ELECTRODE SELECTION

There are a great many AISI grades of stainless steel, and in many cases there is a matching electrode for the AISI type. For instance, if both members of a weldment are AISI type 316, the electrode to be used would be 316 also. It is not necessary to have a matching electrode for every type of stainless steel, however, because some electrodes produce satisfactory welds even though the chemical analysis of the steel may be slightly different.

Type 308 stainless steel electrodes may be used for welding AISI 201 and 202 that have a lower nickel content and a high manganese content. Type 308 electrodes may also be used to weld types 301, 302, 304, 305 and of course, 308 itself. Even though their chromium nickel contents vary slightly, all of these steel types may be considered as one family of alloys.

The chart shows the proper Arc electrode to be used for the various types of AISI steels

AISI Type Number	Carbon	Manganese	Silicon	Chomium	Nicket	Other Elements	Weld with
Austenitic							
201	0.15	5.5/7.5	1.00	16/18	3.5/5.5	N 0.25Max	308/308 ELC
202	0.15	7.5/10.0	1.00	17/19	3.5/5.5	N 0.25Max	308/308 ELC
301	0.15	2.00	1.00	16/18	6.0/8.0	-	308/308 ELC
302	0.15	2.00	1.00	17/19	8.0/10.0	-	308/308 ELC
302B	0.15	2.00	2.00/3.00	17/19	8.0/10.0	-	308/308 ELC
303	0.15	2.00	1.00	17/19	8.0/10.0	S 0.15 Min***	312
303Se	0.15	2.00	1.00	17/19	8.0/10.0	Se 0.15 Min	312
304	0.08	2.00	1.00	18/20	8.0/12.0	-	308/308 ELC
304L	0.03	2.00	1.00	18/20	8.0/12.0	-	308 ELC
305	0.12	2.00	1.00	17/19	10.0/13.0	-	308/308 ELC
308	0.08	2.00	1.00	19/21	10.0/12.0	-	308/308 ELC
309	0.2	2.00	1.00	22/24	12.0/15.0	-	309
309S	0.08	2.00	1.00	22/24	12.0/15.0	-	309

310	0.25	2.00	1.00	24/26	19.0/22.0	-	310
310S	0.08	2.00	1.00	24/26	19.0/22.0	-	310
314	0.25	2.00	1.50/3.00	23/25	19.0/22.0	-	310/312
316	0.08	2.00	1.00	16/18	10.0/14.0	Mo 2.0/3.0	316/316 ELC
316L	0.03	2.00	1.00	16/18	10.0/14.0	Mo 2.0/3.0	316 ELC
317	0.08	2.00	1.00	18/20	11.0/15.0	Mo 3.0/4.0	317/317 ELC
321	0.08	2.00	1.00	17/19	9.0/12.0	Ti 5X C Min	308ELC/347
347	0.08	2.00	1.00	17/19	9.0/13.0	Cb+Ta 10X C Min	308ELC/347
348	0.08	2.00	1.00	17/19	9.0/13.0	Cb+Ta 10X C Min Ta 0.10 Max	308ELC/347
20cB-3	0.06	2.00	1.00	19/21	32.5/35.0	Cb+Ta 8 X C Min Ta 1.00% Max	320LR
Martensitic							
403	0.15	1.00	0.50	11.5/13.0	-	-	309
410	0.15	1.00	1.00	11.5/13.5	-	-	309
414	0.15	1.00	1.00	11.5/13.5	1.25/2.50	-	309/410
416	0.15	1.00	1.00	12.0/14.0	-	S 0.15 Min***	312/410
416Se	0.15	1.25	1.00	12.0/14.0	-	Se 0.15 Min	312/410
420	Over 0.15	1.25	1.00	12.0/14.0	-	-	309/410
431	0.2	1.00	1.00	15.0/17.0	1.25/2.50	-	309/430
CA6NM	0.06	1.00	1.00	11.5/14.0	3.50/4.50	Mo 0.4-1.0	410NiMo
Ferritic							
405	0.08	1.00	1.00	11.5/14.0	-	Al 0.10/0.30	309/410
430	0.12	1.00	1.00	14.0/18.0	-	-	309/430

430F	0.12	1.25	1.00	14.0/18.0	-	S 0.15 Min***	312/430
430Se	0.12	1.25	1.00	14.0/18.0	-	Se 0.15 Min	312/430
442	0.2	1.00	1.00	18.0/23.0	-	-	309/310
446	0.2	1.50	1.00	23.0/27.0	-	N 0.25Max	309/310

* Single values are Maximums Excepts as Noted

** According to AISI Steel Products Manual. Stainless and Heat Resisting Steels

*** Molybdenum Content of up to 0.60% Permissible and is optional with the producer.

WELDING OF DISSIMILAR STEELS

There is no problem of electrode selection when welding stainless steels or any steel to a steel of the same type. Simply match the electrode to the steels. When a change from one type of steel to another (called a transition weld) is made, care must be given to the selection of the electrode used.

There are two general conditions and rules for electrode selection to weld dissimilar steels.

1. When the steels are similar metallurgical but dissimilar chemically, match the electrode to the lower chemical composition or less expensive steel. For example, type 310 steel (25% chromium, 20% nickel) is sometimes welded to type 304 steel (19% chromium, 10% nickel). Both types are austenitic. Type 304 steel, which is welded with 308 electrodes, is less expensive, so that weld would be made with type 308 electrodes rather than type 310 electrodes.

2. When the steels to be jointed are different metallurgical and chemically, the electrode is selected to provide a tough, crack resistant weld between the two steels.

For example, 304 stainless steel is frequently welded to mild structural steel. Corrosion resistance cannot be part of the problem because mild steel is on one side of the joint with practically no corrosion resistance compared to the stainless steel. If this weld is made with mild steel electrodes to match the mild steel side of joint, the weld metal would be enriched by the washing of chromium and nickel from the stainless side. This intermediate chrome-nickel is usually hard and crack sensitive. If the weld is made with type 308 electrodes to match the stainless steel side of the joint, the chromium and nickel contents of the weldment are diluted by the mild steel side of the joint to an intermediate level that would again probably be hard and crack sensitive. When welding mild steel to stainless steel, a proportion of 18% chromium and 8% nickel is desirable in the weld deposit to produce sound welds, with 17% chromium and 7% nickel being the minimum allowable amounts.

The following examples in Figure 14 show the results of making a transition weld of mild steel to 304 stainless steel with three different electrodes.

308 ELECTRODE							
	ELECTRODEx 60%		304X 20%		MILD STEEL X 20%		WELD METAL
CHROMIUM	19.5	11.7	18	3.6	0	0	15.3
NICKEL	9.5	5.7	8	1.6	0	0	7.3
The composition of 15.3% Chromium and 7.3% nickel does not meet the minimum 17-7%							
The weld metal will be fully Austentic and crack sensitive.							

310 ELECTRODE							
	ELECTRODE x 60%		304X 20%		MILD STEEL X 20%		WELD METAL
CHROMIUM	26	15.6	18	3.6	0	0	19.2
NICKEL	21	12.6	8	1.6	0	0	14.2
The composition of 19.2% Chromium and 14.2 % nickel does not meet the minimum 18/8							
The weld metal will be mostly martensitic with a very small amount of ferrite							

309 ELECTRODE							
	ELECTRODEx 60%		304X 20%		MILD STEEL X 20%		WELD METAL
CHROMIUM	23	13.8	18	3.6	0	0	17.4
NICKEL	13	7.8	8	1.6	0	0	9.4
The composition of 17.4 % Chromium and 9.4% nickel is close to the 18/8%							
The weld metal will be some ferrite and a small amount of Martensite to keep the weld metal from being tough and crack resistant, 309 is the best choice							

Normally the most severe dilution of the weld metal by the base metal is 40%. Thus, the weld metal in the joint is comprised of 60% from the electrode and 40% from the base metal as shown in Figure 14. In the case of butt joints between dissimilar steels, half of the dilution comes from each side of the joint, or 20% from each base metal.

Many times, type 310 and 312 electrodes are used erroneously for welding stainless to mild or low alloy steel. In many cases, not only can more dependable welds be made with 309 electrodes, but appreciable savings can be achieved because of their lower cost.

STAINLESS STEEL ELECTRODES AND FILLER METALS

There are several different forms of stainless steel electrodes: covered, continuous solid bare, continuous flux cored and cut length bare welding rods.

Covered Stainless Electrodes – Covered stainless steel electrodes are classified according to the American Welding Society Filler Metal Specification A-5.4-92. As defined by that specification, the electrodes are classified by weld metal composition and type of welding current.

For example,

AWS designation E308-15 means electrode (E), AISI type 308 steel (20% chrome, 10% nickel) and direct current electrode positive (-15).

AWS E308-16, it would indicate an electrode (E), AISI type 308 steel (308) and AC-DC electrode positive operation (-16 & -17).

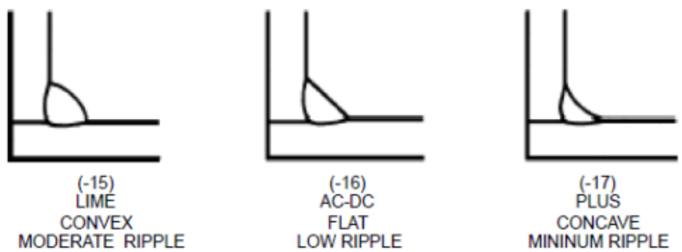
Lime coated electrodes were among the earliest stainless steel electrodes developed in the United States. Designed for welding with direct current, reverse polarity only, the coating contains considerable amounts of limestone and fluorspar producing a fast freezing slag that facilitates welding in the vertical and overhead positions. The weld bead is slightly convex and moderately rippled. A strong globular arc, a moderate amount of spatter and slag removal that is somewhat difficult, the lime type is not the most popular with the welding operators. However, it is the easiest to use stainless electrode for out-of-position welding. Also, the convex bead can provide the necessary margin of safety in highly stressed joints in many cases.

AC-DC Titania coated electrodes were the first such electrodes to receive wide acceptance in this country. Designed to operate on alternating current as well as direct current, the coating contains dominant amounts of rutile (titania), medium amounts of limestone, and limited amounts of fluorspar. By far, the AC/DC type is the most popular of the coated stainless electrodes. Welders like to use it because of the smoother arc action, low amount of fine spatter and easy slag removal. Also, the bead is relatively flat, finely rippled and has good side-wall fusion although used in all positions, vertical and overhead welding requires slightly more operator skill than with the lime types because the slag does not freeze as quickly.

"Plus" electrodes display characteristics not found in the conventional lime and AC-DC Titania coatings. Designed to operate on DCEP or AC, this coating is specially formulated to operate on a broad range of current settings, and most significantly, these electrodes perform their best at high heat inputs where conventional AC-DC electrodes tend to break down.

When operating at high currents, Plus electrodes deposit weld metal at exceptional speeds with a smooth spray transfer. The bead profile is finely rippled, concave, and evenly feathered (See Figure 15). Spatter is minimal. The molten slag does not edge into the weld puddle, thereby assuring easy visibility of the arc transfer.

Plus electrodes were developed for applications on dairy and food processing equipment and chemical containers, to name a few, where the weld radius must be smooth and concave to prevent particle entrapment. When welding in the flat and horizontal fillet positions, the concave deposit and absence of surface irregularities make it ideal for applications where cosmetic appearance, speed, and final finishing are factors.



WELD BEAD SHAPE ARCALOY COATED ELECTRODES

FIGURE 15

The weld metal properties are similar for each of the three coating types: lime, ACDC and AC-DC Plus.

BARE STAINLESS STEEL ELECTRODES OR SOLID WIRE

Bare stainless steel electrodes in continuous spools or coils and in cut lengths are available for welding purpose .Temper, cast, helix, and surface finish are closely controlled. The uniformity of these properties is essential to the maximum efficiency of the Gas Metal Arc Welding (GMAW), GasTungsten Arc Welding (GTAW), and Submerged Arc Welding (SAW) processes.

Bare stainless electrodes and welding rods meet the requirements of AWS Filler Metals Specification A5.9-93. That specification classifies the electrodes on the basis of composition, such as ERXXX where ER represents electrode or rod, and XXX represents the AISI three-digit number of the composition, such as 308, 410, or 502. The chemical composition requirements are based on the electrode rather than the weld metal.

Bare continuous solid stainless electrodes for gas metal arc or automated gas tungsten arc welding are smooth drawn to a bright finish. They are chemically cleaned, layer-wound on plastic spools, sealed in plastic bags, and packed in individual boxes.

Bare solid stainless steel continuous electrodes for Submerged Arc Welding are available in the fully annealed (soft) condition for smoother, easier feeding. The electrodes are random wound on fiber rims into coils, packaged in plastic bags, and boxed.

CORE-BRIGHT STAINLESS STEEL FLUX CORED ELECTRODES

Core-Bright electrodes are flux cored, self-shielding, continuous electrodes designed to operate without an external shielding gas. The carefully formulated mixture of alloys and shielding agents in the electrode core produces weld deposits of excellent appearance, mechanical properties, and radiographic quality. The electrode has low weld penetration that is ideal for overlay and buildup applications. Self shielding, high deposition rates, and reduced cleaning time are all built into Core-Bright electrodes, resulting in maximum economy and optimum efficiency in the welding operation.

Core-Bright electrodes meet the requirements of AWS filler metal Specification A5.22-95 for flux cored corrosion resisting chromium and chromium nickel steel electrodes.
The specification classifies electrodes on the basis of composition, type of electrode, and type

of gas shield, if any, such as EXXXTX-X. The E indicates that it is a current carrying electrode, and the XXX represents the AISI number of the composition, such as 308L, 3092, or 316L (the L signifying a low carbon type). The "T" indicates tubular or flux cored construction.
The number following this "T" indicates positional characteristics; "1" equals All Position, "0" equals flat and horizontal only. The last digit indicates the intended shielding gas. The number "1" equares to carbon dioxide (CO_2) as a shielding gas, a number "3" indicates that no external shielding gas is necessary, a number "4" is 75 - 80% Argon (Ar) and balance carbon dioxide, and a number "5" indicates 100% Argo

FERRITE CONTENT OF CORE-BRIGHT WELD METALS

The ferrite content of Core-Bright weld metal is variable depending upon the nitrogen content of the weld deposit. Nitrogen is a very strong austenite former, said to be 30 times as strong as nickel. Only a small increase in nitrogen causes a considerable decrease in ferrite content. When welding with Core-Bright electrodes, the arc length may be varied by the arc voltage. A longer arc length, caused by higher arc voltage, allows more nitrogen from the atmosphere to enter into the weld metal and the ferrite content decreases. Lower arc voltage produces a shorter arc length, allowing less nitrogen to pass into the weld metal, resulting in an increase of ferrite.

BSRM Stainless Steel Electrodes