
Inconel 625 Superalloy – Technical Material Specification

1.0 Material Overview & Common Uses

Inconel 625 is a nickel-chromium-molybdenum superalloy known for its exceptional resistance to corrosion and oxidation, high strength over a wide temperature range (from cryogenic to 980°C), and excellent fabricability. It is precipitation-hardenable and maintains high tensile and creep-rupture strength in extreme environments.

- Commonly used in aerospace components (e.g., turbine blades, exhaust ducts), chemical processing equipment (e.g., reactors, heat exchangers), marine engineering (e.g., propeller blades, submarine components), and nuclear reactors (e.g., control rod drives).
- Also utilized in oil and gas extraction (e.g., downhole tubing, wellhead components) due to its resistance to sour gas and chloride stress corrosion cracking.

2.0 Core Technical Properties & Sizing

- Density: 8.44 g/cm³ (0.305 lb/in³)
- Melting Range: 1290°C – 1350°C (2350°F – 2460°F)
- Tensile Strength (annealed): 827 MPa (120 ksi) minimum at room temperature
- Yield Strength (0.2% offset, annealed): 414 MPa (60 ksi) minimum
- Elongation (annealed): 30% minimum in 50 mm
- Hardness (annealed): Rockwell B 95 (typical)
- Standard forms: Round bar (diameter 6.35 mm to 300 mm), plate (thickness 3 mm to 100 mm), sheet (thickness 0.5 mm to 6 mm), and seamless pipe (NPS 1/2 to 12).
- Diameter tolerance for round bar: ±0.005 inches (0.13 mm) for diameters up to 2 inches; ±0.010 inches (0.25 mm) for larger diameters.
- Flatness tolerance for plate: 0.005 inches per foot (0.42 mm/m) maximum deviation.

3.0 Processing, Machinability & Application

Inconel 625 is considered difficult to machine due to its high work-hardening rate and low thermal conductivity. Carbide or ceramic tooling is required, with rigid setups and generous coolant flow to prevent work hardening and tool wear.

- Recommended cutting speed for carbide tools: 30–50 SFM (9–15 m/min) for roughing; 50–80 SFM (15–24 m/min) for finishing.
- Feed rate: 0.005–0.015 inches per revolution (0.13–0.38 mm/rev) for turning; 0.002–0.006 inches per tooth (0.05–0.15 mm/tooth) for milling.
- Use positive rake angles and sharp tools to minimize cutting forces and heat generation.
- Welding: Use filler metal ERNiCrMo-3 (AWS A5.14) for gas tungsten arc welding (GTAW) or gas metal arc welding (GMAW). Preheat not required, but interpass temperature must be kept below 150°C (300°F) to avoid cracking.
- Post-weld heat treatment (PWHT) is not mandatory but may be performed at 870°C (1600°F) for 1 hour to relieve residual stresses.

- Hot forming: Perform at 980°C – 1200°C (1800°F – 2200°F); avoid forming below 870°C (1600°F) to prevent cracking.
- Cold forming: Use annealed condition; intermediate annealing may be required for severe bends.

4.0 Common Defects & Quality Control

- Reject if surface cracks or laps are visible under 10x magnification.
- Reject if surface pitting exceeds 0.005 inches (0.13 mm) in depth.
- Reject if out-of-roundness exceeds 0.002 inches per inch (0.05 mm per 25 mm) of diameter.
- Reject if plate flatness deviation exceeds 0.010 inches per foot (0.83 mm/m).
- Reject if hardness exceeds Rockwell C 35 (for annealed condition) indicating improper heat treatment.
- Reject if ultrasonic inspection reveals internal voids or inclusions larger than 0.5 mm in diameter.
- Reject if chemical composition deviates from ASTM B443 (for plate/sheet) or ASTM B564 (for bar) specifications for nickel, chromium, molybdenum, or niobium content.

5.0 Storage, Handling & WHMIS Guidelines

- Store in a dry, indoor environment with relative humidity below 60% to prevent surface oxidation.
- Shelf life: Indefinite if stored properly; no degradation under normal conditions.
- FIFO protocol: Not required for solid forms, but maintain traceability via heat number and mill certificate.
- WHMIS classification: Not classified as hazardous under WHMIS 2015 (GHS) in solid form. Dust or fume from machining may be hazardous.
- Mandatory PPE during machining: NIOSH-approved N95 respirator (for airborne particles), safety glasses with side shields, and cut-resistant gloves (ANSI A4 level or higher).
- Ventilation: Use local exhaust ventilation to control airborne dust and fumes below occupational exposure limits (e.g., 0.5 mg/m³ for nickel as per ACGIH TLV).
- Spill procedure: Sweep or vacuum solid chips; avoid creating dust. Dispose as non-hazardous industrial waste per local regulations.

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