1. Product Overview

C51000 is phosphor bronze Grade A - a wrought copper-tin-phosphorus alloy containing nominally 5% tin with 0.03-0.35% phosphorus as a deliberate deoxidiser addition. The tin dissolves substitutionally in the copper matrix to form a single-phase alpha solid solution at room temperature, providing powerful solid-solution strengthening without the embrittling two-phase effects seen in higher-tin casting bronzes. The phosphorus removes dissolved oxygen during melting (as P_2O_5), improving melt fluidity, soundness and wear resistance, and preventing the formation of brittle Cu_2O networks. The result is a wrought alloy with a rare combination of high tensile and yield strength, an exceptionally high elastic limit, outstanding fatigue endurance, and good corrosion resistance across a broad range of environments.

These properties make C51000 the benchmark spring and electrical-contact alloy. It is the material of choice for flat springs, electrical contacts, switch blades, connector terminals, bellows, diaphragms, fasteners, sleeve bearings and bushings where reliable elastic performance under cyclic load is essential. Unlike brass (C26000, C27000), which softens at moderate cold reduction and suffers stress-corrosion cracking in ammonia, phosphor bronze retains high spring stress and resists corrosion in industrial, marine and many chemical environments. Its moderate electrical conductivity (~15% IACS) is sufficient for most contact and connector applications, while its superior mechanical performance justifies the conductivity trade-off versus pure copper (C11000, C10200).

C51000 is supplied in wrought product forms - strip, sheet, foil, rod, bar, wire, tube and forgings - across a full range of tempers from annealed (soft) through quarter-hard, half-hard, three-quarter-hard, hard and extra-spring. It conforms to ASTM B103 (strip / sheet / plate), B139 (rod / bar / shapes), B159 (wire) and B768 (strip for electronic applications), and is traceable by heat lot with EN 10204 mill test certificates. Because it is single-phase alpha, C51000 can be severely cold worked into thin spring temper strip and fine wire without cracking, and then stress-relief annealed to stabilise the spring performance.

1.1 Key Features

- 5% phosphor bronze - single-phase alpha Cu-Sn solid solution at room temperature.
- Phosphorus (0.03-0.35%) acts as deoxidiser: removes oxygen, improves fluidity and wear resistance, prevents brittle Cu_2O.
- Outstanding elastic limit and fatigue endurance - the benchmark spring and contact alloy.
- High tensile and yield strength: annealed ~325 MPa; spring temper up to ~800 MPa UTS.
- Excellent corrosion resistance in industrial, marine and many chemical environments; superior to brass.
- Moderate electrical conductivity (~15% IACS) - adequate for contacts and connectors; superior mechanical performance justifies the trade-off.
- Excellent cold formability: can be stamped, deep-drawn, coined and rolled into thin spring-temper strip.
- Good wear and galling resistance - used for sleeve bearings, bushings and wear plates.
- Solders and brazes readily; can be resistance-welded and gas-shield welded with care.
- Low machinability (~20%) due to tough, galling chip; free-cutting phosphor bronze (C54400, leaded) preferred for high-speed turning.
- Full heat-lot traceability with EN 10204 3.1 mill test certificates.

1.2 Typical Applications

Application	Description
Springs & contacts	Flat springs, switch blades, relay contacts, pressure contacts, sliding contacts
Electrical connectors	Terminals, socket contacts, pin contacts, stamped connector bodies, lead frames
Bellows & diaphragms	Pressure-sensing bellows, expansion joints, sealed pressure gauge capsules
Fasteners	Rivets, screws, locking washers, spring clips, retaining rings
Bearings & bushings	Sleeve bearings, thrust washers, wear plates (lubricated service)
Telecom & electronics	Switch parts, relay components, terminal boards, wire-wrapping pins
Instrumentation	Precision instrument parts, flexure pivots, Bourdon tubes, gauge movements
Musical instruments	Brass-wind instrument components (valves, slides, acoustic springs)
Marine hardware	Non-critical springs and contacts in mild marine atmospheres

1.3 At-a-Glance Specification

Attribute	Value
UNS designation	C51000 (Phosphor Bronze Grade A)
Also known as	Grade A Phosphor Bronze, 5% Phosphor Bronze, PB-A
Alloy system	Cu-Sn-P, single-phase alpha solid solution at room temperature
Cu content	Balance (nominal 94.8%)
Sn content	4.2 - 5.8% (nominal 5%)
P content	0.03 - 0.35%
Density	8.86 g/cm³ (0.320 lb/in³)
Conductivity	≈ 15% IACS (8.7 MS/m at 20 °C)
Melting range	950 - 1 040 °C (1 742 - 1 904 °F)
Thermal conductivity	≈ 75 W/(m·K)
Elastic modulus	110 GPa (16 × 10⁶ psi)
Product forms	Strip, sheet, foil, rod, bar, wire, tube, forgings
Certificates	MTC EN 10204 3.1 / 3.2, SGS, BV, TUV
MOQ	500 kg per specification

Composition and property limits conform to ASTM B103 / B139 / B159 for the C51000 UNS designation. Verify all values against the MTC for each heat lot. Tin content within 4.2-5.8% and phosphorus within 0.03-0.35% are the controlling variables for strength, elastic limit and conductivity.

1.4 When to Choose C51000

C51000 is the right choice when the application demands a combination of high elastic limit, fatigue endurance and corrosion resistance that neither brass (C26000, C27000) nor pure copper (C11000, C10200) can provide. It is the standard material for flat springs, electrical contacts, switch blades, connector terminals, bellows and sleeve bearings. For applications requiring even higher strength and conductivity, C52100 (8% Sn phosphor bronze) offers higher elastic limit at slightly lower conductivity. For free-machining hardware, leaded C54400 machines far better while retaining phosphor bronze corrosion resistance. For high-conductivity busbar or conductor service, pure copper (C11000, C10200) is required. For decorative architectural trim, brass (C26000, C28000) is more cost-effective. For seawater heat-exchanger tube, cupronickel (C70600, C71500) is the correct choice.

2. Chemical Composition & Standards

C51000 is a ternary Cu-Sn-P alloy. The 5% nominal tin content places the alloy well within the single-phase alpha region of the Cu-Sn phase diagram at room temperature: tin dissolves substitutionally in the copper matrix up to about 15.8% Sn at room-temperature equilibrium, so at 5% Sn the microstructure is a homogeneous face-centred-cubic alpha solid solution with no brittle second phase. This is fundamentally different from casting bronzes (C90700, C90500) which at 10-12% Sn can contain hard delta-phase particles, or from brasses (C28000) which at 40% Zn form a two-phase alpha+beta structure. The single-phase alpha structure is the reason C51000 can be severely cold worked into thin spring-temper strip and fine wire without cracking.

The phosphorus addition (0.03-0.35%) is the defining metallurgical feature that distinguishes phosphor bronze from plain tin bronze. Phosphorus is a powerful deoxidiser: it reacts with dissolved oxygen in the melt to form P_2O_5 which is removed in the slag, preventing the formation of brittle Cu_2O (cuprous oxide) networks at grain boundaries. This improves melt fluidity (better cast-and-roll quality), soundness (fewer oxide inclusions), and wear resistance (harder, cleaner matrix). Phosphorus also provides a modest additional solid-solution strengthening effect. Tin is the primary strengthener: at 5% Sn, the solid-solution strengthening raises tensile strength from ~220 MPa (pure copper) to ~325 MPa annealed, and raises the elastic limit proportionally, which is why phosphor bronze is the benchmark spring alloy.

2.1 Chemical Composition (wt%)

Element	Symbol	Content (% mass)	Note
Copper	Cu	Balance (≈ 94.8%)	Matrix; includes Ag
Tin	Sn	4.2 - 5.8	Primary strengthener; raises elastic limit
Phosphorus	P	0.03 - 0.35	Deoxidiser; improves fluidity & wear
Lead	Pb	≤ 0.05	Trace; not a free-machining grade
Iron	Fe	≤ 0.10	Trace impurity
Zinc	Zn	≤ 0.30	Trace; incidental
Nickel	Ni	□ 0.30	Trace; whitening / strengthening
Aluminium	Al	□ 0.02	Trace; impairs hot work if high
Antimony	Sb	□ 0.05	Trace impurity
Arsenic	As	□ 0.02	Trace impurity
Silicon	Si	□ 0.05	Trace impurity
Other (total)	—	≤ 0.50	Sum of other named elements

Composition limits per ASTM B103 / B139 / B159 for the C51000 UNS designation. Note that C51000 does NOT contain lead as a free-machining additive - for leaded free-cutting phosphor bronze, specify C54400 (Pb 3.0-4.5%). Verify composition on the MTC for each heat lot; tin and phosphorus are the controlling variables for strength, elastic limit and conductivity.

2.2 Applicable Standards by Product Form

Product form	Common standards
Strip / sheet / plate	ASTM B103 (phosphor bronze strip / sheet / plate)
Rod & bar	ASTM B139 (phosphor bronze rod / bar / shapes)
Wire	ASTM B159 (phosphor bronze wire)
Strip for electronic apps	ASTM B768 (phosphor bronze strip for electronic)
Tube (seamless)	Customer specification; ASTM B315 (ref.) / B643 (ref.)
Forgings	ASTM B506 (phosphor bronze forgings, ref.)
Foil	ASTM B103 (thin strip); customer specification
EN equivalent	EN CW451K (CuSn5); DIN 2.1015 (CuSn5)
JIS equivalent	JIS H3131 C5191 (close analog; verify composition)

2.3 Phosphor Bronze Comparison - C51000 vs Related Grades

Property	C51000	C52100	C54400	C26000
Common name	Grade A PB	Grade D PB	Free-Cutting PB	Cartridge Brass
Cu (%)	Balance (~94.8)	Balance (~92)	Balance (~88)	Balance (~70)
Sn (%)	4.2 - 5.8	7.0 - 9.0	3.5 - 4.5	—
P (%)	0.03 - 0.35	0.03 - 0.35	0.01 - 0.50	—
Pb (%)	≤ 0.05	≤ 0.05	3.0 - 4.5	≤ 0.07
Zn (%)	≤ 0.30	≤ 0.30	≤ 0.30	Balance (~30)
Phase (room temp.)	Single alpha	Single alpha	Alpha + Pb	Single alpha
Annealed UTS (MPa)	325	380	340	330
Spring temper UTS	≤ 800	≥ 850	≤ 620	≤ 650
Conductivity (% IACS)	~15	~11	~19	~28
Machinability	Poor (20)	Poor (20)	Excellent (80)	Fair (30)
Primary use	Springs, contacts, bearings	Higher-strength springs, bellows	Machined bushings, gears	Deep-drawn, cartridge cases

Machinability rating relative to C36000 = 100 (ASTM / CDA convention). C51000 is the benchmark 5% phosphor bronze spring alloy; C52100 (8% Sn) offers higher elastic limit at lower conductivity; C54400 (leaded) trades a little strength and corrosion resistance for excellent machinability. C26000 brass is shown for reference - it has higher conductivity but lower elastic limit and inferior corrosion and stress-corrosion resistance.

3. Physical, Thermal & Electrical Properties

C51000 exhibits the physical, thermal and electrical properties of a single-phase alpha Cu-Sn solid solution with 5% tin. The tin dissolved in the copper matrix scatters both electrons and phonons more effectively than zinc does, so the 5% Sn addition lowers electrical conductivity to about 15% IACS and thermal conductivity to about 75 W/(m·K) - both well below pure copper (C11000: 100% IACS, 391 W/(m·K)) and also below brass (C26000: 28% IACS, 120 W/(m·K)). In exchange, tin raises density slightly (8.86 vs 8.89 for pure copper - tin is lighter than copper so the effect is small), raises the melting range (950-1040 C vs 1083 C for pure copper), and raises the elastic modulus modestly (110 GPa vs 117 GPa for pure copper - the modulus of tin-bronze is actually slightly lower than pure copper because tin weakens the interatomic bonding). The alloy is non-magnetic and retains useful strength to moderate temperatures. Values below are typical for annealed material at room temperature; cold finishing raises strength and hardness and lowers conductivity slightly.

Property	Symbol	Value	Unit
Density	ρ	8.86	g/cm³
Melting range (solidus - liquidus)	T_m	950 - 1 040	°C
Specific heat capacity	c_p	0.380	J/(g·K)
Thermal conductivity	λ	75	W/(m·K)
Thermal expansion coeff.	α	17.8	× 10□⁶ / K (20 – 300 °C)
Electrical conductivity	σ	≈ 15	% IACS
Electrical resistivity	ρ	0.115	μΩ·m (at 20 °C)
Temp. coeff. of resistance	$α_r$	0.0018	/°C (0 – 100 °C)
Modulus of elasticity	E	110	GPa
Shear modulus	G	41	GPa
Poisson's ratio	v	0.33	—
Magnetic permeability	μ	≈ 1.0	essentially non-magnetic
Max continuous service temp.	—	200	°C (pressure); higher for non-pressure

Sources: ASTM B103 / B139 / B159 property data; CDA alloy data sheet for C51000 (Phosphor Bronze Grade A). Values are typical for annealed material at 20 °C unless noted. Conductivity and resistivity vary with exact Sn and P content and with temper; cold finishing raises resistivity slightly.

4. Mechanical Properties by Temper

C51000 mechanical properties depend primarily on the degree of cold working applied after hot working and annealing. Because the alloy is single-phase alpha, it work-hardens smoothly and can be cold worked to very high strength levels without cracking - this is the key to its use as spring-temper strip and fine wire. The annealed (soft) temper gives moderate strength with high ductility and is used for deep-drawing and forming operations; cold working raises tensile and yield strength dramatically and raises the elastic limit proportionally, which is the property that matters most for spring applications. The highest-strength tempers (extra-spring, H08) can reach tensile strengths of 800 MPa or more, with elastic limits (0.01% offset yield) well above 600 MPa. For spring applications, a final stress-relief anneal (190-260 C) is applied after forming to stabilise the spring performance and raise the fatigue endurance limit. Typical values at room temperature are shown below.

Temper	Tensile (typ.)	Yield 0.2% (typ.)	Elong. (min.)	Hardness (typ.)
Annealed (O, OS050)	325 - 380 MPa	130 - 165 MPa	≥ 45%	32 - 48 HRB
Cold-rolled 1/4 hard (H01)	390 - 455 MPa	245 - 310 MPa	≥ 30%	45 - 60 HRB
Cold-rolled 1/2 hard (H02)	455 - 550 MPa	345 - 415 MPa	≥ 18%	58 - 72 HRB
Cold-rolled 3/4 hard (H03)	550 - 620 MPa	415 - 515 MPa	≥ 10%	70 - 82 HRB
Hard (H04)	590 - 690 MPa	515 - 585 MPa	≥ 7%	78 - 88 HRB
Extra hard (H06)	655 - 730 MPa	550 - 650 MPa	≥ 5%	85 - 95 HRB
Spring (H08)	700 - 800 MPa	585 - 690 MPa	≥ 3%	92 - 100 HRB
Extra spring (H10)	≥ 760 MPa	≥ 660 MPa	≥ 2%	≥ 95 HRB

Hardness shown in Rockwell B scale. Values are indicative; verify against ASTM B103 / B139 / B159 specification limits and the MTC for each lot. For spring applications, a final stress-relief anneal (190-260 C, 1-2 h, air cool) is applied after forming to stabilise the spring performance. The 0.01% offset elastic limit (proportional limit) is typically 70-85% of the 0.2% yield strength and is the controlling property for spring design.

4.1 Fatigue & Elastic Properties

C51000 is selected for springs and contacts precisely because of its exceptional fatigue endurance and high elastic limit. Typical values for spring-temper (H08) strip at room temperature:

Property	Value
Elastic limit (0.01% offset)	550 - 690 MPa (spring temper)
Proportional limit	70 - 85% of 0.2% yield strength
Endurance limit (10^7 cycles)	≈ 240 - 290 MPa (reverse bending, spring temper)
Endurance limit (annealed)	≈ 140 - 170 MPa (reverse bending)
Modulus of elasticity (E)	110 GPa (tension); 41 GPa (shear)
Modulus of resilience	≈ 1.4 MJ/m³ (spring temper, high for a copper alloy)
Stress-relief anneal	190 - 260 °C, 1 - 2 h, air cool (post-form)
Softening temp. (cold work)	≥ 250 °C (cold-finished tempers soften)

The endurance limit values are indicative for fully-reversed bending fatigue of unnotched spring-temper strip at room temperature. Actual fatigue life depends on surface finish, edge condition, stress concentration, environment and frequency; verify against application-specific testing. The stress-relief anneal (190-260 C) is essential after forming to remove residual stresses, raise the proportional limit, and stabilise the spring performance under cyclic load.

5. Product Forms & Size Range

C51000 is supplied across a range of wrought product forms. Strip and foil are the highest-volume forms, driven by spring, contact and connector manufacturing; rod and bar are supplied for machined bushings, bearings and wear components; wire is produced for springs, contacts and fasteners; tube is available for specialised bearing and instrumentation applications. Because C51000 is single-phase alpha, it can be cold rolled to very thin gauges (spring-temper strip and foil) without cracking, and cold drawn to fine wire gauges. The key production controls are melt deoxidation (phosphorus management), homogenisation (to eliminate tin segregation), grain-size management (critical for forming and fatigue), and temper control (critical for spring performance).

Surface finish, edge condition (for strip), temper uniformity and freedom from inclusions are controlled throughout production. Mill-rolled, cold-rolled precision, and bright-annealed surfaces are offered per the applicable ASTM specification and customer requirements.

5.1 Standard Size Range by Product Form

Form	Typical size range	Notes
Strip / sheet	Thick. 0.05 - 6 mm; width ≤ 400 mm	ASTM B103; spring, contact, connector strip
Foil	Thick. 0.01 - 0.15 mm; width ≤ 300 mm	ASTM B103; thin gauge for electronics
Plate	Thick. 6 - 50 mm; width ≤ 1 000 mm	ASTM B103; bearings, wear plates
Round rod / bar	Dia. 3 - 100 mm; length 1 - 4 m	ASTM B139; bushings, bearings, machined parts
Square / hex bar	5 - 60 mm across flats	ASTM B139; hardware, gear blanks
Wire	Dia. 0.05 - 6 mm	ASTM B159; springs, contacts, fasteners
Tube (seamless)	OD 4 - 60 mm; wall 0.5 - 5 mm	Specialised; bearing and instrumentation
Forgings	Per customer drawing	Bearings, wear components, custom shapes

5.2 Surface Finish & Special Processing

- Strip / foil: cold-rolled precision, bright-annealed, or polished finish per ASTM B103.
- Rod / bar: cold-drawn, centreless-ground or polished per ASTM B139.
- Wire: hard, medium-hard or annealed; bare or tinned per ASTM B159.
- Tube: bright-annealed inside and out for bearing and instrumentation service.
- Edge condition for strip: round, square, deburred or slit-edge per spec.
- Grain size controlled and reported: fine grain (0.015-0.035 mm) for spring temper is critical for fatigue.
- Stress-relief anneal (190-260 C) applied to formed spring parts to stabilise elastic performance.
- Custom slitting, blanking, stamping and drawn profiles to customer drawing.
- Tin-plated or nickel-plated strip available for corrosion or solderability enhancement.

5.3 Packaging

- Strip / foil: coil on cores, moisture-barrier wrapped, desiccant included.
- Sheet / plate: palletised with interleave paper, edge protectors and moisture barrier.
- Rod / bar: bundled in wooden cases with separator strips and end protection.
- Wire: coils or spools, individually bagged, desiccant included.
- Tube: bundled or boxed, capped ends, desiccant for bright-annealed stock.
- Each bundle tagged with heat number, size, temper and quantity.
- Export seaworthy packing with moisture barrier and desiccant.

6. Tolerances, Finish & Quality Control

C51000 products are produced and inspected to the applicable ASTM specification (B103, B139, B159, B768). Because the alloy is used primarily for precision springs, contacts and bearings, the key quality controls are melt deoxidation (phosphorus management to ensure soundness and wear resistance), homogenisation (to eliminate tin segregation), grain-size management (critical for forming and fatigue - fine, uniform grain is essential for spring temper), and temper control (critical for spring performance - tensile, yield, elastic limit and hardness must meet specification). Tensile, elongation and hardness testing applies to every lot; grain-size measurement applies to annealed and spring-temper strip; and bend / formability testing applies to strip and bar stock. For tube, hydrostatic or pneumatic testing applies.

6.1 Dimensional Tolerances (typical)

Parameter	Typical tolerance
Strip thickness	± 0.003 - 0.05 mm (precision; per thickness range, ASTM B103)
Strip width	± 0.10 - 0.50 mm
Sheet / plate thickness	± 0.05 - 0.50 mm (per thickness range, ASTM B103)
Rod diameter (cold-drawn)	h8 - h9 (e.g. ± 0.02 - 0.08 mm)
Wire diameter	± 0.005 - 0.05 mm (per AWG / metric class, ASTM B159)
Tube OD / wall	Per specification class; OD ± 0.05 - 0.15 mm
Straightness (bar)	≤ 2.0 mm in any 1 m length
Flatness (strip / sheet)	Per ASTM B103 class; tighter for spring temper

6.2 Surface Finish & Cleanliness

- Smooth, clean surface per ASTM acceptance standard; no laminations, cracks or inclusions.
- Cold-rolled strip: bright, uniform finish; free from rolling lubricant residue for contact service.
- Bright-annealed strip: oxide-free, bright surface; critical for electrical contact performance.
- Annealed grain size controlled and reported (ASTM E112 intercept method); fine, uniform grain essential for spring fatigue.
- Rod / bar edges and ends deburred; cold-drawn surfaces bright and uniform.
- Wire surfaces bright and clean; tinned wire uniform and continuous.
- Freedom from oxide inclusions (Cu_2O) confirmed by metallographic examination - phosphorus deoxidation verified.

6.3 Quality Control Test List

Test	Standard / method	Frequency
Chemical analysis (full)	ASTM E478 / E118 (Cu, Sn, P, Pb, Fe, all)	Each heat
Tensile / elongation	ASTM E8 / E8M	Each lot
Hardness (HRB / HV)	ASTM E18 / E92	Each lot
Grain size (annealed / spring)	ASTM E112 (intercept method)	Each lot (strip)
Elastic limit / proportional limit	ASTM E8 (0.01% offset); customer method	Each lot (spring temper)
Microstructure (single-phase alpha)	ASTM E3 / E407; no second phase	Each lot
Dimensional inspection	Calipers / micrometers / laser	Each piece / sample
Bend / formability test	ASTM E290 / customer method	Each lot (strip / bar)
Surface / visual inspection	ASTM acceptance criteria; eddy-current (tube)	Each piece
Oxide-inclusion check	Metallographic; confirms phosphorus deoxidation	Each heat
Fatigue (application-specific)	Customer method (reverse bending)	On request

Grain-size measurement is mandatory for spring-temper strip because fine, uniform grain (typically ASTM No. 7-9, or 0.015-0.030 mm) is essential for fatigue endurance and consistent elastic performance. Oxide-inclusion metallographic examination confirms that the phosphorus deoxidation was effective - absence of Cu_2O networks at grain boundaries is critical for soundness, wear resistance and fatigue life. Verify all values against the MTC.

7. Fabrication, Welding & Service Considerations

C51000 is the benchmark spring and contact alloy. Its single-phase alpha microstructure means it can be severely cold worked into thin spring-temper strip and fine wire without cracking, and then stress-relief annealed to stabilise the elastic performance. The fabrication strategy centres on cold forming (stamping, deep-drawing, coining, bending) of strip and wire into spring, contact and connector shapes, followed by stress-relief anneal (190-260 C) to remove residual forming stresses and raise the proportional limit. Machining is poor due to the tough, galling chip characteristic of single-phase tin bronze - for high-speed turning, leaded C54400 is preferred. C51000 solders and brazes readily, and can be resistance-welded and gas-shield welded with care. The guidance below covers the fabrication and service practices that exploit C51000's spring and contact performance advantage and avoid its known limitations.

7.1 Forming & Joining

- Cold formability: excellent - can be stamped, deep-drawn, coined, bent and rolled into thin spring-temper strip and fine wire without cracking.
- Annealing: 475 - 675 °C, air cool; restores soft, ductile single-phase alpha structure for further forming.
- Stress-relief anneal: 190 - 260 °C, 1-2 h, air cool; applied after forming to stabilise spring performance and raise proportional limit.
- Soldering: excellent; surfaces tin readily with tin-lead and lead-free solders after proper fluxing.
- Brazing: good with silver and copper-phosphorus brazing alloys; flux required (phosphorus in alloy does not fully self-flux).
- Welding: gas-shield (GTAW / TIG, GMAW / MIG) acceptable for non-critical joints; resistance welding (spot, seam) good for strip and wire.
- Machining: poor (~20% machinability rating); tough, galling chip; use high-speed steel or carbide tools with sharp positive rake.
- For high-speed turning, use free-cutting C54400 (leaded, 80% machinability) and accept slightly lower strength and corrosion resistance.
- Polishing / plating: takes a bright polish and accepts tin, nickel, silver and gold plating readily for contact enhancement.
- Coining / embossing: excellent for precision stamped contacts and connector shapes.

7.2 Service Limits & Design Notes

C51000 can operate continuously up to about 200 °C for pressure-containing and structural code applications; for spring and contact service, the stress-relief temperature (190-260 C) defines the upper service limit - sustained operation above this level will progressively relieve the cold-worked temper and lower the spring stress. Softening of cold-finished tempers begins near 250 °C, so cold-finished spring parts should not see sustained service above this level. Galvanically, C51000 is compatible with other copper alloys and with steel; it should be insulated from aluminium and from passive stainless steel in conductive media to avoid galvanic attack. C51000 has excellent corrosion resistance in industrial, marine and many chemical environments - superior to brass (C26000, C27000) and to free-machining leaded bronze (C54400). It does not suffer the dezincification or season cracking (ammonia stress-corrosion) problems that limit brass service. For bearing and bushing service, C51000 requires adequate lubrication - it is not a true self-lubricating bearing alloy like leaded bronze (C93200) or aluminium bronze (C95400).

7.3 Design Practices

- Specify C51000 for springs, contacts and connectors where high elastic limit, fatigue endurance and corrosion resistance are required.
- For applications requiring even higher elastic limit, use C52100 (8% Sn phosphor bronze) - higher strength at slightly lower conductivity.
- For high-speed machined bushings and gears, use leaded C54400 (free-cutting phosphor bronze) - far better machinability.
- For self-lubricating sleeve bearings, use cast bearing bronze (C93200, C93700) - C51000 requires lubrication.
- Control grain size for spring temper: fine, uniform grain (ASTM No. 7-9) is essential for fatigue endurance.
- Apply stress-relief anneal (190-260 C) after forming all spring parts to stabilise elastic performance and raise proportional limit.
- For contact and connector service, tin, nickel, silver or gold plating enhances corrosion resistance and contact performance.
- For ammonia-bearing service, phosphor bronze is more resistant than brass - stress-relief anneal is still recommended for cold-worked parts.
- For high-conductivity conductor or busbar service, use pure copper (C11000, C10200) instead - C51000's 15% IACS is too low.
- For decorative architectural trim, brass (C26000, C28000) is more cost-effective and has better formability and colour.

8. About Gnee Metal

Gnee Metal is a supplier of copper and copper-alloy products for export markets. Our ISO 9001 / 14001 / 45001 certified plants serve customers in North America, Europe, the Middle East and Southeast Asia with C51000 phosphor bronze strip, sheet, foil, rod, bar, wire, tube and forgings for spring, contact, connector, bearing and instrumentation applications.

We provide project-specific mill test certificates (EN 10204 3.1 / 3.2) with certified composition, grain size, mechanical data and elastic-limit verification, third-party inspection by SGS / BV / TUV, and value-added services including custom slitting, blanking, stamping, precision cold finishing, stress-relief annealing, tin / nickel / silver plating, and technical consultation to help you select the correct grade, temper and grain size for your spring or contact application. Contact us for a quote or for assistance.

Item	Detail
Website	chinacopperalloys.com
Email	sales@gneemetal.com
Certificates	ISO 9001 / ISO 14001 / ISO 45001
Third-party	SGS, Bureau Veritas, TÜV