



**High Nickel Alloy Welding
Consumables for the Fabrication of
9% Nickel Steels in Liquid Natural
Gas (LNG) Containment and
Transportation Applications**



www.specialmetalswelding.com

Introduction

Special Metals Welding Products Company, the world's leading developer and producer of High Nickel Alloy Welding Consumables, continues to develop and expand the range of products available for the fabrication of 9% Nickel Steels, utilised for the containment and transportation of liquefied natural gases (LNG).

The range detailed in this publication offers the highest metallurgical and mechanical properties allied to applicability with all the major welding processes, to suit contractors need for optimum productivity.

- **Shielded Metal Arc Welding (SMAW) electrodes. All positional for application with both DC/AC power source**
- **Gas Metal Arc Welding (GMAW) & Gas Tungsten Arc Welding (GTAW) for use with manual or fully automatic systems**
- **Submerged Arc Welding (SAW) Filler Metal and fluxes**
- **Gas Shielded Flux Cored Arc Welding (GSFCAW)**

9% NICKEL STEELS

9% Nickel Steels are used widely in the construction of systems and components for storage and transportation of liquefied natural gases. This commercial ferritic steel supplied in the Quenched and Tempered (QT) or Double Normalised & Tempered (NNT) condition is readily weldable and offers excellent strength and toughness at cryogenic temperatures down to -196°C.

High Nickel Alloy Welding Consumables are preferred for the welding of 9% Nickel Steels due to a combination of factors.

- Excellent notch toughness at -196°C
- Strength levels matching those of the 9% Nickel Steels
- Resistance to brittle fracture
- Coefficient of thermal expansion similar to that of the 9% Nickel Steels

These features offer designers, fabricators and operators an increased margin of safety, which is demonstrated by the successful application of these consumable types for more than thirty years.

SMAW WELDING ELECTRODES

INCONEL® Welding Electrode 112 (ENiCrMo-3)

A basic coated electrode with fully alloyed core wire and reduced coating thickness offers:

- Strength levels (0.2% proof stress and ultimate tensile stress) consistently exceeding the minimum requirement of 9% Nickel Steels
- Excellent Charpy impact toughness at -196°C
- All positional weldability
- Applicable on both DC and AC (square wave) power sources
- Non-hygroscopic coating
- Optimum alloy transfer
- Reduced power consumption

INCO-WELD® Welding Electrode C-276 (ENiCrMo-4)

Offers all the features of INCONEL® Welding Electrode 112 with the added benefit of improved Charpy impact toughness at -196°C (70 joules minimum) to meet the latest European specifications. This improvement is attained by removing Niobium (Nb) and increasing Molybdenum (Mo) maintaining the balance of weld deposit strength and low temperature toughness.

GMAW/GTAW FILLER METAL

Special Metals Welding Products Filler Metals for GMAW/GTAW are available in a wide variety of diameters and spool sizes to suit automated systems and in straight length format for manual operations. The filler metals are processed specifically to provide optimum delivery to the weld pool.

INCONEL® Filler Metal 625 (ERNiCrMo-3)

This NiCrMo Filler Metal with NB is suited to applications on both GMAW/GTAW processes, in either manual or automated systems offering:

- Strength levels consistently exceeding the minimum requirements of the 9% Nickel Steels
- Excellent Charpy impact toughness at -196°C
- Improved wire delivery to the weld pool resulting from controlled filler metal processing

INCO-WELD® Filler Metal C-276 (ERNiCrMo-4)

This NiCrMo Filler Metal with increased Mo, W, and reduced Nb is suited to both GMAW or GTAW processes either manually or fully automated and offers:

- Strength levels consistently exceeding the minimum requirements of the 9% Nickel Steels.
- Excellent Charpy impact toughness at -196°C
- Improved wire delivery to the weld pool resulting from controlled filler metal processing

SAW FILLER METALS AND FLUXES

INCONEL® Filler Metal 625 – ERNiCrMo-3

INCO-WELD® Filler Metal C-276 – ERNiCrMo-4

Both of these NiCrMo Filler Metals are utilised extensively for the fabrication of 9% Nickel Steels by the SAW process and offer weld deposits which:

- Exceed the minimum strength requirement of 9% Nickel Steel
- Offer excellent resistance to brittle fracture
- Offer excellent Charpy impact toughness at -196°C

INCONEL® Filler Metal 625 is generally restricted to a maximum diameter of 1.6 mm for use with the SAW process in order to minimise the incidence of hot cracking defects.

INCO-WELD® Filler Metal C-276 with increased Mo and reduced Nb is less sensitive to hot cracking and can generally be utilised in diameters up to and including 2.4 mm. This offers productivity benefits in addition to being commensurate with available on site SAW equipment generally designed to handle larger diameter filler metals.

Material Specifications

Product	Specification Grade	Typical Analysis Wt. %						Typical Mechanical Properties			
		C	Mn	Si	Ni	S	P	.2%PS MPa	UTS MPa	EL %	CV@-196 °C Joules
NNR	ASTM A553	.10	.50-.80	.10-.30	8.75-9.75	.005	.010	520	690	18	34
QT	ASTM A553	.10	.50-.80	.10-.30	8.75-9.75	.005	.010	585	690	18	34

Product Specifications

Product	Specification Grade	Typical Analysis Wt. %						Typical Mechanical Properties			
		Ni	Cr	Mo	Nb	W	Fe	.2%PS MPa	UTS MPa	EL %	CV@-196 °C Joules
INCONEL® Welding Electrode 112	ENiCrMo-3	55 min	20-23	8-10	3.15-4.15	—	7.0 max	540	813	34	40-60
INCO-WELD® Welding Electrode C-276	ENiCrMo-4	69 bal	14.5-16.5	15-17	—	3.0-4.5	4-7	475	760	43	50-70
INCONEL® Filler Metal 625	ERNiCrMo-3	58 min	20-23	8-10	3.14-4.15	—	5.0 max	450	750	40	62
INCO-WELD® Filler Metal C-276	ERNiCrMo-4	bal	14.5-16.5	15-17	—	3.0-4.5	4-7	500	690	39	60-80
INCO-CORED® 625	ENiCrMo3T0-4 ENiCrMo3T1-4	bal	20-23	8.75-9.75	3.15-4.15	—	5.0 max	500	750	42	76
INCONEL® Filler Metal 625 combined INCOFLUX® 9	ERNiCrMo-3	58 min	20-23	8-10	3.15-4.15	—	5.0 max	465	775	47	68
INCO-WELD® Filler Metal C-276 combined INCOFLUX® 9	ERNiCrMo-4	bal	14.5-16.5	15-17	—	3.0-4.5	4-7	450	750	43	75

FLUXES

INCOFLUX® 9

This semi-basic fused flux is suitable for welding on either DC or AC in the downhand and horizontal position with resultant smooth weld beads and self-releasing slag.

- Applicable on both AC/DC power source
- Utilises 10% less energy than agglomerated equivalents
- Greater density supports weld pool in the HV position

INCOFLUX® 7

This basic agglomerated flux is alloy compensated offering optimum alloy transfer on material thickness up to and including 50 mm. The flux operates on Direct Current (DC) and offers excellent weldability in the downhand and horizontal position, provides good melting, self-releasing slag and prevents formation of secondary slag.

Both the above products are applicable with either INCONEL® Filler Metal 625 and INCO-WELD® Filler Metal C-276.

GSFCAW

INCO-CORED® 625 AP/DH

This NiCrMo gas shielded flux cored wire offers weldability and metallurgical integrity of covered electrodes and higher deposition rates associated with automated processes. The fully alloyed sheath allows for optimum alloy transfer to the weld pool and offers deposits which:

- Consistently meet the minimum strength level requirement of the 9% nickel steel
- Exhibit excellent Charpy impact toughness at -196 °C
- Are free from defects
- Offer resistance to brittle fracture



INCONEL[®]

INCOLOY[®]

INCOFLUX[®]

INCO-CORED[®]

INCO-WELD[®]

MONEL[®]

NI-ROD[®]

NIMONIC[®]

DURANICKEL[®]

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