manganese	1,4	**% Nickel**	12,8
% Silicon	0,8	**% Molybdenum**	2,6
% Sulphur	0,01	**% Copper**	0,15
% Phosphorous	0,015	**Ferrite Number**	6,0

Typical Mechanical Properties (All weld metal)		
	MIG	**TIG**
Tensile Strength	570 MPa	605 MPa
0,2% Proof Stress	435 MPa	465 MPa
% Elongation on 4d	42	35
% Elongation on 4d	40	33
Impact Energy at -130°C	<70 J	>100 J
Impact Energy -196°C	30 - 60 J	>60 J
Microstructure	Austenite with a controlled level of ferrite, normally in the range 2 - 10FN depending on the application	

Packing Data
MIG (DC+ or pulsed)

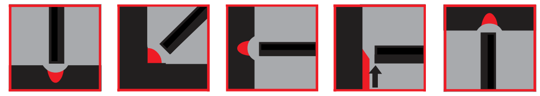
Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
0,8	120	26	15,0	W033069
0,9	160	26	15,0	W033070
1,0	200	26	15,0	W033234
1,2	260	26	15,0	W033232
1,6	280	26	15,0	W033073

TIG (DC-)

Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
1,6	100	12	5,0	W030445
3,2	100	12	5,0	W030448

Suggested gas for welding: Stainshield®, Stainshield® Plus (MIG), Argon (TIG)

Afrox MIG/TIG 316L



MIG/TIG 316L consumables are used for Mo bearing austenitic stainless steels with 1,5 - 3% Mo. Type 316/316L steels are widely used for their good resistance to pitting, many acids and general corrosion.

Classifications		
AWS	A5.9	ER316L
EN ISO	14343-A	G/W 19 12 3 L
EN ISO	14343-B	SS 316L

Typical Chemical Analysis			
% Carbon	0,03 max	**% Chromium**	18,0 - 20,0
% Manganese	1,0 - 2,5	**% Nickel**	11,0 - 14,0
% Silicon	0,3 - 0,65	**% Molybdenum**	2,0 - 3,0
% Sulphur	0,03 max	**Ferrite Number**	3,0 - 10,0
% Phosphorous	0,03 max		

Typical Mechanical Properties (All weld metal)		
	MIG	**TIG**
Tensile Strength	570 MPa	605 MPa
0,2% Proof Stress	435 MPa	465 MPa
% Elongation on 4d	42	35
Impact Energy at -130°C	>70 J	>100 J
Impact Energy at -196°C	30 - 60 J	>60 J
Microstructure	Austenite with a controlled level of ferrite, normally in the range 3 - 10FN depending on the application	

Packing Data
MIG (DC+)

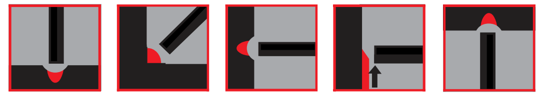
Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
1,2	260	26	15,0	W033066

TIG (DC-)

Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
1,6	100	12	5,0	W030550
2,0	100	12	5,0	W030553
2,4	100	12	5,0	W030551
3,2	130	12	5,0	W030552

Suggested gas for welding: Stainshield® (MIG), Argon (TIG)

Afrox TIG 317L



TIG 317L is used to weld 317/317L stainless steels in which the raised Mo level provides improved resistance to pitting in high chloride environments and to some acids (not nitric acid). These steels are used in marine, chemical process, papermaking, and food processing applications. Also suitable for 316/316L and their stabilised versions when the benefits of higher molybdenum weld metal are required to maximise weld area pitting resistance. Not suitable for structural service above about 400°C or for cryogenic applications.

Classifications		
AWS	A5.9	ER317L
EN ISO	14343-A	W 19 13 4 L
EN ISO	14343-B	SS 317L

Typical Chemical Analysis			
% Carbon	0,015	**% Chromium**	19,0
% Manganese	1,5	**% Nickel**	14,0
% Silicon	0,4	**% Molybdenum**	3,5
% Sulphur	0,01	**Ferrite Number**	5,0
% Phosphorous	0,02		

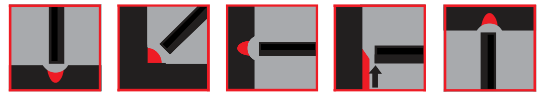
Typical Mechanical Properties (All weld metal)	
Tensile Strength	630 MPa
0,2% Proof Stress	450 MPa
% Elongation on 4d	35
Impact Energy at +20°C	75 J
Microstructure	Austenite with 2 - 10FN (3 - 9% ferrite), typically 5FN

Packing Data
TIG (DC-)

Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
1,6	100	12	5,0	W030453

Suggested shielding gas: Argon

Afrox TIG 318Si



TIG 318Si is used to weld titanium or niobium-stabilised grades of molybdenum-bearing austenite stainless steels, or as an alternative electrode for unstabilised grades such as 316/316L. It is not recommended for structural service above 400°C. It is also used for depositing corrosion resistance overlays and valve seat inlays on medium carbon alloy steels.

Classifications		
AWS	A5.9	ER318
EN ISO	14343-A	W 19 12 3 Nb (nearest)
EN ISO	14343-B	SS 318 Si (nearest)

Typical Chemical Analysis			
% Carbon	0,045	**% Chromium**	19,0
% Manganese	1,3	**% Nickel**	9,5
% Silicon	0,8	**% Molybdenum**	2,5
% Sulphur	0,01	**% Copper**	0,2
% Phosphorous	0,02	**Ferrite Number**	10,0
% Niobium	0,6		

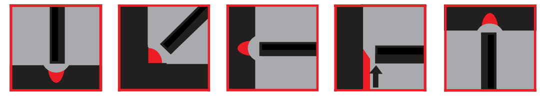
Typical Mechanical Properties (All weld metal)	
Tensile Strength	655 MPa
0,2% Proof Stress	440 MPa
% Elongation on 4d	42
Impact Energy at +20°C	90 J
Microstructure	Austenite with 3 - 14FN (3 - 12% ferrite), typically 10FN

Packing Data
TIG (DC-)

Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
2,4	100	12	5,0	W030459

Suggested shielding gas: Argon

Afrox MIG/TIG 347



MIG/TIG 347 is used to weld titanium and niobium stabilised 18/8 stainless steel types 321 and 347. Also suitable for unstabilised grades such as 304/304L. Service temperatures are typically -100°C to approximately 400°C. Applications are similar to 308L and include food, brewery, pharmaceutical equipment, architectural, general fabrication and nuclear engineering. The 347 consumables covered here are generally not suitable for service in elevated temperature structural applications where 0,04 - 0,08% carbon is specified for creep resistance.

Classifications		
AWS	A5.9	ER347
EN ISO	14343-A	G/W 19 9 Nb
EN ISO	14343-B	SS 347

Typical Chemical Analysis			
% Carbon	<0,04	**% Chromium**	19,5
% Manganese	1,5	**% Nickel**	9,7
% Silicon	0,4	**% Molybdenum**	0,2
% Sulphur	0,005	**% Copper**	0,1
% Phosphorous	0,02	**% Niobium**	0,6
Ferrite Number	8,0		

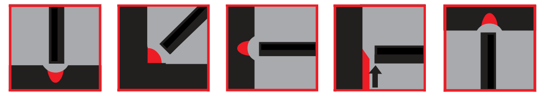
Typical Mechanical Properties (All weld metal)	
Tensile Strength	660 MPa
0,2% Proof Stress	450 MPa
% Elongation on 4d	42
Impact Energy at -20°C	100 J
Microstructure	Austenite with a controlled level of ferrite, normally in the range 3 - 12FN

TIG (DC-)

Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
1,6	100	12	5,0	W030461
2,0	100	12	5,0	W030462
2,4	100	12	5,0	W030463

Suggested gas for welding: Stainshield®, Stainshield® Plus (MIG), Argon (TIG)

Afrox MIG/TIG 904L



MIG/TIG 904L consumables give a fully austenitic, low carbon weld metal with molybdenum and copper, with good resistance to corrosion in sulphuric, phosphoric and other inorganic and organic acids. They are not normally chosen for resistance to corrosion in concentrated nitric acid. For service in severe chloride pitting media, overmatching nickel-based weld metal is recommended. It is the preferred weld metal for some lower alloy austenitics such as Creusot UHB 34L and UHB 734L for wet process phosphoric acid service. Applications include tanks and process vessels, piping systems, agitators, rotors, cast pumps and valves for use in the fertiliser, phosphoric, sulphuric and acetic acid plants, and in salt and seawater environments. It is also used in some offshore applications, including overlays on mild and low alloy steels.

Classifications		
AWS	A5.9	ER385
EN ISO	14343-A	G/W 20 25 5 Cu L
EN ISO	14343-B	SS 385

Typical Chemical Analysis			
% Carbon	0,01	**% Chromium**	20,0
% Manganese	1,7	**% Nickel**	25,0
% Silicon	0,3	**% Molybdenum**	4,5
% Sulphur	0,001	**% Copper**	1,5
% Phosphorous	0,01	**Ferrite Number**	10,0
% Niobium	0,6		

Typical Mechanical Properties (All weld metal)	
Tensile Strength	650 MPa
0,2% Proof Stress	490 MPa
% Elongation on 4d	35
Impact Energy at +20°C	210 J
Microstructure	In the as welded condition the weld metal microstructure is fully austenitic

Packing Data
MIG (DC+)

Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
1,0	200	26	220,0	W033104
1,0	200	26	15,0	W033105
1,2	230	30	15,0	W033106

TIG (DC-)

Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
1,6	100	12	5,0	W030465
2,0	100	12	5,0	W030466
2,4	100	12	5,0	W030467

Suggested shielding gas: Stainshield®, Stainshield® Plus (MIG), Argon (TIG)

Afrox MIG/TIG 2209

MIG/TIG 2209 is used to weld duplex stainless steel pipe, plate, fittings and forgings having an approximate 50:50 microstructure of austenite with a ferrite matrix. This, coupled with general alloying level, confers:

- High strength compared with standard austenitic steels, e.g. type 316L
- Good general corrosion resistance in a range of environments
- High resistance to chloride induced stress corrosion cracking (CSCC)
- High resistance to pitting attack in chloride environments, e.g. sea water.

These alloys are finding widening application in the offshore oil/gas, chemical and petrochemical process industries, e.g. pipework systems, flow-lines, risers, manifolds, etc.

Materials to be Welded	
Standard duplex '2205' types of ferritic – austenitic stainless steels. Proprietary alloys include:	SAF 2205, A 903, SAF 2304, UR 35N, LD X 2101

Classifications		
AWS	A5.9	ER2209
EN ISO	14343-A	G/W 22 9 3 N L
EN ISO	14343-B	SS 2209

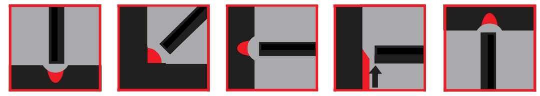
Typical Chemical Analysis			
% Carbon	<0,015	**% Chromium**	23,0
% Manganese	1,6	**% Nickel**	8,2
% Silicon	0,5	**% Molybdenum**	3,2
% Sulphur	0,001	**% Copper**	0,1
% Phosphorous	0,015	**% Nitrogen**	0,17
Pitting Resistance Equivalent	PRE_n = Cr + 3,3 Mo + 16N	**PRE_n**	>35

Typical Mechanical Properties (All weld metal)		
	TIG	**MIG**
Tensile Strength	820 MPa	800 - 835 MPa
0,2% Proof Stress	660 MPa	560 - 620 MPa
% Elongation on 4d	32	28 - 35
Impact Energy at -30°C	>140 J	>70 J
Impact Energy at -50°C	>120 J	>60 J
Impact Energy at -75°C	>70 J	-
Hardness	270 HV	270 HV
Microstructure	Multi-pass welds in the as welded condition contain about 25 - 50% ferrite depending on dilution and heat input/cooling rate conditions	

Packing Data MIG (DC+)				
Diameter (mm)	**Current**		**Pack Mass (kg)**	**Item Number**
	Amps (A)	**Volts (V)**		
1,2	180	28	15,0	W033445
TIG (DC-)				
1,6	100	12	5,0	W030489
2,0	100	12	5,0	W030490
2,4	100	12	5,0	W030491

Suggested gas for welding: Stainshield®, Stainshield® Plus (MIG), Ar/He/CO_2 (Pulse), Argon (TIG)

Afrox TIG 2594



TIG 2594 is a solid electrode for welding Zeron® 100 and other super duplex alloys for service in the as welded condition. This electrode is overmatching with respect to nickel content to achieve the correct austenite-ferrite microstructural phase balance.

Classifications		
AWS	A5.9	ER2594
EN ISO	14343-A	25 9 4 NL

Typical Chemical Analysis			
% Carbon	0,015	**% Nickel**	9,3
% Manganese	0,7	**% Molybdenum**	3,7
% Silicon	0,4	**% Tungsten**	0,6
% Sulphur	0,002	**% Copper**	0,7
% Phosphorous	0,02	**% Nitrogen**	0,23
% Chromium	25,0	**PRE_n** 41	**PRE_W** 42
Pitting Resistance Equivalent		PRE_W = Cr + 3,3Mo + 1,65W + 16N	
		PRE_n = Cr + 3,3 Mo + 16N	

Typical Mechanical Properties (All weld metal)	MIG	TIG
Tensile Strength	645 MPa	695 MPa
0,2% Proof Stress	860 MPa	870 MPa
% Elongation on 5d	23	32
Charpy V-Notch at -50°C	60 J	130 J
Hardness	290 HV	290 HV

TIG (DC-)

Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
1,6	100	12	2,5	W078100
2,4	100	12	2,5	W078102

Recommended shielding gas: Argon (TIG), Ar/He/CO_2 (MIG)

Stainless Steel Consumables for Submerged Arc Welding

Afrox Subarc 308L


Subarc 308L is used to weld 18/8 stainless steels including 301, 302, 303 nitrogen bearing 304LN and titanium stabilised 321. Service temperatures are typically -100°C to about 400°C. Applications include food, brewery, pharmaceutical equipment, architectural, general fabrication and nuclear engineering.

Classifications		
AWS	A5.9	ER308L
EN ISO	14343-A	S 19 9 L
EN ISO	14343-B	SS 308L

Typical Chemical Analysis			
% Carbon	0,01	**% Chromium**	20,0
% Manganese	0,7	**% Nickel**	10,0
% Silicon	0,4	**% Molybdenum**	0,1
% Sulphur	0,01	**% Copper**	0,15
% Phosphorous	0,015	**Ferrite Number**	10,0

Typical Mechanical Properties (All weld metal)	
Tensile Strength	570 MPa
0,2% Proof Stress	450 MPa
% Elongation on 4d	41
Impact Energy at -130°C	50 J
Impact Energy at -196°C	30 J
Microstructure	Austenite with a controlled level of ferrite, normally in the range 2 - 10FN depending on the application

Flux Dependent

Packing Data
SAW Wire (DC+)

Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
2,4	350	28	25,0	W078142
3,2	380	30	25,0	W078144

Suggested flux: Afrox Flux MK-SS or Oerlikon OP33

Afrox Subarc 309L

Subarc 309L is mainly used under high dilution conditions, particularly dissimilar welds between stainless and CMn steels. There are three main areas of application: buffer layers and clad steels, dissimilar joints and similar metal joints.

Classifications		
AWS	A5.9	ER309L
EN ISO	14343-A	S 23 12 L
EN ISO	14343-B	SS 309L

Typical Chemical Analysis			
% Carbon	0,015	**% Chromium**	23,0
% Manganese	1,7	**% Nickel**	13,0
% Silicon	0,5	**% Molybdenum**	0,1
% Sulphur	0,005	**% Copper**	0,15
% Phosphorous	0,015	**Ferrite Number**	12,0

Typical Mechanical Properties (All weld metal)	
Tensile Strength	600 MPa
0,2% Proof Stress	400 MPa
% Elongation on 4d	40
Impact Energy at -130°C	100 J

Flux Dependent

Packing Data
SAW Wire (DC+)

Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
2,4	350	28	25,0	W078152
3,2	400	32	25,0	W078154

Suggested flux: Afrox Flux MK-SS or Oerlikon Flux OP33

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Afrox Subarc 310

Afrox Subarc 310 consumables are used primarily for welding similar wrought or cast 25% Cr, 20% Ni (310) parent alloys with up to 0,25% carbon. Parent metal and weld metal are fully austenitic. The high alloy content of type 310 gives useful oxidation resistance up to peak temperatures of about 1 200°C for heat shields, furnace parts and ducting.

Classifications		
AWS	A5.9	ER310
EN ISO	14343-A	S 25 20
EN ISO	14343-B	SS 310

Typical Chemical Analysis			
% Carbon	0,11	**% Chromium**	26,0
% Manganese	1,8	**% Nickel**	21,0
% Silicon	0,4	**% Molybdenum**	0,1
% Sulphur	0,005	**% Copper**	0,1
% Phosphorous	0,015	**% Ferrite**	10,0

Typical Mechanical Properties (All weld metal)	
Tensile Strength	540 MPa
0,2% Proof Stress	355 MPa
% Elongation on 4d	27
Impact Energy at -130°C	70 J
Microstructure	Fully austenitic. Typical magnetic permeability <1,01

Flux Dependent

Packing Data
SAW Wire (DC+)

Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
2,4	320	30	25,0	W078157

Suggested flux: Afrox Flux MK-SS Oerlikon Flux OP33

Afrox Subarc 316L

Subarc 316L consumables are used for Mo bearing austenitic stainless steels with 1,5 - 3% Mo. They are also suitable for Ti or Nb stabilised and nitrogen-bearing or free machining versions of the above alloys. Type 316/316L steels are widely used for their good resistance to pitting, many acids and general corrosion.

Classifications		
AWS	A5.9	ER316L
EN ISO	14343-A	S 19 12 3 L
EN ISO	14343-B	SS 316L

Typical Chemical Analysis			
% Carbon	0,01	**% Chromium**	18,5
% Manganese	1,4	**% Nickel**	12,8
% Silicon	0,5	**% Molybdenum**	2,6
% Sulphur	0,01	**% Copper**	0,15
% Phosphorous	0,015	**Ferrite Number**	6,0

Typical Mechanical Properties (All weld metal)	
Tensile Strength	570 MPa
0,2% Proof Stress	450 MPa
% Elongation on 4d	41
Impact Energy at -196°C	30 J
Microstructure	Austenite with a controlled level of ferrite, normally in the range 3 - 10FN depending on the application

Flux Dependent

Packing Data
SAW Wire (DC+)

Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
3,2	400	32	25,0	W078164

Suggested flux: Afrox Flux MK-SS or Oerlikon Flux OP33

Afrox Subarc 2209


Subarc 2209 is used on duplex stainless steel pipe, plate, fittings and forgings having an approximate 50:50 microstructure of austenite with a ferrite matrix. This, coupled with general alloying level, confers:

- High strength compared with standard austenitic steels, e.g. type 316L
- Good general corrosion resistance in a range of environments
- High resistance to chloride induced stress corrosion cracking (CSCC)
- High resistance to pitting attack in chloride environments, e.g. sea water.

These alloys are finding widening application in the offshore oil/gas, chemical and petrochemical process industries, e.g. pipework systems, flow-lines, risers, manifolds, etc.

Classifications		
AWS	A5.9	ER2209
EN ISO	14343-A	S 22 9 3 NL
EN ISO	14343-B	SS 2209

Typical Chemical Analysis			
% Carbon	0,015	**% Nickel**	8,2
% Manganese	1,6	**% Molybdenum**	3,2
% Silicon	0,5	**% Chromium**	23,0
% Sulphur	0,001	**% Copper**	0,1
% Phosphorous	0,015	**% Nitrogen**	0,17

Typical Mechanical Properties (All weld metal)	
Tensile Strength	800 - 835 MPa
0,2% Proof Stress	560 - 602 MPa
% Elongation on 4d	28 - 35
Impact Energy at -30°C	85 J
Impact Energy at -50°C	70 J
Microstructure	Multi-pass welds in the as welded condition contain about 25 - 50% ferrite depending on dilution and heat input/cooling rate conditions

Flux Dependent

Packing Data
SAW Wire (DC+)

Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
3,2	400	32	25,0	W078178

Suggested flux: Afrox Flux MK-SS or Oerlikon Flux OP33 or Metrode Flux SSB

Hobart SWX220

Hobart SWX220 flux is an agglomerated flux containing chromium for the welding of AISI 300 and 400 series stainless steels. The addition of chromium helps to reduce the losses caused by oxidation in the arc. The weld has good mechanical properties and impacts and the weld bead appearance is clean and well shaped. Hobart SWX220 can also be used to join dissimilar steels such as 300 series stainless to low carbon steel using an ER309L type wire. When welding stainless steels, it is recommended to keep the heat input to below 25 kJ/cm to avoid cracks during the solidification stage.

Storage and Re-baking

The higher the basicity index of agglomerated fluxes, the more hygroscopic such a flux would be. All agglomerated fluxes should therefore be stored in conditions of less than 70% relative humidity. Welding with damp flux can cause porosity. Re-drying of flux suspected of being moist should be done for approximately two hours at about 300°C at a flux depth of about 25 mm.

Classifications		
AWS	A5.17/ASME SFA 5.17	ER-308, ER-308L, ER-309, ER-309L, ER-316, ER-316L ER-410, ER-420, ER-410NiMo, ER-430, ER-347

Flux Characteristics	
Maximum Welding Current	800 A
Polarity	DC or AC

Packing Data	
Pack Mass (kg)	**Item Number**
25,0	W071404

Oerlikon OP33 Submerged Arc Flux

Oerlikon OP33 is a basic submerged arc welding flux suitable for welding austenitic stainless steels. Its behaviour as to carbon content of the weld metal is neutral, which means that using the appropriate electrode, OP33 can be used for welding extra low carbon steels. It does not possess chromium compensating elements. Nevertheless, chromium burn-out is very low. Its behaviour to silicon and manganese is also neutral, that is, there is neither pick-up nor burn-out of these elements. Burn-out of manganese will only occur when using wire electrodes having high manganese content (ER307). Weld seams are smooth and finely rippled and without undercuts into the base metal. They are free of slag reminders, even when using stabilised materials. Good slag removal makes OP33 ideally suited for fillet welding. It is suitable to be used on DC positive up to 800 A.

Storage and Re-baking

The higher the basicity index of agglomerated fluxes, the more hygroscopic such a flux would be. All agglomerated fluxes should therefore be stored in conditions of less than 70% relative humidity. Welding with damp flux can cause porosity. Re-drying of flux suspected of being moist should be done for approximately two hours at about 300 - 350°C at a flux depth of about 25 mm.

Classifications		
AWS	A5.17	ER-308, ER-308L, ER-309, ER-309L, ER-316, ER-316L ER-410, ER-420, ER-410NiMo, ER-430, ER-347
EN ISO	760	SA AFG 2 54 DC

Approvals	
Qualification Tests	TÜV, UDT
Approvals	DB, Controlas

Packing Data	
Pack Mass (kg)	**Item Number**
35,0	W124501

Main Constituents		
SiO_2 + TiO_2	**Al_2O_3 + MnO**	**CaF_2**
10%	35%	50%
Basicity (Boniszewski)		1,8
Maximum Welding Current		800 A
Polarity		DC

Typical Chemical Analysis

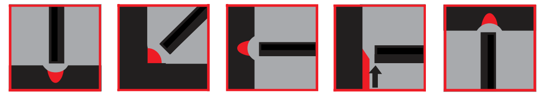
	S19 9 L (308L)	S19 9 Nb (347)	S19 12 3 L (316L)	S19 12 3 Nb (318)	S23 12 (309L)
% Carbon	>0,04	>0,07	>0,04	>0,07	>0,04
% Chromium	>18,0	>18,0	>18,0	>18,0	>23,0
% Nickel	>9,0	>9,0	>10,0	>10,0	>12,0
% Molybdenum	-	-	>2,5	>2,5	-
% Niobium	-	>8 x C	-	>8 x C	-

Typical Mechanical Properties
(All weld metal in the as welded condition)

	S19 9 L (308L)	S19 9 Nb (347)	S19 12 3 L (316L)	S19 12 3 Nb (318)	S23 12 (309L)
Tensile Strength	>510 MPa	>550 MPa	>510 MPa	>550 MPa	>510 MPa
0,2% Proof Stress	>320 MPa	>350 MPa	>320 MPa	>350 MPa	>320 MPa
% Elongation	>30	>25	>25	>25	>25
Impact Energy at +20°C	>75 J	>65 J	>75 J	>65 J	>65 J

Stainless Steel Wires for Flux Cored Welding

Afrox Coremax 308LP



Coremax 308LP is an all-position flux cored wire for welding 304, 304L and 321 type austenitic stainless steels. It has excellent weldability and slag detachment and provides good resistance to intergranular corrosion. Coremax 308LP can also be used as a buffer layer prior to hardfacing.

Classifications		
AWS	A5.22	E308LT1-4
EN ISO	17633-A	T 19 9 L P M 2
EN ISO	17633-B	TS 308L F M I

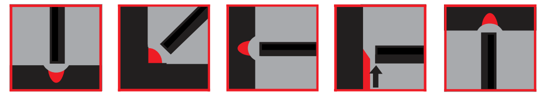
Typical Chemical Analysis			
% Carbon	0,029	**% Phosphorous**	0,025
% Manganese	1,63	**% Nickel**	9,93
% Silicon	0,56	**% Chromium**	19,5
% Sulphur	0,008	**% Molybdenum**	0,06

Typical Mechanical Properties (All weld metal)	
0,2% Proof Stress	400 MPa
Tensile Strength	573 MPa
% Elongation on 5d	43
Charpy V-Notch at -196°C	31 J
Hardness	200 HV

Packing Data (DC+)					
Position	**Diameter (mm)**	**Current**		**Pack Mass (kg)**	**Item Number**
		Amps (A)	**Volts (V)**		
F, HV	1,2	140 - 220	23 - 33	15,0	W081141
UV, OH	1,2	120 - 200	24 - 30	15,0	

Recommended gas: Fluxshield®, but can be used with 100% CO_2

Afrox Coremax 309LP



Coremax 309LP is an all-position flux cored wire for welding 24% Cr, 13% Ni type austenitic stainless steels in the cast and wrought forms. It has excellent weldability and slag detachment and provides good resistance to intergranular corrosion. Coremax 309LP can also be used as a buffer layer prior to hardfacing and for joining 300 grade stainless steel to mild steels.

Classifications		
AWS	A5.22	E309LT1-4
EN ISO	17633-A	T 23 12 L P M 2
EN ISO	17633-B	TS 309L F M I

Typical Chemical Analysis			
% Carbon	0,026	**% Phosphorous**	0,024
% Manganese	1,51	**% Nickel**	12,78
% Silicon	0,55	**% Chromium**	24,07
% Sulphur	0,009	**% Molybdenum**	0,06

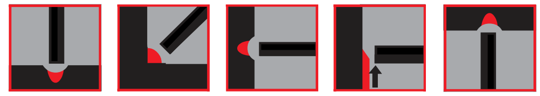
Typical Mechanical Properties (All weld metal)	
0,2% Proof Stress	450 MPa
Tensile Strength	568 MPa
% Elongation on 5d	40
Charpy V-Notch at -40°C	32 J
Hardness	205 HV

Packing Data (DC+)

Position	Diameter (mm)	Current		Pack Mass (kg)	Item Number
		Amps (A)	Volts (V)		
F, HV	1,2	130 - 220	23 - 33	15,0	W081142
VU, OH	1,2	130 - 180	24 - 30	15,0	

Recommended gas: Fluxshield®, but can be used with 100% CO_2

TIG Superoot 316L



TIG Superoot 316L is designed specifically for situations where it is impractical to apply back-purge for TIG root runs, or to gain the economic benefit of eliminating back-purge. The use of a 316L root bead is considered compatible with subsequent filling with 308L, 347 or 316L as appropriate.

Classifications		
AWS	A5.22	E316T1-5
EN ISO	17633-A	T 19 12 3 L R I 1 (nearest)
EN ISO	17633-B	TS 316L R I 1

Typical Chemical Analysis			
% Carbon	0,01	**% Nickel**	12,5
% Manganese	1,6	**% Molybdenum**	2,2
% Silicon	0,8	**% Chromium**	19,2
% Sulphur	0,005	**% Copper**	0,05
% Phosphorous	0,02		

Typical Mechanical Properties (All weld metal)	
0,2% Proof Stress	450 MPa
Tensile Strength	605 MPa
% Elongation on 4d	38

Packing Data (DC+)				
Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
2,2	90	12	3,0	W078065

Suggested shielding gas: Argon