



WELDING PRODUCT PROGRAMME

Nickel Alloys

- Customized formulations
- Consistent quality
- Single point source for complete range
- Technical expertise
- Experience in worldwide major projects
- Selectarc range covers a wide range of specifications

 **Selectarc**
WELDING

FSH Welding Group works to ensure its customers get the full benefit of its very extensive expertise.

For more than six decades FSH Welding Group has played a crucial role in the development of welding technology. Wherever arc welding processes are being used, you will find FSH Welding Group products and know-how. Selectarc Industries' arc welding electrodes manufacturing plant has built up a reputation for leading expertise in the field, ranking it one of the global market leaders in welding technology.

High Quality Products, its services and its highly focused Research & Development has over the years made the group a benchmark among the largest manufacturers in the world.

A comprehensive range of high-quality products for welding and cutting, combined with a flexible range of services, forward-looking research and development and reliability becomes first choice of Customer for FSH welding consumables.

Our aim is simple yet ambitious: to constantly improve to ensure the satisfaction of every single customer.



Highly Corrosion resistant Ni-Base Consumables for Welding and Cladding

The main constituent of Nickel-based alloys is Ni as major element with >50%. Nickel alloys have a higher tolerance for alloying elements in solid solution than stainless steels and other iron-based alloys but maintain good metallurgical stability. These factors have prompted development of nickel-based alloys with multiple alloying additions to provide resistance to a wide variety of corrosive environments.

The most important group of general-purpose nickel alloys are the Inconel® types which are based on the general corrosion and heat resistant alloy 600 made of Ni, Cr and Fe. These alloys are used for applications from cryogenic processes at -196°C to elevated temperatures of up to 1000°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.

Nickel Alloys

Properties / Advantages

- Austenitic Structure
- No phase transformations
- Do not harden
- In most environments Nickel is more corrosion resistant than Iron
- Alloying with chromium provides resistance to oxidation thus providing a broad spectrum of alloys for optimum corrosion resistance in both reducing and oxidizing environments
- High resistance to corrosion fatigue and erosion
- Good stress corrosion resistance
- High creep strength
- Excellent toughness
- Good workability and weldability



Nickel alloys used in varied fields

For high temperature strength and structural stability. In high temperature dissimilar joints.

Cryogenic 3%, 5% and 9% Ni steels (welding).

Dissimilar welds which exploit the corrosion resistance, strength and toughness.

For resistance to general corrosion. To give sufficient resistance against Pitting and Crevice corrosion as well as against Stress corrosion cracking in severe chloride media (see graphic).

For the fabrication of:

- Heat exchanger piping, Evaporators, Ventilators
- Overlays on pumps, valves and shafts in offshore and marine environments.
- Conveyors belts
- Coal gasification
- Pipes and mould casting parts
- Gas turbines, rocket drives, nuclear reactors
- Forging tools
- Furnace parts
- ...

In the fields of:

- Marine and offshore environments
- Power generation industries
- Chemical and Petrochemical industry
- ...



Weldability of Nickel Alloys

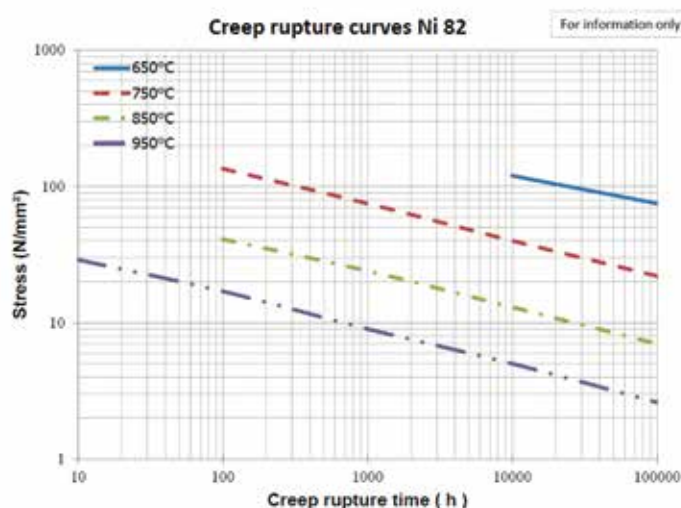


Nickel alloys can be joined, with some limitations, by all the common types of welding processes such as Manual Metal Arc (MMA / SMAW), Metal Inert Gas (GMAW / MIG), Tungsten Inert Gas (GTAW / TIG) and Submerged Arc Welding (SAW).

Welding procedure of Nickel alloys are similar to those of Stainless steel.

With respect to corrosion resistance, low impurities and high impact resistance, the TIG process is thought to give best results; but due to its low deposition rate it is mainly used for root and hot passes and thin walled pipes. The application of SAW is limited to thick walled components. For some nickel base alloys it cannot be applied as the weld deposit is more sensitive to hot cracks than for other processes. The diameter of the wire electrode is limited to 2,4mm for SAW to reduce the linear heat put. In most corrosive media, the resistance of the weld metal is similar to that of the base metal. Overmatching filler metals may be required for joints in some aggressive environments.

Example of Creep Resistance graphic



Welding Procedure

1 Pre-heating treatment

Preheating nickel alloys prior to welding is not normally required. However, if the base metal is cold (12°C or less), it should be warmed to at least 20°C above the ambient temperature to prevent the formation of condensate as moisture can cause weld porosity. Preheat of the steel component may be required when joining a nickel alloy to carbon steel. Preheat is often beneficial when joining special steel castings.

2 Welding

The following hints have to be followed to get sound and highly corrosion resistant weld joints:

- **Cleanliness** is extremely important.
- The weld surface can be cleaned by grinding, brushing or pickling.
- The joint area has to be **free of contaminations**, especially of oil, grease, dust, ink, paint, shop dirt, etc. Oxide films have to be removed on both sides of the weld joint to a minimum of 10 mm
- The **opening angle** must be wider than for carbon steel weld preparations, in general **60-70 degrees**
- Tack-welding must be performed in shorter intervals and a sufficiently wide root gap of about 2-3 mm has to be provided.

When using MMA, electrodes have to be re-baked before welding.

The stringer-bead-technique is recommended, where weaving should be restricted to 2.5 times the core wire diameter (except for vertical-up- welds).

- The electrodes should be held in a **steep angle of 10-20 degrees** to the vertical and an arc as short as possible should be maintained.
- End craters have to be filled and ground out on the root run.
- When welding the other beads, strike the arc approximately 10 mm before the end crater of the last deposited electrode, then move back to the end crater and weld over the strike point.

Welding Parameters - Shielding Gases

For all processes the inter-pass temperature should not exceed 150 °C and the linear energy input E_s should be between 8-12 kJ/cm.

**Where $E_s = (V \times A) / S \times 60/1000$; $V =$ Arc voltage (V) ; $A =$ Welding current (A) ;
 $S =$ welding speed (mm / min).**

In multiple pass applications, slag and oxide films have to be removed with a stainless steel brush after each pass.

GTAW: To weld nickel alloys in general pure argon is used but also helium or mixtures of the two can be used. For back shielding Argon or in some cases Argon plus < % Hydrogen is used.

GMAW: Argon or Argon- Helium mixtures can be used, but for better arc stability multi-component shielding gases (Ar+He+H₂+CO₂) are recommended.



3 Post weld heat treatment

A post weld heat treatment (PWHT) is not recommended. Precipitation hardenable alloys welded with hardenable welding products must be heat treated to develop full strength. It may also be desirable to stress relieve or anneal heavily stressed welded structures to be exposed to environments which can induce stress corrosion cracking (applies almost for all clad components).

4 Cleaning, Pickling and Passivation

Cleaning the surface of a nickel alloy may be required to prevent process contamination or to ensure performance. Surface conditions that can effect corrosion resistance may be due to surface contamination (including embedded iron), to mechanical damage, and to welding related artefacts. Some contaminants may be removed by degreasing. The use of a non-chlorinated solvent is effective (acetone). The use of a chlorinated solvent is not recommended.

During fabrication, metal products often come in contact with steel components and tools. Transportation, handling, forming, grinding and welding can all result in physical contact with iron-based structures. During such contact, iron may become embedded into the surface of an alloy component. Parts fabricated from such grades should be cleaned prior to exposure to this type of service environment to optimize resistance to corrosion.



Storage and Handling

In general, MMA electrodes should be used in the dry condition. In the course of time, electrode coatings will absorb moisture from the humidity of the ambient air. Therefore, it is recommended that MMA electrodes are stored in a dry location with undamaged packaging until use.

Depending on the coating type and the base metal to be welded electrodes have to be re-cooked before welding.



Packaging

- MMA:**
5 Kg plastic boxes or Metcan
- TIG:**
5 Kg tubes
- MIG:**
D300 (15Kg), D200 (5Kg), D100 (1Kg)
- SAW:**
D400 (25Kg)
Flux: 25Kg bags



Selectarc Product Selection

Product Name		Main features	Description
MMA	WIRES		
B90 AWS A5.11: E NiCrFe-3		NiCrFe - type Inconel® 600	Semi-synthetic basic coated electrode with 140% recovery. Product used for Oven parts, burners, Cement works , moulds, tanks, Chemical industries, petrochemical industries, Repair and maintenance.
B91 AWS A5.11: E NiCrMo-3		NiCrMo - type Inconel® 625	Rutile-basic coated electrode with a high recovery (170%) for welding of Nickel-Chromium- Molybdenum alloys to themselves and to lower alloyed steels. High deposition Butt-welding and surfacing on low alloyed, difficult to weld steels and high strength steels. Dissimilar joints.
B94 AWS A5.11: E NiCrFe-2		for 5% - 9% nickel steels	Basic coated electrode with 150% recovery. Welding cryogenic 5 and 9% Ni-steels and high temperature steels, For CrMo-creep resistant steels to stainless steels, for repair on HK and HP reformer grades.
B96 AWS A5.11: E NiCrMo-6		for 5% - 9% nickel steels	Basic coated electrode with approx. 160% recovery. Construction and repair welding of high strength cold-tough 3; 5 and 9% Ni-steels used for transportation and storage tanks of liquid natural gas.
Ni59 AWS A5.11: E NiCrMo-13	TIG Ni59 / MIG Ni59 AWS A5.14: ERNiMo-13	NiCrMo - type Alloy 59	Products used to welding Alloy 59 or C-22 type for Off-shore components, boilers, containers, piping systems in the chemical and petrochemical industries.
Ni82 AWS A5.11: -E NiCrFe-3 (For nuclear applications)	TIG Ni82 / MIG Ni82 AWS A5.14: ERNiCr-3	NiCrFe - type Inconel® 600	Product used in high temperature and nickel alloys in component manufacturing, furnace construction. Mainly used in welding oven parts, burners, heat treatment equipment, cement works, moulds, tanks. Exist also for SAW et Cladding : UP Ni82 (AWS A5.14 : ERNiCr-3) Strip Ni82 (AWS A5.14 : EQNiCr-3)
Ni182 AWS A5.11: E NiCrFe-3	FCW Ni182 AWS A5.34: ENiCrFe3T0-4	NiCrFe - type Inconel® 600	Welding of High temperature and nickel alloys in component manufacturing, furnace construction, cement industry.
Ni190 AWS A5.11: E NiCu-7	TIG Ni60 / MIG Ni60 AWS A5.14: ERNiCu-7	NiCu type "Monel"®	Welding of Naval constructions and installations for sea water desalination.
Ni276 AWS A5.11: E NiCrMo-4	TIG Ni276 / MIG Ni276 AWS A5.14: ERNiCrMo-4	NiCrMo - type C-276	Welding of Off-shore components, boilers, containers, piping systems.
Ni617 AWS A5.11: -E NiCrCoMo-1	TIG Ni617 / MIG Ni617 AWS A5.14: ERNiCrCoMo-1	High temperature	Alloys used for Combustion chambers, ovens, thermal equipment for heat treatment, petrochemical installation.
Ni625 AWS A5.11: E NiCrMo-3	TIG Ni625 / MIG Ni625 AWS A5.14: ERNiCrMo-3 FCW Ni625 AWS A5.34 : E NiCrMo3T0/4	NiCrMo - type Inconel® 625	Welding of Off-shore components, boilers, vessels, piping systems. Exist also for SAW : UP Ni625 (AWS A5.14 : ERNiCrMo-3)
Ni825 S A5.11: -	TIG Ni65 / MIG Ni65 AWS A5.14: ERNiFeCr-1	NiFeCrCrMo - type Alloy 825	Welding of Ni-Fe-Cr-Mo-Cu alloys (alloy 825) and other highly corrosion resistant Ni-Fe-Cr-Mo alloys as well as special austenitic stainless steel types. Exist also for SAW et Cladding : UP Ni65 (AWS A5.14 : ERNiFeCr-1) Strip Ni65 (AWS A5.14 : EQNiFeCr-1)
NiA AWS A5.11: E NiCrFe-2		High Temperature Repair	Electrode used to join and repair high temperature alloys in Thermal power stations, ovens, thermal equipment for heat treatment
NiTi3 AWS A5.11: E Ni-1	TIG Ni61 / MIG Ni61 AWS A5.14: ERNi-1	Pure Nickel	Construction of equipment for the chemical industry and electrochemical industry, food stuff industry. For caustic soda production as well as for soap and detergents
	Flux UP Ni02 EN 760 : SA AF 2 DC		Alumino Fluoride agglomerated flux to be used with solid wire and strip for corrosion resistant in submerged arc cladding

For more details please consult our Technical Datasheets on contact

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wires@fsh-welding.com



Services

- **Advice and assistance**

A team of engineers and experienced welders help customers with selecting the materials that are best suited for each application.

- **Research and Development (R&D)**

The R&D Department carries out product tests (mechanical and non-destructive tests) in accordance with customers' requests.

- **Customer Service**

The sales department is available to respond quickly to any request.

Quality

ISO 9001 certification



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