COPPER C110 (C11000)
Comprehensive Material Guide

Electrolytic Tough Pitch (ETP) Copper Alloy

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Executive Summary

Copper C110, also known as UNS C11000, CDA 110, or Electrolytic Tough Pitch (ETP) Copper, represents one of the most widely used and commercially important copper alloys globally. With a purity level of 99.9% minimum copper content, this alloy exhibits exceptional electrical and thermal conductivity, excellent formability, and superior corrosion resistance. C110 copper achieves an electrical conductivity rating of 101% IACS (International Annealed Copper Standard), making it ideal for electrical applications, while its thermal conductivity of approximately 226-391 W/(m·K) ensures effective heat transfer in various industrial applications. This comprehensive guide provides detailed information on the composition, properties, applications, and processing characteristics of Copper C110.

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1. Material Identification and Nomenclature

Primary Designations

Copper C110 is identified by multiple standardized designations across different industries and regions. The primary designations include UNS C11000 (Unified Numbering System), CDA 110 (Copper Development Association), C110 (common industrial reference), and ISO Cu-ETP (International Organization for Standardization). In British standards, it may be referenced as BS1433 C110 or BS13604 CW009A. The alloy is commonly known by its descriptive name "Electrolytic Tough Pitch" (ETP) copper, which refers to its production method and characteristic properties.

Common Names

- Electrolytic Tough Pitch (ETP) Copper
- Copper 110
- C110 Alloy
- UNS C11000
- CDA 110 ETP
- ISO Cu-ETP
- High Conductivity Copper

2. Chemical Composition

Primary Composition

Copper C110 is characterized by exceptional purity with a minimum copper content of 99.90%, including silver content. The alloy contains a controlled amount of oxygen, typically between 0.02% and 0.04%, which contributes to its mechanical properties. This oxygen content is carefully balanced to optimize electrical conductivity while maintaining excellent ductility and strength.

Element	Minimum (%)	Maximum (%)	Typical (%)
Copper (Cu + Ag)	99.90	-	99.9-99.99
Oxygen (O)	-	0.04	0.02-0.04
Phosphorus (P)	-	0.0003	Trace
Sulfur (S)	-	0.002	Trace
Lead (Pb)	-	0.001	Trace
Others (Total)	-	0.005	Trace

3. Physical Properties

The physical properties of Copper C110 make it highly suitable for a wide range of applications. Its density, color, and other physical characteristics are consistent with high-purity copper.

Property	Value (Metric)	Value (Imperial)
Density	8.89-8.95 g/cm³	0.322-0.323 lb/in³
Melting Point	1083°C	1981°F
Color	Red to pinkish	Red to pinkish
Electrical Resistivity (20°C)	1.7 × 10■■ Ω·m	0.000106 Ω·in

4. Mechanical Properties

The mechanical properties of Copper C110 vary depending on the temper and processing conditions. The alloy demonstrates excellent ductility, fatigue strength, and formability, making it suitable for applications requiring repeated flexing or bending without failure.

Property	Annealed	Half Hard (H02)	Hard
Tensile Strength	26-32 ksi (179-220 MPa)	38-42 ksi (262-290 MPa)	42+ ksi (290+ MPa)
Yield Strength	10 ksi (69 MPa)	32 ksi (220 MPa)	38+ ksi (262+ MPa)
Elongation	45-55%	10-20%	5-10%
Hardness (Rockwell)	40-45 HRB	45-60 HRB	60-70 HRB

5. Electrical and Thermal Properties

Copper C110 exhibits outstanding electrical and thermal conductivity, which are among its most important characteristics. With an electrical conductivity of 101% IACS in the annealed condition, it surpasses the international standard for pure copper, making it the preferred material for electrical applications requiring maximum conductivity.

Property	Value	Unit
Electrical Conductivity (Annealed)	100-101%	IACS
Electrical Conductivity (Hard)	97-100%	IACS
Thermal Conductivity (25°C)	391-400	W/(m·K)
Thermal Conductivity (Imperial)	226-238	BTU/(hr·ft²·°F)
Temperature Coefficient of Resistance	0.00393	per °C

Key Performance Characteristics

- Highest commercially available electrical conductivity
- Excellent heat transfer capabilities
- Superior performance in high-power electrical applications
- Minimal energy loss during electrical transmission
- Effective for both electrical conductors and thermal management systems

6. Corrosion Resistance

Copper C110 demonstrates excellent corrosion resistance in most non-oxidizing environments. When exposed to air, a natural protective oxide layer forms on the surface, which shields the underlying metal from further degradation. This passivation layer gives copper its characteristic patina over time and provides long-term protection against atmospheric corrosion.

Environmental Resistance

Excellent Resistance:
• Atmospheric conditions (urban and rural)
• Fresh water and potable water systems
• Non-oxidizing acids
• Most organic chemicals
• Dry gases and steam

Good Resistance:
• Seawater (with proper maintenance)
• Mildly alkaline solutions
• Many industrial atmospheres

Limited Resistance:
• Strong oxidizing acids (e.g., nitric acid)
• Ammonia compounds (risk of stress corrosion cracking)
• Sulfur compounds at elevated temperatures

7. Formability and Workability

Copper C110 exhibits outstanding formability and workability characteristics, making it highly suitable for various forming and fabrication processes. The alloy can be easily bent, stamped, drawn, and shaped without cracking or excessive work hardening.

Process	Rating	Notes
Cold Working	Excellent	Easy bending and forming at room temperature
Hot Working	Excellent	Recommended temperature: 1400-1600°F (760-870°C)
Machinability	Fair (20%)	Compared to free-cutting brass (C360 = 100%)
Annealing	Excellent	Annealing temperature: 700-1200°F (370-650°C)

8. Applications and Uses

Copper C110 finds extensive application across multiple industries due to its exceptional combination of electrical conductivity, thermal properties, formability, and corrosion resistance. The versatility of this alloy makes it indispensable in modern manufacturing and construction.

Electrical and Electronics Applications

- Electrical wiring and conductors
- Bus bars and power distribution systems
- Transformer windings and field coils
- Generator and motor windings
- Electrical contacts, switches, and terminals
- Cable shielding and RFI (Radio Frequency Interference) shielding
- Circuit breakers and switchgear components
- Coaxial cables and overhead line conductors
- Electronic connectors and terminals

Building and Construction Applications

- Plumbing hardware and fittings
- Water supply lines and pipes
- Roofing and architectural facades
- Building fronts and skylight frames
- Gutters, downspouts, and flashing
- Screening and wire mesh
- Door handles and window frames
- Decorative architectural elements

Industrial and Manufacturing Applications

- Heat exchangers and cooling systems
- HVAC equipment components
- Chemical process equipment
- Anodes for electroplating
- Printing rolls and cylinders
- Kettles, pans, and vats
- Resistance welding electrodes
- Electromagnets and inductors

Automotive Applications

- Radiators and cooling systems
- Gaskets and seals
- Spark plug electrodes
- Brake and fuel lines
- Electrical harnesses and connectors

Hardware and Fasteners

- Rivets, nails, and tacks
- Screws, bolts, and nuts

- Cotter pins and ball floats
- Hinges and butts
- Soldering copper and brazing components

9. Fabrication and Processing

Proper fabrication techniques are essential to achieve optimal performance from Copper C110. Understanding the appropriate methods for joining, machining, and heat treatment ensures successful implementation in various applications.

Joining Methods

Joining Method	Rating	Recommendations
Soldering	Excellent	All heating methods suitable; use appropriate flux
Brazing	Good to Excellent	Avoid hydrogen atmosphere; use inert or oxidizing atmosphere
Oxy-Acetylene Welding	Good	Possible with proper technique and gas control
Gas-Shielded Arc Welding	Fair to Good	TIG welding possible but not generally recommended
Resistance Welding	Not Recommended	Spot and seam welding not suitable

Important Joining Considerations

Hydrogen Embrittlement Warning: As a tough pitch copper containing oxygen, C110 is susceptible to hydrogen embrittlement when heated in reducing atmospheres containing hydrogen. The hydrogen reacts with internal oxygen to form water vapor, causing internal cracking and embrittlement. For critical welding applications, oxygen-free copper grades (such as C101 or C102) should be considered as alternatives.

Recommended Practices:
- Use inert gas shielding (argon) for arc welding
- Maintain oxidizing or neutral atmosphere during brazing
- Pre-clean surfaces thoroughly before joining
- Use appropriate filler materials matched to base metal
- Consider post-joining heat treatment for stress relief

Machining Recommendations

Copper C110 has relatively low machinability (rated at 20% compared to free-cutting brass at 100%) due to its soft, ductile nature. However, acceptable machining results can be achieved with proper techniques:

Tool Selection:
- Use sharp carbide or high-speed steel tools
- Maintain positive rake angles (10-20°)
- Use tools with adequate clearance angles

Machining Parameters:
- High cutting speeds (150-400 ft/min for HSS)
- Moderate to high feed rates
- Shallow depth of cut to minimize work hardening
- Continuous chip evacuation to prevent built-up edge

Lubrication:
- Mandatory use of cutting fluids or lubricants
- Prevents galling and seizing between tool and workpiece
- Improves surface finish quality

• Reduces tool wear

Work Hardening Prevention:
• Anneal material before extensive machining if possible
• Avoid interrupted cuts that cause work hardening
• Maintain consistent feed rates

10. Standards and Specifications

Copper C110 is manufactured and supplied in accordance with numerous national and international standards. Compliance with these standards ensures consistent quality, composition, and performance characteristics.

Primary Standards

Organization	Standard Number	Description
ASTM International	B152, B187, B1	Copper sheet, rod, bar specifications
ASTM International	B246, B33, B272	Wire and additional forms
ASTM International	B133	Rod and bar specifications
SAE International	J461, J463	Automotive copper specifications
Federal (US)	QQ-C-502C	Federal specification for copper
Federal (US)	QQ-B-575	Copper rod, bar, shapes
British Standards	BS1433	British copper standards
ISO	Cu-ETP	International copper standard

11. Material Forms and Availability

Copper C110 is commercially available in a wide variety of forms and sizes to accommodate diverse application requirements. The material is typically supplied in specific temper conditions to meet mechanical property requirements.

Available Product Forms

- **Round Bars:** Various diameters from small rods to large bars
- **Square Bars:** Multiple sizes for structural and mechanical applications
- **Rectangular Bars:** Flat bars in various widths and thicknesses
- **Plates:** Heavy flat products, typically over 0.188" thick
- **Sheets:** Thin flat products, available in various gauges
- **Foil:** Very thin sheets for specialized applications
- **Wire:** Round wire in various diameters
- **Tape:** Thin strips for specialized applications
- **Threaded Rod:** Pre-threaded rods for fastening applications
- **Shim Stock:** Very thin sheets for precision spacing
- **Tubes and Pipes:** Hollow forms for fluid handling

Standard Temper Conditions

Annealed (Soft): Maximum formability, lowest strength
1/8 Hard (H01): Light cold work, good formability with increased strength
1/4 Hard (H02): Moderate cold work, balanced properties (most common)
1/2 Hard (H03): Significant cold work, higher strength
Hard (H04): Extensive cold work, maximum strength, limited formability
Spring (H06-H08): Maximum hardness for spring applications

Note: C110 is anneal resistant and typically supplied in 1/8 Hard or 1/4 Hard conditions for optimal performance in most applications.

Key Advantages and Limitations

Primary Advantages

• **Exceptional Electrical Conductivity:** 101% IACS, highest among commercial copper alloys
• **Superior Thermal Conductivity:** Excellent heat transfer properties
• **Outstanding Formability:** Easily shaped, bent, and formed without cracking
• **Excellent Corrosion Resistance:** Long service life in most environments
• **High Purity:** 99.9% minimum copper content ensures consistent properties
• **Good Ductility:** Can withstand repeated flexing and bending
• **Excellent Joining Characteristics:** Easily soldered and brazed
• **Cost-Effective:** Competitive pricing for high-purity copper
• **Wide Availability:** Readily available in multiple forms and sizes
• **Recyclable:** 100% recyclable without loss of properties
• **Proven Track Record:** Decades of successful use in critical applications

Limitations and Considerations

• **Low Machinability:** Relatively difficult to machine compared to free-cutting alloys
• **Hydrogen Embrittlement Risk:** Susceptible to embrittlement in reducing atmospheres
• **Limited Welding Suitability:** Not recommended for extensive welding operations
• **Moderate Strength:** Lower mechanical strength compared to hardened copper alloys
• **Work Hardening:** Can work harden during forming, requiring annealing
• **Ammonia Sensitivity:** Susceptible to stress corrosion cracking in ammonia compounds
• **Oxidizing Acid Resistance:** Limited resistance to strong oxidizing acids
• **Cost Sensitivity:** Price fluctuates with copper market conditions

Comparison with Alternative Copper Grades

When selecting copper materials, it's important to understand how C110 compares to other copper grades for specific applications:

C101 (Oxygen-Free Electronic Copper - OFE):
• Higher purity (99.99% Cu minimum)
• No hydrogen embrittlement issues
• Slightly higher cost
• Preferred for welding and brazing applications
• Ideal for electronic and high-vacuum applications

C102 (Oxygen-Free Copper - OF):
• 99.95% Cu minimum
• Better weldability than C110
• Good for applications requiring welding
• Higher cost than C110

C122 (Phosphorus Deoxidized Copper - DHP):
• Contains 0.015-0.040% phosphorus
• Better machinability than C110
• Slightly lower conductivity
• Better for brazing in reducing atmospheres

Selection Criteria:

- Choose C110 for maximum conductivity and cost-effectiveness
- Choose C101/C102 for welding-intensive applications
- Choose C122 for brazing in hydrogen atmospheres
- Consider C110 as the default choice for electrical applications

Conclusion

Copper C110 (C11000) stands as one of the most widely used and versatile copper alloys in modern industry. Its exceptional combination of electrical and thermal conductivity, excellent formability, superior corrosion resistance, and cost-effectiveness makes it the material of choice for a vast array of applications spanning electrical, electronic, construction, automotive, and industrial sectors.

With a purity level of 99.9% minimum copper and an electrical conductivity rating of 101% IACS, C110 provides unmatched performance in applications where conductivity is paramount. Its availability in numerous forms and temper conditions, combined with compliance with rigorous international standards, ensures consistent quality and reliable performance across diverse applications.

While the material has certain limitations—particularly regarding machinability and hydrogen embrittlement susceptibility—these can be effectively managed through proper processing techniques and material selection. For applications requiring welding or operation in reducing atmospheres, alternative grades such as oxygen-free copper (C101 or C102) should be considered.

The extensive track record of Copper C110 in critical applications, combined with its recyclability and environmental sustainability, positions it as a foundational material for both current and future technological developments. Its importance in electrical power distribution, electronics, renewable energy systems, and advanced manufacturing continues to grow as global demand for efficient energy transmission and high-performance materials increases.

Understanding the properties, capabilities, and limitations of Copper C110 enables engineers, designers, and manufacturers to make informed decisions and optimize material selection for specific applications, ensuring both technical success and economic efficiency.

This comprehensive guide is based on industry standards, manufacturer specifications, and technical literature current as of December 2025. For specific applications, always consult with material suppliers and refer to applicable ASTM, SAE, and other relevant standards for complete specifications and requirements.