Inconel 617, UNS N06617, NiCr23Co12Mo, 2.4663

Inconel 617, also known as NiCr23Co12Mo, UNS N06617, 2.4663, NiCr22Co12Mo9, or ЭП617, is a solid-solution strengthened nickel-chromium-cobalt-molybdenum alloy renowned for its exceptional high-temperature strength, oxidation resistance, and creep performance. Its unique combination of properties makes it a preferred material for extreme environments in industries such as aerospace, power generation, and chemical processing. This article provides a detailed analysis of its chemical composition, mechanical and physical properties, heat treatment, machining, welding, applications, and equivalent grades.

Applications

Inconel 617's unique properties make it suitable for demanding applications, including:

- **Aerospace**: Gas turbine components, combustion cans, afterburners, and heat exchangers.
- **Power Generation**: Steam generator superheaters, re-heater parts, and heat exchangers in gas-cooled reactors and advanced ultra-supercritical (A-USC) boilers.
- **Chemical Processing**: Catalyst grid supports for nitric acid production and equipment for high-temperature corrosive environments.
- **Industrial Heating**: Furnace liners, heat shields, and radiant tubes.
- **Nuclear and Fossil Fuel Plants**: Reactor internals, piping systems, and heat-treating baskets.

Equivalent or Similar Grades - Chemical Composition

Inconel 617 is a nickel-based superalloy with a carefully balanced composition to ensure high-temperature stability and corrosion resistance. Below is the typical chemical composition for Inconel 617 and its equivalent designations:

Element	Inconel 617, UNS N06617	NiCr23Co12Mo, 2.4663	NiCr22Co12Mo9	ЭП617(GOST)
Nickel (Ni)	Bal. (44.5% min)	Bal.	Bal.	Bal.
Chromium (Cr)	20.0–24.0%	22.0–24.0%	21.0–23.0%	20.0–24.0%
Cobalt (Co)	10.0–15.0%	10.0–13.0%	11.0–13.0%	10.0–15.0%
Molybdenum (Mo)	8.0–10.0%	8.0–10.0%	8.0–10.0%	8.0–10.0%
Aluminum (Al)	0.8–1.5%	0.8–1.5%	0.8–1.5%	0.8–1.5%

Element	Inconel 617, UNS N06617	NiCr23Co12Mo, 2.4663	NiCr22Co12Mo9	ЭП617(GOST)
Iron (Fe)	3.0% max	2.0% max	2.0% max	3.0% max
Titanium (Ti)	0.6% max	0.6% max	0.6% max	0.6% max
Carbon (C)	0.05–0.15%	0.05–0.10%	0.05–0.10%	0.05–0.15%
Silicon (Si)	1.0% max	0.7% max	0.7% max	1.0% max
Manganese (Mn)	1.0% max	0.5% max	0.5% max	1.0% max
Sulfur (S)	0.015% max	0.015% max	0.015% max	0.015% max

Note: Minor variations may exist depending on specific standards (e.g., ASTM, ASME, DIN, GOST). The high nickel content ensures corrosion resistance, while chromium and aluminum enhance oxidation resistance. Cobalt and molybdenum provide solid-solution strengthening.

Mechanical Properties

Inconel 617 exhibits excellent mechanical properties, particularly at elevated temperatures. Below are the typical mechanical properties at room temperature per ASTM standards:

Property	Value (ASTM B166/B168)
Tensile Strength	690–758 MPa (100–110 ksi)
Yield Strength (0.2% offset)	310–345 MPa (45–50 ksi)
Elongation	25–30% min
Hardness (Brinell)	150–220 HB

The alloy retains significant strength up to 1100°C (2012°F), with a creep-rupture strength that remains stable at 950°C (1742°F).

High-Temperature Mechanical Properties

Inconel 617 excels in high-temperature environments due to its solid-solution strengthening and resistance to thermal degradation. Key high-temperature properties include:

- **Tensile Strength at 1000°C**: Approximately 300–400 MPa, depending on heat treatment.
- **Creep-Rupture Strength**: Maintains integrity at 950°C (1742°F) with a creep rate of less than 0.1% per 1000 hours under 15–35 MPa stress.
- **Allowable Stress (ASME SC VIII, Div. 1)**: Varies by temperature; e.g., 69 MPa at 900°C.

The alloy's high nickel, chromium, cobalt, and molybdenum content, combined with ~1% aluminum, ensures excellent oxidation and carburization resistance up to 1100°C.

Creep Performance

Inconel 617's creep resistance is critical for applications involving prolonged exposure to high temperatures and stress. Studies show:

- **Biaxial Creep at 850–950°C**: Tertiary creep dominates, with secondary creep being minimal. Creep rupture life is reduced under biaxial stress compared to uniaxial conditions.
- **Monkman-Grant Relation**: Effective for estimating long-term creep life in Inconel 617, unlike some other alloys like Haynes 230.
- **Microstructural Stability**: The alloy retains ductility after prolonged exposure, with minimal formation of deleterious phases. However, internal aluminum nitrides may form in highly oxidizing combustion environments.

Creep voids nucleate, grow, and coalesce, leading to fracture, but the alloy's microstructure minimizes degradation.

Physical Properties

The physical properties of Inconel 617 contribute to its suitability for high-temperature applications:

Property	**Value**
Density	8.36 g/cm³ (0.302 lb/in³)
Melting Range	1330–1410°C (2426–2570°F)
Thermal Conductivity (at 20°C)	11 W/m·K (56 BTU/hr·ft²·°F)
Coefficient of Thermal Expansion (20–1000°C)	13.6 µm/m·°C (7.6 µin/in·°F)
Specific Heat Capacity (at 20°C)	419 J/kg·K (0.100 BTU/lb·°F)
Modulus of Elasticity	211 GPa (30.6 × 10^6 psi)

The low coefficient of thermal expansion minimizes distortion in high-temperature environments, making it ideal for gas turbines and heat exchangers.

Heat Treatment

Inconel 617 is typically supplied in the solution-annealed condition to achieve an austenitic matrix free of carbide precipitates. The recommended heat treatment per ASME SB-176 is:

- **Solution Annealing**: 1140–1232°C (2084–2250°F) for a time proportional to section size,

followed by water quenching or rapid air cooling.
- **Aging Treatment**: Optional aging at 760–870°C (1400–1600°F) may be applied to enhance creep-rupture strength, depending on application requirements. [](https://www.hysuperalloy.com/inconel-617-barsheetstripwirepipediscringflange.html)

Heat treatment enhances the alloy's creep resistance and ensures microstructural stability at high temperatures.

Processing Performance

Machining Performance

Machining Inconel 617 is challenging due to its high strength and work-hardening tendency. Key considerations include:

- **Tooling**: Use high-speed steel or carbide cutters with coolants to manage heat buildup.
- **Techniques**: Slow feed rates and shallow depths of cut are recommended to minimize vibrations and tool wear.
- **Cold Working**: Requires frequent intermediate anneals to restore workability due to rapid work hardening.

With proper techniques, Inconel 617 can achieve a high-quality finish, though it demands skilled machining practices.

Welding Performance

Inconel 617 exhibits good weldability, classified under weldability group 46 (ISO 15608) and 43 (ASME Section IX). Key welding characteristics include:

- **Welding Methods**: Suitable for gas tungsten arc welding (GTAW), gas metal arc welding (GMAW), and other fusion methods using Inconel Filler Metal 617 or ERNiCrCoMo-1 filler.
- **Challenges**: The alloy's affinity for nitrogen requires high-nitrogen filler metals to prevent cracking. Pre- and post-weld heat treatments may be necessary to maintain properties.
- **Dissimilar Welding**: Studies on Inconel 617/P92 steel dissimilar welds show heterogeneous microstructures at the interface, with macrosegregation and element diffusion. Narrow V-groove designs may reduce residual stresses compared to double V-grooves.

Proper preparation and technique are critical to achieving crack-free welds with optimal strength.