NICKEL

Welding of Nickel-Based Alloys

Nickel-based alloys have nickel as their main constituent, generally making up over 50% of these types of alloys. They are primarily used for their corrosion properties, but are also used for their heat resistance, low expansion characteristics and electrical resistance.

The most important group of general-purpose nickel alloys are the Inconel® types which are based on the heat resistant alloy 600 made of nickel, chrome and iron. These alloys are used in applications from cryogenic processes at -196°C to elevated temperatures of up to 1 000°C. They are also used in power generation for steam turbine power plants, aircraft gas turbines, nuclear power plants, furnaces as well as in the chemical and petrochemical industries.

Monel® 400 is an alloy made from nickel and copper, used in marine and offshore environments for the fabrication of heat exchangers, evaporators, piping and vessels as well as in the chemical, petrochemical, and power generation industries.

These alloys are known by many other proprietary alloy names in the industries in which they are used, such as Inconel®, Monel® and Incoloy® from Special Metals, Nicrofer® and Nicorros® from Krupp VDM, Pyromet® from Carpenter Alloys and Hastelloy® from Haynes International Inc. Generally, these alloys are readily joined by most welding processes.

Nickel alloys can be joined by all the common types of welding process such as Manual Metal Arc (MMA), Metal Inert Gas (MIG), Tungsten Inert Gas (TIG) and Submerged Arc Welding (SAW), but not by the forge welding or oxy-acetylene processes. For the majority of applications on wrought nickel alloys, no preheat or post weld heat treatment will be required. In certain special cases, a post weld heat treatment may be required for stress relief of a fabricated structure or to avoid age hardening and stress corrosion cracking problems in acid or caustic environments. Nickel and nickel alloys can however be susceptible to embrittlement by low melting point elements such as sulphur, lead and phosphorous. These elements can occur in grease, paint, oil crayons, inks, cutting fluids, shop dirt or processing chemicals. It is therefore important that components to be welded are completely free of these contaminants before welding begins.

Shielding Gases for Nickel Alloys

Either argon or helium or mixtures of the two can be used to weld nickel alloys. Any additions of oxygen, carbon dioxide or nitrogen will usually cause problems with porosity and result in erosion of the electrode in TIG welding. Argon with 5% hydrogen can be used and can be beneficial when welding pure nickel by reducing the formation of oxides.

Afrox Products for Welding Nickel Alloys

Product	Specification	Alloys to be Welded	Applications
Afrox 182 Filmax NiCr-3 TIG NiCr-3	AWS A5.11 ENiCrFe-3 EN ISO 14172 E6182 AWS A5.14 ERNiCr-3 EN ISO 18274 SNi6082	Inconel® 600 Nimonic 75	Nickel-based alloys to themselves and to mild, low alloy steels and stainless steels. High temperature transition joints. Cryogenic 3% and 5% Ni steels. Transition welds between creep-resisting ferritic and austenitic steels such as 2CrMo (B3) and 316H.
Afrox 625 Filmax NiCrMo-3 TIG NiCrMo-3 SAW NiCrMo-3	AWS A5.11 ENiCrMo-3 EN ISO 14172 ENi6625 AWS A5.14 ERNiCrMo-3	Inconel® 625 Nicrofer® 6020hMo Nicrofer® 6022hMo Inconel® 601 Incoloy® 800H Incoloy® 825 UNS S31254 254SMO 904L 9% Ni steels Combinations of the above	For welding proprietary alloys 625 for high temperature strength and structural stability. Also widely used for corrosion resistance to general corrosion, pitting, crevice and stress corrosion cracking in severe chloride media. Also used in overlays on pumps, valves and shafts in offshore and marine environments. Other applications include furnace parts, petrochemical and power generation plants.
Afrox C276 Filmax NiCrMo-4 TIG NiCrMo-4	AWS A5.11 ENiCrMo-4 EN ISO 14172 ENi6276 AWS A5.14 ERNiCrMo-4	Hastelloy® alloy C-276 Inco alloy C-276 Nicrofer® 5716hMoW	For welding proprietary alloy C276. The alloy has higher resistance to corrosion in a wide range of acids and salts under oxidising and especially reducing conditions. These include hydrochloric and hydrofluoric acids, hypochlorites, chlorides and wet chlorine gas, sulphuric, phosphoric and many organic acids. Exceptional resistance to crevice corrosion and pitting in sea water and chloride-induced stress corrosion cracking (superior to alloy 625). High temperature stability is limited by intermetallic phase formation. These consumables have good tolerance to dilution by most ferrous and high nickel alloys, and are suitable for surfacing and dissimilar welds which exploit the corrosion resistance, strength and toughness. Excellent properties, below -196°C, allows its use for welding 5 - 9% Ni steels in cryogenic installations. Applications include pumps, valves, pipework and vessels for use in aggressive environments in chemical process plants; also in equipment for flue gas desulphurisation and critical equipment in offshore oil and gas production.

Product	Specification	Alloys to be Welded	Applications
Afrox NiCu-7 Filmax NiCu-7 TIG NiCu-7	AWS A5.11 ENiCu-7 EN ISO 14172 ENi4060 AWS A5.14 ERNiCu-7	Monel® alloy 400, R405, K500 Nicorros®	For welding alloy 400 and similar parent metals to itself and to others in the Ni-Cu alloy system, such as pure nickel and cupro-nickel. Welds in alloy K500 are satisfactory, but cannot match the strength of this precipitation-hardening alloy. Castings of alloy 400 with up to about 1,5% Si are welded with Afrox NiCu-7, but higher grades such as BS3071 NA2 and ASTM A743 M35-2 are virtually unweldable because of HAZ cracking. For dissimilar joints between alloy 400 and other alloy steels, sensitivity to dilution by Fe (20 - 30%) or Cr (3 - 6%) can lead to low ductility (or bend test fissures) in weld metal close to the fusion boundary. Direct welds to mild steel or low alloy steels are satisfactory with dilution control, although ENiCrFe-X (ERNiCr-3 wire) is preferable and necessary for stainless steel and higher chromium alloys. Alternatively, the steel alloy can be buttered with pure nickel, and this procedure is also useful when surfacing with alloy 400 consumables. Alloy 400 has a useful combination of strength, thermal conductivity and resistance to corrosion by seawater, inorganic salts, sulphuric and hydrofluoric acids, hydrogen fluoride and alkalis. Applications include heat exchangers piping, vessels and evaporators in offshore, marine, chemical, petrochemical and power generation industries.
Metrode Nimrod 200Ti Filmax Ni-1 TIG Ni-1	AWS A5.11 ENi-1 EN ISO 14172 ENi2061 AWS A5.14 ERNi-1	Nickel 200 and 201 Nickel 99.6 and 99.2	These consumables give low carbon pure nickel weld metal with the addition of titanium for refinement and de-oxidation. They are used for joining pure nickel to itself, for buffer layers, and for cladding joint faces and flanges. The solid wire is also useful for welding cast iron to give soft low strength deposit. Applications include tanks and vessels, process pipework and heat exchangers, in chemical plants for salt production, chlorination and evaporation of caustic soda. Also used for handling corrosive alkalis and halides.

Nickel Electrodes

Afrox 182

Afrox 182 is a basic coated, semi-synthetic, high recovery, nickel-based electrode for the welding of nickel alloys and many dissimilar metal joints. Characteristics include smooth bead appearance, low spatter loss, and easy slag removal. Afrox 182 is suitable for the welding of alloys 600, 601, 800 and similar high nickel steels as well as 5% and 9% nickel steels. Afrox 182 is also suitable for dissimilar joints between nickel-based alloys and carbon and stainless steels, and can also be used for the joining of difficult to weld steels.

Applications

Applications include heat-resisting nickel-based alloys to themselves for use in furnace equipment up to about 900°C. Other applications include: mixed welds between most nickel-based alloys, including Monel® 400 and stainless, low alloy or CMn steels without need to preheat. Transition welds between creep-resisting ferritic and austenitic steels, such as 2CrMo and 316H for long-term service at an elevated temperature in petrochemical and power generation plants. Low temperature applications such as 3% or 5% Ni steels used for cryogenic vessels and pipework in service at or below -100°C. Stress relief may be carried out if required.

Materials to be Welded

Nickel alloys such as Inconel® 600 and Nimonic 75. Nickel-based alloys to themselves and to mild, low alloy and stainless steels. High temperature transition joints. Cryogenic 3% and 5% Ni steels.

Storage and Re-baking

Re-dry at 250°C for 2 hours to restore to as-packed condition. Maximum 380°C, 3 cycles, 10 hours total.

Storage of re-dried electrodes at 50 – 200°C in holding oven or heated quiver: no limit, but maximum 6 weeks recommended.

Classifications		
AWS	A5.11	ENiCrFe-3
EN ISO	14172	ENi6182 (NiCr15Fe6Mn)

Typical Chemical Analysis			
% Carbon	0,10 max	**% Chrome**	13,0 - 17,0
% Manganese	5,0 - 9,5	**% Nickel**	60,0 min
% Silicon	1,0 max	**% Niobium**	1,0 - 2,5
% Sulphur	0,015 max	**% Iron**	2,0 - 9,0
% Phosphorous	0,02 max	**% Titanium**	1,0 max

Typical Mechanical Properties (All weld metal in the as welded condition)	
0,2% Proof Stress	350 MPa min
Tensile Strength	635 MPa min
% Elongation on 5d	32
Impact Energy at -196°C	65 J min
Hardness	190 HV

Packing Data (DC+)				
Diameter (mm)	**Electrode Length (mm)**	**Current (A)**	**Pack Mass (kg)**	**Item Number**
3,2	350	100 - 140	5,0	W075943
4,0	350	140 - 180	5,0	W075944

Afrox 625

Afrox 625 is a basic coated electrode for the welding of nickel alloys, super austenitic alloys, cryogenic 9% nickel steels, and for dissimilar metal joints. The weld deposit is resistant to general corrosion, pitting, crevice and stress corrosion cracking in severe chloride media. It is also used for welding heat resisting alloys, such as Inconel® 600 and 625 as well as Incoloy® 800 and 825. The electrodes are also used for the joining of these nickel alloys to low and high alloy steels and cast steels. These properties are conferred by high levels of chromium, molybdenum and niobium, which also raise strength to the highest amongst standard nickel-based alloys. Useful properties from -269°C to above 1 000°C are achieved.

Applications

In addition to matching alloy 625, suitable for welding heat resisting alloys including Inconel® 601 (except severe sulphidising conditions), Incoloy® 800/800H, or combinations of these with other alloys for furnace equipment, petrochemical and power generation plants. Some other applications include: overmatching corrosion resistant welds in alloy 825, Hastelloy® G and G3, alloy 28, 904L, 6% Mo super austenitic stainless 254 SMO®. Also in overlays on pumps, valves and shafts, often in offshore and marine environments where high pitting resistance (PRE = 50) and tolerance to weld metal dilution are essential. Welds in high strength ferrous alloys including cryogenic 9% nickel steels and for reclamation of dies where rapid work hardening and toughness are required.

Storage and Re-baking

Re-dry electrodes for 2 hours at 250ºC.

Storage of re-dried electrodes at 50 – 200°C in holding oven or heated quiver: no limit, but maximum 6 weeks recommended.

Materials to be Welded		
Matching Alloy 625		
ASTM-ASME	**DIN**	**BS**
UNS N06625	**2.4856**	**NA21**
A494 CW-6MC (cast)		
Proprietary Alloys		
Inconel® 625 (Inco)		
Nicrofer® 6020hMo (VDM)		
Nicrofer® 6022hMo (VDM)		
Other Alloys		
High Nickel Alloys	**Super Austenitic Alloys**	
Inconel® 601 (Inco)	UNS S31254	
Incoloy® 800H (Inco)	254 SMO® (Avesta)	
Incoloy® 825	904L (Inco)	
And equivalents	Similar alloys	
Cryogenic	**Dissimilar**	
9% Ni steels	Combinations of above	

Classifications		
AWS	A5.11	ENiCrMo-3
EN ISO	14172	ENi6625 (NiCr22Mo9Nb)

Typical Chemical Analysis (All weld metal)			
% Carbon	0,1 max	**% Chrome**	20,0 - 23,0
% Manganese	2,0 max	**% Nickel**	55,0 min
% Silicon	0,8 max	**% Molybdenum**	8,0 - 10,0
% Sulphur	0,015 max	**% Niobium**	3,0 - 4,0
% Phosphorous	0,02 max	**% Iron**	7,0 max

Typical Mechanical Properties (All weld metal in the as welded condition)	
0,2% Proof Stress	520 MPa
Tensile Strength	780 MPa
% Elongation on 5d	35
Impact Energy at +20°C	80 J
Impact Energy at -196°C	50 J
Hardness	250 HV
Hardness (Work hardened)	450 HV

Packing Data and Operating Current (DC+)

Diameter (mm)	Electrode Length (mm)	Current (A)	Pack Mass (kg)	Item Number
2,5	350	50 - 70	5,0	W075952
3,2	350	75 - 95	5,0	W075953
4,0	350	90 - 120	5,0	W075954

Afrox C276

Afrox C276 is an MMA electrode for the manufacture and repair of hot forming tools and for oxidation and corrosion resistant overlays. It is used for the manufacture and repair of drop forging dies, hot forming dies, pump impellers, retorts and valves. Not only can it be used for overlays, but it can be used for joining special alloys such as Hastelloy® C276 to itself or to stainless steels.

Afrox C276 is a heavily coated electrode with approximately 170% metal recovery. The electrode has excellent welding characteristics and de-slagging properties.

Alloy C276 has high resistance to corrosion in a wide range of acids and salts under oxidising and especially reducing conditions. These include hydrochloric and hydrofluoric acids, hypochlorites, chlorides and wet chlorine gas, sulphuric, phosphoric and many organic acids. Exceptional resistance to crevice corrosion and pitting in seawater and chloride-induced stress corrosion cracking (superior to alloy 625). High temperature stability is limited by intermetallic phase formation. In addition to fabrication welds in alloy C276, these consumables have good tolerance to dilution by most ferrous and high nickel alloys. Also suitable for surfacing and dissimilar welds which exploit the corrosion resistance, strength and toughness. Excellent properties to below -196°C allow its use for welding 5 - 9% Ni cryogenic installations.

Applications

Applications include pumps, valves, pipework and vessels for use in aggressive environments in chemical process plants; also in equipment for flue gas desulphurisation and critical equipment in offshore oil and gas production.

Storage and Re-baking

Re-dry electrodes for 2 hours at 250°C.

Storage of re-dried electrodes at 50 – 200°C in holding oven or heated quiver: no limit, but maximum 6 weeks recommended.

Materials to be Welded	
Wrought	
ASTM	**DIN**
UNS N10276	2.4819 (NiMo16Cr15W)
Cast	
A494 CW-12MW	
A743/A744 CW-12M	
2.4883 (G-NiMo16Cr)	
Proprietary	
Hastelloy® alloy C-276 (Haynes)	
Inco alloy C-276 (Special Metals)	
Nicrofer® 5716hMoW (VDM)	

Classifications		
AWS	A5.11	ENiCrMo-4 (nearest)
EN ISO	14172	ENi6276 (NiCr15Mo15Fe6W4 nearest)

Typical Chemical Analysis (All weld metal)			
% Carbon	0,03 max	**% Nickel**	Bal.
% Sulphur	0,03 max	**% Molybdenum**	14,5
% Phosphorous	0,04 max	**% Tungsten**	4,2
% Chrome	14,5	**% Iron**	6,5

Typical Mechanical Properties (All weld metal in the as welded condition)	
0,2% Proof Stress	520 MPa
Tensile Strength	710 MPa
% Elongation on 5d	27
Hardness*	220 - 230 HB

*Work hardens to about 375 - 420 HB

Packing Data and Operating Current (AC/DC+)

Diameter (mm)	Electrode Length (mm)	Current (A)	Pack Mass (kg)	Item Number
2,5	350	110 - 125	5,0	W075962
3,2	350	140 - 155	5,0	W075963
4,0	350	170 - 185	5,0	W075964

Afrox NiCu-7

Afrox NiCu-7 is an electrode for the welding of Monel® and Monel® plated steel and the cladding of steel. It is used mainly in the chemical industry and in shipbuilding for propellers, shafts and pumps. It can be used for welding alloy 400 and similar parent materials to itself and to others in the NiCu alloy system, such as pure nickel and cupro-nickel. Welds in alloy K500 are satisfactory, but cannot match the strength of this precipitation-hardened alloy. Castings of alloy 400 with up to about 1,5% Si are welded with Afrox NiCu-7, but higher silicon grades such as BS3071 NA2 and ASTM A743 M35-2 are virtually unweldable because of HAZ cracking. For dissimilar joints between alloy 400 and other alloys or steels, sensitivity to dilution by Fe (20 - 30%) or Cr (3 - 6%) can lead to low ductility (or bend-test fissuring) in weld metal close to the fusion boundary. Direct welds to mild or low alloy steels are satisfactory with dilution control, although ENiCrFe-X (ERNiCr-3 wire) is preferable and necessary for stainless and higher chromium alloys. Alternatively, the steel or alloy can be buttered with pure nickel and this procedure is also useful when surfacing with alloy 400 consumables. Alloy 400 has a useful combination of strength, thermal conductivity and resistance to corrosion by seawater, inorganic salts, sulphuric and hydrofluoric acids, hydrogen fluoride and alkalis.

Applications

Applications include heat exchangers, piping, vessels and evaporators in the offshore, marine, chemical, petrochemical and power engineering industries.

Storage and Re-baking

Re-dry at 250°C for 2 hours to restore to as-packed condition. Maximum 350°C, 3 cycles, 10 hours total.

Storage of re-dried electrodes at 50 – 200°C in holding oven or heated quiver: no limit, but maximum 6 weeks recommended.

Materials to be Welded		
ASTM-ASME	**DIN**	**BS**
UNS N04400	2.4360	NA13
UNS N04405	2.4361	NA1 (cast)
UNS N05500	2.4365 (cast)	
A494 M-35-1 (cast)		
A494 M-35-2 (cast)		
Proprietary Alloys		
Monel® alloy 400, R405, K500 (Special Metals)		
Nicorros® (VDM)		

Classifications		
AWS	A5.11	ENiCu-7
EN ISO	14172	ENi4060 (NiCu30Mn3Ti)

Typical Chemical Analysis (All weld metal)			
% Carbon	0,15 max	**% Copper**	27,0 - 34,0
% Manganese	4,0 max	**% Nickel**	62,0
% Silicon	1,0 max	**% Titanium & % Niobium**	0,6
% Sulphur	0,015 max	**% Iron**	< 3,0
% Phosphorous	0,02 max		

Typical Mechanical Properties (All weld metal in the as welded condition)	
0,2% Proof Stress	520 MPa
Tensile Strength	400 - 600 MPa
% Elongation on 5d	30
Impact Energy at +20°C	110 J
Hardness	160 - 180 HV

Packing Data and Operating Current (DC+)

Diameter (mm)	Electrode Length (mm)	Current (A)	Pack Mass (kg)	Item Number
2,5	350	70 - 90	5,0	W075972
3,2	350	80 - 125	5,0	W075973
4,0	350	105 - 165	5,0	W075974

Nickel MIG & TIG Wires

Afrox Filmax Ni-1
Afrox TIG Ni-1

Afrox Ni-1 solid wires for TIG and MIG welding are designed to give a low carbon pure nickel deposit with the addition of titanium for refinement and de-oxidation. They are used for joining pure nickel to itself, for buffer layers and for cladding joint faces and flanges. The solid wire is also useful for welding cast iron to give a soft low strength deposit.

Applications

Applications include tanks and vessels, process pipework and heat exchangers, in chemical plants for salt production and chlorination and evaporation of caustic soda. Also used for handling corrosive alkalis and halides. Repair and rebuilding of standard grades of grey cast irons and malleable cast irons.

Materials to be Welded		
ASTM-ASME	**DIN**	**BS**
UNS N02200	2.4066	NA11
UNS N02201	2.4068	NA12
	2.4061	
Proprietary Alloys		
Nickel 200 and 201 (Special Metals)		
Nickel 99.6 and 99.2 (VDM)		

Classifications		
AWS	A5.14	ERNi-1
EN	18274	ENi2061 (NiTi3)

Typical Chemical Analysis (All weld metal)			
% Carbon	0,15 max	**% Nickel**	93,0 min
% Manganese	1,0 max	**% Titanium**	2,0 - 3,5
% Silicon	0,7 max	**% Copper**	0,2 max
% Sulphur	0,015 max	**% Iron**	1,0 max
% Phosphorous	0,02 max	**% Aluminium**	1,5 max

Typical Mechanical Properties (All weld metal in the as welded condition)	
0,2% Proof Stress	355 MPa
Tensile Strength	585 MPa
% Elongation on 4d	35
% Elongation on 5d	31
% Reduction of Area	65
Hardness cap/mid	155/185 HV

Packing Data (DC+ AC 70 OCV min)						
MIG			TIG			
Diameter (mm)	Pack Mass (kg)	Item Number	Diameter (mm)	Pack Mass (kg)	Consumable Length (mm)	Item Number
1,0	15,0	W077672	1,6	5,0	1 000	W077667
1,2	15,0	W077673	2,0	5,0	1 000	W077668
1,6	15,0	W077674	2,4	5,0	1 000	W077669

Afrox Filmax NiCr-3
Afrox TIG NiCr-3

Afrox NiCr-3 is a solid wire for welding of nickel-based alloys and dissimilar joints between nickel alloys, ferritic and austenitic stainless steels. These weld metals have no directly equivalent parent material, although the composition is related to Inconel® 600. Mn and Nb are added to give high resistance to hot cracking, tolerance to dilution by many combinations of nickel-based and ferrous alloys, with stable properties over a wide range of service temperatures from -196°C to above 900°C.

Applications

Applications include heat-resisting nickel-based alloys to themselves for use in furnace equipment up to about 900°C. Other applications include: mixed welds between most nickel-based alloys, including Monel® 400 and stainless, low alloy or CMn steels without need to preheat. Transition welds between creep-resisting ferritic and austenitic steels, such as 2CrMo and 316H for long-term service at elevated temperature in petrochemical and power generation plants. Low temperature applications such as 3% or 5% Ni steels used for cryogenic vessels and pipework in service at or below -100°C. Stress relief may be carried out if required.

Materials to be Welded

Nickel alloys such as Inconel® 600, Nimonic 75. Nickel-based alloys to themselves and to mild, low alloy and stainless steels. High temperature transition joints. Cryogenic 3% and 5% Ni steels.

Classifications		
AWS	A5.14	ERNiCr-3
EN	18274	ENi6082 (NiCr20Mn3Nb)

Typical Chemical Analysis (All weld metal)			
% Carbon	0,05 max	**% Nickel**	67,0 min
% Manganese	2,5 - 3,5	**% Titanium**	0,7 max
% Silicon	0,5 max	**% Niobium**	2,0 - 3,0
% Sulphur	0,015 max	**% Iron**	3,0 max
% Phosphorous	0,02 max	**% Copper**	0,50 max
% Chrome	18,0 - 22,0		

Typical Mechanical Properties (All weld metal in the as welded condition)	
0,2% Proof Stress	360 MPa
Tensile Strength	640 MPa
% Elongation on 4d	40
Impact Energy at -196°C	100 J min

Packing Data

MIG			TIG			
Diameter (mm)	**Pack Mass (kg)**	**Item Number**	**Diameter (mm)**	**Pack Mass (kg)**	**Consumable Length (mm)**	**Item Number**
1,0	15,0	W077631	1,6	5,0	1 000	W077626
1,2	15,0	W077632	2,0	5,0	1 000	W077627
-	-	-	2,4	5,0	1 000	W077628

Afrox Filmax NiCrMo-3
Afrox TIG NiCrMo-3

Afrox NiCrMo-3 solid wires for TIG and MIG welding are designed to match the composition and properties of alloy 625. Originally developed to give high temperature strength and structural stability, alloy 625 is also widely used for its resistance to general corrosion, pitting, crevice and stress corrosion cracking in severe chloride media. These properties are conferred by high levels of chromium, molybdenum and niobium, which also raise strength to the highest amongst standard nickel-based alloys. Useful properties from -269°C to above 1 000°C are achieved.

Applications

In addition to matching alloy 625, suitable for welding heat resisting alloys including Inconel® 601 (except severe sulphidising conditions), Incoloy® 800/800H, or combinations of these with other alloys for furnace equipment, petrochemical and power generation plants. Some other applications include: overmatching corrosion resistant welds in alloy 825, Hastelloys® G and G3, alloy 28, 904L, 6% Mo super austenitic stainless 254 SMO®. Also used for overlays on pumps, valves and shafts, often in offshore and marine environments where high pitting resistance (PRE = 50) and tolerance to weld metal dilution are essential. Welds in high strength ferrous alloys including cryogenic 9% nickel steels and for reclamation of dies where rapid work-hardening and toughness are required.

Materials to be Welded		
Matching Alloy 625		
ASTM-ASME	**DIN**	**BS**
UNS N06625	**2.4856**	**NA21**
A494 CW-6MC (cast)		
Proprietary Alloys		
Inconel® 625 (Inco)		
Nicrofer® 6020hMo (VDM)		
Nicrofer® 6022hMo (VDM)		
Other Alloys		

High Nickel Alloys	**Super Austenitic Alloys**
Inconel® 601 (Inco)	UNS S31254
Incoloy® 800H (Inco)	254 SMO® (Avesta)
Incoloy® 825	904L (Inco)
And equivalents	Similar alloys
Cryogenic	**Dissimilar**
9% Ni steels	Combinations of above

Classifications		
AWS	A5.14	ERNiCrMo-3
EN	18274	ENi6625 (NiCr22Mo9Nb)

Typical Chemical Analysis (All weld metal)			
% Carbon	0,05 max	**% Titanium**	0,4 max
% Manganese	0,5 max	**% Niobium**	3,15 - 4,15
% Silicon	0,5 max	**% Iron**	1,0 max
% Sulphur	0,015 max	**% Copper**	0,5 max
% Phosphorous	0,015 max	**% Aluminium**	0,4 max
% Chrome	20,0 - 23,0	**% Molybdenum**	8,0 - 10,0
% Nickel	60,0 min		

Typical Mechanical Properties (All weld metal in the as welded condition)	
0,2% Proof Stress	520 MPa
Tensile Strength	780 MPa
% Elongation on 4d	42
% Elongation on 5d	40
Impact Energy at -100°C	100 J
Impact Energy at -196°C	80 J
Hardness cap/mid	205/225 HV

Packing Data

MIG			TIG			
Diameter (mm)	**Pack Mass (kg)**	**Item Number**	**Diameter (mm)**	**Pack Mass (kg)**	**Consumable Length (mm)**	**Item Number**
0,8	15,0	W077646	1,6	5,0	1 000	W077642
1,0	15,0	W077647	2,0	5,0	1 000	W077643
1,2	15,0	W077648	2,4	5,0	1 000	W077644

Afrox Filmax NiCrMo-4
Afrox TIG NiCrMo-4

Afrox NiCrMo-4 solid wires for TIG and MIG welding are designed to match the composition and properties of parent alloy C276 with Ni-15% Cr-16% Mo-4% W-5% Fe. Carbon and silicon controlled as close as possible to the very low levels of the wrought alloy to minimise carbide and intermetallic phase precipitates which can reduce as-welded corrosion resistance. Cast versions of the alloy typically have higher carbon and silicon (like the original wrought Hastelloy® alloy C, now obsolete), but repair welds are usually solution treated for optimum corrosion resistance. Alloy C276 has high resistance to corrosion in a wide range of acids and salts under oxidising and especially reducing conditions. These include hydrochloric and hydrofluoric acids, hypochlorites, chlorides and wet chlorine gas, sulphuric, phosphoric and many organic acids. Exceptional resistance to crevice corrosion and pitting in seawater and chloride-induced stress corrosion cracking (superior to alloy 625). High temperature stability is limited by intermetallic phase formation. In addition to fabrication welds in alloy C276, these consumables have good tolerance to dilution by most ferrous and high nickel alloys, and are suitable for surfacing and dissimilar welds which exploit the corrosion resistance, strength and toughness. Excellent properties to below -196°C allow its use for welding 5 - 9% Ni cryogenic installations.

Applications

Applications include pumps, valves, pipework and vessels for use in aggressive environments in chemical process plants; also in equipment for flue gas desulphurisation and critical equipment in offshore oil and gas production.

Materials to be Welded
Wrought
ASTM UNS N10276
Cast
A494 CW-12MW
A743/A744 CW-12M
2.4883 (G-NiMo16Cr)
Proprietary
Hastelloy® alloy C-276 (Haynes)
Inco alloy C-276 (Special Metals)
Nicrofer® 5716hMoW (VDM)

Classifications		
AWS	A5.14	ERNiCrMo-4
EN	18274	ENi6276 (NiCr15Mo16Fe6W4)

Typical Chemical Analysis (All weld metal)			
% Carbon	0,02 max	**% Nickel**	Bal.
% Manganese	1,0 max	**% Tungsten**	3,0 - 4,5
% Silicon	0,08 max	**% Vanadium**	0,3 max
% Sulphur	0,015 max	**% Iron**	4,0 - 7,0
% Phosphorous	0,02 max	**% Copper**	0,5 max
% Chrome	14,5 - 16,5	**% Molybdenum**	15,0 - 17,0

Typical Mechanical Properties (All weld metal in the as welded condition)	
0,2% Proof Stress	500 MPa
Tensile Strength	740 MPa
% Elongation on 4d	46
% Elongation on 5d	43
% Reduction of Area	50

Packing Data

MIG			TIG			
Diameter (mm)	**Pack Mass (kg)**	**Item Number**	**Diameter (mm)**	**Pack Mass (kg)**	**Consumable Length (mm)**	**Item Number**
1,2	15,0	W077746	1,6	5,0	1 000	W077654

Afrox Filmax NiCu-7
Afrox TIG NiCu-7

Afrox NiCu-7 solid wires for TIG and MIG welding are designed to deposit 65% Ni-30% Cu weld metal based on Monel® alloy 400 with raised levels of manganese and titanium to suppress hot cracking and porosity. It is optimised to give the highest as welded ductility and strength attainable in weld metal of this type. For welding alloy 400 and similar parent material to itself and to others in the NiCu alloy system, such as pure nickel and cupronickel. Welds in alloy K500 are satisfactory, but cannot match the strength of this precipitation-hardened alloy. Castings of alloy 400 with up to about 1,5% Si are welded with Nimrod 190, but higher silicon grades such as BS3071 NA2 and ASTM A743 M35-2 are virtually unweldable because of HAZ cracking. For dissimilar joints between alloy 400 and other alloys or steels, sensitivity to dilution by Fe (20 – 30%) or Cr (3 – 6%) can lead to low ductility (or bend-test fissuring) in weld metal close to the fusion boundary. Direct welds to mild or low allow steels are satisfactory with dilution control, although ENiCrFe-X (ERNiCr-3 wire) is preferable and necessary for stainless and higher chromium alloys. Alternatively, the steel alloy can be buttered with pure nickel and this procedure is also useful when surfacing with alloy 400 consumables. Alloy 400 has a useful combination of strength, thermal conductivity and resistance to corrosion by seawater, inorganic salts, sulphuric and hydrofluoric acids, hydrogen fluoride and alkalis.

Applications

These include heat exchangers, piping, vessels and evaporators in the offshore, marine, chemical, petrochemical and power engineering industries.

Materials to be Welded		
ASTM-ASME	**DIN**	**BS**
UNS N04400	**2.4856**	**NA21**
UNS N04405	2,4361	NA1 (cast)
UNS N05500		2,4365 (cast)
A494 M-35-1 (cast)		
A494 M-35-2 (cast)		
Proprietary		
Monel® alloy 400, R405, K500 (Special Metals)		
Nicorros (VDM)		

Classifications		
AWS	A5.14	ERNiCu-7
DIN	1736	SG-NiCu30MnTi (2,4377)
BS2901	PT5	NA33

Typical Chemical Analysis (All weld metal)			
% Carbon	0,15 max	**% Nickel**	62,0 - 69,0
% Manganese	3,0 - 4,0	**% Copper**	28,0 - 34,0
% Silicon	1,0 max	**% Titanium**	1,5 - 3,0
% Sulphur	0,015 max	**% Iron**	2,5 max
% Phosphorous	0,02 max	**% Aluminium**	1,25 max

Typical Mechanical Properties (All weld metal in the as welded condition)	
0,2% Proof Stress	280 MPa
Tensile Strength	525 MPa
% Elongation on 4d	41
% Elongation on 5d	38
Impact Energy at -30°C	120 J

Packing Data						
MIG			TIG			
Diameter (mm)	Pack Mass (kg)	Item Number	Diameter (mm)	Pack Mass (kg)	Consumable Length (mm)	Item Number
1,2	15,0	W077688	1,6	5,0	1 000	W077682
1,6	15,0	W077689	2,0	5,0	1 000	W077683
-	-	-	2,4	5,0	1 000	W077684

Nickel Submerged Arc Wires

Afrox Subarc NiCrMo-3

Afrox Subarc NiCrMo-3 is a submerged arc welding wire and is designed to match the composition and properties of alloy 625. These properties are conferred by high levels of chromium, molybdenum and niobium, which also raise strength to the highest amongst standard nickel-based alloys. Useful properties from -196°C to above 1 000°C are achieved.

Applications

Originally developed to give high temperature strength and structural stability, alloy 625 is also widely used for its resistance to general corrosion, pitting, crevice and stress corrosion cracking in severe chloride media. Recommended flux: Metrode NiCr Flux (Item Number W077702).

Materials to be Welded		
Matching Alloy 625		
ASTM-ASME	**DIN**	**BS**
UNS N06625	**2.4856**	**NA21**
A494 CW-6MC (cast)		
Proprietary Alloys		
Inconel® 625 (Inco)		
Nicrofer® 6020hMo (VDM)		
Nicrofer® 6022hMo (VDM)		
Other Alloys		
High Nickel Alloys	**Super Austenitic Alloys**	
Inconel® 601 (Inco)	UNS S31254	
Incoloy® 800H (Inco)	254 SMO® (Avesta)	
Incoloy® 825	904L (Inco)	
And equivalents	Similar alloys	
Cryogenic	**Dissimilar**	
9% Ni steels	Combinations of above	

Classifications		
AWS	A5.14	ERNiCrMo-3
EN	18274	ENi6625 (NiCr22Mo9Nb)

Typical Chemical Analysis (All weld metal)			
% Carbon	0,05 max	**% Titanium**	0,4 max
% Manganese	0,5 max	**% Niobium**	3,15 - 4,15
% Silicon	0,5 max	**% Iron**	1,0 max
% Sulphur	0,015 max	**% Copper**	0,5 max
% Phosphorous	0,015 max	**% Aluminium**	0,4 max
% Chrome	20,0 - 23,0	**% Molybdenum**	8,0 - 10,0
% Nickel	60,0 min		

Typical Mechanical Properties (All weld metal in the as welded condition)	
0,2% Proof Stress	430 MPa
Tensile Strength	715 MPa
% Elongation on 4d	50
% Elongation on 5d	47
Impact Energy at -196°C	100 J
Hardness cap/mid	235/255 HV

Packing Data

SAW		
Diameter (mm)	**Pack Mass (kg)**	**Item Number**
2,4	25,0	W077639
3,2	25,0	W077640