Problem Steels

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Welding Consumables

Welding of Problem Steels

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 1 200°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. Afrox 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

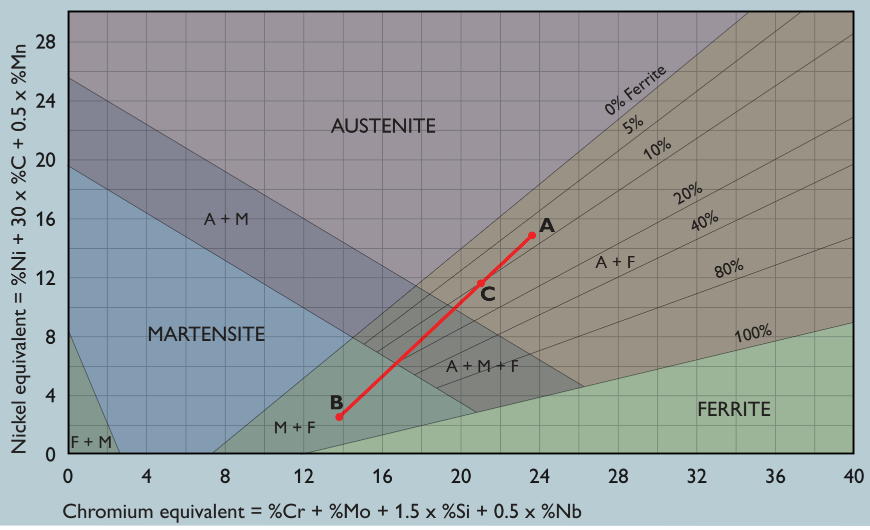
The final weld metal chemistry, and therefore properties, depend on the amount of dilution that occurs during welding.

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 Afrox 309Mo (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 Afrox 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 30% dilution, point C will give the resultant microstructure (i.e. austenite with 10% ferrite). This weld is therefore possible without any danger of hot cracking.



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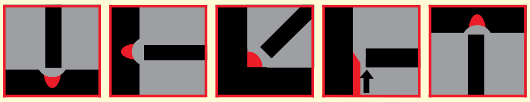
Problem Steels Electrodes

Afrox 312



Afrox 312 is a rutile basic coated low carbon electrode of the 29% chromium, 9% nickel type. The structure is highly resistant to hot cracking and extremely tolerant of dilution from medium and high carbon steels, etc. Afrox 312 is a universal electrode specifically designed for welding steels of low weldability. The electrode is suitable for welding austenitic manganese steel, medium and high carbon hardenable steels, tools, dies, springs, etc. which may be of unknown composition.

Classifications		
AWS	A5.4	E312-16
ISO	3581-A	E29 9 R12
ISO	3581-B	ES 312-16

Typical Chemical Analysis			
% Carbon	0,12 max	**% Nickel**	8,0 - 10,5
% Manganese	0,5 - 2,5 max	**% Molybdenum**	0,2 max
% Silicon	1,0 max	**% Sulphur**	0,025 max
% Chromium	28,0 - 32,0	**% Phosphorous**	0,025 max

Typical Mechanical Properties (All weld metal in the as welded condition)	
0,2% Proof Stress	600 MPa min
Tensile Strength	700 MPa
% Elongation on 4d	22 min
Charpy V-Notch at +20°C	30 J min

Packing Data
(DC+ AC 70 OCV min)

Diameter (mm)	Electrode Length (mm)	Current (A)	Item Number (4 electrode sleeve)	Item Number (1kg electrode pack)	Pack Mass (kg)	Item Number (multi-kg pack)
2,5	300	45 - 80	W072692	W072682	3 x 4,0	W075692
3,25	350	75 - 105	W072693	W072683	3 x 4,0	W075693
4,0	350	110 - 150	-	-	3 x 4,0	W075694

Superweld 312

Superweld 312 is a rutile basic coated low carbon electrode of the 29% chromium, 9% nickel type. The structure is highly resistant to hot cracking and extremely tolerant of dilution from medium and high carbon steels, etc. Superweld 312 is a universal electrode specifically designed for welding steels of low weldability. The electrode is suitable for welding austenitic manganese steel, medium and high carbon hardenable steels, tools, dies, springs, etc. which may be of unknown composition.

Classifications		
AWS	A5.4	E312-16
ISO	3581-A	E29 9 R12
ISO	3581-B	ES 312-16

Typical Chemical Analysis			
% Carbon	0,1	**% Nickel**	10,0
% Manganese	1,0	**% Sulphur**	0,01
% Silicon	0,85	**% Phosphorous**	0,03
% Chromium	28,5		

Typical Mechanical Properties (All weld metal in the as welded condition)	
0,2% Proof Stress	600 MPa min
Tensile Strength	760 MPa min
% Elongation on 4d	22 min
Charpy V-Notch at +20°C	30 J min

Packing Data (DC+ AC 70 OCV min)

Diameter (mm)	Electrode Length (mm)	Current (A)	Pack Mass (kg)	Item Number (multi-kg pack)
2,5	300	50 - 90	3 x 5,0	W085692
3,25	350	80 - 110	3 x 5,0	W085693
4,0	350	100 - 170	3 x 5,0	W085694

Inox DW

Inox DW is an austenitic-ferritic electrode with approximately 50% ferrite content and is non-scaling to 1 100°C. The weld metal of Inox DW is highly crack resistant and is therefore suitable for difficult to weld steels and joining dissimilar materials, e.g high alloy and unalloyed steels. It is also suitable as a stress compensating buffer layer on parent metals susceptible to cracking. Good all positional weldability. Unalloyed steels with C >0,25% should be preheated to 150-300°C depending on the carbon content and plate thickness. Note: Do not use for dissimilar joints in creep resisting applications.

Open Circuit Voltage

70 min

Re-drying

Only dry electrodes should be used. Re-drying should be carried out at 300°C for 2 hours.

Classifications		
AWS	A5.4	E312-16
ISO	3581-A	E29 9 R12
ISO	3581-B	ES 312-16

Typical Chemical Analysis			
% Carbon	0,12 max	**% Chromium**	29,0
% Manganese	1,0	**% Nickel**	9,0
% Silicon	0,9		

Typical Mechanical Properties (All weld metal in the as welded condition)	
0,2% Proof Stress	>500 MPa
Tensile Strength	740 - 840 MPa
% Elongation on 5d	>22
Microstructure	Austenitic with approximately 50% delta ferrite

Packing Data (DC+ AC 70 OCV min)

Diameter (mm)	Electrode Length (mm)	Current (A)	Pack Mass (kg)	Item Number
2,5	300	55 - 85	5,0	W113082
3,25	350	80 - 120	5,0	W113083
4,0	350	110 - 150	5,0	W113084
5,0	350	160 - 200	5,0	W113085

Afrox 309Mo

Afrox 309Mo is a rutile basic coated low carbon electrode of the 23% chromium, 12% nickel and 2,5% molybdenum type. It is recommended for welding corrosion resistant CrNiMo steels to themselves and to mild and low alloy steels. 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. Afrox 309Mo 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 steels.

Classifications		
AWS	A5.4	E309MoL-16
ISO	3581-A	E23 12 2 L R12
ISO	3581-B	ES 309L Mo-16

Typical Chemical Analysis			
% Carbon	0,04 max	**% Nickel**	13,2
% Manganese	1,0	**% Molybdenum**	2,5
% Silicon	0,75	**% Sulphur**	0,015
% Chromium	22,5	**% Phosphorous**	0,03

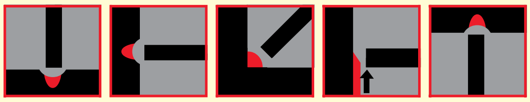
Typical Mechanical Properties (All weld metal in the as welded condition)	
0,2% Proof Stress	520 MPa
Tensile Strength	560 MPa min
% Elongation on 4d	30 min
Charpy V-Notch at +20°C	50 J min
Charpy V-Notch at -70°C	30 J min

Packing Data
(DC+ AC 70 OCV min)

Diameter (mm)	Electrode Length (mm)	Current (A)	Pack Mass (kg)	Item Number (4 electrode sleeve)
2,5	300	50 - 90	3 x 4,0	W075792
3,25	350	70 - 130	3 x 4,0	W075793
4,0	350	100 - 170	3 x 4,0	W075794

Problem Steels MIG & TIG Wires

MIG/TIG 312



MIG/TIG 312 is used for welding medium and high carbon hardenable steels, of known or unknown specifications. Combination of high alloy and high ferrite content gives extreme tolerance to dilution on a wide range of hardenable and alloy steels with minimum or no preheat. Weld deposit work hardens and gives good wear and friction resistance. Not recommended for applications operating above 300°C or for welds to be post weld heat treated.

Materials to be Welded

Medium and high carbon hardenable steels, tool steels and free cutting steels.

Classifications		
AWS	A5.9	ER 312
EN	14343-A	E29 9
EN	14343-B	SS 312

Typical Chemical Analysis			
% Carbon	0,1	**% Chromium**	30,0
% Manganese	1,8	**% Nickel**	9,3
% Silicon	0,4	**% Molybdenum**	0,1
% Sulphur	0,005	**% Copper**	0,1
% Phosphorous	0,02		

Typical Mechanical Properties (All weld metal)			
	MIG		**TIG**
	Argoshield® 5	**Stainshield® Plus**	**Argon**
Tensile Strength	813 MPa	789 MPa	790 MPa
0,2% Proof Stress	628 MPa	638 MPa	640 MPa
% Elongation on 4d	25	10	21
% Reduction of Area	31	10	35
Impact Energy +20°C	-	27 J	>50 J
Hardness	270 HV	300 HV	275 HV
Microstructure	Duplex austenite-ferrite microstructure with approximately 40% ferrite		

Packing Data
MIG (DC+)

Diameter (mm)	Current		Pack Mass (kg)	Item Number
	Amps (A)	Volts (V)		
1,2	220	26	15,0	W033060

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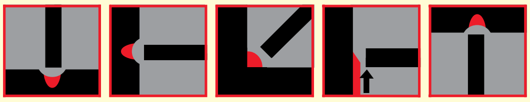
Packing Data TIG (DC-)				
Diameter (mm)	**Current**		**Pack Mass (kg)**	**Item Number**
	Amps (A)	**Volts (V)**		
1,6	120	14	5,0	W030437
2,0	120	14	5,0	W030438
2,4	120	14	5,0	W030439

Suggested gas for welding: Argoshield® 5, Stainshield®, Stainshield® Plus (MIG), Argon (TIG)

MIG/TIG 309LMo



MIG/TIG 309LMo is mainly used under high dilution conditions, particularly, dissimilar welds between stainless and CMn steels. There are no comparable base materials.

Materials to be Welded

There are three main areas of application: buffer layers and clad steels, dissimilar joints and hardenable steels.

Classifications		
AWS	A5.9	ER309LMo (nearest)
EN	14343-A	E23 12 2 L
EN	14343-B	SS 309LMo

Typical Chemical Analysis			
% Carbon	0,015	**% Chromium**	22,0
% Manganese	1,7	**% Nickel**	14,5
% Silicon	0,5	**% Molybdenum**	2,7
% Sulphur	0,005	**% Copper**	0,2
% Phosphorous	0,015	**% Ferrite**	10,0

Typical Mechanical Properties (All weld metal) TIG	
0,2% Proof Stress	350 MPa min
Tensile Strength	550 MPa min
% Elongation on 5d	25 min
Charpy V-Notch at +20°C	>90 J min

Packing Data
MIG (DC+)

Diameter (mm)	Current		Item Number	Pack Mass (kg)
	Amps (A)	Volts (V)		
1,2	220	26	W033048	15,0

TIG (DC-)

Diameter (mm)	Current		Item Number	Pack Mass (kg)
	Amps (A)	Volts (V)		
1,6	100	12	W030429	5,0
2,0	100	12	W030430	5,0
2,4	100	12	W030431	5,0

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

Problem Steels Flux Cored Wires

Metrode Supercore 309Mo

Supercore 309Mo is a flux cored wire for welding under high dilution conditions, particularly dissimilar welds between stainless and CMn steels. There are no comparable base metals. There are three main areas of application.

Buffer layer and clad steel: Overlays on CMn, mild steel or low alloy steels and for joining 316L clad plate. Subsequent layers are deposited with an electrode chosen to not match the cladding, eg. 316L, 318. Also as a buffer layer prior to hard surfacing with chromin carbide type consumables.

Dissimilar joints: Tolerance to dilution is exploited in joining stainless types 410, 304L, 321 and 316L to mild and low alloy steels such as stiffeners, brackets and other attachments. Service temperatures above 300°C are normally avoided. For some of these applications, a more economic alternative may be suitable, eg 309L, 307.

Hardenable steels: The high level of alloying and ferrite level tolerates dilution from a wide range of alloyed and hardenable steels to give crack-free welds.

Classifications		
WS	A5.22	E309LMo T0-4
EN	17633-A	T23 12 2 L R M 3
EN	17633-B	TS309LM0-FM0

Typical Chemical Analysis			
% Carbon	0,03	**% Chromium**	23,0
% Manganese	1,3	**% Nickel**	12,8
% Silicon	0,7	**% Molybdenum**	2,7
% Sulphur	0,01	**% Copper**	2,3
% Phosphorous	0,02		

Typical Mechanical Properties (All weld metal in the as welded condition)	
0,2% Proof Stress	550 MPa
Tensile Strength	700 MPa
% Elongation on 5d	30
Charpy V-Notch at +20°C	50 J
Hardness HV	245
Microstructure	Austenite with ferrite in the range 10-30FN

Packing Data
MIG (DC+)

Position	Diameter (mm)	Current		Item Number	Pack Mass (kg)
		Amps (A)	Volts (V)		
F, HF	1,2	180	26	W081112	15,0

Suggested gas for welding: Afrox Fluxshield® but can be used with 100% CO_2. For CO_2, increase voltage by 3 V