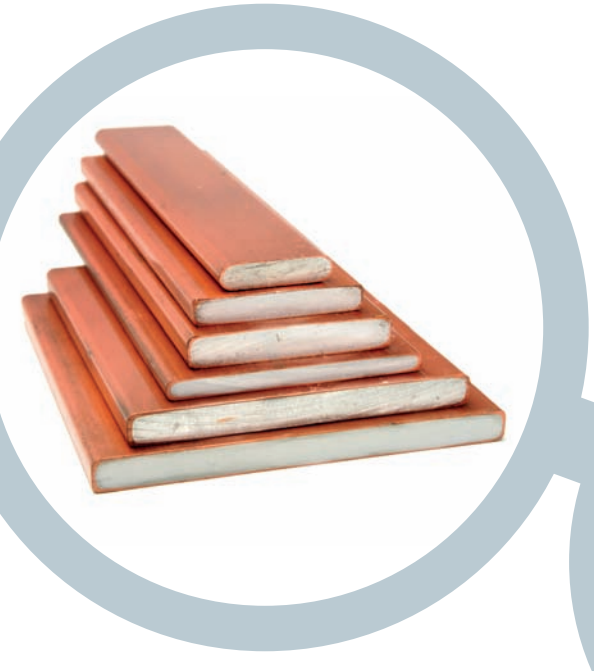
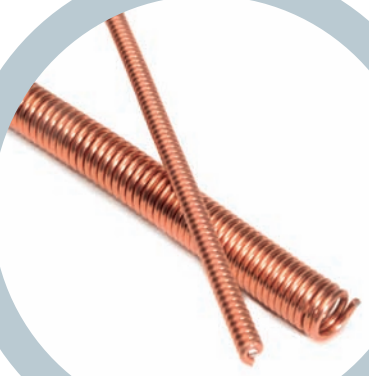
Bruker EST
Hydrostatic Extrusions Limited

Metal matrix extrusions with advanced characteristics

CUPONAL™
Copper Clad Aluminium
The Engineered Alternative
to Copper

sales.hydrostatic@bruker.com





The Engineered Alternative to Copper Busbar

CUPONAL™

Cuponal is a copper-clad aluminium (CCA) bi-metal conductor developed to provide an economic alternative to solid copper. Produced by the hydrostatic extrusion process, Cuponal consists of a solid core of electrical grade aluminium with a pressure bonded seamless outer layer of high conductivity copper.

Cuponal delivers economic and weight saving advantages over solid copper, yet retains the surface properties of a copper busbar. It is often possible to substitute a copper bar with a Cuponal bar of equal dimensions, which yields the maximum cost saving.

A wide range of standard sections are available. All rectangular and round sections are produced using a nominal copper cladding of 15% by volume (37% by weight) with the exception of certain sizes of high aspect ratio which are produced with nominally 20% copper by volume (45% by weight).

Special profiles, for example 'L' or 'T' shapes can be made to order, and are produced with a 20% copper cladding by volume.

Weigh Up The Benefits

- **Reduce costs by up to 40%**
  A Cuponal bar can save as much as 40% compared with a copper bar of equal dimensions.
- **Reduce weight by up to 60%**
  The relative density of Cuponal vs copper results in the mass of Cuponal busbars being only 41% of that of a copper bar of equal dimensions.
- **Smooth out cost fluctuations**
  Cuponal prices are more stable over time when compared with copper prices.
- **Reduce the cost of your inventory**
  1 metre of Cuponal costs less than 1 metre of copper, therefore the same stock length provides lower inventory values, meaning lower financing costs.
- **Lighten the load**
  Cuponal's lower weight makes it much easier to handle. Combined with ease of punching, drilling and bending, your work force will be glad you made the switch
- **Reduce freight costs**
  Lower weight means lower freight costs to your customer



Applications

Cuponal has been successfully evaluated and used by many of the worlds leading electrical equipment manufacturers. Applications include the following:

LV, MV, HV distribution; switchboards; motor control centres; panel boards; busbar chambers; busbar trunking systems; rectifiers; motor windings; fuse gear; crane rail supply systems; vacuum switchgear; generator sets; transformer substations; railway traction equipment; bi-metal connectors for use in aluminium foil wound transformers and railway applications.

Short Circuit Testing

Cuponal has been successfully tested for short circuit performance in many applications by authorities such as: ASTA (The Association of Short Circuit Testing Authorities); KEMA (NV tot van Elektrotechnische Materialen); Electrisches Prüfamt, München

Metal Forming Characteristics

Cuponal is easy to bend, having less springback than copper. The relevant data sheet should be consulted for recommended bending radii. Cuponal is also easy to drill, cut and punch.

Approvals

Cuponal has been approved for use in equipment by many authorities, including the following:

Germanischer Lloyd; Det Norske Veritas; ABS; Bureau Veritas; Lloyds Register of Shipping: SABS; ULA; National Power Supply Company; National Grid Company; electrical and water utilities.

Cuponal complies with BS 159:1957, and conforms to DIN 43670 Part2.

The aluminium core is of electrical grade and the copper cladding is to BS 2871/C101.

Standard Supply

Standard length: 4000 mm
Maximum length: 6000 mm
Width range: 10-120 mm
Thickness range: 3-15 mm
Diameter: Up to 40 mm
Area range: 20-1260 mm^2
Square and round edge bar is available

Special Profiles

Enquiries for profiles should be made at the earliest opportunity during switchgear design, to investigate the feasibility of producing the desired profile in Cuponal.

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A Bruker Corporation Company

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Materials extruded by our hydrostatic extrusion process have performance parameters that are not achievable by any other extrusion method, opening up a performance-enhancing/cost-saving route for equipment as well as product designers and specifiers.

- **Cuponal** Co-extruded copper-clad aluminium (CCA) busbar, rod and wire for high-and low-voltage electrical distribution, telecoms and wireless applications.
- **High-performance alloys** Extruded with high dimensional accuracy and uniform fine grain structure; characteristics and performance unattainable by conventional extrusion methods.

Aluminium extruded by the hydrostatic process benefits from a uniform fine grain structure coupled with great dimensional accuracy, thus providing a high quality feedstock material for onward processing such as impact extrusion and forging.

Customer supplied material is made extrusion-ready in house, extruded to the requested dimensions and profile and shipped to customer instructions.

- **Composite materials** Extruded with exact replication of cross-sectional parameters; unique to the hydrostatic extrusion process.

The Engineered Alternative to Copper Wire

CUPONAL™

Cuponal is a copper-clad aluminium (CCA) bi-metal conductor developed to provide an economic alternative to solid copper. Produced by the hydrostatic extrusion process, Cuponal consists of a solid core of electrical grade aluminium with a pressure bonded seamless outer layer of high conductivity copper.

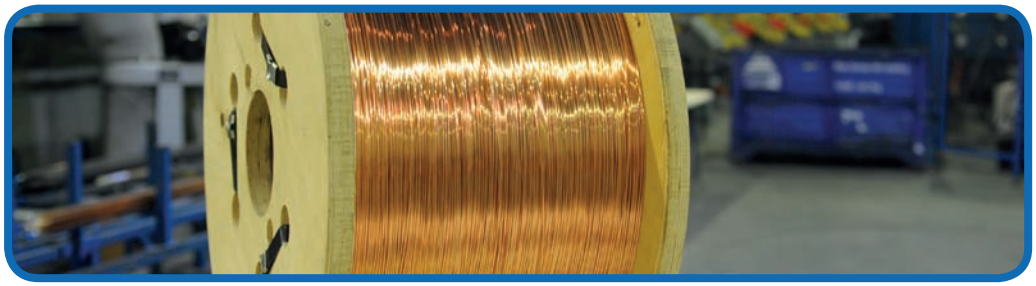
Cuponal delivers economic and weight saving advantages over solid copper, yet retains the surface properties of a copper conductor. It is often possible to substitute copper wire with Cuponal wire of equal diameter, which yields the maximum cost saving.

Diameters from 2mm to 8mm are supplied as drawn or fully annealed. Diameters greater than 10mm are supplied in straight lengths in the as extruded condition.

Standard Cuponal wire has a nominal copper cladding of 15% by volume (37% by weight).

Weigh Up The Benefits

- **Reduce costs by up to 40%**
  Cuponal wire can save as much as 40% compared with copper wire of equal diameter.
- **Reduce weight by up to 60%**
  The relative density of Cuponal vs copper results in the mass of Cuponal being only 41% of that of copper of equal diameter.
- **Smooth out cost fluctuations**
  Cuponal prices are more stable over time when compared with copper prices.
- **Reduce the cost of your inventory**
  1 metre of Cuponal costs less than 1 metre of copper, therefore the same stock length provides lower inventory values, meaning lower financing costs.
- **Lighten the load**
  Cuponal's lower weight makes it much easier to handle. Your work force will be glad you made the switch
- **Reduce freight costs**
  Lower weight means lower freight costs to your customer



Cuponal is regularly drawn to fine wire, e.g. 0,2 Dia. Conforms to ASTM B566.

Physical Properties

Property	Units	Annealed	Hard Drawn
Density at 20°C	kg/m^3	3.63 x 10^3	
Max. electrical resistivity at 20°C	Ohm m	2.65 x 10^{-8}	2.67 x 10^{-8}
Max. electrical conductivity at 20°C	1/Ohm m % IACS	37.7 x 10^5 65.0	37.45 x 10^6 64.6
Temp. coefficient of resistance at 20°C	1/°K	4.01 x 10^{-3}	
Min. ultimate tensile strength	N/mm^2	130	207
Modulus of elasticity	N/mm^2	85 x 10^3	
Coefficient of linear thermal expansion (20-100°C)	1/°K	21.9 x 10^{-6}	
Melting Point (Aluminium Core)	°C	658	
Specific Heat	J/kg/°K	711.7	
Thermal Conductivity	W/m^2/°K	2.38 x 10^6	

Material Specification

1. Material: Cuponal - 15% copper by volume over electrical grade aluminium
2. Copper Grade: Copper cladding – Cu > 99.9% purity
3. Aluminium Grade: Aluminium core – Al > 99.7% purity

Round section (Diameter ø mm)

Range	Tolerance ±
2 ≤ Ø ≤ 3	0.02
3 < Ø ≤ 6	0.03
6 < Ø ≤ 12	0.05
12 < Ø ≤ 25	0.08
25 < Ø ≤ 40	0.12

Diameter: 2 mm - 40 mm

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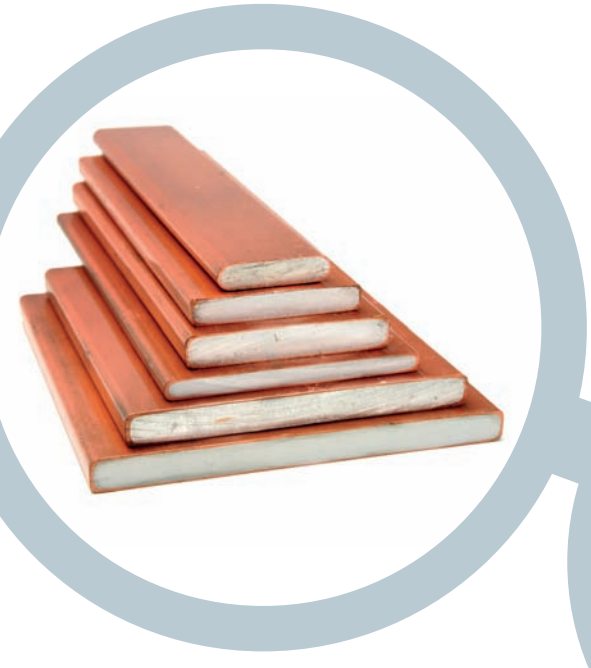
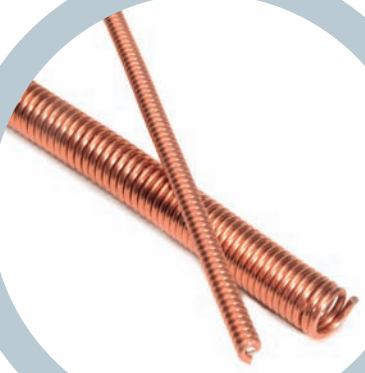
Aluminium extruded by the hydrostatic process benefits from a uniform fine grain structure coupled with great dimensional accuracy, thus providing a high quality feedstock material for onward processing such as impact extrusion and forging.

Customer supplied material is made extrusion-ready in house, extruded to the requested dimensions and profile and shipped to customer instructions.

- **Composite materials** Extruded with exact replication of cross-sectional parameters; unique to the hydrostatic extrusion process.





The Engineered Alternative for Aluminium Foil Transformers

CUPONAL™

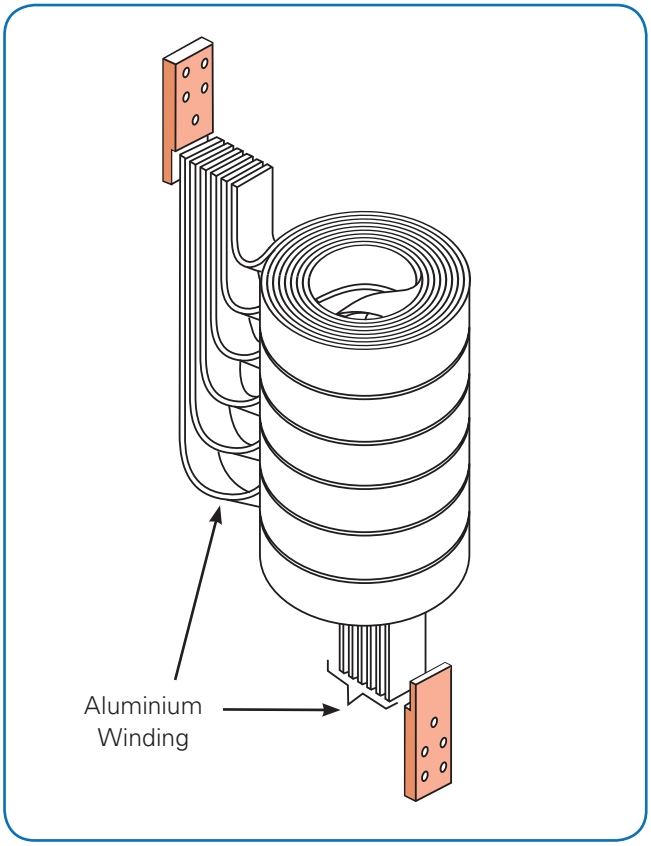
Provides a simple copper connection for the transformer manufacturer who wind coils with aluminium foil.

Termination is made simple by using Cuponal.

Connecting links and the star point can also utilize Cuponal. Lower costs and easy working properties ensure considerable savings.

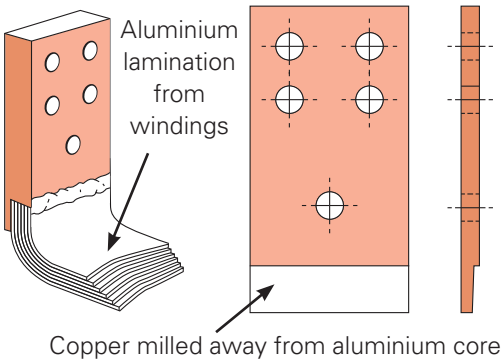
Benefits

- **Strong welded aluminium to aluminium joint**
- **Copper outgoing terminals**
- **Competitive price**
- **Can be punched and bent easily**
- **Many sizes and ratings**
- **Can be plated with many different finishes**
- **Supplied in standard lengths or cut to size**
- **Can be supplied as a finished component**
- **Prompt deliveries**



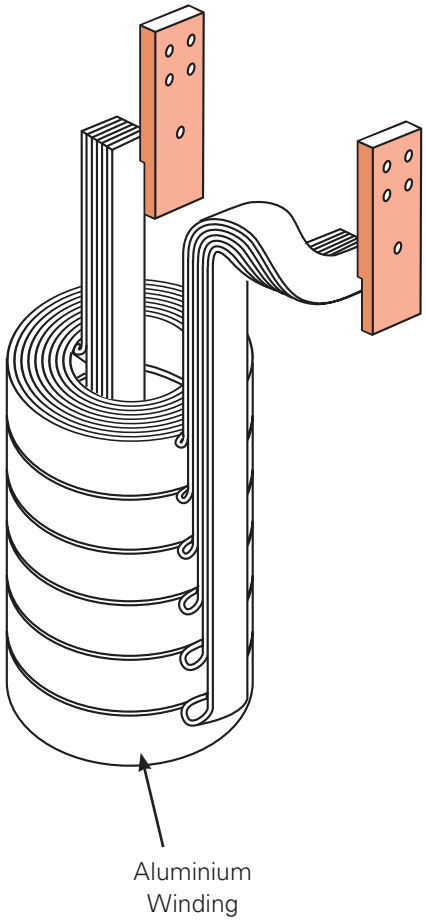
Cuponal Component

Holes punched and copper removed ready for final welding and assembly.



Cuponal in use

Dry Type Transformer. The aluminium windings have been welded to the Cuponal outgoing terminal so the benefit to the installer is a simple copper to copper termination.



Working with Cuponal

Cuponal is an established bi-metallic conductor developed to provide an economic alternative to solid copper in busbar applications.

Cuponal consists of a solid core of electrical grade aluminium with an outer layer of copper molecularly bonded to the aluminium core during manufacture.

Cuponal has been successfully evaluated and used by many of the world's leading electrical equipment manufacturers. Applications include L.V. distribution, switchboards, motor busbar centres, panel boards, overhead busbar trunking systems, H.V. distribution, vacuum switchgear and generator sets. Cuponal is also used in transformer and rectifier applications, motor winding, fuse gear and crane rail supply systems.

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Cuponal Standard Supply

Standard supply availability of Cuponal busbars (†= sq. corner)

Cuponal Size Selector																								
thickness mm	width mm																							
	10	12	15	16	18	20	24	25	28	30	32	34	38	40	42	50	60	63	65	75	80	92	90	100	120
3	✓							✓																	
4	✓			✓		✓		✓		✓				✓											
5	✓	✓	†			✓†		✓		✓†				✓†		✓	✓				✓				
6						✓		✓	✓	✓				✓		✓	✓			✓	✓				✓
6.3		✓		✓		✓		✓	✓		✓		✓	✓		✓		✓	✓		✓	✓		✓	✓
8				✓		✓		✓		✓		✓		✓		✓	✓			✓	✓		✓	✓	
10	†	✓	†✓			✓†		✓†		✓†				✓†		✓†	✓†	✓		✓	✓†			✓†	✓
12		†			†	✓	†			†				✓	†	✓	✓							✓	✓
12.5																		✓							
15							†							✓		✓	✓								✓
16											✓														

Round section

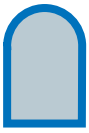
Available diameters (mm)

5, 6.3, 8, 10, 11, 12, 14, 18, 20, 24, 35, 40

Special sections

L-section (mm)

70 x 32 x 10
50 x 30 x 5
35 x 30 x 5



DD - radius both edges

D-section (inches)

3 x 1 D
2.5 x 1 D
2.5 x 1 DD
80 x 15 D (mm)

Dimensional specifications for standard supply Cuponal

Bar length	
Range	Tolerance mm
Standard length	+9 -0
Cut to length	+2 -2
Straightness: 2mm per 1000mm	
Maximum length: call with your requirements	

Rectangular section				
Width mm		Thickness tolerance mm ±		
Range	Tolerance ±	3 ≤ t ≤ 6	6 < t ≤ 10	10 < t ≤16
w ≤ 10	0.08	0.07	0.08	
10 < w ≤ 18	0.1	0.07	0.09	0.1
18 < w ≤ 30	0.15	0.07	0.09	0.1
30 < w ≤ 50	0.2	0.09	0.1	0.12
50 < w ≤ 80	0.25	0.11	0.12	0.15
80 < w ≤ 120	0.3	0.12	0.15	0.18
Maximum width: 120mm				

Round section	
Diameter ø mm	
Range	Tolerance ±
ø ≤ 3	0.02
3 < ø ≤ 6	0.03
6 < ø ≤ 12	0.05
12 < ø ≤ 25	0.08
25 < ø ≤ 40	0.12
Max diameter: 40mm	

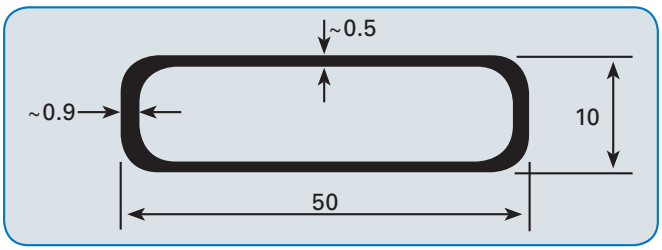
Properties of Busbar Materials

Property	Units	H C Copper		Cuponal	Aluminium		
					EIE (EC)		E91E(6101)
		Annealed	1/2 Hard	15%	M	H2	TF
0.1% proof stress	MN/m^2	62	108-186	*	-	-	163
0.2% proof stress	MN/m^2	78		†	-	-	170
Min. ultimate tensile strength	MN/m^2	217	235-300	130-170	60	85	200
Modus of elasticity	MN/m^2	$95x10^3$	$120x10^3$	$85x10^3$	$69x10^3$	$69x10^3$	$65x10^3$
Density at 20°C	kg/m^3	$8.89x10^3$	$8.89x10^3$	$3.63x10^3$	$2.70x10^3$	$2.70x10^3$	$2.70x10^3$
Max.electrical resistivity at 20°C	≤ m	$1.724x10^{-8}$	$1.777x10^{-8}$	$2.65x10^{-8}$	$2.826x10^{-8}$	$2.826x10^{-8}$	$3.133x10^{-8}$
Min. electrical conductivity at 20°C	1/≤ m	$58x10^6$	$56x10^6$	$37.7x10^6$	$35.4x10^6$	$35.4x10^6$	$31.9x10^6$
	%IACS	100	97	65	61	61	55
Temp. coefficient of resistance at 20°C	1/°C	$3.93x10^{-3}$	$3.93x10^{-3}$	$4.01x10^{-3}$	$4.03x10^{-3}$	$4.03x10^{-3}$	$3.64x10^{-3}$
Coeff. of linear thermal expansion 20-100°C	1/°C	$17x10^{-6}$	$17x10^{-6}$	$21.9x10^{-6}$	$23x10^{-6}$	$23x10^{-6}$	$23x10^{-6}$
Melting point	°C	1083	1083	658	658	658	600-650
Specific heat	J/kg/°C	393.5	393.5	711.7	921.1	921.1	879.2
Thermal conductivity	$W/m^2/°C$	$3.85x10^6$	$3.85x10^6$	$2.38x10^6$	$2.22x10^6$	$2.22x10^6$	$1.80x10^6$

* 0.1% proof stress = 70% of ultimate tensile strength
† 0.2% proof stress = 80% of ultimate tensile strength

Cuponal - copper clad aluminium busbar

Cuponal consists of a solid core of electrical grade aluminium, with a pressure bonded outer layer of high conductivity copper. The copper cladding is nominally 15% by volume, with the exception of certain sizes of high aspect ratio, which are produced with nominally 20% by volume. The purpose of the copper cladding is to seal the aluminium and provide a copper joining surface. The diagram below shows the typical distribution of the copper cladding on a rectangular profile Cuponal bar.



Cuponal Busbar Technical Data: AC/DC Current Ratings

NB. Check parameters to ensure compatability of these current ratings with design specification. Recalculation graphs should be used for design conditions different than those stated. For compatability, recalculation graphs computed for the same base parameters must be used with these tabulated values. These parameters are clearly stated in the table below.

Parameters

The calculated values on this data sheet are based on the following parameters:

Ambient temperature °C	35	Supply frequency Hz	50
Busbar temperature °C	85	Emissivity	0.4
Temperature rise °C	50	Current ratings and recalculation graphs can be supplied for different specified parameters.	

n = number of bars in parallel
Current ratings assume still but unconfined air, with busbars mounted on edge.
Current ratings are based on "Temperature Rise of Busbars", H B Dwight; Gen. Elec. Rev., vol 43
For multiple bar arrangements, the space between the bars is equal to busbar thickness.
AC ratings are based on spacings at which the proximity effect is negligible.
These approximate calculated values should not be regarded as a substitute for experimental testing.

Cuponal Rod 15% Cu/vol

Diameter	Area	Weight	DC Resistance at 20°C	DC Resistance at 85°C	Current Ratings (Amps): 50°C Rise Over 35°C Ambient	
mm	mm²	kg/m	µOhm/m	µOhm/m	dc	ac
5	19.63	0.071	1350	1701	89	89
6.3	31.17	0.113	850	1072	122	122
8	50.27	0.182	527	665	171	171
10	78.54	0.285	337	425	234	234
11	95.03	0.345	279	352	267	267
12	113.10	0.411	234	295	302	302
14	153.94	0.559	172	217	375	374
18	254.47	0.924	104	131	534	532
20	314.16	1.140	84	106	620	616
24	452.39	1.642	59	74	801	794
35	962.11	3.492	28	35	1364	1315
40	1256.64	4.562	21	27	1647	1551

Cuponal Busbar Sections 15% Cu/vol (unless stated otherwise)

Size	Corner radius	Area	Weight	DC Resistance at 20°C	DC Resistance at 85°C	Current Ratings (Amps): 50°C Rise Over 35°C Ambient							
						n=1		n=2		n=3		n=4	
mm	mm	mm²	kg/m	µOhm/m	µOhm/m	dc	ac	dc	ac	dc	ac	dc	ac
10x3	0.5	29.79	0.108	890	1122	131	131	249	249	367	367	485	485
25x3	0.5	74.79	0.271	354	447	280	280	512	512	743	740	973	968
10x4	0.5	39.79	0.144	666	840	157	157	303	303	449	449	595	593
16x4	1.5	62.07	0.225	427	538	224	224	423	423	621	619	819	815
20x4	1	79.14	0.287	335	422	272	272	507	507	742	738	976	970
25x4	1	99.14	0.36	267	337	328	328	606	605	882	877	1159	1149
30x4	1	119.14	0.432	222	280	383	383	702	700	1019	1012	1336	1323
40x4*	1	159.14	0.627	164	207	494	494	897	892	1296	1283	1695	1666
10x5	0.5	49.79	0.181	532	671	182	182	353	353	524	524	696	693
12x5	0.5	59.79	0.217	443	559	209	209	403	403	598	596	792	788
15x5	sq	75	0.272	353	445	248	248	474	474	700	697	926	920
20x5	1.5	98.07	0.356	270	341	309	309	582	580	854	849	1127	1118
20x5	sq	100	0.363	265	334	312	312	588	586	863	858	1138	1129
25x5	1.5	123.07	0.447	215	271	371	371	692	690	1012	1005	1332	1317
30x5	1.5	148.07	0.537	179	226	433	433	800	797	1166	1155	1532	1509
30x5	sq	150	0.545	177	223	436	436	806	802	1174	1163	1541	1518
40x5	1.5	198.07	0.719	134	169	553	552	1011	1003	1466	1444	1919	1871
40x5	sq	200	0.726	133	167	556	555	1016	1007	1473	1450	1929	1879
50x5*	1.5	248.07	0.977	105	133	677	674	1225	1209	1770	1729	2313	2223
60x5*	1.5	298.07	1.174	88	110	794	790	1428	1402	2057	1990	2683	2538
80x5*	1.5	398.07	1.568	66	83	1024	1014	1825	1773	2616	2473	3405	3108
20x6	2	116.57	0.423	227	287	343	343	653	650	961	955	1270	1257
25x6	2	146.57	0.532	181	228	412	412	774	770	1136	1125	1497	1475
28x6	2	164.57	0.597	161	203	453	452	846	841	1238	1224	1629	1600
30x6	2	176.57	0.641	150	189	479	479	893	887	1305	1289	1717	1682
40x6	2	236.57	0.859	112	141	611	610	1124	1112	1634	1601	2143	2068
50x6	2	296.57	1.077	89	113	741	737	1349	1326	1954	1893	2557	2422
60x6	2.5	354.63	1.287	75	94	866	860	1566	1529	2260	2162	2952	2742
75x6*	2	446.57	1.759	58	74	1064	1052	1909	1843	2745	2563	3579	3209
80x6*	2	476.57	1.878	55	69	1127	1112	2017	1940	2897	2684	3774	3348
120x6*	2	716.57	2.823	36	46	1617	1577	2857	2681	4080	3540	5297	4335
12x6.3	2	72.17	0.262	367	463	238	238	462	462	686	683	910	905
16x6.3	2	97.37	0.353	272	343	297	297	572	571	847	843	1122	1113
20x6.3	2	122.57	0.445	216	273	354	354	675	672	995	988	1315	1301
25x6.3	2	154.07	0.559	172	217	425	424	800	795	1174	1162	1548	1523
28x6.3	2	172.97	0.628	153	193	466	466	873	867	1279	1263	1684	1651
32x6.3	2	198.17	0.719	134	169	521	520	969	961	1416	1395	1862	1816
38x6.3	2	235.97	0.857	112	142	602	600	1112	1099	1619	1586	2125	2051
40x6.3	2	248.57	0.902	107	134	629	627	1158	1144	1685	1648	2211	2127
50x6.3	2	311.57	1.131	85	107	761	757	1389	1363	2013	1944	2635	2484
63x6.3	2	393.47	1.428	67	85	930	922	1682	1635	2428	2301	3171	2906
65x6.3*	2	406.07	1.6	64	81	964	954	1740	1688	2510	2368	3277	2983
80x6.3*	2	500.57	1.972	52	66	1157	1140	2073	1989	2979	2742	3883	3415
82x6.3*	2	513.17	2.022	51	64	1182	1165	2117	2028	3041	2789	3963	3469
100x6.3*	2	626.57	2.469	42	53	1410	1381	2508	2374	3592	3193	4672	3933
120x6.3*	2	752.57	2.965	35	44	1659	1616	2934	2742	4192	3604	5443	4409
16x8	0.25	127.95	0.464	207	261	353	353	686	683	1018	1011	1351	1335
20x8	2	156.57	0.568	169	213	413	413	797	792	1181	1169	1564	1539
25x8	2	196.57	0.714	135	170	492	491	939	930	1384	1364	1829	1784

*20% Cu by volume

Cuponal Busbar Sections 15% Cu/vol (unless stated otherwise)

Size	Corner radius	Area	Weight	DC Resistance at 20°C	DC Resistance at 85°C	Current Ratings (Amps): 50°C Rise Over 35°C Ambient							
						n=1		n=2		n=3		n=4	
mm	mm	mm²	kg/m	µOhm/m	µOhm/m	dc	ac	dc	ac	dc	ac	dc	ac
30x8	2	236.57	0.859	112	141	570	569	1076	1063	1581	1549	2086	2013
34x8	2	268.57	0.975	99	124	631	629	1185	1167	1736	1691	2287	2187
40x8	2	316.57	1.149	84	106	722	719	1344	1319	1964	1895	2582	2430
50x8	2	396.57	1.44	67	84	872	864	1605	1560	2334	2211	3062	2803
60x8	2	476.57	1.73	56	70	1019	1006	1860	1791	2696	2502	3530	3140
75x8	2	596.57	2.166	44	56	1236	1213	2235	2122	3226	2900	4215	3595
80x8	2	636.57	2.311	42	52	1307	1281	2359	2228	3401	3023	4440	3736
90x8	2	716.57	2.601	37	47	1449	1414	2603	2436	3745	3260	4884	4011
100x8	2	796.57	2.892	33	42	1590	1545	2845	2640	4086	3483	5323	4274
10x10	sq	100	0.363	265	334	298	298	583	582	867	862	1152	1143
12x10	1	119.14	0.432	222	280	335	335	654	652	973	967	1292	1279
12x12	sq	144	0.523	184	232	385	385	753	749	1121	1111	1489	1467
15x10	1	149.14	0.541	178	224	391	391	762	759	1133	1123	1504	1481
15x10	sq	150	0.545	177	223	392	392	765	761	1136	1126	1508	1486
20x10	3	192.27	0.698	138	174	474	473	921	913	1368	1348	1814	1771
20x10	sq	200	0.726	133	167	483	482	939	931	1395	1374	1850	1803
25x10	3	242.27	0.879	109	138	563	561	1086	1073	1609	1575	2132	2055
25x10	sq	250	0.908	106	134	572	570	1104	1089	1635	1598	2166	2082
30x10	3	292.27	1.061	91	114	650	647	1242	1220	1833	1777	2424	2300
30x10	sq	300	1.089	88	111	659	655	1258	1236	1857	1798	2456	2325
40x10	3	392.27	1.424	68	85	821	814	1544	1501	2265	2148	2985	2736
40x10	sq	400	1.452	66	84	829	821	1559	1514	2287	2165	3014	2755
50x10	3	492.27	1.787	54	68	988	975	1837	1764	2682	2478	3526	3118
50x10	sq	500	1.815	53	67	996	982	1851	1776	2703	2493	3553	3133
60x10	3	592.27	2.15	45	56	1152	1132	2123	2013	3088	2779	4052	3461
60x10	sq	600	2.178	44	56	1160	1139	2137	2024	3108	2791	4078	3474
63x10	3	622.27	2.259	43	54	1201	1178	2208	2085	3208	2864	4208	3557
75x10	3	742.27	2.694	36	45	1395	1359	2543	2367	3683	3184	4821	3929
80x10	3	792.27	2.876	33	42	1475	1434	2681	2481	3879	3310	5073	4079
80x10	sq	800	2.904	33	42	1482	1440	2694	2490	3898	3320	5098	4090
100x10	3	992.27	3.602	27	34	1791	1723	3226	2920	4647	3786	6064	4654
100x10	sq	1000	3.63	27	33	1798	1729	3238	2929	4665	3794	6088	4665
120x10	3	1192.27	4.328	22	28	2103	2003	3760	3341	5399	4234	7033	5194
18x12	sq	216	0.784	123	155	507	506	988	979	1469	1444	1950	1892
20x12	3	232.27	0.843	114	144	538	536	1047	1036	1556	1525	2065	1996
24x12	sq	288	1.045	92	116	625	622	1215	1194	1804	1750	2393	2274
30x12	sq	360	1.307	74	93	739	734	1427	1393	2115	2021	2802	2598
40x12	3	472.27	1.714	56	71	918	907	1744	1678	2568	2387	3392	3021
42x12	sq	504	1.83	53	66	963	950	1823	1747	2682	2471	3540	3118
50x12	3	592.27	2.15	45	56	1101	1082	2066	1956	3028	2724	3988	3406
60x12	3	712.27	2.586	37	47	1281	1251	2380	2217	3475	3028	4568	3755
100x12	3	1192.27	4.328	22	28	1981	1885	3591	3164	5187	4068	6779	5007
120x12	3	1432.27	5.199	19	23	2323	2184	4177	3604	6012	4538	7842	5571
63x12.5	3	779.77	2.831	34	43	1367	1330	2538	2341	3705	3172	4869	3928
24x15	sq	360	1.307	74	93	727	722	1416	1383	2106	2012	2795	2591
40x15	3	592.27	2.15	45	56	1058	1039	2035	1925	3011	2709	3986	3405
50x15	3	742.27	2.694	36	45	1263	1231	2397	2216	3529	3051	4661	3798
60x15	3	892.27	3.239	30	37	1464	1414	2750	2488	4033	3360	5314	4169
120x15	3	1792.27	6.506	15	19	2628	2423	4763	3942	6881	4954	8994	6086
32x16	3	504.27	1.831	53	66	930	918	1809	1734	2688	2476	3566	3140

*20% Cu by volume

Recalculation Graphs for Alternative Conditions

Use of Recalculation Graphs

Alternative Temperature Conditions

Obtain correction factor Fc from the graph as follows:
1. Locate isotherm for new ambient temperature
2. Locate new busbar operating temperature on x-axis
3. Read correction factor Fc from y-axis

Typical emissivities for copper surfaces:

Bright metal	0.1
Partly oxidised	0.3
Heavily oxidised	0.7
Dull non-metallic paint	0.9

Alternative Emissivity Condition

Obtain temperature factor k as follows:
1. If temperature parameters are unchanged. k = 1
2. Otherwise, locate isothermal for new ambient temperature
3. Locate new bus bar operating temperature on x-axis
4. Read temperature factor k from y-axis
5. Calculate temperature factor k x busbar height h

Obtain correction factor Fe as follows:
1. Locate line of constant emissivity for the new condition
2. Locate k . h on the x-axis
3. Read correction factor Fe from y-axis

NB. Recalculation factors may be determined from the graphs on this data sheet to correct tabulated Cuponal current ratings for different design parameters. For compatability, these recalculation graphs must only be used with tabulated values computed for the same base parameters. These parameters are clearly stated in the tables on page 1 of this data sheet.

Correction Factor Example

Size	100x10	Fc	0.75
Bar height	100	k	1.14
New ambient temperature °C	35	k. h	114
New busbar temperature °C	65	Fe	1.00
New emissivity	0.4	F = Fe. Fc	0.75
Idc (from table)	1798	New Idc	1357
Iac (from table)	1729	New Iac	1305

Alternative Supply Frequency

Obtain correction factor Fs as follows:
1. Calculate X using the following formula:

$$X = \sqrt{\frac{A \times f}{26.5[1+0.00401(Ts - 20)]}}$$

f = new supply frequency, Hz
A = area of busbar, mm²
Ts = new busbar temperature, °C

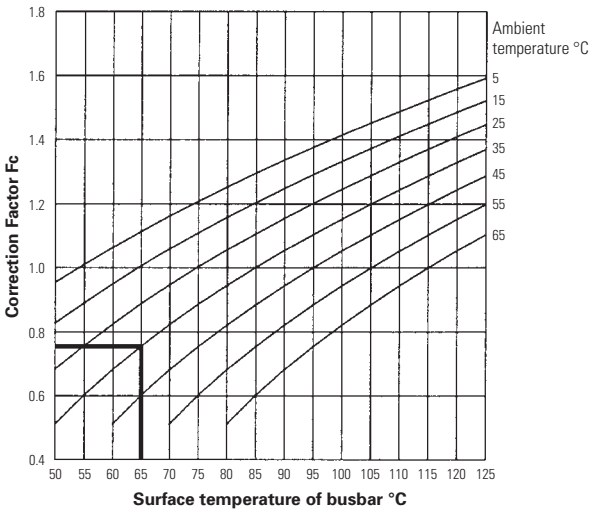
2. Locate aspect ratio line for busbar size (use AR=1 for round bar)
3. Locate calculated X value on the x-axis
4. Read correction factor Fs from y-axis
5. Use Fs with Ide values to compute Iac

ie New Iac = Idc for condition x Fs

New supply frequency Hz	60	AR	10
X (from formula)	43.80	Fs	0.948
Corrected Idc (from above)	1357	New Iac	1287

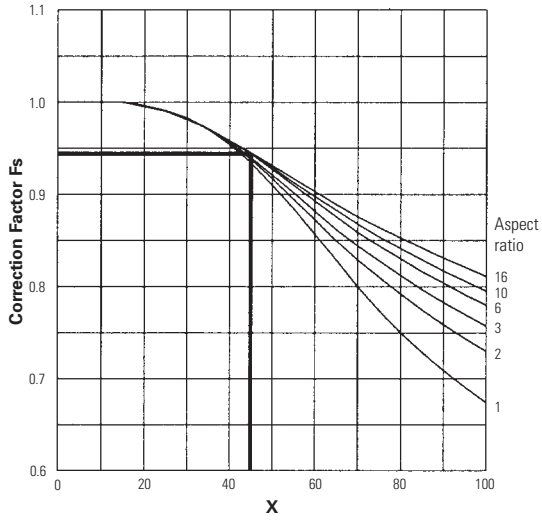
Alternative Temperature Conditions

Correction Factor Fc



Alternative Supply Frequency

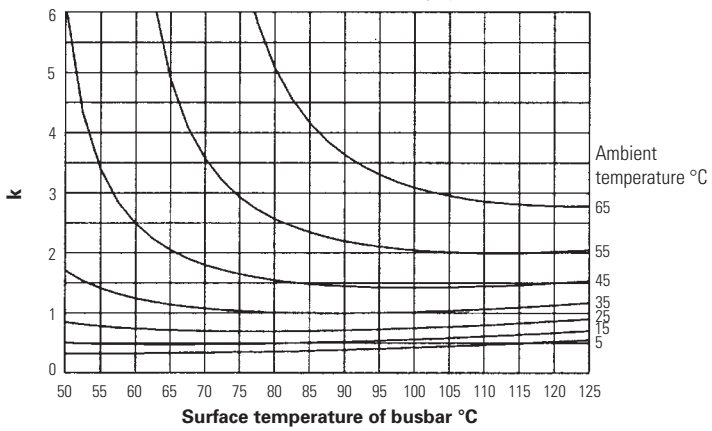
Correction Factor Fs



Alternative Emissivity Condition

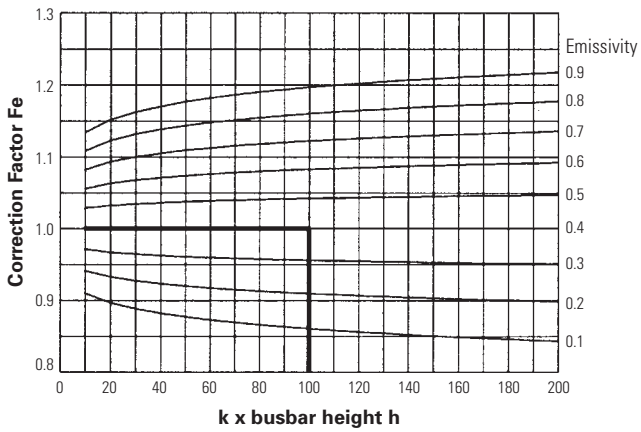
Temperature Factor k

For use in Correction Factor Fe graph



NB k = 1 if no change in temperature parameters

Correction Factor Fe



Cuponal Mechanical Data

Size	Corner Radius	Area	Weight	2nd Moment of Area		Section Modulus		Radius of Gyration		Minimum UTS
				Ixx	Iyy	Zxx	Zyy	Kxx	Kyy	
mm	mm	mm^2	kg / m	mm^4		mm^3		mm		MN/m^2
10 x 3	0.5	29.79	0.108	250	23	50	15	2.89	0.87	-
25 x 3	0.5	74.79	0.271	3906	56	313	38	7.22	0.87	130
10 x 4	0.5	39.79	0.144	333	53	67	27	2.89	1.15	-
16 x 4	1.5	62.07	0.225	1365	85	171	43	4.62	1.15	130
20 x 4	1	79.14	0.287	2667	107	267	53	5.77	1.15	130
25 x 4	1	99.14	0.36	5208	133	417	67	7.22	1.15	133
30 x 4	1	119.14	0.432	9000	160	600	80	8.66	1.15	135
40 x 4*	1	159.14	0.627	21333	213	1067	107	11.55	1.15	140
10 x 5	0.5	49.79	0.181	417	104	83	42	2.89	1.44	-
12 x 5	0.5	59.79	0.217	720	125	120	50	3.46	1.44	-
15 x 5	sq	75	0.272	1406	156	188	63	4.33	1.44	136
20 x 5	1.5	98.07	0.356	3333	208	333	83	5.77	1.44	133
20 x 5	sq	100	0.363	3333	208	333	83	5.77	1.44	133
25 x 5	1.5	123.07	0.447	6510	260	521	104	7.22	1.44	136
30 x 5	1.5	148.07	0.537	11250	313	750	125	8.66	1.44	140
30 x 5	sq	150	0.545	11250	313	750	125	8.66	1.44	140
40 x 5	1.5	198.07	0.719	26667	417	1333	167	11.55	1.44	143
40 x 5	sq	200	0.726	26667	417	1333	167	11.55	1.44	143
50 x 5*	1.5	248.07	0.977	52083	521	2083	208	14.43	1.44	146
60 x 5*	1.5	298.07	1.174	90000	625	3000	250	17.32	1.44	150
80 x 5*	1.5	398.07	1.568	213333	833	5333	333	23.09	1.44	154
20 x 6	2	116.57	0.423	4000	360	400	120	5.77	1.73	134
25 x 6	2	146.57	0.532	7813	450	625	150	7.22	1.73	140
28 x 6	2	164.57	0.597	10976	504	784	168	8.08	1.73	142
30 x 6	2	176.57	0.641	13500	540	900	180	8.66	1.73	142
40 x 6	2	236.57	0.859	32000	720	1600	240	11.55	1.73	146
50 x 6	2	296.57	1.077	62500	900	2500	300	14.43	1.73	150
60 x 6	2.5	354.63	1.287	108000	1080	3600	360	17.32	1.73	152
75 x 6*	2	446.57	1.759	210938	1350	5625	450	21.65	1.73	157
80 x 6*	2	476.57	1.878	256000	1440	6400	480	23.09	1.73	-
120 x 6*	2	716.57	2.823	864000	2160	14400	720	34.64	1.73	-
12 x 6.3	2	72.17	0.262	907	250	151	79	3.46	1.82	-
16 x 6.3	2	97.37	0.353	2150	333	269	106	4.62	1.82	133
20 x 6.3	2	122.57	0.445	4200	417	420	132	5.77	1.82	135
25 x 6.3	2	154.07	0.559	8203	521	656	165	7.22	1.82	140
28 x 6.3	2	172.97	0.628	11525	583	823	185	8.08	1.82	142
32 x 6.3	2	198.17	0.719	17203	667	1075	212	9.24	1.82	143
38 x 6.3	2	235.97	0.857	28808	792	1516	251	10.97	1.82	145
40 x 6.3	2	248.57	0.902	33600	833	1680	265	11.55	1.82	146
50 x 6.3	2	311.57	1.131	65625	1042	2625	331	14.43	1.82	150
63 x 6.3	2	393.47	1.428	131275	1313	4167	417	18.19	1.82	154
65 x 6.3*	2	406.07	1.6	144178	1354	4436	430	18.76	1.82	-
80 x 6.3*	2	500.57	1.972	268800	1667	6720	529	23.09	1.82	-
82 x 6.3*	2	513.17	2.022	289468	1709	7060	542	23.67	1.82	162
100 x 6.3*	2	626.57	2.469	525000	2084	10500	662	28.87	1.82	164
120 x 6.3*	2	752.57	2.965	907200	2500	15120	794	34.64	1.82	170

*20% Cu by volume

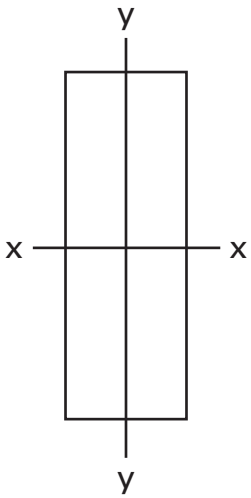
Cuponal Mechanical Data (continued)

Size	Corner Radius	Area	Weight	2nd Moment of Area		Section Modulus		Radius of Gyration		Minimum UTS
				Ixx	Iyy	Zxx	Zyy	Kxx	Kyy	
mm	mm	mm^2	kg / m	mm^4		mm^3		mm		MN/m^2
16 x 8	0.3	127.95	0.464	2731	683	341	171	4.62	2.31	136
20 x 8	2	156.57	0.568	5333	853	533	213	5.77	2.31	140
25 x 8	2	196.57	0.714	10417	1067	833	267	7.22	2.31	140
30 x 8	2	236.57	0.859	18000	1280	1200	320	8.66	2.31	146
34 x 8	2	268.57	0.975	26203	1451	1541	363	9.81	2.31	148
40 x 8	2	316.57	1.149	42667	1707	2133	427	11.55	2.31	150
50 x 8	2	396.57	1.44	83333	2133	3333	533	14.43	2.31	154
60 x 8	2	476.57	1.73	144000	2560	4800	640	17.32	2.31	158
75 x 8	2	596.57	2.166	281250	3200	7500	800	21.65	2.31	163
80 x 8	2	636.57	2.311	341333	3413	8533	853	23.09	2.31	165
90 x 8	2	716.57	2.601	486000	3840	10800	960	25.98	2.31	169
100 x 8	2	796.57	2.892	666667	4267	13333	1067	28.87	2.31	170
10 x 10	sq	100	0.363	833	833	167	167	2.89	2.89	134
12 x 10	1	119.14	0.432	1440	1000	240	200	3.46	2.89	135
15 x 10	1	149.14	0.541	2813	1250	375	250	4.33	2.89	140
15 x 10	sq	150	0.545	2813	1250	375	250	4.33	2.89	140
20 x 10	3	192.27	0.698	6667	1667	667	333	5.77	2.89	143
20 x 10	sq	200	0.726	6667	1667	667	333	5.77	2.89	143
25 x 10	3	242.27	0.879	13021	2083	1042	417	7.22	2.89	146
25 x 10	sq	250	0.908	13021	2083	1042	417	7.22	2.89	146
30 x 10	3	292.27	1.061	22500	2500	1500	500	8.66	2.89	150
30 x 10	sq	300	1.089	22500	2500	1500	500	8.66	2.89	150
40 x 10	3	392.27	1.424	53333	3333	2667	667	11.55	2.89	154
40 x 10	sq	400	1.452	53333	3333	2667	667	11.55	2.89	154
50 x 10	3	492.27	1.787	104167	4167	4167	833	14.43	2.89	160
50 x 10	sq	500	1.815	104167	4167	4167	833	14.43	2.89	160
60 x 10	3	592.27	2.15	180000	5000	6000	1000	17.32	2.89	163
60 x 10	sq	600	2.178	180000	5000	6000	1000	17.32	2.89	163
63 x 10	3	622.27	2.259	208373	5250	6615	1050	18.19	2.89	164
75 x 10	3	742.27	2.694	351563	6250	9375	1250	21.65	2.89	170
80 x 10	3	792.27	2.876	426667	6667	10667	1333	23.09	2.89	170
80 x 10	sq	800	2.904	426667	6667	10667	1333	23.09	2.89	170
100 x 10	3	992.27	3.602	833333	8333	16667	1667	28.87	2.89	170
100 x 10	sq	1000	3.63	833333	8333	16667	1667	28.87	2.89	170
120 x 10	3	1192.27	4.328	1440000	10000	24000	2000	34.64	2.89	170
12 x 12	sq	144	0.523	1728	1728	288	288	3.46	3.46	-
18 x 12	sq	216	0.784	5832	2592	648	432	5.2	3.46	-
20 x 12	3	232.27	0.843	8000	2880	800	480	5.77	3.46	-
24 x 12	sq	288	1.045	13824	3456	1152	576	6.93	3.46	-
30 x 12	sq	360	1.307	27000	4320	1800	720	8.66	3.46	-
40 x 12	3	472.27	1.714	64000	5760	3200	960	11.55	3.46	-
42 x 12	sq	504	1.83	74088	6048	3528	1008	12.12	3.46	-
50 x 12	3	592.27	2.15	125000	7200	5000	1200	14.43	3.46	163
60 x 12	3	712.27	2.586	216000	8640	7200	1440	17.32	3.46	168
100 x 12	3	1192.27	4.328	1000000	14400	20000	2400	28.87	3.46	170
120 x 12	3	1432.27	5.199	1728000	17280	28800	2880	34.64	3.46	-
63 x 12.5	3	779.77	2.831	260466	10254	8269	1641	18.19	3.61	170

Cuponal Mechanical Data (continued)

Size	Corner Radius	Area	Weight	2nd Moment of Area		Section Modulus		Radius of Gyration		Minimum UTS
				Ixx	Iyy	Zxx	Zyy	Kxx	Kyy	
mm	mm	mm^2	kg / m	mm^4		mm^3		mm		MN/m^2
24 x 15	sq	360.00	1.307	17280	6750	1440	900	6.93	4.33	-
40 x 15	3.0	592.27	2.150	80000	11250	4000	1500	11.55	4.33	163
50 x 15	3.0	742.27	2.694	156250	14063	6250	1875	14.43	4.33	170
60 x 15	3.0	892.27	3.239	270000	16875	9000	2250	17.32	4.33	170
120 x 15	3.0	1792.27	6.506	2160000	33750	36000	4500	34.64	4.33	-
32 x 16	3.0	504.27	1.831	43691	10923	2731	1365	9.24	4.62	-

Diameter	Area	Weight	2nd Moment of Area Ixx	Section Modulus Zxx	Radius of Gyration Kxx	Minimum UTS
mm	mm^2	kg / m	mm^4	mm^3	mm	MN/m^2
5	19.63	0.071	31	12	1.25	-
6.3	31.17	0.113	77	25	1.58	-
8	50.27	0.182	201	50	2.00	-
10	78.54	0.285	491	98	2.50	130
11	95.03	0.345	719	131	2.75	133
12	113.10	0.411	1018	170	3.00	134
14	153.94	0.559	1886	269	3.50	140
18	254.47	0.924	5153	573	4.50	145
20	314.16	1.140	7854	785	5.00	150
24	452.39	1.642	16286	1357	6.00	158
35	962.11	3.492	73662	4209	8.75	170
40	1256.64	4.562	125664	6283	10.00	170



Recommendations for Bending, Drilling, Punching & Cutting

Cuponal busbars may be readily bent, normal to the plane or on edge, by the methods outlined below. Cuponal has less spring back than copper, and as a result a bend is easier to achieve. However, a larger radius is required than with copper to allow for the flow characteristics of the copper aluminium mating face. Cuponal busbar should not be bent around a knife edge. The recommended radii for bending standard rectangular sizes of Cuponal busbar are detailed in the table. Forming pressure should be applied gradually and not by impact. Drilling and punching should be performed after bending is complete.

Recommended radius of forming tool				
Thickness t	**Width w**	**≤90°**	**90° - 120°**	**>120**
t ≤ 3	10 - 25	1t	1t	1t
3 < t ≤ 5	16 - 60	1t	2t	4t
5 < t ≤ 6.3	12 - 50	1t	2t	4t
	50 - 120	2t	3t	4t
6.3 < t ≤ 10	10 - 120	2t	3t	4t
10 < t ≤ 15	40 - 120	2t	3t	4t
N.B. Above factors are for bending normal to the plane. For edge bending the forming tool radius should be multiples of the width w.				

Bending method 1

This involves pressing a forming tool against the bar, the reverse side of which is resting against two smooth supports. The surfaces of both the forming tool and the supports must be smooth. It is important that the two supports are set sufficiently far apart to permit the bar to move and bend freely as pressure is applied to the forming tool. For angles of bend greater than ninety degrees, it may be necessary to set the supports closer together to complete the final stage of the bend.

Bending method 2

This involves holding the busbar firmly against a forming tool and applying pressure to the reverse side of the bar by means of a rolling or sliding follower. When using this method with the busbar gripped in a vice or clamp, it is important that the point of grip is sufficiently far from the bend to allow for elongation and material flow at the bend. A distance of about four times the thickness (or width for an edge bend) from the clamp to the start of the bend has proved adequate.

Drilling

Recommended drill characteristics	
Cutting speed	50m/min
Drill cutting angle	135° - 140°
Helix angle	45°
Lubricant & coolant	white spirit

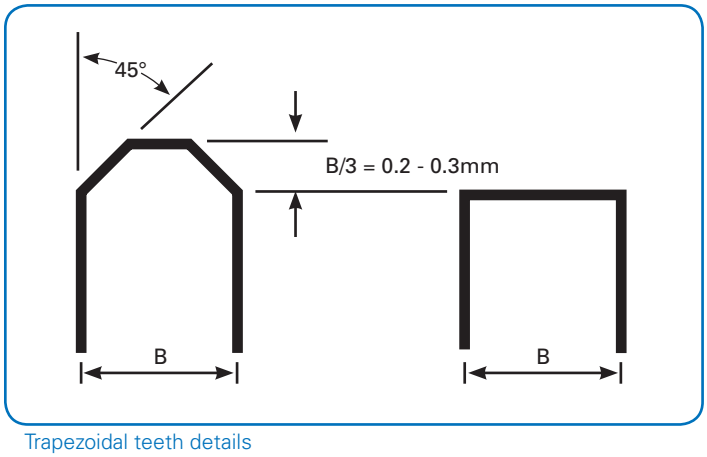
Cutting

Cuponal can be cut using methods that apply to aluminium. Grinding of alternative saw teeth to a trapezoidal shape gives good results and deburring is not necessary.

Recommendations	
Cutting speed	50 - 90m/sec
Lubricant & coolant	white spirit

Punching

The punching tool should be designed in the same way as for use with flat copper bars. It is important that the die should give adequate support as near as possible to the shearing edge.



Trapezoidal teeth details

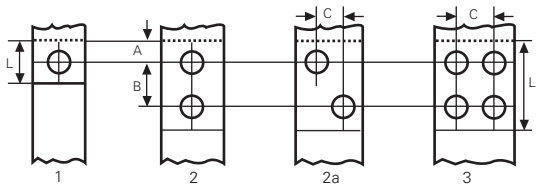
Recommendations for Bolted Joints

In order to obtain an efficient electrical contact between busbars, it is necessary to penetrate the surface film of oxides, sulphides and other contaminants that may be present when the metal has been freely exposed to air. The contact is therefore more easily achieved when the surface is rugged, has extrusion lines or has been knurled. The naturally occurring extrusion lines in Cuponal therefore help achieve a good electrical contact.

Copper oxide has a much lower electrical resistance than aluminium oxide, and a negative temperature coefficient of resistance. Therefore, as the temperature rises, the conductivity of a joint between two oxidised copper surfaces tends to increase. Because of the copper cladding, Cuponal has the same excellent contact properties as copper. Hence, in bolted joints, Cuponal busbars can be used in exactly the same way as copper busbars.

The contact between two surfaces is initially limited to the peaks on each surface, which are therefore subjected to a much higher pressure than the average joint pressure, and will therefore deform during the jointing process. Within a completed joint, the actual contact area is much smaller than the total surface area of the joint. The effective contact area is usually confined to the region in which the pressure is applied, ie near the bolts. A sufficient overlap is therefore required in order to allow for this and also the "streamline effect" - the distortion of lines of current flow through the overlap joint.

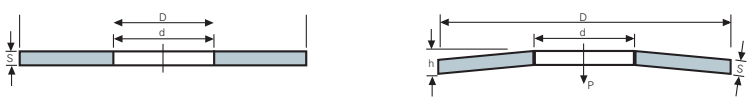
Bolting arrangements (DIN 43 673)



Bar	Shape 1		Shape 2 & 2a				Shape 3				Bolt	Hole
width	L	A	L	A	B	C	L	A	B	C	size	DIA
12	12	6									M5	5.5
15	15	7.5									M6	6.6
20	20	10									M8	9
25	25	12.5	55	12.5	30						M10	11
30	30	15	60	15	30						M10	11
40	40	20	80	20	40						M12	13.5
50	50	25	80	20	40						M12	13.5
60			80	20	40						M12	13.5
60			60	17	26	26					M12	13.5
80							80	20	40	40	M12	13.5
100							80	20	40	50	M12	13.5
120							80	20	40	60	M12	13.5

Contact surfaces should be flat, clean and uniformly roughened. Perfectly flat joint faces are not necessary since very good results will be obtained merely by ensuring that the joint is clean and tight. A slight improvement may be gained by preventing reoxidation of the surfaces after cleaning by coating the surfaces with petroleum jelly. If the joint surfaces are pressed together without removing the jelly, any excess is squeezed out, and that which remains will help to seal the joint and protect it from deterioration.

Bolt tightening torque and washer dimensions:



Bolt	Torque Nm to DIN 43673		Plain washer to DIN 7349			Spring disc washer to DIN 6796				
size	Indoors[1]	In/Outdoors[2]	D mm	d mm	S mm	D mm	d mm	S mm	h mm	P kN
M5	2.5	3	15	5.3	2	11	5.3	1.2	1.45	5.5
M6	4.5	5.5	17	6.4	3	14	6.4	1.5	1.85	8.6
M8	10	15	21	8.4	4	18	8.4	2	2.42	14.9
M10	20	30	25	10.5	4	23	10.5	3.0	3	22.1
M12	40	60	30	13	6.0	29	13.0	3.5	3.69	34.1

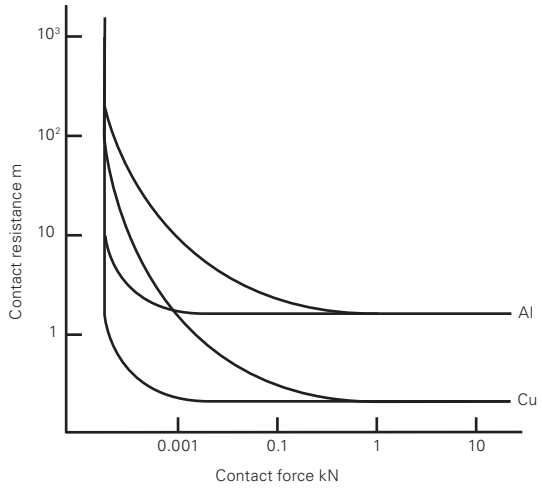
[1]Oil or grease lubricant [2]MoS_2 based lubricant (molybdenum disulphide)

For a given contact pressure, a copper surface has a contact resistance 20 to 50 times less than an aluminium surface. Joint resistance falls rapidly with increasing pressure, but the improvement above a pressure of about 20N/mm^2 is minimal. It is important that the proof stress of the busbar material is not exceeded, and therefore a contact pressure of 20N/mm^2 is the recommended maximum. DIN 43 673 recommends bolting arrangements that result in average contact pressures of between 7 and 20 N/mm^2. The creep characteristics of Cuponal are between that of copper and aluminium.

Bolts may be of various grades of steel, brass or bronze. From the point of view of availability, steel bolts are recommended. These should be of high strength (8.8 or higher) and should be suitably protected, eg hot dip galvanised. The contact pressure should be distributed by the use of oversize washers. Spring washers help maintain a constant pressure during thermal cycling, allow for any differential expansion between the bolts and the bar, and compensate for any eventual relaxation of the metal.

Cuponal can be tin or silver plated.

Effect of pressure on contact resistance



Recommendations for Electroplating of Cuponal Busbars

Cuponal may be electroplated to achieve a coating of metals such as nickel (Ni), tin (Sn) or silver (Ag).

An electroplated coating may be achieved on the copper surfaces of the Cuponal bar by following a normal copper plating procedure. This will not necessarily result in a coating also being deposited on the exposed aluminium at the cut ends.

In order to obtain an electroplated coating on all surfaces of a Cuponal bar - i.e. also coating the exposed aluminium at the cut ends - it is necessary to use an aluminium pre-treatment for the whole bar. The process to be followed is a zincating process, and any proprietary process of this nature should be suitable, provided that account is taken of the presence of copper on the other surfaces of the bar. The use of nitric acid should therefore be avoided.

Reputable electroplating specialists should be able to advise on the choice of suitable materials and the associated procedures to achieve satisfactory plating.

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