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Copper vs copper-clad steel earthing assessment

SAMPLE – hypothetical project, illustrating format and method

This sample shows what the free assessment we provide for each project contains and how it is calculated. The figures are for a hypothetical project and do not correspond to any real site; the formal report is issued from the customer's data and signed by the chief engineer.

1 Inputs (as received)

Project	110 kV distribution substation (hypothetical project, coastal site)
Original design	Horizontal grid conductor 120 mm² bare copper strand; vertical rods Ø16 × 2.5 m copper-bonded
Quantities	Grid conductor 6,200 m; rods 120 pcs
Design current in the grid conductor	20 kA (from the owner's short-circuit study, after the split factor); clearing time t_c = 1.0 s (backup protection)
Soil	Resistivity 45 Ω·m; pH 6.9; chloride 0.18 % (coastal, saline); high moisture
Design life	40 years
Standards	IEEE Std 80-2013 (sizing) · DL/T 1312-2023 (product, type tests) · IEEE 837 / DL/T 1342-2014 (joints)

2 Soil corrosivity class and copper thickness

With 0.18 % chloride, high moisture and a coastal environment, the soil is classed **high corrosivity**. Under the anti-corrosion standards Q/GDW 12015-2020 and DL/T 2094-2020 and the supervision guide DL/T 2650-2023 (cl. 5.1.1.5, Table 4), high corrosivity calls for copper-clad steel or copper with at least 0.80 mm copper; the allowance is checked per DL/T 2094 for a 40-year life at the copper corrosion rate of DL/T 1312-2023 cl. 4.6, Table 1, 0.012 mm/a; pH 6.9 does not trigger an upgrade.

Allowance = 0.012 × 40 = 0.48 mm Residual layer at end of life = 0.25 mm Minimum copper = 0.48 + 0.25 = **0.73 mm → select the 0.8 mm class**

Minimum copper thickness at any point ≥ 0.80 mm (DL/T 1312 clause 7, nine points, minimum governs, ISO 2178 magnetic method).

3 Thermal check (IEEE Std 80-2013 clause 11.3.1)

Full equation (37) with the Table 1 material constants, ambient 40 °C, fusing temperature:

$$A_{mm^2} = I / \sqrt{[\ (TCAP \cdot 10^{-4} / (t_c \cdot \alpha_r \cdot \rho_r)) \cdot \ln((K_0+T_m)/(K_0+T_a))\ ]}$$

Material	α_r (1/°C)	ρ_r (μΩ·cm)	K_0	T_m (°C)	TCAP (J/cm³·°C)	Required section @ 20 kA, 1 s	Simplified check $A_{kcmil} = I \cdot K_f \cdot \sqrt{t_c}$
Copper, annealed soft-drawn	0.00393	1.72	234	1083	3.42	**71.0 mm²**	20 × 7.00 = 140 kcmil = 70.9 mm²
CCS wire, 30 % IACS	0.00378	5.86	245	1084	3.85	**122.3 mm²**	20 × 12.06 = 241 kcmil = 122.1 mm²
CCS 31 % IACS (Ø16 / 1.0 mm, actual resistivity per clause 11.3.1.2)	0.00378	5.56	245	1084	3.85	**119.1 mm²**	—

1 kcmil = 0.5067 mm². Option A (Ø14 / 0.8 mm) is about 29 % IACS by the rule of mixtures; the check uses the 30 % class constants, a difference under 3 % covered by the 26 % section margin.

The original 120 mm² copper withstands 120 / (7.00 × 0.5067) = 33.8 kA at t_c = 1 s – more than the 20 kA design current, i.e. the original design carries margin. Two options are therefore given: an equal-diameter option checked against the design current, and an equal-withstand option that keeps the original copper conductor's capacity.

4 Options

Option A – equal diameter: Ø14 round wire, 0.8 mm copper, annealed

Section 154 mm² ≥ 122 mm² required (margin 26 %); same outside diameter as the original 120 mm² strand (≈ Ø14), so moulds and laying practice are unchanged; model CCS CC 25-0.8-Φ14, a size covered by a full DL/T 1312 type-test report.

Option B – equal short-circuit withstand: Ø16 round wire, 1.0 mm copper, annealed

Keeping the original copper's withstand (33.8 kA · 1 s): with the 31 % IACS constants the required section is 201 mm², and Ø16 provides 201 mm² – a match; model CCS CC 30-1.0-Φ16. This size is outside the present type-test matrix and is type-tested on request under our rule (free for orders of US$ 30,000 and above). Alternative: Ø18 / 0.8 mm (254 mm², ≈ 25 % IACS), already reported, with more margin.

Vertical rods

Ø20 × 2.5 m, 0.8 mm continuous-cast rods (CCS CC 20-0.8-Φ20, hard temper, tensile ≥ 550 N/mm²), a type-tested size; quantity 120 pcs unchanged.

5 Copper quantity and copper value (grid conductor, 6,200 m)

Conductor	Section mm²	Copper mm²	% IACS	kg/m	Copper kg/m	Copper t	Saving	Copper value US$
Original: 120 mm² bare copper strand	120	120.0	100	1.08	1.075	6.67	0 %	98,660
Option A – Ø14 round wire, 0.8 mm copper, annealed (CCS CC 25-0.8-Φ14)	154	33.2	29	1.25	0.297	1.84	72 %	27,276
Option B – Ø16 round wire, 1.0 mm copper, annealed (CCS CC 30-1.0-Φ16)	201	47.1	31	1.63	0.422	2.62	61 %	38,744

Copper value at US$ 14,800/t (LME reference, updated at quotation date) – conductor copper content only, not product price; the copper-clad steel price includes the steel core and processing and is given in the quotation. Densities 8.96 and 7.85 g/cm³.

6 Test evidence and joints

Size	Type-test status	Routine tests
Ø14 / 0.8 mm (CCS CC 25-0.8-Φ14)	Full DL/T 1312-2023 report available (CMA/CNAS), English summary with the quotation	Per lot ≤ 5,000 m: copper thickness (9 points), surface, tensile, bend, resistivity; factory report with each lot; retest at any accredited laboratory
Ø16 / 1.0 mm (CCS CC 30-1.0-Φ16)	Type-tested on request, about two months	
Ø20 rod / 0.8 mm (CCS CC 20-0.8-Φ20)	Report available	

Joints: exothermic welding, CCS–CCS and CCS–copper (equipment leads) with moulds for the sizes concerned and the same powder as copper–copper; acceptance per DL/T 1342-2014 (full enclosure of the parent conductor, DC resistance ≤ 1.1 × an equal length of parent, tensile ≥ parent), or IEEE 837 for US-specification projects. Every cut end is buried only inside a weld or after corrosion-protective coating. We supply moulds, powder and the procedure, and attend the first joints on site.

7 What this report does not cover

Grid resistance and touch and step voltages are governed by the soil model and grid geometry, not by the conductor material, and remain the design institute's calculation by its usual method; rod layout and mesh spacing are unchanged. Changing the conductor material changes the conductor section and copper layer, not the grid's electrical results.

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Customer acknowledgement (formal report)

Sample notice: all inputs are hypothetical; the method and constants are those used in formal reports. Formal reports are issued within 24–48 hours of complete data, free of charge.