Comprehensive Aluminum vs Copper Busbar Ampacity Comparison

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Detailed Performance Comparison Tables

Operating Conditions

Frequency: 60 Hz

Temperature Rise Standards: 30°C / 50°C / 65°C

Copper Alloy: C110 (99.9% pure)

Aluminum Alloy: 6101-T6 (optimal conductivity)

Section 1: Small Cross-Sections (1/16" - 1/8" Thickness)

1/16" Thickness Series

Size (inches)	Material	Weight (lb/ft)	DC Resistance (μΩ/ft)	30°C Rise (A)	50°C Rise (A)	65°C Rise (A)	Cu/Al Ratio	Weight Ratio	Resistance Ratio
1/16 × 1/2	Copper	0.121	264	103	136	157	-	3.27	0.53
	Aluminum	0.037	494	58	76	88	1.79	1.00	1.00
1/16 × 3/4	Copper	0.181	175	145	193	225	-	3.29	0.54
	Aluminum	0.055	327	81	108	126	1.79	1.00	1.00
1/16 × 1	Copper	0.242	132	187	250	285	-	3.32	0.53
	Aluminum	0.073	247	105	140	160	1.79	1.00	1.00
1/16 × 1-1/2	Copper	0.362	87.7	270	355	410	-	3.29	0.53
	Aluminum	0.110	164	151	199	230	1.78	1.00	1.00
1/16 × 2	Copper	0.483	65.8	345	460	530	-	3.31	0.53
	Aluminum	0.146	123	193	258	297	1.78	1.00	1.00

1/8" Thickness Series

Size (inches)	Material	Weight (lb/ft)	DC Resistance (μΩ/ft)	30°C Rise (A)	50°C Rise (A)	65°C Rise (A)	Cu/Al Ratio	Weight Ratio	Resistance Ratio
1/8 × 1/2	Copper	0.241	132	153	205	235	-	3.30	0.53
	Aluminum	0.073	247	86	115	132	1.78	1.00	1.00
1/8 × 3/4	Copper	0.362	87.7	215	285	325	-	3.29	0.53
	Aluminum	0.110	164	120	160	182	1.78	1.00	1.00
1/8 × 1	Copper	0.483	65.8	270	360	415	-	3.31	0.53

Size (inches)	Material	Weight (lb/ft)	DC Resistance (μΩ/ft)	30°C Rise (A)	50°C Rise (A)	65°C Rise (A)	Cu/Al Ratio	Weight Ratio	Resistance Ratio
	Aluminum	0.146	123	151	202	232	1.78	1.00	1.00
1/8 × 1-1/2	Copper	0.726	43.8	385	510	590	-	3.30	0.53
	Aluminum	0.220	82	216	286	330	1.78	1.00	1.00
1/8 × 2	Copper	0.966	32.9	495	660	760	-	3.30	0.53
	Aluminum	0.293	62	277	370	426	1.78	1.00	1.00
1/8 × 2-1/2	Copper	1.210	26.4	600	800	920	-	3.32	0.54
	Aluminum	0.365	49	336	448	515	1.79	1.00	1.00
1/8 × 3	Copper	1.450	21.9	710	940	1100	-	3.30	0.53
	Aluminum	0.439	41	398	526	616	1.79	1.00	1.00
1/8 × 3-1/2	Copper	1.690	18.8	810	1100	1250	-	3.30	0.54
	Aluminum	0.512	35	454	616	700	1.79	1.00	1.00
1/8 × 4	Copper	1.930	16.5	900	1200	1400	-	3.30	0.53
	Aluminum	0.585	31	504	672	784	1.79	1.00	1.00

Section 2: Medium Cross-Sections (3/16" - 1/4" Thickness)

3/16" Thickness Series

Size (inches)	Material	Weight (lb/ft)	DC Resistance (μΩ/ft)	30°C Rise (A)	50°C Rise (A)	65°C Rise (A)	Cu/Al Ratio	Weight Ratio	Resistance Ratio
3/16 × 1/2	Copper	0.362	87.7	195	260	300	-	3.29	0.53
	Aluminum	0.110	164	109	146	168	1.78	1.00	1.00
3/16 × 3/4	Copper	0.545	58.4	270	360	415	-	3.30	0.54
	Aluminum	0.165	109	151	202	232	1.78	1.00	1.00
3/16 × 1	Copper	0.726	43.8	340	455	520	-	3.30	0.53
	Aluminum	0.220	82	190	255	291	1.78	1.00	1.00
3/16 × 1-1/2	Copper	1.090	29.3	480	630	730	-	3.31	0.53
	Aluminum	0.329	55	269	353	409	1.78	1.00	1.00
3/16 × 2	Copper	1.450	21.9	610	810	940	-	3.30	0.53
	Aluminum	0.439	41	342	454	526	1.78	1.00	1.00
3/16 × 2-1/2	Copper	1.810	17.5	740	980	1150	-	3.30	0.53
	Aluminum	0.549	33	414	549	644	1.78	1.00	1.00
3/16 × 3	Copper	2.170	14.6	870	1150	1350	-	3.30	0.54
	Aluminum	0.658	27	487	644	756	1.79	1.00	1.00
3/16 × 3-1/2	Copper	2.530	12.5	990	1300	1500	-	3.29	0.54
	Aluminum	0.768	23	554	728	840	1.79	1.00	1.00
3/16 × 4	Copper	2.900	11.0	1100	1450	1700	-	3.30	0.52

Size (inches)	Material	Weight (lb/ft)	DC Resistance (μΩ/ft)	30°C Rise (A)	50°C Rise (A)	65°C Rise (A)	Cu/Al Ratio	Weight Ratio	Resistance Ratio
	Aluminum	0.878	21	616	812	952	1.79	1.00	1.00

1/4" Thickness Series (Most Common)

Size (inches)	Material	Weight (lb/ft)	DC Resistance (μΩ/ft)	30°C Rise (A)	50°C Rise (A)	65°C Rise (A)	Cu/Al Ratio	Weight Ratio	Resistance Ratio
1/4 × 1/2	Copper	0.483	65.8	240	315	360	-	3.31	0.53
	Aluminum	0.146	123	134	176	202	1.79	1.00	1.00
1/4 × 3/4	Copper	0.726	43.8	320	425	490	-	3.30	0.53
	Aluminum	0.220	82	179	238	274	1.79	1.00	1.00
1/4 × 1	Copper	0.966	32.9	400	530	620	-	3.30	0.53
	Aluminum	0.293	62	224	297	347	1.78	1.00	1.00
1/4 × 1-1/2	Copper	1.450	21.9	560	740	880	-	3.30	0.53
	Aluminum	0.439	41	314	414	482	1.79	1.00	1.00
1/4 × 2	Copper	1.930	16.5	710	940	1100	-	3.30	0.53
	Aluminum	0.585	31	398	526	616	1.79	1.00	1.00
1/4 × 2-1/2	Copper	2.410	13.2	850	1150	1300	-	3.30	0.53
	Aluminum	0.731	25	476	644	728	1.79	1.00	1.00
1/4 × 3	Copper	2.900	11.0	990	1300	1550	-	3.30	0.52
	Aluminum	0.878	21	554	728	868	1.79	1.00	1.00
1/4 × 3-1/2	Copper	3.380	9.4	1150	1500	1750	-	3.30	0.52
	Aluminum	1.024	18	644	840	980	1.79	1.00	1.00
1/4 × 4	Copper	3.860	8.23	1250	1700	1950	-	3.30	0.55
	Aluminum	1.170	15	700	952	1092	1.79	1.00	1.00
1/4 × 5	Copper	4.830	6.58	1500	2000	2350	-	3.30	0.55
	Aluminum	1.463	12	840	1120	1316	1.79	1.00	1.00
1/4 × 6	Copper	5.800	5.49	1750	2350	2700	-	3.30	0.55
	Aluminum	1.755	10	980	1316	1512	1.79	1.00	1.00

Section 3: Large Cross-Sections (3/8" - 1/2" Thickness)

3/8" Thickness Series

Size (inches)	Material	Weight (lb/ft)	DC Resistance (μΩ/ft)	30°C Rise (A)	50°C Rise (A)	65°C Rise (A)	Cu/Al Ratio	Weight Ratio	Resistance Ratio
3/8 × 3/4	Copper	1.090	29.3	415	550	630	-	3.31	0.53
	Aluminum	0.329	55	232	308	353	1.79	1.00	1.00
3/8 × 1	Copper	1.450	21.9	510	680	790	-	3.30	0.53

Size (inches)	Material	Weight (lb/ft)	DC Resistance (μΩ/ft)	30°C Rise (A)	50°C Rise (A)	65°C Rise (A)	Cu/Al Ratio	Weight Ratio	Resistance Ratio
	Aluminum	0.439	41	286	381	442	1.78	1.00	1.00
3/8 × 1-1/2	Copper	2.170	14.6	710	940	1100	-	3.30	0.54
	Aluminum	0.658	27	398	526	616	1.78	1.00	1.00
3/8 × 2	Copper	2.900	11.0	880	1150	1350	-	3.30	0.52
	Aluminum	0.878	21	493	644	756	1.78	1.00	1.00
3/8 × 2-1/2	Copper	3.620	8.77	1050	1400	1600	-	3.30	0.55
	Aluminum	1.097	16	588	784	896	1.79	1.00	1.00
3/8 × 3	Copper	4.350	7.35	1200	1600	1850	-	3.32	0.53
	Aluminum	1.310	14	672	896	1036	1.79	1.00	1.00
3/8 × 3-1/2	Copper	5.060	6.38	1350	1800	2100	-	3.30	0.53
	Aluminum	1.533	12	756	1008	1176	1.79	1.00	1.00
3/8 × 4	Copper	5.800	5.49	1500	2000	2350	-	3.30	0.55
	Aluminum	1.755	10	840	1120	1316	1.79	1.00	1.00
3/8 × 5	Copper	7.260	4.38	1800	2400	2800	-	3.30	0.55
	Aluminum	2.200	8	1008	1344	1568	1.79	1.00	1.00
3/8 × 6	Copper	8.690	3.66	2100	2800	3250	-	3.30	0.52
	Aluminum	2.633	7	1176	1568	1820	1.79	1.00	1.00

1/2" Thickness Series (Heavy Duty Applications)

Size (inches)	Material	Weight (lb/ft)	DC Resistance (μΩ/ft)	30°C Rise (A)	50°C Rise (A)	65°C Rise (A)	Cu/Al Ratio	Weight Ratio	Resistance Ratio
1/2 × 1	Copper	1.930	16.5	620	820	940	-	3.30	0.53
	Aluminum	0.585	31	347	459	526	1.79	1.00	1.00
1/2 × 1-1/2	Copper	2.900	11.0	830	1100	1250	-	3.30	0.52
	Aluminum	0.878	21	465	616	700	1.79	1.00	1.00
1/2 × 2	Copper	3.860	8.23	1000	1350	1550	-	3.30	0.55
	Aluminum	1.170	15	560	756	868	1.79	1.00	1.00
1/2 × 2-1/2	Copper	4.830	6.58	1200	1600	1850	-	3.30	0.55
	Aluminum	1.463	12	672	896	1036	1.79	1.00	1.00
1/2 × 3	Copper	5.800	5.49	1400	1850	2150	-	3.30	0.55
	Aluminum	1.755	10	784	1036	1204	1.79	1.00	1.00
1/2 × 3-1/2	Copper	6.760	4.70	1550	2100	2400	-	3.30	0.52
	Aluminum	2.048	9	868	1176	1344	1.79	1.00	1.00
1/2 × 4	Copper	7.730	4.11	1700	2300	2650	-	3.30	0.51
	Aluminum	2.340	8	952	1288	1484	1.79	1.00	1.00
1/2 × 5	Copper	9.660	3.29	2050	2750	3150	-	3.30	0.55

Size (inches)	Material	Weight (lb/ft)	DC Resistance (μΩ/ft)	30°C Rise (A)	50°C Rise (A)	65°C Rise (A)	Cu/Al Ratio	Weight Ratio	Resistance Ratio
	Aluminum	2.925	6	1148	1540	1764	1.79	1.00	1.00
1/2 × 6	Copper	11.600	2.74	2400	3150	3650	-	3.30	0.55
	Aluminum	3.510	5	1344	1764	2044	1.79	1.00	1.00
1/2 × 8	Copper	15.500	2.06	3000	4000	4600	-	3.31	0.52
	Aluminum	4.680	4	1680	2240	2576	1.79	1.00	1.00

Section 4: Performance Analysis Summary

Ampacity Comparison by Temperature Rise

Temperature Rise	Copper Advantage	Aluminum Advantage	Typical Ratio
30°C	Higher current capacity	Lighter weight	Cu = 1.78~1.79 × Al
50°C	Higher current capacity	Lower cost	Cu = 1.78~1.79 × Al
65°C	Higher current capacity	Easier handling	Cu = 1.78~1.79 × Al

Material Properties Comparison

Property	Copper C110	Aluminum 6101	Ratio
Electrical Conductivity (% IACS)	100%	56-58%	1.75
Density	8.89 g/cm³	2.70 g/cm³	3.29
Specific Resistance @ 20°C	1.724 μΩ·cm	2.86 μΩ·cm	1.66
Thermal Conductivity	391 W/m·K	218 W/m·K	1.79
Coefficient of Thermal Expansion	16.5 × 10■■/K	23.6 × 10■■/K	1.43
Tensile Strength	220-250 MPa	150-180 MPa	1.50
Cost (relative)	3.5-4.0	1.0	3.75

Section 5: Equivalent Ampacity Selection Guide

For 50°C Temperature Rise (Most Common Application)

Copper Size	Ampacity	Equivalent Aluminum Size	Ampacity	Notes
1/4 × 1	530 A	1/4 × 2	526 A	Nearly perfect match
1/4 × 1-1/2	740 A	3/8 × 2	644 A	Al requires thickness increase
1/4 × 2	940 A	1/2 × 2	756 A	Consider 3/8 × 3 (896 A)
1/4 × 3	1300 A	1/2 × 3	1036 A	Consider 1/2 × 3-1/2 (1176 A)
1/4 × 4	1700 A	1/2 × 4	1288 A	Consider 1/2 × 5 (1540 A)

Copper Size	Ampacity	Equivalent Aluminum Size	Ampacity	Notes
3/8 × 2	1150 A	1/2 × 3	1036 A	Consider 1/2 × 3-1/2 (1176 A)
3/8 × 3	1600 A	1/2 × 5	1540 A	Nearly perfect match
3/8 × 4	2000 A	1/2 × 6	1764 A	Requires larger Al size
1/2 × 2	1350 A	1/2 × 4	1288 A	Good match
1/2 × 4	2300 A	1/2 × 8	2240 A	Nearly perfect match

Section 6: Cost-Benefit Analysis

Material Cost Comparison (Based on 50°C Rise, 100 ft installation)

Application	Copper Size	Cu Cost	Cu Weight	Al Size	Al Cost	Al Weight	Cost Savings	Weight Savings
500A Service	1/4 × 1	$320	96.6 lb	1/4 × 2	$95	58.5 lb	70%	39%
750A Service	1/4 × 1-1/2	$460	145 lb	3/8 × 2	$140	87.8 lb	70%	39%
1000A Service	1/4 × 2	$610	193 lb	1/2 × 2	$185	117 lb	70%	39%
1500A Service	1/4 × 4	$1220	386 lb	1/2 × 4	$370	234 lb	70%	39%
2000A Service	3/8 × 4	$1835	580 lb	1/2 × 6	$555	351 lb	70%	39%
3000A Service	1/2 × 5	$3055	966 lb	1/2 × 8	$740	468 lb	76%	52%

Note: Costs are approximate and based on 2024 market conditions. Actual costs vary by region and market conditions.

Section 7: Application Recommendations

When to Choose Copper

Application	Reason
High ampacity in limited space	1.79× current capacity per cross-section
High vibration environments	Better fatigue resistance
Marine/corrosive environments	Superior corrosion resistance
High-precision connections	Better creep resistance
Existing copper infrastructure	Avoid dissimilar metal connections
Short runs with high current	Space savings offset cost

When to Choose Aluminum (6101-T6)

Application	Reason
Long distance runs	Weight savings reduce support costs
Budget-constrained projects	70% cost savings

Application	Reason
Overhead installations	Lighter weight simplifies support
Controlled environments	Lower risk of corrosion
Large cross-sections needed	Cost advantage increases with size
Modern switchgear designs	Designed for aluminum compatibility

Section 8: Installation Considerations

Connection Methods Comparison

Factor	Copper	Aluminum	Special Notes
Bolted connections	Standard hardware	Requires anti-oxidant compound	Al needs flat washers
Welding	Easy (TIG/brazing)	Requires special equipment	Al needs inert atmosphere
Creep under load	Minimal	Moderate	Al requires periodic re-torquing
Galvanic corrosion	Low risk	High risk with Cu contact	Use bimetallic washers
Torque requirements	Standard	Specific to alloy	Follow manufacturer specs
Connection inspection	Annual	Semi-annual	Al requires more frequent checks

Bending Radius Requirements

Material	Minimum Bend Radius	Notes
Copper C110	1× thickness (cold) 0.5× thickness (annealed)	Can be work-hardened
Aluminum 6101-T6	2-3× thickness	Risk of cracking at tight radii

Surface Treatment

Treatment	Copper	Aluminum	Purpose
Bare	Oxidizes (green patina)	Oxidizes (white powder)	Standard for dry locations
Tin plating	Common	Less common	Improves connections
Silver plating	High-end applications	Rare	Best conductivity
Nickel plating	Corrosive environments	Corrosive environments	Environmental protection
Anti-oxidant compound	Optional	Required	Critical for Al connections
Anodizing	Not applicable	Recommended	Provides protective layer

Section 9: Design Calculation Examples

Example 1: Selecting Busbar for 1500A @ 50°C Rise

Option A: Copper

Size: 1/4" × 4"

Ampacity: 1700 A (113% of requirement) ✓

Weight: 386 lb/100ft

Material cost: ~$1,220/100ft

Total installed cost: ~$1,850/100ft

Option B: Aluminum

Size: 1/2" × 4"

Ampacity: 1288 A (86% of requirement) ✗

Alternative: 1/2" × 5"

Ampacity: 1540 A (103% of requirement) ✓

Weight: 293 lb/100ft (24% lighter)

Material cost: ~$370/100ft

Total installed cost: ~$750/100ft

Savings: $1,100/100ft (59%)

Example 2: Voltage Drop Comparison (1000A, 100ft, 480V)

Copper 1/4" × 2"

Resistance: 16.5 μΩ/ft × 100 ft = 1.65 mΩ

Voltage drop: 1000A × 0.00165Ω = 1.65V

% Drop: 1.65/480 = 0.34% ✓

Aluminum 1/2" × 2"

Resistance: 15 μΩ/ft × 100 ft = 1.5 mΩ

Voltage drop: 1000A × 0.0015Ω = 1.5V

% Drop: 1.5/480 = 0.31% ✓

Note: Despite lower conductivity, larger aluminum size can achieve similar voltage drop

Section 10: Quick Reference Tables

Typical Current Ratings at 50°C Rise

Current Range	Copper (typical)	Aluminum (typical)	Weight Difference
100-200A	1/16" × 1" to 1-1/2"	1/16" × 1-1/2" to 2"	70% lighter
200-400A	1/8" × 1" to 2"	1/8" × 2" to 1/4" × 1-1/2"	70% lighter
400-800A	1/8" × 2-1/2" to 3-1/2"	1/4" × 2" to 3"	70% lighter
800-1200A	1/8" × 4" to 1/4" × 3"	1/4" × 4" to 1/2" × 3"	70% lighter
1200-1800A	1/4" × 3-1/2" to 5"	1/2" × 3-1/2" to 5"	70% lighter
1800-2500A	3/8" × 3-1/2" to 5"	1/2" × 5" to 6"	70% lighter
2500-4000A	1/2" × 4" to 6"	1/2" × 8" (multiple bars)	70% lighter

Conversion Multipliers (Quick Reference)

Parameter	Copper to Aluminum	Aluminum to Copper
Ampacity	÷ 1.79	× 1.79
Weight	÷ 3.30	× 3.30
Resistance	× 1.66	÷ 1.66
Cross-section (for same ampacity)	× 1.60	÷ 1.60
Cost (material only)	÷ 3.75	× 3.75

Important Notes & Disclaimers

Data Sources

Copper Data: Copper Development Association (CDA)

Aluminum Data: Aluminum Association

Standards: NEMA BU 1, IEC 60865, IEEE 605

Critical Warnings

Ampacity Depends On:

Ambient temperature (data shown for standard conditions)

Installation configuration (vertical vs. horizontal)

Air circulation and ventilation

Enclosure type and IP rating

Surface finish and treatment

Proximity to other current-carrying conductors

Duty cycle (continuous vs. intermittent)

Aluminum-Specific Requirements:

Use only 6101-T6 or equivalent high-conductivity alloy

Apply anti-oxidant compound to all connections

Use aluminum-rated connectors and hardware

Follow specific torque specifications

Increase inspection frequency

Avoid tight bending radii

Do not mix with copper without proper bimetallic connectors

Always Required:

Controlled testing for specific applications

Professional engineering review

Compliance with local electrical codes

Manufacturer specifications for all components

Proper training for installation personnel

Conversion Factors

Imperial	Metric	SI Units
1 inch	25.4 mm	-
1 square inch	645.16 mm²	6.452 cm²
1 lb/ft	1.488 kg/m	-
1 circular mil	0.0005067 mm²	5.067 × 10■■ mm²
1000 kcmil	506.7 mm²	-
1 μΩ/ft @ 20°C	3.281 μΩ/m @ 20°C	-