INCONEL® nickel-chromium alloy 625 (UNS N06625/W.Nr. 2.4856) is used for its high strength, excellent fabricability (including joining), and outstanding corrosion resistance. Service temperatures range from cryogenic to 1800°F (982°C). Composition is shown in Table 1.

Strength of INCONEL alloy 625 is derived from the stiffening effect of molybdenum and niobium on its nickel-chromium matrix; thus precipitation-hardening treatments are not required. This combination of elements also is responsible for superior resistance to a wide range of corrosive environments of unusual severity as well as to high-temperature effects such as oxidation and carburization.

The properties of INCONEL alloy 625 that make it an excellent choice for sea-water applications are freedom from local attack (pitting and crevice corrosion), high corrosion-fatigue strength, high tensile strength, and resistance to chloride-ion stress-corrosion cracking. It is used as wire rope for mooring cables, propeller blades for motor patrol gunboats, submarine auxiliary propulsion motors, submarine quick-disconnect fittings, exhaust ducts for Navy utility boats, sheathing for undersea communication cables, submarine transducer controls, and steam-line bellows. Potential applications are springs, seals, bellows for submerged controls, electrical cable connectors, fasteners, flexure devices, and oceanographic instrument components.

High tensile, creep, and rupture strength; outstanding fatigue and thermal-fatigue strength; oxidation resistance; and excellent weldability and brazeability are the properties of INCONEL alloy 625 that make it interesting to the aerospace field. It is being used in such applications as aircraft ducting systems, engine exhaust systems, thrust-reverser systems, resistance-welded honeycomb structures for housing engine controls, fuel and hydraulic line tubing, spray bars, bellows, turbine shroud rings, and heat-exchanger tubing in environmental control systems. It is also suitable for combustion system transition liners, turbine seals, compressor vanes, and thrust-chamber tubing for rocket

The outstanding and versatile corrosion resistance of INCONEL alloy 625 under a wide range of temperatures and pressures is a primary reason for its wide acceptance in the chemical processing field. Because of its ease of fabrication, it is made into a variety of components for plant equipment. Its high strength enables it to be used, for example, in thinner-walled vessels or tubing than possible with other materials, thus improving heat transfer and saving weight. Some applications requiring the combination of strength and corrosion resistance offered by INCONEL alloy 625 are bubble caps, tubing, reaction vessels, distillation columns, heat exchangers, transfer piping, and valves.

In the nuclear field, INCONEL alloy 625 may be used for reactor-core and control-rod components in nuclear water reactors. The material can be selected because of its high strength, excellent uniform corrosion resistance, resistance to stress cracking and excellent pitting resistance in 500°-600°F (260-316°C) water. Alloy 625 is also being considered in advanced reactor concepts because of its high allowable design strength at elevated temperatures, especially between 1200°-1400°F (649-760°C).

The properties given in this bulletin, results of extensive testing, are typical of the alloy but should not be used for specification purposes. Applicable specifications appear in the last section of this publication.

Table 1 – Limiting Chemical Composition, %

Nickel	58.0 min.
Chromium	20.0-23.0
Iron	5.0 max.
Molybdenum	8.0-10.0
Niobium (plus Tantalum)	3.15-4.15
Carbon	0.10 max.
Manganese	0.50 max.
Silicon	0.50 max.
Phosphorus	0.015 max.
Sulfur	0.015 max.
Aluminum	0.40 max.
Titanium	0.40 max.
Cobalt[a]	1.0 max.

[a]If determined

INCONEL® alloy 625

Machining

Guidelines for machining INCONEL alloy 625 are given in the publication 'Machining' on the Special Metals website, www.specialmetals.com.

Table 12 – Recommended Conditions for Turning with Single-Point Tools

High Speed Steel				Coated Carbide			
Surface Speed		Feed		Surface Speed		Feed	
fpm	m/min	lpr	Mm/rev	fpm	m/min	lpr	m/rev
13-35	4.0-10.7	0.005-0.020	0.13-0.51	45-110	14-34	0.005-0.020	0.13-0.51

Welding

INCONEL alloy 625 is readily joined by conventional welding processes and procedures. INCONEL Filler Metal 625 and INCONEL Welding Electrode 112 are nickel-chromium-molybdenum products designed for welding INCONEL alloy 625 to itself and to other materials. Compositions of the two products are shown in Table 13. Like alloy 625, deposited weld metals from both products are highly resistant to corrosion and oxidation and have high strength and toughness from the cryogenic range to 1800°F. They require no postweld heat treatments to maintain their high strength and ductility. When used to weld INCONEL alloy 625 to dissimilar metals, both products tolerate a high degree of dilution yet maintain characteristic properties.

INCONEL Filler Metal 625 and INCONEL Welding Electrode 112 are also used as "overmatching composition" welding products for iron-nickel-chromium-molybdenum corrosion-resistant alloys including 316 and 317 stainless steels, 6% molybdenum super-austenitic stainless steels, INCOLOY® alloys 825 and 020, and INCONEL alloy G-3. The higher alloy content of the alloy 625 welding products offsets the effects of elemental segregation in weldments which can result in preferential weld corrosion.

INCONEL Filler Metal 625 is designed for use with the gas-tungsten-arc and various gas-metal-arc processes. Operating characteristics are similar to those of other nickel-chromium filler metals. INCONEL Welding Electrode 112, for shielded metal-arc welding, has excellent operability. The slag produced is hard, but it detaches in large sections when fractured, leaving clean weld metal.

Table 13 – Limiting Chemical Composition, %, of Welding Products

	INCONEL Filler Metal 625	INCONEL[a] Welding Electrode 112
Nickel[b]	58.0 min.	55.0 min.
Carbon	0.10 max.	0.10 max.
Manganese	0.50 max.	1.0 max.
Iron	5.0 max.	7.0 max.
Sulfur	0.015 max.	0.02 max.
Silicon	0.50 max.	0.75 max.
Chromium	20.0-23.0	20.0-23.0
Niobium (plus Tantalum)	3.15-4.15	3.15-4.15
Molybdenum	8.0-10.0	8.0-10.0
Aluminum	0.40 max.	-
Titanium	0.40 max.	-
Cobalt[c]	-	0.12[c]
Phosphorus	0.02 max.	0.03
Copper	0.50 max.	0.50 max.
Other	0.50 max.	0.50 max.

[a]Deposited weld metal. [b]Plus cobalt. [c]When specified.

All-Weld-Metal Properties

High-temperature properties of weld metals are shown in Figures 19, 20, and 21. These welds were made by the gas-tungsten-arc process and the shielded-metal-arc process. Low-temperature toughness of weld metals is shown by the impact-strength data in Table 14.

Room-temperature fatigue strength (10^6 cycles; rotating-beam tests at 10,000 rpm) of polished all-weld-metal specimens was found to be 68,000 psi (Filler Metal 625) and 58,000 psi (Electrode 112).

The results of stress-rupture tests performed on all-weld-metal specimens of Electrode 112 are reported in Figure 22.

Table 14 – Low-Temperature Impact Strength of INCONEL Welding Products All-Weld Metal

Welding Material	Notch Orientation To Welding Direction	Charpy V-Notch Impact Strength, ft-lb (J)		
		-320°F (-196°C)	-110°F (-79°C)	Room Temperature
Filler Metal 625a	Perpendicular	57.0 (77.3)	60.0 (81.5)	68.5 (92.9)
Electrode 112	Perpendicular	34.8 (47.2)	42.5 (57.6)	46.5 (63.1)
	Parallel	32.8 (44.5)	41.5 (56.3)	45.0 (61.0)

[a]Gas-tungsten-arc welding process.

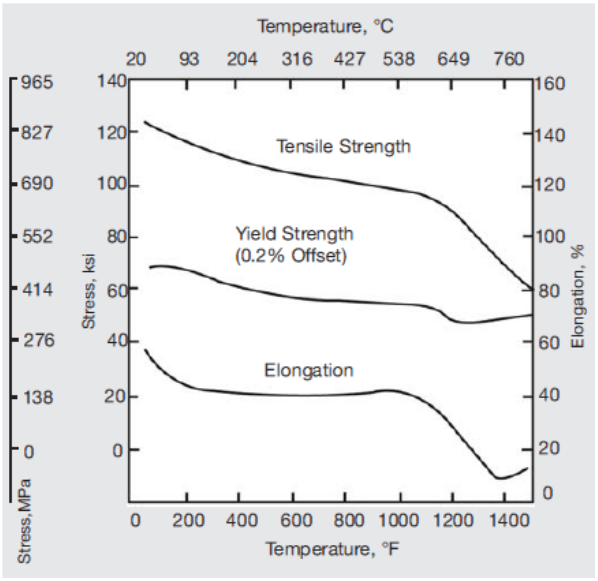

Figure 19 – High-temperature tensile properties of transverse specimens of INCONEL alloy 625 welds (1/2-in. solution-treated plate; gas-tungsten-arc process with INCONEL Filler Metal 625).

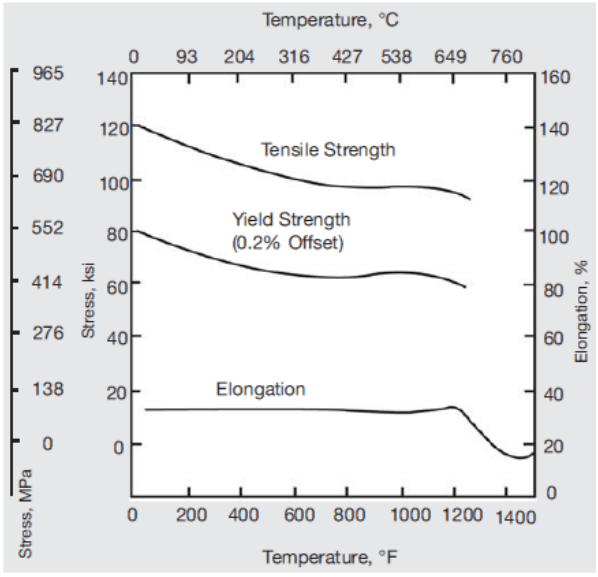

Figure 20 – High-temperature tensile properties of INCONEL alloy 625 all-weld metal (1/2-in. solution-treated plate; gas-tungsten-arc process with INCONEL Filler Metal 625).

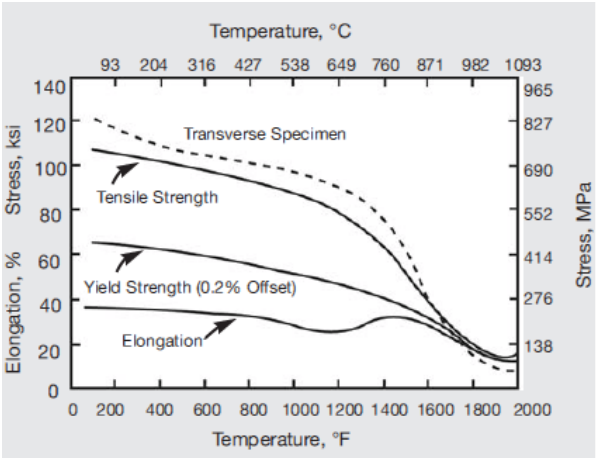

Figure 21 – High-temperature tensile properties of deposited weld metal from weld made in alloy 625 with Welding Electrode 112.

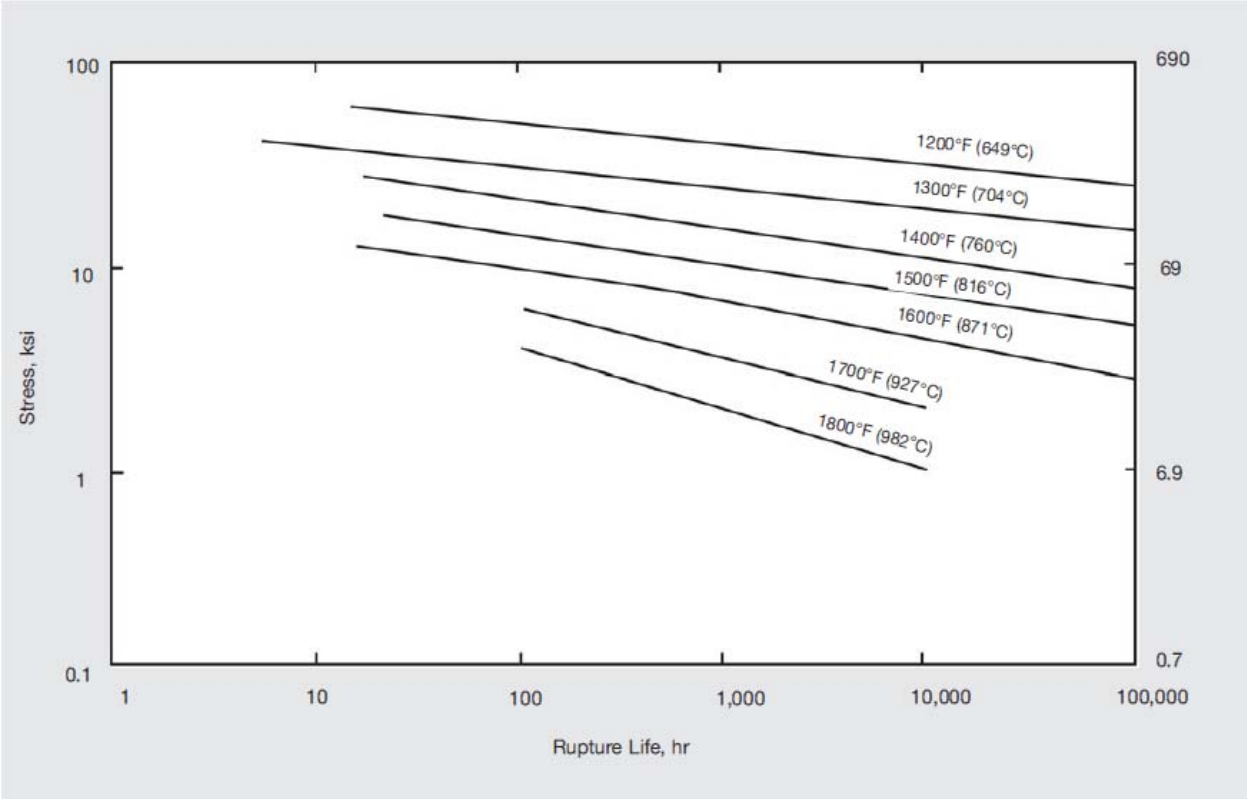

Figure 22 – Rupture strength of INCONEL Welding Electrode 112 all-weld metal.

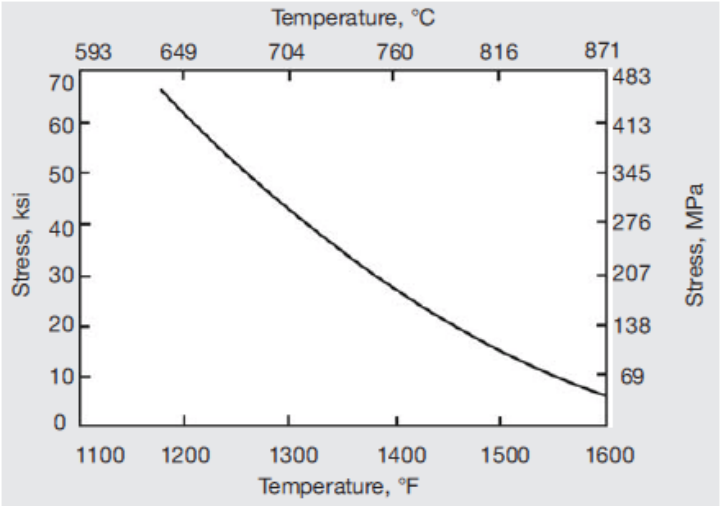

Figure 23 – 100-hr rupture strength of transverse specimens from joints n alloy 625 made by gas-tungsten-arc process using Filler Metal 625.

Transverse Properties

Properties of INCONEL alloy 625 welds made with the recommended welding products are shown in Figures 19 and 21.

As another example of weld quality, the gas-tungsten-arc process with 1/8-in. Filler Metal 625 was used to join 1/2-in. annealed plate. Transverse bends with a radius equal to two thicknesses (2T) had no fissuring or cracking.

Rupture strength of alloy 625 welds made by the gas-tungsten-arc process and Filler Metal 625 is shown in Figure 23.

Both INCONEL Filler Metal 625 and INCONEL Welding Electrode 112 have been used to join alloy 625 to a variety of dissimilar metals. The results of tests made on welds of alloy 625 joined to a nickel-iron-chromium-molybdenum alloy (Hastelloy® alloy X), a precipitation-hardenable nickel-chromium alloy (INCONEL alloy 718), a cast chromium-nickel-iron-tungsten alloy (MO-RE 1) and Types 304 and 410 stainless steel are shown in Table 15. All the joints passed dye-penetrant and radiographic inspection and guided-bend tests. Barker, Cox, and Margolin report the results of tests on joints between alloy 625 sheet and other dissimilar metals.

Table 15 – Strength of Dissimilar Welds[a]

INCONEL alloy 625 Joined to	Gas-Metal-Arc (Spray Transfer) With Filler Metal 265		Gas-Tungsten-Arc With Filler Metal 625		Shielded-Metal-Arc With Welding Electrode 112	
	Tensile Strength, Ksi (MPa)	Fracture Location	Tensile Strength, Ksi (MPa)	Fracture Location	Tensile Strength, Ksi (MPa)	Fracture Location
Hastelloy alloy X	121.2 (835.6)	Alloy X	119.7 (825.3)	Alloy X	118.5 (817.0)	Alloy X
INCONEL alloy 718	120.7 (832.2)	Alloy 718	107.5 (741.2)	Alloy 718	110.25 (760.1)	Alloy 718
Type 304 Stainless Steel	88.5 (610.2)	Type 304	92.0 (634.3)	Type 304	91.25 (629.1)	Type 304
Type 410 Stainless Steel	65.6 (452.3)	Type 410	67.6 (466.1)	Type 410	61.6 (424.7)	Type 410
MO-RE® 1	-	-	97.3 (670.9)	MO-RE 1	94.7 (653.0)	MO-RE 1

[a]Transverse specimens. Joints were 3/8 in. thick except for those with MO-RE 1, which were ½ in.
[b]These joints were preheated to 300°F.
Hastelloy is a trademark of Haynes International, and MO-RE is a trademark of Blaw-Knox Corporation

Available Products and Specifications

INCONEL alloy is designated as UNS N06625, Werkstoff Number 2.4856 and ISO NW6625 and is listed in NACE MR-01-75. It is available in all standard mill forms including rod, bar, wire, and wire rod, plate, sheet, strip, shapes, tubular products, and forging stock. Full information on available products may be obtained from the offices listed on the back cover.

Rod, Bar, Wire and Forging Stock - ASTM B 446/ASME SB 446 (Rod & Bar), ASTM B 564/ASME SB 564 (Forgings), SAE/AMS 5666 (Bar, Forgings, & Rings), SAE/AMS 5837 (Wire), ISO 9723 (Rod & Bar), ISO 9724 (Wire), ISO 9725 (Forgings), VdTÜV 499 (Rod & Bar), BS 3076NA21 (Rod & Bar), EN 10095 (Rod, Bar, & Sections), DIN 17752 (Rod & Bar), ASME Code Case 1935 (Rod, Bar, & Forgings), DIN 17754 (forgings), DIN 17753 (Wire).

Plate, Sheet and Strip - ASTM B 443/ASTM SB 443 (Plate, Sheet & Strip), SAE/AMS 5599 & 5869 & MAM 5599 (Plate, Sheet & Strip), ISO 6208 (Plate, Sheet & Strip), VdTÜV 499 (Plate, Sheet & Strip), BS 3072NA21 (Plate & Sheet), EN 10095 (Plate, Sheet & Strip), DIN 17750 (Plate, Sheet & Strip), ASME Code Case 1935.

Pipe & Tube - ASTM B 444/B 829 & ASME SB 444/SB 829 (Seamless Pipe & Tube), ASTM B704/B 751 & ASME SB 704/SB 751 (Welded Tube), ASTM B705/B 775 & ASME SB 705/SB 775 (Welded Pipe), ISO 6207 (Tube), SAE/AMS 5581 (Seamless & Welded Tube), VdTÜV 499 (Tube), BS 3074NA21 (Seamless Pipe & Tube), DIN 17751 (Tube), ASME Code Case 1935.

Other Product Forms - ASTM B 366/ASME SB 366 (Fittings), ISO 4955A (Heat Resisting Steels & Alloys), DIN 17744 (Chemical composition of all product forms).