Copper 110 Electrolytic Tough Pitch (ETP) – Technical Material Specification

1.0 Material Overview & Common Uses

Copper 110, also known as C11000 or Electrolytic Tough Pitch (ETP) copper, is the most widely used copper alloy in industrial applications. It is produced by electrolytic refining and contains a minimum of 99.90% copper with a small oxygen content (0.02% to 0.04%) to control conductivity and toughness. ETP copper offers exceptional electrical and thermal conductivity, good ductility, and moderate strength, making it the standard choice for electrical components, bus bars, terminals, heat exchangers, and plumbing systems.

- Primary applications: electrical bus bars, switchgear components, transformer windings, heat exchanger tubes, roofing and flashing, plumbing fittings, and decorative architectural elements.
- Common stock forms: sheet, plate, rod, bar, tube, pipe, and wire in various tempers including soft (annealed), half-hard, and hard.
- Industry standards: ASTM B152 (sheet/plate), ASTM B187 (bar/rod), ASTM B188 (tube), ASTM B280 (ACR tube), and SAE J461.

2.0 Core Technical Properties & Sizing

- Density: 8.94 g/cm³ (0.323 lb/in³) at 20°C.
- Melting point: 1083°C (1981°F) – solidus/liquidus essentially identical due to high purity.
- Electrical conductivity: 101% IACS (International Annealed Copper Standard) minimum at 20°C.
- Thermal conductivity: 391 W/m·K at 20°C.
- Tensile strength (annealed): 200–250 MPa (29–36 ksi).
- Yield strength (annealed): 70–100 MPa (10–15 ksi).
- Elongation (annealed): 45–55% in 50 mm.
- Hardness (annealed): 40–50 HRF (Rockwell F scale).
- Standard sheet/plate thickness tolerances per ASTM B152: ±0.005 inches for thickness up to 0.125 inches; ±0.007 inches for 0.126–0.250 inches.
- Standard bar/rod diameter tolerances per ASTM B187: ±0.002 inches for diameters up to 1 inch; ±0.003 inches for 1–2 inches.
- Flatness tolerance for sheet/plate: 0.030 inches per foot maximum deviation.
- Squareness tolerance for bar stock: 0.005 inches per inch of width.

3.0 Processing, Machinability & Application

Copper 110 is rated as having fair to good machinability (20% of free-cutting brass C36000). It produces long, stringy chips that require careful chip control. The material is gummy and tends to work-harden, so sharp tooling and adequate coolant are essential. For welding, ETP copper is susceptible to hydrogen embrittlement when heated in reducing atmospheres;

therefore, oxy-fuel welding is not recommended. TIG and MIG welding with deoxidized filler metals (e.g., ERCu) are preferred. Brazing and soldering are common for electrical joints.

- Machining feed rate: 0.005–0.015 inches per revolution (roughing), 0.002–0.005 inches per revolution (finishing).
- Machining speed: 200–400 surface feet per minute (SFM) for high-speed steel tools; 400–800 SFM for carbide tools.
- Tooling: Use sharp, polished carbide or high-speed steel tools with positive rake angles (10–15 degrees). Avoid negative rake geometries.
- Coolant: Flood coolant with water-soluble oil or synthetic coolant to prevent built-up edge and improve surface finish.
- Welding: TIG welding with ERCu filler rod (AWS A5.7). Preheating to 300–500°C (570–930°F) for sections over 0.25 inches thick. Use argon shielding gas at 15–25 CFH.
- Brazing: Use silver-based brazing alloys (BAg series) with flux. Brazing temperature range: 620–760°C (1150–1400°F).
- Soldering: Use lead-free tin-silver or tin-copper solders. Soldering temperature: 230–300°C (450–570°F).
- Forming: Excellent for cold forming (bending, drawing, stamping). Annealing required after severe cold work to restore ductility.

4.0 Common Defects & Quality Control

- Reject if surface cracks or seams are visible under 5x magnification that exceed 0.005 inches in depth.
- Reject if surface pitting exceeds 0.003 inches in depth or 0.010 inches in diameter on critical electrical contact surfaces.
- Reject if out-of-flatness exceeds 0.030 inches per foot for sheet/plate.
- Reject if out-of-square exceeds 0.005 inches per inch of width for bar stock.
- Reject if diameter or thickness is outside the tolerances specified in Section 2.0.
- Reject if electrical conductivity is below 100% IACS at 20°C (measured per ASTM B193).
- Reject if hydrogen embrittlement is detected (visible cracking after heating in reducing atmosphere) per ASTM B577.
- Reject if inclusion or porosity exceeds 0.5% area fraction on polished cross-section per ASTM E3.
- Reject if tensile strength or elongation falls below minimum values per applicable ASTM standard for the specified temper.

5.0 Storage, Handling & WHMIS Guidelines

- Store in a dry, indoor environment with relative humidity below 60% to prevent tarnishing and oxidation.
- Temperature range: 10–40°C (50–104°F). Avoid condensation by allowing material to acclimate before unwrapping.
- Shelf life: Indefinite under proper storage conditions. Use FIFO (First-In, First-Out) to prevent surface oxidation from prolonged exposure.
- WHMIS classification: Copper 110 is not classified as a hazardous material under WHMIS 2015 (GHS). However, dust and fumes generated during machining or welding are hazardous.
- Hazardous decomposition products: Copper oxide fumes (CuO, Cu2O) from welding or high-temperature processing. Inhalation may cause metal fume fever.
- Mandatory PPE during machining/welding: N95 respirator or supplied-air respirator if ventilation is inadequate; safety glasses with side shields; welding helmet with appropriate shade (e.g., shade 10–12 for TIG); flame-resistant clothing; leather welding gloves; hearing protection if noise exceeds 85 dBA.
- First aid: For dust/fume inhalation, move to fresh air. For skin contact, wash with soap and water. For eye contact, flush with water for 15 minutes. Seek medical attention if irritation persists.
- Spill procedure: Sweep or vacuum solid material. Avoid generating dust. Dispose of waste in accordance with local environmental regulations.
- Fire hazard: Copper 110 is not flammable, but fine dust may be combustible. Use Class D extinguisher (dry powder) for metal fires.

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