Stainless Steel

Weldability of Stainless Steel

Introduction

Stainless steels are a group of high alloy steels that contain at least 12% chromium. In general, they are alloyed with a number of other elements that make them resistant to a variety of different environments.

These elements also 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 chromium content between 12 and 18% with 0.15–0.30% carbon.
- Ferritic-austenitic (Duplex) 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 three of these groups will be discussed in greater 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 may be 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 may depend 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 the sigma phase at operating temperatures between 500 and 900°C, delta ferrite in weld metal is necessary to overcome the possibility of hot cracking (tearing).

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 content can be calculated by 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, and 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.

Ferritic stainless steels

These steels, which contain 12–30% chromium with a carbon content below 0.10% do not exhibit the good weldability of the austenitic types. They become fully ferritic at high temperatures and undergo rapid grain growth, which leads to brittle, heat affected zones in the fabricated product. No refinement of this coarse structure is possible without cold working and recrystallization. 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 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 and 18% chromium with 0.15–0.30% carbon. Because 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 low alloy steels, can also occur in martensitic stainless steels and thus hydrogen-controlled consumables should 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.

Procedure for welding stainless steels

The procedure for welding stainless steel 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, necessitating extra precautions and attention to detail.

Stainless steel can be welded using either AC or DC, with 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 2 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.

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. See the table at the end of this section for specific recommendations.

Ferritic steels

The need for preheating is determined to a large extent by composition, desired mechanical properties, thickness and conditions of restraint. Preheat, when employed, is normally at no more than 200°C.

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 stainless steel electrode is recommended. This would tend to alleviate many of the toughness problems of ferritic stainless steel weld metal and could obviate 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 200–300°C followed by slow cooling after welding. This should be followed, if possible, by a post-weld heat treatment.

Austenitic stainless steel electrodes are normally used for welding this material.

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 to 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 or 18% chromium 10% nickel types, 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, while 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 closed 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. Smootharc S309) for the initial root run on the clad side is advisable. This applies particularly to preparations in which the back-cutting 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 that is clad or lined with 13% chromium (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 in which it becomes necessary to weld an austenitic stainless steel to a mild 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 to 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 mild or low alloy steel electrode is used to weld stainless to mild steel, the pick up of chromium and nickel from the stainless steel side to the joint could enrich the weld metal by up to 5 percent 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 mild 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 because, 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 contents are 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 Smootharc S309L 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.

Effects of alloying elements and impurities in stainless steels

Carbon (C)

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

Manganese (Mn)

1 Austenite former

Silicon (Si)

1 A ferite former
2 Used to increase the corrosion resistance of austenitic steels
3 Used to improve high-temperature scaling resistance
4 Used to improve resistance of high-temperature steels to carburisation
5 Promotes wetting by weld metal at 0.8–1.0%

Chromium (Cr)

1 A ferrite former
2 Primary contributor to resistance to scaling and corrosion
3 12% chromium minimum essential for passivation

Nickel (Ni)

1 An austenite former
2 Provides good low temperature toughness
3 Used to improve the general corrosion resistance against non-oxidizing liquids
4 Sometimes added in small amounts to straight chromium grades to improve the mechanical properties

Molybdenum (Mo)

1 A ferrite former
2 Used to improve high-temperature strength and creep resistance
3 Used to improve general corrosion resistance of steels in non-oxidizing media, and resistance to pitting corrosion in all media

Copper (Cu)

1 Used to improve corrosion resistance of stainless steel in environments that are reducing rather than oxidizing

Niobium (Nb)

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

Titanium (Ti)

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

Cobalt (Co)

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

Tungsten (W)

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

Nitrogen (N)

1 A strong austenite former
2 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 that has higher corrosive 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 that have 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

If unstabilised Cr-Ni 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 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 1100°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, as much of it is oxidised during transfer across the arc, 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 that contribute to creep resistance are titanium, niobium, molybdenum, cobalt and tungsten.

Sigma phase embrittlement

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

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.

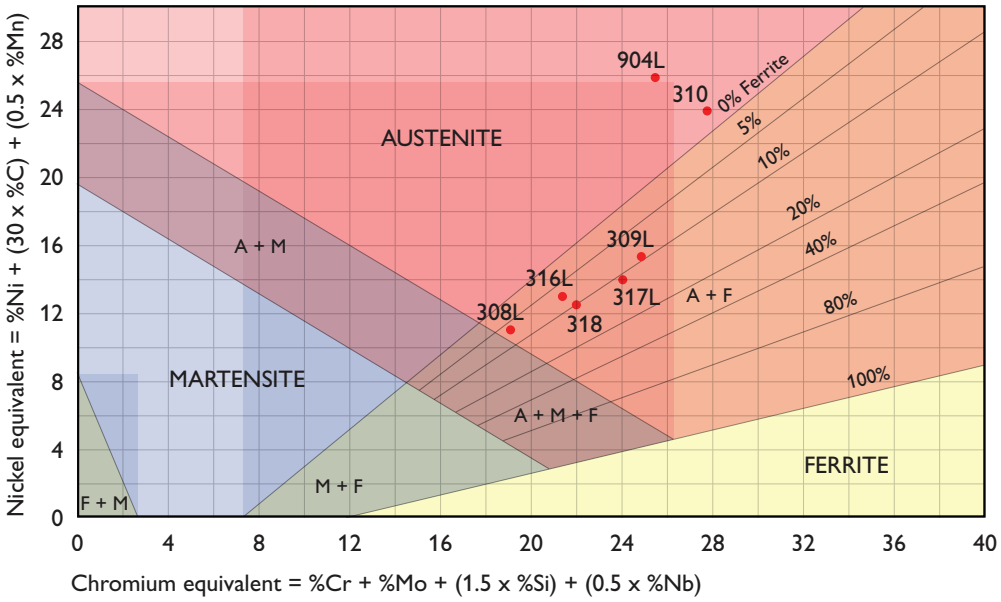
Schaeffler and Delong diagrams

A useful method of assessing the general metallurgical characteristics of any stainless steel weld metal is by means of the Schaelflar and Delong diagrams. The various alloying elements are expressed in terms of nickel or chromium equivalents (i.e. elements which, like 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 that indicates the main phases present in the stainless steel in terms of percentage ferrite and ferrite number respectively. This provides certain information as to its behaviour during welding.

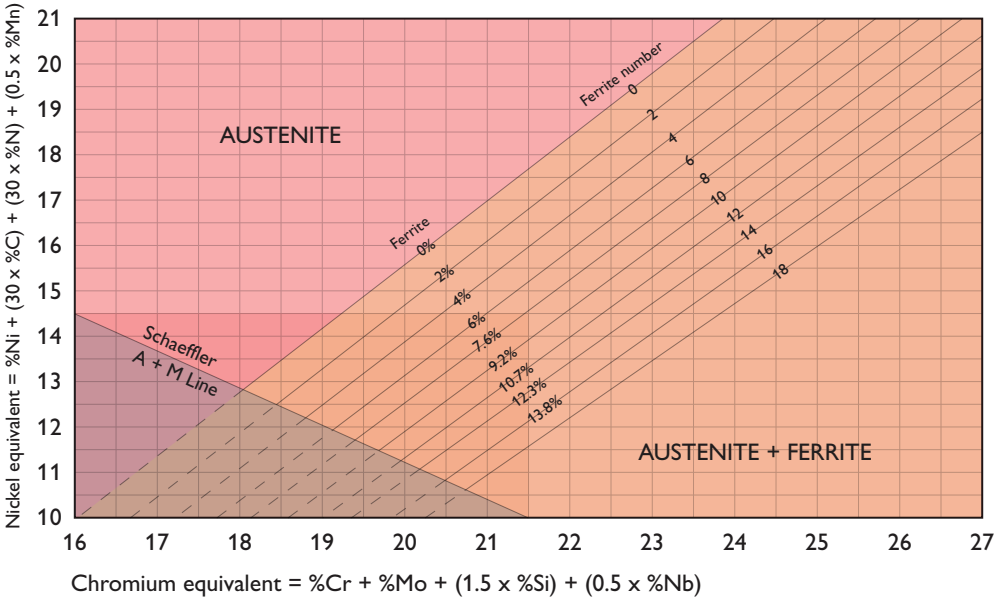
The Schaeffler diagram indicates that the comparatively low alloyed steels are hardenable, since they contain the martensitic phase in the as-welded state. As the alloying elements increase, the austenite and ferrite phases become more stable and the alloy ceases to be quench hardenable. Steels with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

Schaeffler diagram



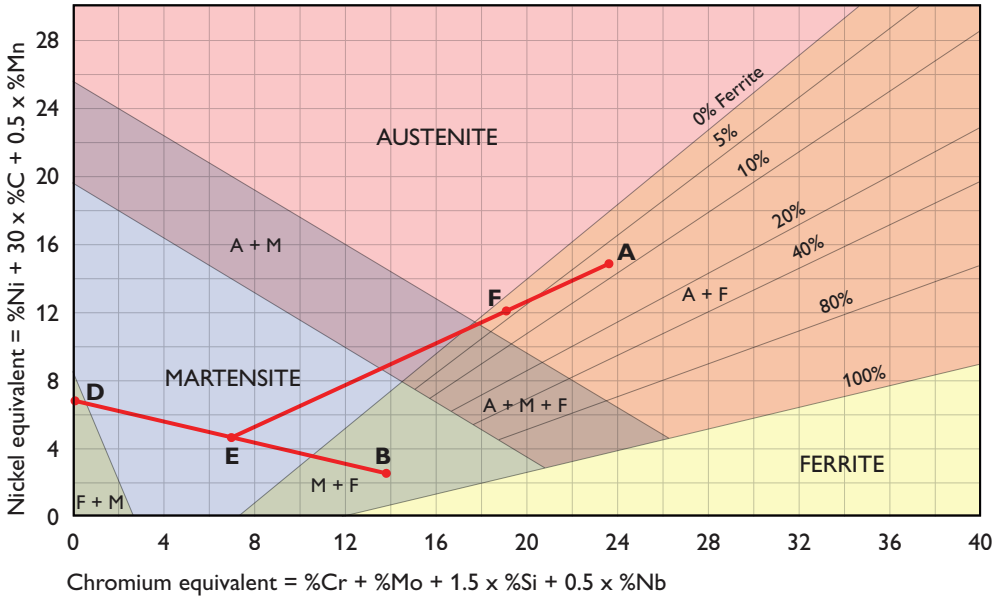
Delong diagram



Types of corrosion (cont)

The Schaeffler diagram also lets us forecast the composition of heterogenous welds (different materials).

Suppose we want to weld 410 plate (13% chromium; 0.8% manganese; 0.5% silicon; 0.08% carbon) point B to a carbon-steel (0.2% carbon; 1.0% manganese) point D, using (23% chromium; 12% nickel; 1.0% manganese; 0.5% silicon and 0.4% carbon) point A. We assume that both plates (410 and carbon steel) play equal parts in the weld and the dilution is 30% Point E is the resultant of both plates and point F, the resultant of applying 30% dilution to the AE section. Therefore, the resulting weld will have 4% ferrite. This weld is also possible without the danger of hot cracking.



Welding of 11-14% manganese steel

Owing to its great ductility, toughness and work hardening properties, 11-14% manganese steel is extensively used for the wearing parts of stone-breaking and ore-crushing machinery, tumblers, buckets, digger teeth, rail points and crossings and similar applications subject to high impact service.

The inherent toughness of 11-14% manganese steel can be seriously reduced if the material is excessively heated during welding; the degree of embrittlement that occurs being greater as the temperature and heating period is increased.

For this reason, very careful control over the amount of reheating must be exercised during welding.

Points to note when welding manganese steel

- NEVER use preheating or stress relieving
- Use minimum currents consistent with a stable arc
- Weld beads should be of high build-up to avoid dilution of the weld by the base material
- Prior to welding, care should be taken to remove work hardened areas
- Minimise heat build-up in the component so that the temperature is below 200 degrees Celsius by:
  a) Sequence of staggered welding
  b) Direct cooling of the welded area by an air blast
  c) Indirect cooling with water
- Any surfaces prepared by thermal cutting should be ground prior to welding
- For strength welding of 11–14% manganese, the use of the BOC Smootharc S 309 MoL electrode is recommended.

Coating Types

AWS A5.4-2000

Usability Designation -15

The electrodes are usable with DCEP (electrode positive) only. While use with alternating current is sometimes accomplished, they are not intended to qualify for use with this type of current. Electrode sizes 5/32 in. (4.0 mm) and smaller may be used in all positions of welding.

Usability Designation -16

The covering for these electrodes generally contains readily ionizing elements, such as potassium, in order to stabilise the arc for welding with AC. Electrode sizes 5/32 in. (4.0 mm) and smaller may be used in all positions of welding.

Usability Designation -17

The covering of these electrodes is a modification of the -16 covering, in that considerable silica replaces some of the titania of the -16 covering. Since both the -16 and the -17 electrode coverings permit AC operation, both covering types were classified as -16 in the past, because there was no classification alternative until this revision of ANSI/AWS A5.4. However, the operational differences between the two types have become significant enough to warrant a separate classification.

On horizontal fillet welds, electrodes with a -17 covering tend to produce more of a spray arc and a finer rippled weld-bead surface than those with the -16 coverings. A slower freezing slag of the -17 covering also permits improved handling characteristics when employing a drag technique. The bead shape on horizontal fillets is typically flat to concave with -17 covered electrodes as compared to flat to slightly convex with -16 covered electrodes. When making fillet welds in the vertical position with upward progression, the slower freezing slag of the -17 covered electrodes requires a slight weave technique to produce the proper bead shape. For this reason, the minimum leg-size fillet that can be properly made with a -17 covered electrode is larger than that for a -16 covered electrode. While these electrodes are designed for all-position operation, electrode sizes 3/16 in. (4.8 mm) and larger are not recommended for vertical or overhead welding.

Problem Steels

Introduction

Steels containing carbon in excess of 0.25%, chromium and molybdenum over 1.5% and manganese over 1.5% exhibit increased strength and hardenability and decreased weldability.

Additional elements such as vanadium, silicon, nickel, boron, niobium and titanium also influence hardenability and weldability. Steels of increased hardenability tend to form brittle microstructures in the heat-affected zone, which may result in cracking. Steels featuring reduced weldability are commonly referred to as 'problem steels' as a result of the problem areas that are directly caused by shrinkage stresses, rapid cooling rates and the presence of hydrogen.

Electrodes for welding problem steels are chromium nickel austenitic types containing delta ferrite in the range of 10–80% The weld metal is insensitive to hot cracking above 1200°C. At ambient temperatures, the weld metal is strong and tough and is capable of withstanding heavy impact and shock loading in service.

Problem steels fall into two categories, i.e. ferritic types which require preheat and austenitic steels such as 11–14% manganese steels, which require minimum heat input.

When hardenable ferritic steel types are to be welded, reference should be made to the section on mild and medium tensile steels for the calculation of the carbon equivalent and preheat temperatures.

Problem steel electrodes are suitable for welding combinations of dissimilar steels such as chromium, molybdenum. creep-resistant steels and stainless steels to mild and low alloy steels. Care should be taken, when welding such combinations, to ensure that excessive dilution between the base and weld metal does not occur.

The welding of dissimilar steels

When welding dissimilar steels, a number of factors must be taken into account. For example:

- The weld metal must be capable of accepting dilution from both dissimilar base materials without forming crack-sensitive microstructures. These structures must remain stable at the desired operating temperatures.
- The mechanical properties of the weld metal should be superior to the weaker of the two base materials.
- The coefficients of expansion should preferably be between those of the base materials in order to reduce possible stress concentrations.
- The corrosion resistance of the weld metal should be superior to at least one of the base materials to avoid preferential attack of the weld metal.

In many instances, it is not possible to satisfy all of the foregoing points and a compromise has to be made. BOC Smootharc S 309 and 312 problem steel electrodes have been specially designed to weld a large number of dissimilar materials such as stainless steels to carbon manganese steels and low alloy steels, and low alloy steels to 11–14% manganese steels, high carbon and tool steels etc.

Calculation of final weld metal structures

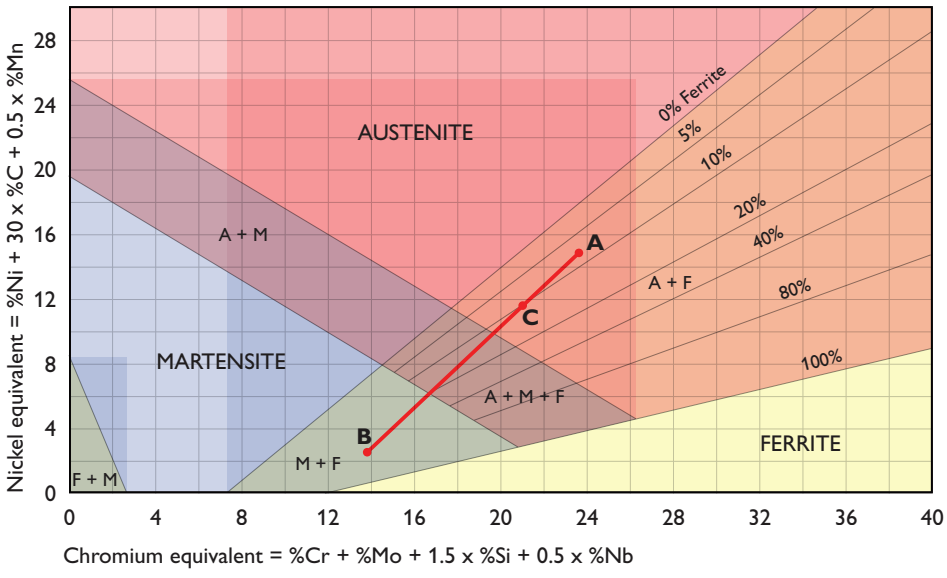
The final weld metal chemistry, and therefore properties, depend on the amount of dilution that occurs during welding.

Weld metal dilution is normally expressed as a percentage of the final weld metal composition, the effect depending on a number of factors such as the joint configuration, the welding technique and the welding process. With the manual metal arc process, dilution in the vicinity of ±25% can occur. This will obviously be greatest in the root pass and least in fill-in passes where two or more runs per layer are used.

The Schaeffler diagram is a useful tool, in that it allows us to determine, theoretically, the microstructures after dilution. This is illustrated by means of the following example:

Suppose we want to weld 410 steel (13 Cr; 0.8 Mn; 0.5 Si and 0.08 C) with BOC Smootharc S 309 MoL (23 Cr; 12 Ni; 1.0 Mn; 0.5 Si and 0.03 C), and we assume 30% dilution (the base metal contributes 30% of the union and the electrode the other 70%). What is the composition of the resultant weld metal?

The 410 plate is represented by point B (Cr equivalent 13.75%; Ni equivalent 2.8%) and the BOC Smootharc S 309 MoL electrode by point A (Cr equivalent 23.75%; Ni equivalent 14.5%). Any resultant weld metal from this mixture of A and B will be on the line that joins them. As we have assumed 30percent dilution, point C will give the resultant microstructure (i.e. austenite with 10percent ferrite). This weld is therefore possible without any danger of hot cracking.



Stainless Steels (BOC Smootharc S)

Base Metal ASTM, AISI, UNS	201, 202	304, 304L	309, 309S	310, 310S	317, 316	317L, 316L, 316Ti	321, 347	S30815, (253MA), 904L, (N08904)	409, 430, 446, 5CR12	410, 420	Duplex S31500 S31803 S32304	Carbon and Low Alloy Steels
201, 202	347 308L	347 308L	347 309MoL	347 310 309MoL	318 347	308L 316L 347	347	347 309MoL	309MoL 309L	309MoL 309L	Duplex 309MoL	309MoL
304, 304L		347 308L	347 309MoL 308L 309L	347 310 308L	347 318 308L	347 318 308L	347 308L	347 308L	309MoL 309L	309MoL	Duplex 309MoL 309L	309MoL 309L
309, 309S			309MoL 309L	309MoL 309L 310	309MoL 318 316 309L	309L 316L 318	347 309MoL	Match above 309MoL 347	309MoL 309L	309MoL 309L	Duplex 309MoL 309L	309MoL 309L
310, 310S				310	316L 318 310	316L 318 310	347 310	Match above 309L 310	309MoL 309L 316L	309MoL 309L 310	Duplex 309MoL 309L	309L 309MoL 310
317, 316					318 316L	316L 318	347 316L	Match above 309MoL 316L	309MoL 309L	309MoL 309L	Duplex 309MoL 309L	309MoL 309L
317L, 316L, 316Ti						316L	347 316L	Match above 309MoL 309L	309MoL 309L	309MoL 309L	Duplex 309MoL 309L	309MoL 309L
321, 347							347	Match above 309MoL 347	309MoL 309L	309MoL 309L	Duplex 309MoL 347	309MoL 309L
S30815, (253MA), 904L, (N08904)								Matching	309MoL 309L	309MoL 309L	Duplex 309MoL 309L	309MoL 309L
409, 430, 446, 5CR12									309L 309MoL	309MoL 309L	Duplex 309MoL 309L	309MoL 309L
410, 420										Matching or 309MoL 309L	Duplex 309MoL 309L	309MoL 309L
Duplex, S31500, S31803, S32304											Matching	Duplex 309MoL 309L
Carbon and Low Alloy Steels												Matching

NOTES
(1) Consumables listed against a steel may not achieve matching corrosion resistance or mechanical properties.
(2) Welding procedure qualification should be carried out prior to welding in critical applications.
(3) Consult you BOC welding process specialist or visit BOC's Inform website (subscription required) for more detailed information.

This table can also be found on page 643 of this manual.

Smootharc™ S 308L

Description

Smootharc S 308L is a rutile coated, low carbon grade, AC/DC electrode for the high quality welding of austenitic stainless steel of the 19Cr/9Ni type. The electrode is very easy to strike and restrike. Welding performance is excellent with a very smooth, low spatter arc producing a finely rippled bead surface with excellent slag detachability.

Application

Smootharc S 308L is recommended for single and multi-pass welding of austenitic stainless steel 302, 304 and 304L grades. Austenitic stainless steel of the 19Cr/9Ni type 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 handling equipment.

Technique

Stainless steel can be welded using either AC or DC, using as short an arc as possible to minimise alloy loss across the arc and, to control the ferrite level. 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 2 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.

Storage

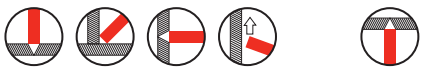
Smootharc S 308L electrodes are packaged in hermetically sealed containers. For critical applications in damp environments, once the seal is broken, electrodes should be stored in heated cabinets at 70–120°C.

Re-Drying/Conditioning

All electrode coatings are hydroscopic and, when left in the opened state for a period of time will absorb moisture. Austenitic materials are generally insensitive, to the presence of hydrogen. However, moisture in the electrode coating can lead to porosity in the weld metal. Start porosity is generally indicative of damp electrodes and is more common in fillet welds than in butt welds, where pores only occur at high moisture contents.

Electrodes that have been stored outside of their hermetically sealed cans and have become damaged by moisture pick-up, can be redried at temperatures of 300–350°C for 1–2 hours. Redrying should be restricted to a maximum of 3 cycles.

Welding Positions



Specifications

Coating Type	Rutile	
Classification	AWS/ASME-SFA A5.4 AS/NZS 1553.3	E308L-17 E308L-17
Welding current	AC, OCV 50V or DC+	
Scaling temperature	Approx. 850°C in air	

Chemical Composition, wt% – All Weld Metal					
	C	Si	Mn	Cr	Ni
Typical	0.02	0.8	0.7	20.0	10.2

Ferrite content FN 5 (WRC-92)

Mechanical Properties – All Weld Metal	
	Typical (as welded)
Yield strength	450 MPa
Tensile strength	580 MPa
Elongation	39% min
Impact energy, CVN	60J @ –20°C 35J @ –196°C

Packaging Data			
Dia. (mm)	2.5	3.2	4.0
Part No.	188082	188083	188084
Length (mm)	300	350	350
Weight can (kg)	2.5	3.0	3.0
Weight carton (kg)	7.5	9.0	9.0
Electrodes pkt (approx)	141	86	59

Welding Parameters			
Dia. (mm)	2.5	3.2	4.0
Current (A)	40–80	80–120	100–160
Voltage (V)	28	29	30

Deposition Data			
Dia. (mm)	2.5	3.2	4.0
Kg weld metal/ kg electrode	0.62	0.64	0.64
No. of electrodes / kg weld metal	91	45	31
Kg weld metal/ hour arc time	1.0	1.5	2.0
Burn off time / electrode (sec)	33	45	55

Smootharc™ S 316L

Description

Smootharc S 316L is a rutile coated, low carbon, 19 Cr, 12 Ni, 3 Mo, AC/DC electrode for the high quality welding of molybdenum alloyed, acid resisting austenitic stainless steels of the 316/316L type. The electrode is very easy to strike and restrike. Welding performance is excellent with a very smooth, low spatter arc producing a finely rippled bead surface with excellent slag detachability. Fillet welds have a slightly concave profile with excellent toe line blend-in.

Application

Smootharc S 316L is recommended for single and multi-pass welding of molybdenum alloyed austenitic stainless steels 316 and 316L. It is also suitable for welding the Nb or Ti stabilised steels, provided service temperatures are below 400°C. Austenitic stainless steels of the 316/316L type may be used for applications such as food handling equipment, structures in marine environments, heat exchangers, chemical storage and transportation tanks, oil refining equipment and pharmaceutical equipment.

Technique

Stainless steel can be welded using either AC or DC, with 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 2 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.

Storage

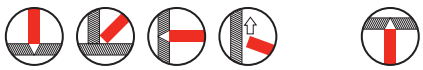
Smootharc S 316L electrodes are packaged in hermetically sealed containers. For critical applications in damp environments, once the seal is broken, electrodes should be stored in heated cabinets at 70–120°C.

Re-Drying/Conditioning

All electrode coatings are hydroscopic and, when left in the an opened state for a period of time, will absorb moisture. Austenitic materials are generally insensitive to the presence of hydrogen. However, moisture in the electrode coating can lead to porosity in the weld metal. Start porosity is generally indicative of damp electrodes and is more common in fillet welds, than in butt welds where pores only occur at high moisture contents.

Electrodes that have been stored outside of their hermetically sealed cans and have become damaged by moisture pick-up, can be redried at temperatures of 300–350°C for 1–2 hours. Redrying should be restricted to a maximum of 3 cycles.

Welding Positions



Specifications

Coating Type	Rutile	
Classification	AWS/ASME-SFA A5.4 AS/NZS 1553.3	E316L-17 E316L-17
Approvals	American Bureau of Shipping	
Welding current	AC, OCV 50V or DC+	
Scaling temperature	Approx. 850°C in air	

Chemical Composition, wt% – All Weld Metal

	C	Si	Mn	Cr	Ni	Mo
Typical	0.02	0.8	0.7	18.5	12.0	2.7

Ferrite content FN 6 (WRC-92)

Mechanical Properties – All Weld Metal

	Typical (as welded)
Yield strength	490 MPa
Tensile strength	600 MPa
Elongation	32% min
Impact energy, CVN	55J @ –20°C 45J @ –120°C

Packaging Data				
Dia. (mm)	2.5	3.2	4.0	5.0
Part No.	188162	188163	188164	188165
Length (mm)	300	350	350	450
Weight can (kg)	2.5	3.0	3.0	5.0
Weight carton (kg)	7.5	9.0	9.0	15.0
Electrodes pkt (approx)	136	84	58	45

Welding Parameters				
Dia. (mm)	2.5	3.2	4.0	5.0
Current (A)	40–80	80–120	100–160	170–230
Voltage (V)	29	29	30	30

Deposition Data				
Dia. (mm)	2.5	3.2	4.0	5.0
Kg weld metal/ kg electrodes	0.64	0.64	0.65	0.65
No. of electrodes / kg weld metal	85	44	30	14
Kg weld metal/ hour arc time	1.1	1.5	2.1	2.8
Burn off time/ electrode (sec)	35	43	56	89

Smootharc™ S 347

Description

Smootharc S 347 is a rutile coated, niobium stabilised AC/DC electrode of the 19 Cr, 10 Ni type. The electrode is very easy to strike and restrike. Welding performance is excellent, with a very smooth, low spatter arc producing a finely rippled bead surface with excellent slag detachability. The electrode has good positional welding characteristics.

Application

Smootharc S 347 has been especially designed for the welding of 321 and 347 stabilised steels. The electrode is also suitable for the unstabilised grades 304 and 304L. Smootharc S 347 is primarily intended for use where resistance to weld metal sensitisation and intergranular corrosion is required. Stabilised 321 and 347 austenitic stainless steel grades may be used for applications such as aircraft exhaust manifolds, fire walls, pressure vessels and elevated temperature chemical handling equipment.

Technique

Stainless steel can be welded using either AC or DC, with as short an arc as possible to minimise alloy loss across the arc and to control ferrite level. 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 2 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.

Storage

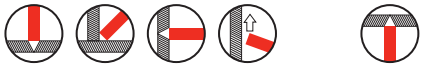
Smootharc S 347 electrodes are packaged in hermetically sealed containers. For critical applications in damp environments, once the seal is broken, electrodes should be stored in heated cabinets at 70–120°C.

Re-Drying/Conditioning

All electrode coatings are hydroscopic and, when left in an opened state for a period of time, will absorb moisture. Austenitic materials are generally insensitive to the presence of hydrogen. However, moisture in the electrode coating can lead to porosity in the weld metal. Start porosity is generally indicative of damp electrodes and is more common in fillet welds than in butt welds, where pores only occur at high moisture contents.

Electrodes that have been stored outside of their hermetically sealed cans and have become damaged by moisture pick-up can be redried at temperatures of 300–350°C for 1–2 hours. Redrying should be restricted to a maximum of 3 cycles.

Welding Positions



Specifications

Coating Type	Rutile	
Classification	AWS/ASME-SFA A5.4	E347-17
	AS/NZS 1553.3	E347-17
Welding current	AC, OCV 50V or DC+	
Scaling temperature	Approx. 850°C in air	

Chemical Composition, wt% – All Weld Metal

	C	Si	Mn	Cr	Ni	Nb
Typical	0.02	0.9	0.6	19.0	10.2	0.5

Ferrite content FN 4 (WRC-92)

Mechanical Properties – All Weld Metal

	Typical (as welded)
Yield strength	460 MPa
Tensile strength	580 MPa
Elongation	35% min
Impact energy, CVN	40J @ –60°C

Packaging Data			
Dia. (mm)	2.5	3.2	4.0
Part No.	188472	188473	184164
Length (mm)	300	350	350
Weight can (kg)	2.5	3.0	3.0
Weight carton (kg)	7.5	9.0	9.0
Electrodes pkt (approx)	139	88	58

Welding Parameters			
Dia. (mm)	2.5	3.2	4.0
Current (A)	50–80	80–110	130–170
Voltage (V)	21	22	22

Deposition Data			
Dia. (mm)	2.5	3.2	4.0
Kg weld metal/ kg electrodes	0.62	0.64	0.63
No. of electrodes/ kg weld metal	90	46	31
Kg weld metal/ hour arc time	1.0	1.3	1.9
Burn off time/ electrode (sec)	34	55	62

Smootharc™ S 309L

Description

Smootharc S 309L is a rutile coated, AC / DC electrode that deposits a low carbon, 23 Cr, 13 Ni austenitic stainless steel weld metal. The electrode is very easy to strike and restrike. Welding performance is excellent with a very smooth, low spatter arc producing a finely rippled bead surface with excellent slag detachability.

Application

Smootharc S 309L is recommended for welding corrosion resistant and heat resistant steels of the 309 type, which are often used for furnace parts, aircraft and jet engine parts, heat exchangers and chemical processing equipment.

Smootharc S 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.

Technique

Stainless steel can be welded using either AC or DC, with as short an arc as possible to minimise alloy loss across the arc and to control ferrite level. 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 2 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.

Storage

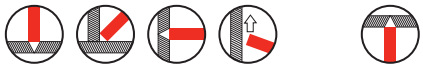
Smootharc S 309L electrodes are packaged in hermetically sealed containers. For critical applications in damp environments, once the seal is broken, electrodes should be stored in heated cabinets at 70–120°C.

Re-Drying / Conditioning

All electrode coatings are hydroscopic and, when left in the opened state for a period of time, will absorb moisture. Austenitic materials are generally insensitive to the presence of hydrogen. However, moisture in the electrode coating can lead to porosity in the weld metal. Start porosity is generally indicative of damp electrodes and is more common in fillet welds than in butt welds, where pores only occur at high moisture contents.

Electrodes that have been stored outside of their hermetically sealed cans and have become damaged by moisture pick-up can be redried at temperatures of 300–350°C for 1–2 hours. Redrying should be restricted to a maximum of 3 cycles.

Welding Positions



Specifications

Coating Type	Rutile	
Classification	AWS / ASME-SFA A5.4	E309L-17
	AS / NZS 1553.3	E309L-17
Welding current	AC, OCV 50V or DC+	
Scaling temperature	Approx. 1000°C in air	

Chemical Composition, wt% – All Weld Metal

	C	Si	Mn	Cr	Ni
Typical	0.02	0.8	0.8	23.0	13.0

Ferrite content FN 9 (WRC-92)

Mechanical Properties – All Weld Metal

	Typical (as welded)
Yield strength	470 MPa
Tensile strength	560 MPa
Elongation	34% min
Impact energy, CVN	48J @ –20°C 45J @ –60°C

Packaging Data			
Dia. (mm)	2.5	3.2	4.0
Part No.	188092	188093	188094
Length (mm)	300	350	350
Weight can (kg)	2.5	3.0	3.0
Weight carton (kg)	7.5	9.0	9.0
Electrodes pkt (approx)	207	126	84

Welding Parameters			
Dia. (mm)	2.5	3.2	4.0
Current (A)	40–80	80–120	100–160
Voltage (V)	27	28	29

Deposition Data			
Dia. (mm)	2.5	3.2	4.0
Kg weld metal / kg electrodes	0.67	0.67	0.67
No. of electrodes / kg weld metal	83	42	28
Kg weld metal / hour arc time	0.9	1.4	1.9
Burn off time / electrode (sec)	42	53	59

Smootharc™ S 309MoL

Description

Smootharc S 309MoL is a rutile coated, AC / DC electrode that deposits a low carbon, 23 Cr, 12 Ni, 2.5 Mo austenitic stainless steel weld metal with a ferrite content of FN 20. The high alloy content and ferrite level enable the weld metal to tolerate dilution from dissimilar and difficult-to-weld materials without hot cracking.

The electrode is very easy to strike and restrike. Welding performance is excellent, with a very smooth, low spatter arc producing a finely rippled bead surface with excellent slag detachability.

Application

Smootharc S 309MoL is recommended for welding corrosion-resistant Cr Ni Mo steels to themselves and to mild and low alloy steels without hot cracking. The electrode is suitable for welding armour plate, austenitic manganese steel, medium and high carbon hardenable steels, tools, dies, springs etc. which may be of unknown composition.

Smootharc S 309MoL is also recommended for welding dissimilar steels, such as stainless steels to carbon manganese or low alloy steels and for welding austenitic manganese steel to carbon manganese and low alloy steel.

Technique

Stainless steel electrodes can be welded using either AC or DC, with as short an arc as possible to minimise alloy loss across the arc and to control ferrite level. 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 2 times the electrode diameter.

Storage

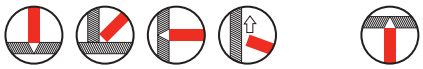
Smootharc S 309MoL electrodes are packaged in hermetically sealed containers. For critical applications in damp environments, once the seal is broken, electrodes should be stored in heated cabinets at 70–120°C.

Re-Drying / Conditioning

All electrode coatings are hydroscopic and, when left in the opened state for a period of time, will absorb moisture. Austenitic materials are generally insensitive to the presence of hydrogen. However, moisture in the electrode coating can lead to porosity in the weld metal. Start porosity is generally indicative of damp electrodes and is more common in fillet welds than in butt welds where pores only occur at high moisture contents.

Electrodes that have been stored outside of their hermetically sealed cans and have become damaged by moisture pick-up can be redried at temperatures of 300–350°C for 1–2 hours. Redrying should be restricted to a maximum of 3 cycles.

Welding Positions



Specifications

Coating Type	Rutile	
Classification	AWS / ASME-SFA A5.4	E309MoL-17
	AS / NZS 1553.3	E309MoL-17
Welding current	AC, OCV 50V or DC+	
Scaling temperature	Approx. 1000°C in air	

Chemical Composition, wt% – All Weld Metal

	C	Si	Mn	Cr	Ni	Mo
Typical	0.02	0.8	0.8	22.8	12.8	2.4

Ferrite content FN 20 (WRC-92)

Mechanical Properties – All Weld Metal

	Typical (as welded)
Yield strength	555 MPa
Tensile strength	680 MPa
Elongation	33% min
Impact energy, CVN	50J @ –20°C

Packaging Data			
Dia. (mm)	2.5	3.2	4.0
Part No.	188096	188097	188098
Length (mm)	300	350	350
Weight can (kg)	2.5	3.0	3.0
Weight carton (kg)	7.5	9.0	9.0
Electrodes pkt (approx)	210	129	87

Welding Parameters			
Dia. (mm)	2.5	3.2	4.0
Current (A)	40–80	80–120	100–160
Voltage (V)	27	28	29

Deposition Data			
Dia. (mm)	2.5	3.2	4.0
Kg weld metal / kg electrodes	0.64	0.65	0.65
No. of electrodes / kg weld metal	84	43	29
Kg weld metal / hour arc time	1.1	1.5	2.1
Burn off time / electrode (sec)	38	55	59

Smootharc™ S 312

Description

Smootharc S 312 is a rutile coated, AC/DC electrode that deposits a 29 Cr/9 Ni austenitic/ferritic stainless steel weld metal with a ferrite content of FN 50. The resultant weld metal is high strength with high ductility and the structure is highly resistant to hot cracking and extremely tolerant of dilution from medium and high carbon steels.

The electrode is very easy to strike and restrike. Welding performance is excellent, with a very smooth, low spatter arc producing a finely rippled bead surface with excellent slag detachability.

Application

Smootharc S 312 is a universal electrode specifically designed for welding steels of poor weldability. The electrode is suitable for welding armour plate, austenitic manganese steel, medium and high carbon hardenable steels, tools, dies, springs etc that may be of unknown composition. It is also suitable for welding dissimilar steels (e.g. stainless to mild steel).

Technique

Stainless steel electrodes can be welded using either AC or DC, with as short an arc as possible to minimise alloy loss across the arc and to control ferrite level. 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 2 times the electrode diameter.

Storage

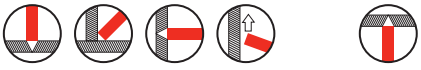
Smootharc S 312 electrodes are packaged in hermetically sealed containers. For critical applications in damp environments, once the seal is broken, electrodes should be stored in heated cabinets at 70–120°C.

Re-Drying/Conditioning

All electrode coatings are hydroscopic and, when left in the opened state for a period of time, will absorb moisture. Austenitic materials are generally insensitive to the presence of hydrogen. However, moisture in the electrode coating can lead to porosity in the weld metal. Start porosity is generally indicative of damp electrodes and is more common in fillet welds than in butt welds where pores only occur at high moisture contents.

Electrodes that have been stored outside of their hermetically sealed cans and have become damaged by moisture pick-up can be redried at temperatures of 300–350°C for 1–2 hours. Redrying should be restricted to a maximum of 3 cycles.

Welding Positions



Specifications

Coating Type	Rutile	
Classification	AWS/ASME-SFA A5.4 AS/NZS 1553.3	E312-17 E312-17
Welding current	AC, OCV 50V or DC+	
Scaling temperature	Approx. 1100°C in air	

Chemical Composition, wt% – All Weld Metal					
	C	Si	Mn	Cr	Ni
Typical	0.10	1.2	0.8	28.8	9.7
Ferrite content	FN 50 (WRC-92)				

Mechanical Properties – All Weld Metal	
	Typical (as welded)
Yield strength	590 MPa
Tensile strength	760 MPa
Elongation	25% min

Packaging Data			
Dia. (mm)	2.5	3.2	4.0
Part No.	188122	188123	188124
Length (mm)	300	350	350
Weight can (kg)	2.5	3.0	3.0
Weight carton (kg)	7.5	9.0	9.0
Electrodes pkt (approx)	225	141	93

Welding Parameters			
Dia. (mm)	2.5	3.2	4.0
Current (A)	40–80	80–120	100–160
Voltage (V)	25	26	27

Deposition Data			
Dia. (mm)	2.5	3.2	4.0
Kg weld metal/ kg electrodes	0.64	0.64	0.65
No. of electrodes/ kg weld metal	90	47	31
Kg weld metal/ hour arc time	1.1	1.5	2.1
Burn off time/ electrode (sec)	36	51	55

Satincrome 308L-17

- Rutile type, stainless steel electrode
- Outstanding operator appeal, improved slag lift
- All positional (except vertical-down) welding capabilities
- Applications include the single and multi-pass welding of 19 Cr / 10 Ni type stainless steel grades, including 201, 202, 301, 302, 303, 304, 304L, 305, 308 etc.

Classifications
AS / NZS 1553.3: E308L-17
AWS / ASME-SFA A5.4: E308L-17

Typical all weld metal mechanical properties	
0.2% Proof stress	500 MPa
Tensile strength	630 MPa
Elongation	40%
CVN impact values	75J av @ +20°C

Typical all weld metal analysis (%)		
C: 0.025	Mn: 0.76	Si: 0.87
Cr: 20.4	Ni: 9.8	S: 0.010
P: 0.017		
Ferrite number		
3.0–10.0 FN (using Severn Gauge)		

Approvals	
American Bureau of Shipping	AWS A5.4: E308L-17

Packaging and operating data — AC (minimum 45 OCV) DC+ polarity

Electrode Size (mm)	Length (mm)	Approx No. (rods / kg)	Current range (A)	Packet (kg)	Carton (kg)	Part No.
2.5	300	47	40–70	2.5	15 (6 x 2.5)	611602
3.2	350	28	75–110	2.5	15 (6 x 2.5)	611603
4.0	350	18	110–150	2.5	15 (6 x 2.5)	611604

Satincrome 316L-17

- Rutile type, stainless steel electrode
- Outstanding operator appeal, improved slag lift
- All positional (except vertical-down) welding capabilities
- Applications include the single and multi-pass welding of matching molybdenum bearing stainless steels, 316 and 316L. Also suitable for the general purpose welding of other '300 series' austenitic stainless steels, including 301, 302, 303 and 304 / 304L, 305, 3CR12-types

Classifications
AS / NZS 1553.3: E316L-17
AWS / ASME-SFA A5.4: E316L-17

Typical all weld metal mechanical properties	
0.2% Proof stress	480 MPa
Tensile strength	600 MPa
Elongation	40%
CVN impact values	30J av @ -120°C

Typical all weld metal analysis (%)		
C: 0.025	Mn: 0.8	Si: 0.85
Cr: 19.4	Ni: 11.5	Mo: 2.5
S: 0.011	P: 0.017	
Ferrite number		
3.0–10.0 FN (using Severn Gauge)		

Approvals	
American Bureau of Shipping	AWS A5.4: E316L-17

Packaging and operating data — AC (minimum 45 OCV) DC+ polarity

Electrode Size (mm)	Length (mm)	Approx No. (rods / kg)	Current range (A)	Packet (kg)	Carton (kg)	Part No.
2.0	300	87	35–55	2.5	15 (6 x 2.5)	611661
2.5	300	46	40–70	2.5	15 (6 x 2.5)	611662
3.2	350	28	75–110	2.5	15 (6 x 2.5)	611663
4.0	350	18	110–150	2.5	15 (6 x 2.5)	611664

Satincrome 318-17

(Supersedes Satincraft 318-16)

- Rutile type, stainless steel electrode.
- Outstanding operator appeal!
- Now with improved slag lift!
- All positional (except vertical-down) welding capabilities.
- Advanced moisture resistant flux coating.

Classifications

AS/NZS 1553.3: E318-17.
AWS/ASME-SFA A5.4: E318-17.

Typical all weld metal mechanical properties	
0.2% Proof Stress	490 MPa
Tensile Strength	610 MPa
Elongation	36%

Typical all weld metal analysis (%)				
C	Mn	Si	Cr	Ni
0.04	0.8	0.90	19	12
Mo	Nb	S	P	
2.30	0.35	0.017	0.02	
Ferrite number				
5.0 – 10.0 FN (using Severn Gauge)				

Packaging and operating data

AC (min 45 OCV), DC+ polarity.

Electrode Size (mm)	Length (mm)	Approx No. (rods/kg)	Current Range (A)	Packet	Carton (kg)	Easyweld Handipaks	Part No.
2.5	300	46	40–70	2.5kg	15 (6x2.5)		611652
2.5	300	46	40–70			20 rod	322105
3.2	350	28	75–110	2.5kg	15 (6x2.5)		611653

Satincrome 309Mo-17

- Rutile type, stainless steel electrode
- Outstanding operator appeal, improved slag lift
- All positional (except vertical-down) welding capabilities
- Applications include the single and multi-pass welding of matching 309 and 309L stainless steels. Also suitable for the dissimilar welding of other '300 series' austenitic stainless steels and selected '400 series' ferritic grades to mild or low alloy steels

Classifications

AS/NZS 1553.3: E309Mo-17
AWS/ASME-SFA A5.4: E309Mo-17

Typical all weld metal mechanical properties	
0.2% Proof stress	500 MPa
Tensile strength	620 MPa
Elongation	35%
CVN impact values	60J av @ +20°C

Typical all weld metal analysis (%)		
C: 0.05	Mn: 0.75	Si: 0.9
Cr: 23.0	Ni: 13.0	Mo: 2.2
S: 0.012	P: 0.017	
Ferrite number		
15.0 – 20.0 FN (using Severn Gauge)		

Approvals	
American Bureau of Shipping	AWS A5.4: E309Mo-17

Packaging and operating data — AC (min. 45 OCV) DC+ polarity

Electrode Size (mm)	Length (mm)	Approx No. (rods/kg)	Current range (A)	Packet (kg)	Carton (kg)	Part No.
2.5	300	52	40–70	2.5	15 (6x2.5)	611692
3.2	350	30	75–110	2.5	15 (6x2.5)	611693
4.0	350	19	110–150	2.5	15 (6x2.5)	611694

Weldall

- Easy-to-use rutile type, high alloy electrode
- Outstanding operator appeal
- Welds all steels
- Ideal for repair and maintenance jobs
- Easy arc starting and excellent stability on low OCV welding machines
- Not recommended for welding cast irons

Classifications

AS/NZS 1553.3 312-17
AWS/ASME-SFA A5.4: E312-17

Typical all weld metal mechanical properties	
0.2% proof stress	630 MPa
Tensile strength	780 MPa
Elongation	25%
CVN impact values	30J av @ +20°C

Typical all weld metal analysis (%)		
C: 0.11	Mn: 0.60	Si: 0.88
Cr: 27.0	Ni: 9.10	S: 0.011
P: 0.020		

Packaging and operating data — AC (min. 45 OCV) DC+ polarity

Electrode Size (mm)	Length (mm)	Approx No. (rods/kg)	Current range (A)	Packet (kg)	Carton (kg)	Easyweld Handipack	Part No.
2.5	300	57	40–80	2.5	15 (6x2.5)	–	611702
2.5	300	–	–	–	–	20 rods	322101
3.2	350	30	75–110	2.5	15 (6x2.5)	–	611703
3.2	350	–	–	–	–	15 rods	322102
4.0	350	20	110–150	2.5	15 (6x2.5)	–	611704

Limarosta 304L

A rutile-basic, all position stainless steel electrode for 304L or equivalent steels. Mirror-like bead appearance. Self releasing slag. Excellent side wall wetting. No undercut. Highly resistant to porosity.

Nearest classification
AWS E308L-16

Size (mm)	Carton(kg)	Part No
2.50	2.7	557329
3.20	4.7	557367
4.00	5.8	557398

Limarosta 316L

A rutile-basic, all position stainless steel electrode for 316L or equivalent steels. Molybdenum level min 2.7% Mirror-like bead appearance. Self releasing slag. Good side wall fusion. No undercut. High resistance to porosity. Weldable on AC and DC+ polarity.

Nearest classification
AWS E16L-16

Size (mm)	Carton (kg)	Part No.
2.50	2.7	557442
3.20	4.8	557466
4.00	5.9	557497

Limarosta 309S

A rutile-basic, all position Cr Ni over alloyed buffer electrode. Developed for welding stainless steel to mild steel and for clad steel. Self releasing slag. Excellent side wall wetting. No undercut. Mirror like bead appearance. High resistance to porosity. Weldable on AC and DC+ polarity.

Nearest classification
AWS E309L-16

Size (mm)	Carton (kg)	Part No.
2.50	2.8	556534
3.20	4.9	557565
4.00	5.9	557589

Limarosta 312

A rutile-basic, high Cr Ni alloyed, all position electrode. Excellent for repair welding. Specially developed for welding steels that are difficult to weld, such as: armour plate, austenitic Mn-steel, high C-steel. Excellent weldability and self releasing slag.

Nearest classification
AWS E312-16

Size (mm)	Carton (kg)	Part No.
2.50	2.6	557640
3.20	5.0	557664
4.00	5.0	557671

Arosta 304L

Rutile basic, all position, stainless steel electrode for 304L or equivalent steels. Excellent corrosion resistance to intergranular corrosion and in oxidising environments such as nitric acid. Smooth bead appearance and easy slag release. AC/DC+

Classification	AWS E308L-16

Size (mm)	Carton (kg)	Part No.
2.60	2.6	527537
3.20	4.8	527834
4.00	4.5	527940

Arosta 309

A high Cr Ni Mo alloyed, all position, rutile basic electrode. High corrosion resistant deposit. Specially developed for welding stainless steel to mild steel and root runs in cladding. Max plate thickness in butt welds - 12mm. Suitable for repair welding in dissimilar joints and steels difficult to weld. AC/DC+

Classification	AWS E309Mo-16

Size (mm)	Carton (kg)	Part No
2.50	2.6	528633
3.20	4.7	528824
4.00	4.8	528930

Arosta 316L

Rutile basic, all position, stainless steel electrode for 316L or equivalent steels. Molybdenum level minimum 2.7% High resistance to general and intergranular corrosion. Smooth weld appearance and easy slag release. AC/DC+.

Classification	AWS E316L-16

Size (mm)	Carton (kg)	Part No.
2.50	2.7	529180
3.20	4.9	529487
4.00	4.8	529593

Limarosta electrodes are predominantly used for welding downhand fillets, although out of position welds are possible. On the other hand, Arosta electrodes have superior out of position capabilities.

BOC Stainless Steel MIG Wire 308LSi

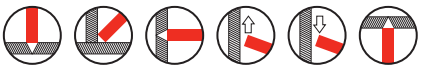
Welding characteristics

- High silicon levels improve arc characteristics and weld pool fluidity, and flatten weld bead profile
- Low carbon increases resistance to corrosion and maintains mechanical properties

Applications

- Welding of 18 Cr 8 Ni type stainless steels (i.e. 301, 302, 321, 347, 409 and 444-type alloys)
- Welding of 304 and 304L in cryogenic applications

Welding positions



Classifications
AS/NZS 2717.3, ES308LSi, AWS/ASME-SFA, A5-9, ER308LSi

Approvals: TÜV X2 CrNi 19 9 DIN 8556
DB (Ü-Sign) SG-X2 CrNi 19 9

Mechanical properties – all weld metal	
	Typical as welded
Yield strength (MPa)	415
Tensile strength (MPa)	570
Elongation (%)	35
Reduction of area	40
Impact Levels J @ 20°C	140
J @ -110°C	84
J @ -196°C	52
Ferrite No.	FN 14
Welding current	DC+

Welding data				
	Dip Transfer		Spray Transfer	
Dia. (mm)	0.9	1.2	0.9	1.2
Wire Feed	4–8	3–7	7–14	5–9
Current (A)	50–130	90–160	130–220	180–260
Voltage (V)	15–19	17–21	22–25	24–29
Shielding Gas	Stainshield®		Stainshield® Heavy Stainshield® 66	

Packing data		
Dia. (mm)	0.9	1.2
Part No.	109308	112308
Spool Weight (kg)	15	15

Chemical Composition, wt% – all weld metal											
	C	Mn	Si	S	P	Cr	Ni	Mo	Co	Cu	N
Min.		1.50	0.65	0.005		19.5	10.00				
Typical as welded	0.014	1.78	0.85	0.001	0.015	19.67	10.4				
Max.	0.02	2.00	1.00	0.015	0.020	20.50	10.75	0.30	0.20	0.20	0.060

BOC Stainless Steel MIG Wire 309LSi

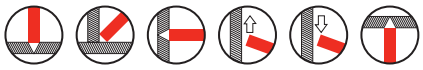
Welding characteristics

- High silicon levels improve arc characteristics and weld pool fluidity, and flatten weld bead profile
- Low carbon increases resistance to corrosion and maintains mechanical properties

Applications

- Welding of 23 Cr / 12 Ni type stainless steels
- For welding mild or low alloy steels to 300 and selected 400 series stainless steels
- Ideal for buttering layer on carbon for hardfacing consumables
- A stainless overlay on mild steels

Welding positions



Classifications
AS/NZS 2717.3 ES309LSi AWS/ASME – SFA A5 – 9 ER309LSi

Mechanical properties – all weld metal	
	Typical as welded
Yield strength (MPa)	440
Tensile strength (MPa)	600
Elongation (%)	40
Impact levels J @ 20°C	160
Ferrite No.	FN 15
Welding current	DC+

Packaging		
Dia. (mm)	0.9	1.2
Part No.	109309	112309
Spool Weight (kg)	15	15

Welding data				
	Dip Transfer		Spray Transfer	
Dia. (mm)	0.9	1.2	0.9	1.2
Wire Feed	4–8	3–7	7–14	5–9
Current (A)	50–130	90–160	130–220	180–260
Voltage (V)	15–19	17–21	22–25	24–29
Shielding Gas	Stainshield®		Stainshield® Heavy Stainshield® 66	

Chemical composition, wt% – all weld metal

	C	Mn	Si	S	P	Cr	Ni	Mo	Co	Cu	N
Min.		1.50	0.65	0.005		23.0	13.00				
Typical as welded	0.015	1.79	0.80	0.012	0.014	23.4	13.63				
Max.	0.02	2.00	1.00	0.015	0.020	24.0	14.00	0.30	0.20	0.20	0.060

BOC Stainless Steel MIG Wire 316LSi

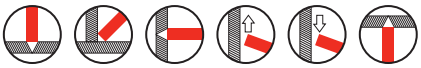
Welding characteristics

- High silicon levels improve arc characteristics and weld pool fluidity, and flatten weld bead profile
- Low carbon increases resistance to corrosion and maintains mechanical properties

Applications

- Welding of 18 Cr / 8 Ni and 18 Cr / 8 Ni / 3 Mo type stainless steels
- Most suitable for the welding of 316, 318 and 316L alloys
- Suitable for 301, 302, 304, 321, 347, 410 and 430 alloys

Welding positions



Classification
AS / NZS 2717.3, ES316LSi, AWS / ASME – SFA, A5 – 9, ER316LSi

Approvals:
TÜV X 2 CrNiMo 1912 DIN 8556 DB SG – X2 CrNiMo 19 12

Mechanical properties – all weld metal	
	Typical as welded
Yield strength (MPa)	490
Tensile strength (MPa)	630
Elongation (%)	32
Reduction of area	46
Impact levelsJ @ 20°C	152
J @ – 110°C	110
J @ – 196°C	53
Ferrite content	FN 13
Welding current	DC+

Packaging		
Dia. (mm)	0.9	1.2
Part No.	109316	112316
Spool Weight (kg)	15	15

Welding data				
	Dip Transfer		Spray Transfer	
Dia. (mm)	0.9	1.2	0.9	1.2
Wire Feed	4–8	3–7	7–14	5–9
Current (A)	50–130	90–160	130–220	180–260
Voltage (V)	15–19	17–21	22–25	24–29
Shielding Gas	Stainshield®		Stainshield® Heavy Stainshield® 66	

Chemical composition, wt% – all weld metal											
	C	Mn	Si	S	P	Cr	Ni	Mo	Co	Cu	N
Min.		1.50	0.65	0.005		18.00	12.00	2.50			
Typical as welded	0.012	1.70	0.93	0.008	0.016	18.58	12.2	2.63			
Max.	0.02	2.00	1.00	0.015	0.020	19.00	13.00	3.300	0.30	0.20	0.060

Autocraft 307Si

- For the GMAW Welding of hardenable steels, 13 Mn steels and difficult to weld steels
- Extra low carbon (<0.07%) Weld deposits for resistance to intergranular corrosion
- High silicon level for improved arc stability and increased weld pool fluidity and edge wetting
- New ultrafeed matt finish

Classifications
AS 2717.3: ES307Si.
AWS/ASME-SFA A5.9: ES307Si.

Typical All Weld Metal Mechanical Properties	
	Stainshield
0.2% Proof Stress	450 MPa
Tensile Strength	640 MPa
Elongation	40%
CVN Impact Values	150 J av @ 20°C

Typical Wire Analysis			
C	Mn	Si	Cr
0.07	8.9	0.8	18.5
Ni	P	S	Fe
8.5	0.03	0.015	Balance

Ferrite Number
10–15 FN

Comparable Cigweld Products:
Coabalarc Austex
AS/NZS 2576 1315-A4

Recommended shielding gas
Stainshield®
Stainshield® Heavy

Packaging and operating data

These machine settings are a guide only. Actual voltage and welding current used will depend on machine characteristics, plate thickness, run size, shielding gas and operator technique etc.

Wire Dia. (mm)	Voltage Range (V)	Wire Feed Speed (m/min)	Current Range (A)	Pack Type*	Weight (kg)	Part No.
0.9	16–24	4.5–15.0	70–200	Spool	15kg	721300
1.2	20–28	3.0–10.0	150–280	Spool	15kg	721301

* Spool (ø300mm).

Autocraft 308LSi

- A steel wire for the GMA welding of 304 and 304L type stainless steels
- Recommended for the general welding of 201, 302, 321, 347, 409 and 444 type stainless steels

Classifications
AS/NZS 2717.3: ES308LSi
AWS/ASME-SFA A5.9: ER308LSi

Typical all weld metal mechanical properties	
	Argon 1–3% CO_2
0.2% Proof stress	450 MPa
Tensile strength	620 MP
Elongation	36%
CVN impact values	90J av @ -60°C

Typical wire analysis (%)		
C: 0.02	Mn: 2.05	Si: 0.80
Cr: 19.95	Ni: 10.25	P: 0.020
S: 0.005	Fe: Balance	

Ferrite number
5–10 FN

Recommended shielding gas
Stainshield®
Stainshield® Heavy

Packaging and operating data

Dia. (mm)	Voltage (V)	Wire feed speed m/min	Current range (A)	Pack type*	Pack weight (kg)	Part No.
0.9	16–24	4.5–15.0	70–200	Spool	15	721271
1.2	20–28	3.0–10.0	150–280	Spool	15	721272

Autocraft 309LSi

- A stainless steel wire for the GMA welding of 309 and 309L type stainless steels
- Also suitable for a wide range of other welding applications, including: the dissimilar joining of '300 series' and stainless steel grades to mild or low alloy steels, an intermediate or buttering layer in the butt welding of clad steel

Classifications
AS/NZS 2717.3: ES309LSi AWS/ASME-SFA A5.9: ER309LSi

Typical all weld metal mechanical properties	
	Argon 1–3% CO_2
0.2% Proof stress	450 MPa
Tensile strength	610 MPa
Elongation	36%
CVN impact values	90J av @ -110°C

Typical wire analysis (%)		
C: 0.02	Mn: 2.10	Si: 0.75
Cr: 23.75	Ni: 13.75	P: 0.020
S: 0.005	Fe: Balance	

Ferrite Number
10–15 FN

Recommended shielding gas
Stainshield®
Stainshield® 66
Stainshield® Heavy

Packaging and operating data						
Dia. (mm)	Voltage (V)	Wire feed speed m/min	Current range (A)	Pack type*	Pack weight (kg)	Part No.
0.9	16–24	4.5–15.0	70–200	Spool	15	721276
1.2	20–28	3.0–10.0	150–280	Spool	15	721277

Autocraft 316LSi

- A stainless steel wire for the GMA welding of 316 and 316L type stainless steels
- Also suitable for the general welding of other 300 and 400 series stainless steels including 301, 302, 304/304L, 321, 347, 410 and 430

Classifications
AS/NZS 2717.3: ES316LSi AWS/ASME-SFA A5.9: ER316LSi

Typical all weld metal mechanical properties	
	Argon 1–3% CO_2
0.2% Proof stress	450 MPa
Tensile strength	620 MPa
Elongation	36%
CVN impact values	90J av @ -60°C

Typical wire analysis (%)		
C: 0.02	Mn: 2.05	Si: 0.80
Cr: 19.95	Ni: 10.25	P: 0.020
S: 0.005	Fe: Balance	

Ferrite number
5–10 FN

Recommended shielding gas
Stainshield®
Stainshield® 66
Stainshield® Heavy

Packaging and operating data						
Dia. (mm)	Voltage (V)	Wire feed speed m/min	Current range (A)	Pack type*	Pack weight (kg)	Part No.
0.8	16–20	5.0–15.0	60–150	Mini spool – Pack of 4	4 x 1	721285
0.9	16–24	4.5–15.0	70–200	Handi spool	5	720283
				Spool	15	721286
1.2	20–28	3.0–10.0	150–280	Spool	15	721287
0.9	16–24	4.5–15.0	70–200	Drum	150	722286

Autocraft 2209

- For the GMAW welding of 22 Cr / 5 Ni / 3 Mo duplex type stainless steels
- Extra low carbon (<0.03%) corrosion resistant weld deposits
- Precision layer wound for improved feedability and performance
- New Ultrafeed matt finish

Classifications

AS 2717.3: ES2209
AWS/ASME-SFA A5.9: ER2209.
Werkstoffe No: 1.4462

Typical All Weld Metal Mechanical Properties

	Welding grade Argon
0.2% Proof Stress	600 MPa
Tensile Strength	765 MPa
Elongation	28%
CVN Impact Value	60J av @ -40°C
	80J av @ -20°C
	100J av @ +20°C

Typical Wire Analysis

C	Mn	Si	Cr	Ni	Mo
0.012	1.6	0.44	22.8	8.63	3.1
N	P	S	Cu	Fe	
0.14	0.018	0.007	0.06	bal	

Ferrite Number

30- 50 FN (Procedure dependent)

Comparable Cigweld Products:

Comweld 2209 TIG rod
AWS A5.9: ER 2209

Recommended Shielding Gas

Stainshield®

Some nitrogen bearing shielding gases assist in maintaining an optimum Austenite/Ferrite ratio. Consult your gas supplier for specific details.

Packaging and operating data

These machine settings are a guide only. Actual voltage and welding current used will depend on machine characteristics, plate thickness, run size, shielding gas and operator technique etc.

Wire Dia. (mm)	Voltage Range (V)	Wire Feed Speed (m/min)	Current Range (A)	Pack Type*	Weight (kg)	Part No.
0.9	16–24	4.5–15.0	65–165	Spool	15kg	721261
1.2	20–26	3.0–10.0	180–280	Spool	15kg	721262

GMAW Wire

Lincoln 308 LSi

For joining common austenitic stainless steel grades referred to as '18-8' steels.

Classifications	AWS ER308LSi

Size (mm)	Carton (kg)	Part No.
0.80	15.0	331088
0.90	15.0	331089
1.20	15.0	331082
1.60	15.0	331086

Lincoln 309 LSi

For joining higher alloyed austenitic stainless steels. Can also be used on '18-8' steels since it over matches the corrosion resistance, if the weldment will not be exposed to temperatures of 535–927°C.

Classifications	AWS ER309LSi

Size (mm)	Carton (kg)	Part No.
0.80	15.0	331098
0.90	15.0	331099
1.20	15.0	331092
1.60	15.0	331096

Lincoln 316 LSi

The undiluted weld metal is designed to contain considerable ferrite for high crack resistance in 316L joining and cladding. Should not be used on 316L joints or overlay for service in urea manufacture, as this environment will attack the ferrite. Can also be used on '18-8' steels.

Classifications	AWS ER 316LSi

Size (mm)	Carton (kg)	Part No.
0.80	15.0	331068
0.90	15.0	331069
1.20	15.0	331062
1.60	15.0	331066

Shieldcrome 308LT

- Gas shielded stainless steel flux cored wire
- Formulated for CO_2 or Argon+20–25% CO_2 shielding gases
- Vacuum sealed in aluminised plastic packs
- All positional capabilities
- High deposition rate welding of stainless steels
- For a wide range of positional and downhand welding applications on 19Cr/9Ni stainless steel grades including AISI types 301, 302, 304 and 304L etc

Classifications
Shieldcrome 308LT AWS/ASME-SFA A5.22: E308LT1-1(CO_2) E308LT1-4 (Ar + 20–25%CO_2)

Typical all weld metal mechanical properties	Using CO_2	Using Argon +20–25% CO_2
0.2% Proof stress	390 MPa	400 MPa
Tensile strength	550 MPa	580 MPa

Typical all weld metal mechanical properties		
Elongation	43%	40%

Typical all weld metal analysis (%)		
Using welding grade CO_2		
C: 0.03	Mn: 1.30	Si: 0.70
Cr: 19.5	Ni: 9.9	P: 0.020
S: 0.003		

Recommended shielding gases
Argoshield® 52
Welding Grade CO_2

Packaging data			
Dia. (mm)	Pack type	Pack weight (kg)	Part No.
1.2	Spool	12.5	720889

Operating data				
All welding conditions recommended below are for use with semi-automatic operation and DC electrode positive and welding grade CO_2 shielding gas with a flow rate of 15–20 L/min.				
Dia. (mm)	Current range (A)	Voltage (V)	Electrode stick-out ESO (mm)	Welding positions
1.2	150–250	23–28	15–20	Flat
1.2	150–200	23–28	15–20	HV Fillet
1.2	120–180	22–27	15–20	Vertical-up
1.2	140–180	22–27	15–20	Overhead

Shieldcrome 309LT / 309LTD

- Gas shielded stainless steel flux cored wires
- 309LT – all positional capabilities
- 309LTD – fast downhand capabilities
- Vacuum sealed in aluminised plastic packs
- Formulated for CO_2 or argon +20–25% CO_2 shielding gases
- High deposition rate welding of stainless steels
- For a wide range of positional and downhand welding applications on matching 309 and 309L stainless steels

Classifications
Shieldcrome 309LT AWS/ASME-SFA A5.22: E309LT1-1 (CO_2)/E309LT1-4 (Ar+20–25%CO_2)
Shieldcrome 309LTD AWS/ASME-SFA A5.22: E309LT0-1 (CO_2)/E309LT0-4 (Ar+20–25%CO_2)

Typical all weld metal mechanical properties	Using CO_2	Using Argon +20–25% CO_2
0.2% Proof stress	410 MPa	430 MPa
Tensile strength	550 MPa	580 MPa
Elongation	40 %	38 %

Typical all weld metal analysis (%)		
Using welding grade CO_2		
C: 0.03	Mn: 1.12	Si: 0.60
Cr: 23.6	Ni: 13.0	P: 0.023
S: 0.003		

Recommended shielding gases
Argoshield® 52
Welding Grade CO_2

Packaging data			
Dia. (mm)	Pack type	Pack weight (kg)	Part No.
1.2/309LT	Spool	12.5	720881
1.6/309LTD	Spool	12.5	720882

Operating data				
All welding conditions recommended below are for use with semi-automatic operation and DC electrode positive and welding grade CO_2 shielding gas with a flow rate of 15–20 L/min.				
Dia. (mm)	Current range (A)	Voltage (V)	Electrode stick-out ESO (mm)	Welding positions
1.2/309LT	150–250	23–28	15–20	Flat
1.6/309LTD	300–400	28–35	25–30	
1.2/309LT	150–200	23–28	15–20	HV Fillet
1.6/309LTD	250–350	28–35	25–30	
1.2/309LT	120–180	22–27	15–20	Vertical-up
1.2/309LT	140–180	22–27	15–20	Overhead

Shieldcrome 316LT

- Gas shielded stainless steel flux cored wires, all positional capabilities
- Vacuum sealed in aluminised plastic packs
- Formulated for CO_2 or argon +20–25% CO_2 shielding gases
- High deposition rate welding of stainless steels
- For a wide range of positional and downhand welding applications on matching molybdenum bearing 316 and 316L stainless steels

Classifications
Shieldcrome 316LT AWS/ASME-SFA A5.22: E316LT1-1 (CO_2)/E316LT1-4 (Ar + 20–25%CO_2)

Typical all weld metal mechanical properties		
	Using CO_2	Using Argon +20–25% CO_2
0.2% Proof stress	400 MPa	410 MPa
Tensile strength	555 MPa	580 MPa
Elongation	42%	39%

Typical all weld metal analysis (%)		
Using welding grade CO_2		
C: 0.03	Mn: 1.10	Si: 0.60
Cr: 18.8	Ni: 12.0	Mo: 2.5
P: 0.024	S: 0.002	

Recommended shielding gases
Argoshield® 52
Welding Grade CO_2

Packaging data			
Dia. (mm)	Pack type mm	Pack weight (kg)	Part No.
1.2	Spool	12.5	720885

Operating data

All welding conditions recommended below are for use with semi-automatic operation and DC electrode positive and welding grade CO_2 shielding gas with a flow rate of 15–20 L/min.

Dia. (mm)	Current range (A)	Voltage (V)	Electrode stick-out ESO (mm)	Welding positions
1.2	150–200	23–28	15–20	HV Fillet
1.2	120–180	22–27	15–20	Vertical-up
1.2	140–180	22–27	15–20	Overhead

These machine settings are a guide only. Actual Voltage (V), welding current and ESO used will depend on machine characteristics, plate thickness, run size, shielding gas and operator technique etc.

ProFill 308L

ProFill 308L stainless steel is a high qualit,y low carbon rod for the gas or gas tungsten arc (TIG) welding of a wide range of low carbon and stabilised 300 series stainless steels. It is recommended for the critical welding of 304 and 304L stainless steels in corrosion resistant and cryogenic applications.

- Resealable 5 kg tube
- Suitable for gas and GTA (TIG) welding

Classification
AS1167.2:308LSi AWS/ASME-SFA A5.9:ER308LSi

Dia. (mm)	Weight (kg)	Part No.
1.2 mm	5 kg	BTGS308L12
1.6 mm	5 kg	BTGS308L16
2.0 mm	5 kg	BTGS308L20
2.4 mm	5 kg	BTGS308L24
3.2 mm	5 kg	BTGS308L32

Weld Deposit Properties	
Typical weld metal 0.2% proof stress	450 MPa
Typical weld metal tensile strength	600 MPa
Approx. melting point	1,400°C
Weld metal density	7.95 g/cm³
All weld metal microstructure	Austenite with 5–8% ferrite

Procedure for Gas Tungsten Arc (TIG) Welding

- Thoroughly clean all areas to be joined
- For the butt welding of thick plates, bevel edges to 60–70° included angle
- Use a thoriated or ceriated tungsten electrode, ground to a sharp needle point, making sure the grinding lines run with the length (longitudinally) of the electrode's axis. The length of the needle point should be approximately 2–3 times the diameter of the tungsten electrode
- Use direct current electrode negative (DC-) and welding grade argon
- Preheat surfaces to be welded. Heat a spot on the base metal until it shows signs of melting and progressively add the filler rod to the weld-pool
- For the best cleaning and finishing results, use BOC Weld-Guard™ Pickling Paste

ProFill 309L

ProFill 309L stainless steel is a high quality low carbon rod for the gas or gas tungsten arc (TIG) welding of highly alloyed 309 or 309L type stainless steels. ProFill 309L is also suitable for the dissimilar joining of other 300 series austenitic stainless steels ferritic steels.

- Resealable 5 kg tube
- Suitable for gas and GTA (TIG) welding

Classification
AS1167.2:309LSi ASME-SFA A5.9: ER309LSi

Dia. (mm)	Weight (kg)	Part No.
1.6 mm	5 kg	BTGS309L16
2.0 mm	5 kg	BTGS309L20
2.4 mm	5 kg	BTGS309L24
3.2 mm	5 kg	BTGS309L32

Weld deposit properties	
Typical weld metal 0.2% proof stress	440 MPa
Typical weld metal tensile strength	590 MPa
Approx. melting point	1400°C
Weld metal density	7.95 g/cm³
All weld metal microstructure	Austenite with 15–20% ferrite

Procedure for Gas Tungsten Arc (TIG) Welding

- Thoroughly clean all areas to be joined.
- For the butt welding of thick plates, bevel edges to 60–70° included angle
- Use a thoriated or ceriated tungsten electrode, ground to a sharp needle point, making sure the grinding lines run with the length (longitudinally) of the electrode's axis. The length of the needle point should be approximately 2 to 3 times the diameter of the tungsten electrode
- Use direct current electrode negative (DC-) and welding grade argon
- Preheat surfaces to be welded. Heat a spot on the base metal until it shows signs of melting and progressively add the filler rod to the weld-pool
- For the best cleaning and finishing results, use BOC Weld-Guard™ Pickling Paste

ProFill 316L

ProFill 316L stainless steel is a high quality low carbon rod for the gas or gas tungsten arc (TIG) welding of molybdenum bearing stainless steels; in particular matching 316 and 316L alloys. ProFill 316L is also suitable for the general welding of 304 and 304 stainless steels and ferritic stainless steels, including 409, 444 and 3Cr12.

- Resealable 5 kg tube
- Suitable for gas and GTA (TIG) welding

Classification
AS1167.2:316LSi AWS/ASME-SFA A5.9:ER316LSi

Dia. (mm)	Weight (kg)	Part No.
0.9 mm	5 kg	BTGS316L09
1.2 mm	5 kg	BTGS316L12
1.6 mm	5 kg	BTGS316L16
2.0 mm	5 kg	BTGS316L20
2.4 mm	5 kg	BTGS316L24
3.2 mm	5 kg	BTGS316L32

Weld deposit properties	
Typical weld metal 0.2% proof stress	470 MPa
Typical weld metal tensile strength	640 MPa
Approx. melting point	1400°C
Weld metal density	7.95 g/cm³
All weld metal microstructure	Austenite with 7–10% ferrite

Procedure for Gas Tungsten Arc (TIG) Welding

- Thoroughly clean all areas to be joined
- For the butt welding of thick plates, bevel edges to 60–70° included angle
- Use a thoriated or ceriated tungsten electrode, ground to a sharp needle point making sure the grinding lines run with the length (longitudinally) of the electrode's axis. The length of the needle point should be approximately 2–3 times the diameter of the tungsten electrode
- Use Direct current electrode negative (DC-) and welding grade argon
- Preheat surfaces to be welded. Heat a spot on the base metal until it shows signs of melting and progressively add the filler rod to the weld-pool
- For the best cleaning and finishing results, use BOC Weld-Guard™ Pickling Paste

ProFill 347

ProFill 347 stainless steel is a high quality gas or gas tungsten arc (TIG) welding rod. Niobium stabilised for improved resistance to intergranular corrosion, ProFill 347 is recommended for the TIG welding of 347, 348 and 321 type stainless steels stabilised with either niobium or titanium.

ProFill 347 is also suitable for the general purpose welding of other 300 series stainless steels, including 301, 302, 304 and 304L etc.

- Resealable 5 kg tube
- Suitable for gas and GTA (TIG) welding

Classification
AS1167.2:347 AWS/ASME-SFA A5.9:ER347

Dia. (mm)	Weight (kg)	Part No.
1.6 mm	5 kg	BTGS34716
2.0 mm	5 kg	BTGS34720
3.2 mm	5 kg	BTGS34732
2.4 mm	5 kg	BTGS34724

Weld deposit properties	
Typical weld metal 0.2% proof stress	540 MPa
Typical weld metal tensile strength	640 MPa
Approx. melting point	1440°C
Weld metal density	7.95 g/cm³
All weld metal microstructure	Austenite with 8–11% ferrite

Procedure for Gas Tungsten Arc (TIG) Welding

- Thoroughly clean all areas to be joined.
- For the butt welding of thick plates, bevel edges to 60–70° included angle
- Use a thoriated or ceriated tungsten electrode, ground to a sharp needle point making sure the grinding lines run with the length (longitudinally) of the electrode's axis. The length of the needle point should be approximately 2–3 times the diameter of the tungsten electrode
- Use direct current electrode negative (DC-) and welding grade argon
- Preheat surfaces to be welded. Heat a spot on the base metal until it shows signs of melting and progressively add the filler rod to the weld-pool
- For the best cleaning and finishing results use BOC Weld-Guard™ Pickling Paste

Comweld 308L

- Resealable 5 kg plastic tube
- Suitable for gas and GTA (TIG) welding
- End stamped with AS/AWS Class '308L'
- Dark blue colour coded label for instant identification

Classifications
AS/NZS 1167.2: R308L AWS/ASME-SFA A5.9: ER308L

Typical rod analysis (%)		
C: 0.015	Mn: 1.90	Si: 0.50
Cr: 19.90	Ni: 9.75	P: 0.020
S: 0.005	Fe: Balance	

Recommended shielding gas
Argon Welding Grade

Packaging data

Rod Size (mm)	Weight (kg), Pack type	Approx. (rods/kg)	Part No.
1.6 x 914	5 plastic tube*	69	321406
2.4 x 914	5 plastic tube*	30	321407

*Resealable

Comweld 309L

- Resealable 5 kg plastic tube
- Suitable for gas and GTA (TIG) welding of highly alloyed 309 or 309L type stainless steel
- End stamped with AS/AWS class '309L'
- Red colour coded pack label for instant identification
- Also suitable for the dissimilar joining of other 300 series austenitic stainless steels to ferritic steels

Classifications
AS/NZS 1167.2: R309L AWS/ASME-SFA A5.9: ER309L

Typical rod analysis (%)		
C: 0.015	Mn: 1.90	Si: 0.45
Cr: 23.5	Ni: 13.5	P: 0.020
S: 0.005	Fe: Balance	

Recommended shielding gas
Argon Welding Grade

Packaging data

Rod Size (mm)	Weight (kg), Pack type	Approx. (rods/kg)	Part No.
1.6 x 914	5 plastic tube*	69	321403
2.4 x 914	5 plastic tube*	30	321404

*Resealable

TIG

Comweld 316L

- Resealable 5 kg plastic tube
- Suitable for gas and GTA (TIG) welding of-molybdenum bearing stainless steels; in particular matching 316 and 316L alloys
- End stamped with AS/AWS class '316L'
- Gold colour coded pack label for instant identification
- Also suitable for the general welding of other 300 series stainless steels, including 302 and 304 as well as ferritic stainless steels grades such as 409, 444 and 3Cr12

Classifications
AS/NZS 1167.2: R316L AWS/ASME-SFA A5.9: ER316L

Typical rod analysis (%)		
C: 0.012	Mn: 1.57	Si: 0.50
Cr: 19.00	Ni: 12.6	Mo: 2.50
P: 0.015	S: 0.001	Fe: Balance

Recommended shielding gas
Argon Welding Grade

Packaging data			
Rod Size (mm)	Weight, Pack type	Approx No. (rods/kg)	Part No.
1.6 x 914	5 kg plastic tube*	69	321400
	25 rod Handipack	–	322054
2.4 x 914	5 kg plastic tube*	30	321401

*Resealable

Comweld 2209

- For the GTA (TIG) welding of 22 Cr/5 Ni/3 Mo duplex type stainless steels
- Resealable 5 kg cardboard tube
- Suitable for GTA (TIG) welding
- End stamped with AWS Class 'ER2209' for easy identification

Classifications
AWS/ASME-SFA A5.9: ER2209. Werkstoffe No: 1.4462

Joining process
Gas Tungsten Arc (TIG) welding

Typical all weld deposit mechanical properties	
0.2% Proof Stress	600 MPa.
Tensile Strength	765 MPa.
Metal Density	7.95 gms/cm3
Microstructure	Austenite and ferrite (≈ 50:50)

Ferrite number
30-50 FN (Procedure dependent)

Typical rod analysis (%)					
C	Mn	Si	Cr	Ni	Mo
0.012	1.06	0.44	22.8	8.63	3.1
N	P	S	Cu	Fe	
0.14	0.018	0.007	0.06	Bal.	

Comparable Cigweld products:
Autocraft 2209 GMAW wire AWS A5.9: E2209

Recommended shielding gas
Argon Welding Grade

Packaging data			
Rod Size (mm)	Weight (kg), Pack Type	Approx No. (rods/kg)	Part No.
1.6 x 1,000	5 kg cardboard tube*	69	321393
2.4 x 1,000	5 kg cardboard tube*	30	321394

* Resealable

Lincoln 308L

For joining the more common austenitic stainless steel grades referred to as '18-8' steels.

Classification	AWS ER308L

Size (mm)	Carton (kg)	Part No.
2.40	25.0	330082
3.20	25.0	330083

Lincoln 309L

For joining more high alloyed austenitic stainless steels. Can also be used on '18-8' steels, since it over matches the corrosion resistance if the weldment will not be exposed to temperatures of 540–925°C.

Classification	AWS ER309L

Size (mm)	Carton (kg)	Part No.
2.40	25.0	330092
3.20	25.0	330093

Lincoln 316L

Undiluted weld metal is designed to contain considerable ferrite for maximum crack resistance. Should not be used on 316L joints in service for urea manufacture, as this environment will attack the ferrite.

Classification	AWS ER316L

Size (mm)	Carton (kg)	Part No.
2.40	25.0	330062
2.40	25.0	330063

Lincoln 2209

Solid wire for welding duplex stainless steels. High resistance to general corrosion, pitting and stress corrosion conditions.

Classification	AWS ER2209

Size (mm)	Carton (kg)	Part No.
2.40	25.0	330222

Submerged Arc Flux

Refer to page 491–492 for a listing of Submerged Arc Flux