Applied Composite Material Co.

Production Standards

QJ/ACM 01.01—2014

Copper Clad Aluminum Composite Bus for the Purposes of Electrical and Equipment of Power Transmission and Transformation

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Contents

Preamble

This standard refers to copper clad aluminum composite ("CCAC") bus for the purpose of electrical and equipment of power transmission and transformation, which is authorized to production by Applied Composite Material Co. ("ACM") , USA.

This standard refers to copper clad aluminum composite bus for the purpose of electrical and equipment of power transmission and transformation, which is produced by adaption of US and international patent "Mechanism of Isothermal Short-Flow Process for Continuous Fabrication of Copper Clad Aluminum Composite Bus", patent application no. US 61/880,856, invented by Applied Composite Material Co., USA.

This standard is drafted in accordance with GB/T1.1-2009 rules.

This standard is proposed by Applied Composite Material Co., Hangzhou.

This standard is drafted by Applied Composite Material Co., Hangzhou

The follows has contribution to this draft: Dr. Jay J. Song, Mr. Haitao Wu, Mr. Xiaojun Wei, Mr. Wei Zhao, Mr. Chengwen Wang, Mr. Pengkun Wang, Mr. Zengren Li.

Copper Clad Aluminum Composite Bus for the Purposes of Electrical and Equipment of Power Transmission and Transformation

1 Scope

This standard stipulates the models, specifications, technical requirements, test methodology, inspection rules, and delivery requirements of copper clad aluminum composite ("CCAC") bus.

This standard is applicable to CCAC bus (commonly known as CCAC busbar, CCAC bar, CCAC flat wire) for the purposes of electrical and equipment of power transmission and transformation.

2 Informative Referenced Documents

The following documents are indispensable for applications of this standard. To dated documents, the version to the date applies. To no dated documents, the latest version (including all amendments) applies.

ASTM D4541-09e1 Pull-Off Strength of Coatings Using Portable Adhesion Testers
GB/T 467—2010 Cathode Copper
GB/T 1196—2008 Remelting Aluminum Ingot
GB/T 2900.10—2001 Electrotechnical vocabulary–Electric cables
GB/T 3048.2—2007 Test methods for electrical properties of cables and wires, Part 2: Test of electrical resistivity of metallic material
GB/T 4909.2—2009 Test methods of bare wires, Part 2: Size measurement
GB/T 4909.3—2009 Test methods of bare wires, Section Three: Tensile Test
GB/T 4909.6—2009 Test methods of bare wires, Part 6: Bend test - Single bend test

3 Terminology and Definition

GB/T 2900.10-2001 defined as well as the following terminology and definition applies to this standard.

3. 1 Copper Clad Aluminum Composite Bus

The rectangular shapped bus, which is characterized by layered structure and metallurgical bonding onto the bimetal interface, is made of the cladding copper uniformly coated over the aluminum core.

3. 2 Flatness

The maximum vertical distance between the CCAC bus surface to the reference surface while CCAC bus is placed onto the reference surface.

3.3 Volume Ratio of the Cladding Copper

The ratio of the cladding copper volume to the total volume of CCAC bus.

3.4 Interfacial Bonding Strength

The binding force of the aluminum core and the cladding copper in unit area.

3.5 Interfacial Shear Strength

Copper and aluminum interface capability of resistance to shear stress.

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3.6 Metallurgical Bonding

Atoms at bimetal interface bonding through diffusion and fusion.

4 Model

CCAC bus model is made of the type code (TLM), specification and coding of this standard.

TLM— □ QB/ACM 01.01-2014

Specification a×b: "a" is length of the narrow edge, "b" is length of the wide edge.

Type code

Example: for the length of 10 mm of narrow edge (i.e., thickness), 100mm of wide edge (i.e. width), the model is represented as: TLM-10×100 QB/ACM 01.01-2014。

5 Technical Requirement

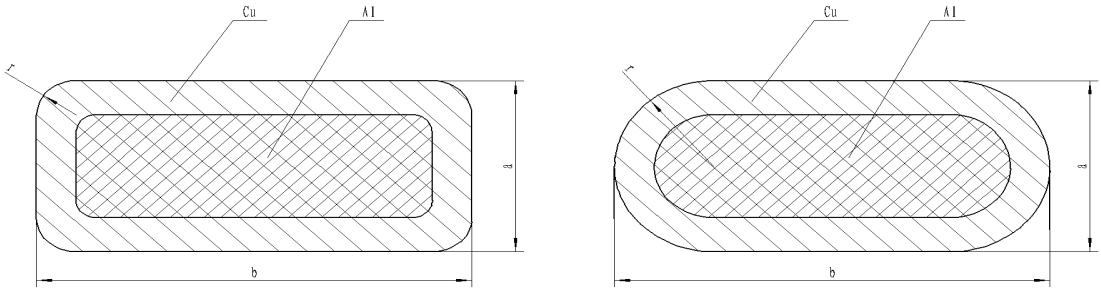
5.1 Material

5.1.1 In accordance with GB/T 467 – 2010, the cladding copper should be made of the standard cathode copper (Cu-CATH-2), its composition should be compatible with the performacne requirements as stipulated in this standard.

5.1.2 In accordance with GB/T 467 – 2008 , the aluminum core should be made of the Al 99.7E grades remelting aluminum ingot, its composition should be compatible with the performance requirements as stipulated in this standard.

5.2 Shape of Section

The cross-sectional shape of CCAC bus is shown in Fig.1, including (a) round corner; and (b) full circle edge. The radius r and deviation of the round corner and full circle edge cross-section shall be consistent with the provisions of 5.5.



(a) Round Corner Cross-Section **(b)** Full Circle Edge Cross-Section

Fig.1 Cross-sectional shape of CCAC bus

5. 3 Surface Quality

The surface of CCAC bus shall be smooth, flat, bumpless and crackless, and free of any defect which is not matching with good industrial product standard.

5. 4 Dimension and Deviation

5. 4. 1 Section size of CCAC bus ranged from 3 mm ≤ a ≤ 35 mm; 30 mm ≤ B ≤ 300 mm. Recommended CCAC bus specifications as shown on table 1.

Table 1. Recommended Specifications Unit:mm

Width b	Thickness a										
	3	4	5	6	8	10	12	14	16	20	30
30	○	○	○	○							
40	○	○	○	○							
50	○	○	○	○							
60	○	○	○	○	○	○					
80	○			○	○	○	○				
100	○			○	○	○	○	○			
120	○	○		○	○	○	○	○			
140	○			○	○	○	○				
160	○	○		○	○	○	○		○		
175				○	○						
180	○			○	○	○	○		○		
200		○		○	○	○	○		○		
240		○		○	○	○	○		○		
280		○		○	○	○	○		○		
300				○	○	○	○		○	○	○

Note 1: Tagged with "O" means as common specifications.

Note 2: By negotiation, other CCAC bus specification can be supplied.

5. 4. 2 Deviation of thickness “a” is corelated with width “b”, it shall comply with table 2.

Table 2. Thickness deviation Unit: mm

Thickness "a"	Width "b"		
	30.00≤b≤50.00	50.00＜b≤100.00	100.00＜b≤300.00
3.00≤a≤4.75	±0.06	±0.08	±0.10
4.75＜a≤12.50	±0.08	±0.10	±0.12
12.50＜a≤20.00	±0.10	±0.12	±0.15
20.00＜a≤30.00	±0.12	±0.15	±0.25

5. 4. 3 Deviation of width "b" shall comply with table 3

Table 3. Deviation of width Unit: mm

Width "b"	Deviation
30.00≤b≤35.50	±0.25
35.50＜b≤100.00	±0.40
100.00＜b≤200.00	±0.70
200.00＜b≤300.00	±1.00

5. 5 Radius of Round Corner and Full Circle Edge Cross-Section

5. 5. 1 Radius "r" of round corner cross-section should be consistent with the provision of table 4, it is measured with the sample radius.

Table 4. Radius of the round corner cross-section Unit: mm

Thickness "a"	Radius "r"
3.00≤a≤6.00	≤1.50
6.00＜a≤30.00	≤2.00

5. 5. 2 Radius "r" of the full circle edge cross-section shall be equal to half of the thickness "a", its deviation shall be 0~12.5% of "a", the unit is "mm".

5. 6 Cross-Section Area

5. 6. 1 The cross-section area "S" of the round corner cross-section is calculated with the formula (1) :

$$S = a \times b - 0.858 \times r^2 \qquad \cdots\cdots\cdots\cdots\cdots\cdots (1)$$

5. 6. 2 The cross-section area "S" of the full circle edge cross-section is calculated with the formula (2) :

$$S = a \times b - 0.214 \times a^2 \qquad \cdots\cdots\cdots\cdots\cdots\cdots (2)$$

5. 7 Flatness

5. 7. 1 Tolerance of Flatness

The tolerance of flatness within the specified length shall not exceed 3‰ of the specified length.

5.7.2 Measurement of Flatness

The sample with specified length is placed on a reference plate to directly measure the maximum distance of the gap between the measured surface and reference plane by a feeler gauge.

5.8 Volume Ratio of Cladding Copper

5.8.1 The volume ratio of the cladding copper to the CCAC bus should be ranged from 18% to 22%, the standard volume ratio is 20%.

5.8.2 The volume ratio of cladding copper is determined by weighting method. Take a length of 200 mm flat sample with both ends flush, measure the length *(l)* of the sample by vernier caliper and the weight (m) by balance scale by accuracy not less than 0.1g. In consider the formula to calculate cross-sectional area as well as copper and aluminum density, the volume ratio of cladding copper can be carried out according to the formula (3) and (4) for the round corner and full circle edge cross-section respectively.

$$V_{Cu}=[\frac{m\times10^3}{6.187l(a\times b-0.858r^2)}-0.437]\times100\% \quad \cdots(3)$$

$$V_{Cu}=[\frac{m\times10^3}{6.187l(a\times b-0.214a^2)}-0.437]\times100\% \quad \cdots(4)$$

Among it:

V_{Cu}——Volume ration of cladding copper;

m ——Sample weight, the unit is “g”;

l ——Sample length, the unit is “mm”;

a ——Bus thickness, the unit is “mm”;

b ——Bus width, the unit is “mm”;

r ——Radius of the round corner, the unit is “mm”.

5.8.3 During calculation, the following physical parameters for copper and aluminum are taken

Density of copper: 8.890 (kg/dm^3);

Density of aluminum: 2.703 (kg/dm^3).

5.9 Thickness of the Cladding Copper

5.9.1 The thickness at the thinnest point should be not less than 90% of the average thickness of the cladding copper.

5.9.2 The thickness measurement of the cladding copper is performed by preparing a small flat sample, both ends flatting, placing the sample under a microscope by magnification of 100 times, the measuring position is shown in Figure 2, the thickness of

cladding copper is measured by the narrow-side and the broad-side from four directions respectively, at least three measurements for each of the two narrow-side and nine measurements for each of the two broad-side. Taking the minimum measurement data as the value of thickness as the thinnest cladding copper for the narrow-side and broad-side, then calculate the average thickness of the broad-side based on those measurements on the broad-side.

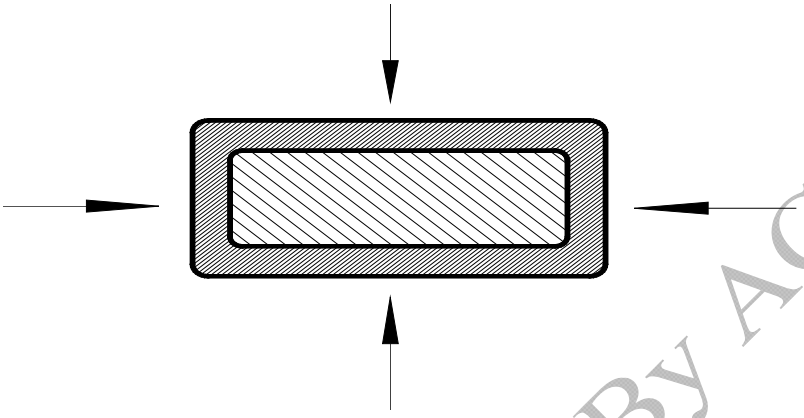


Fig.2. Method of thickness measurement

5. 10 **Mechanical Properties**

5. 10. 1 Tensile Strength and Elongation

5. 10. 1. 1 The tensile strength of CCAC bus shall not be less than 100MPa, the elongation shall not be less than 12%.

5. 10. 1. 2 The tensile test shall be carried out in accordance with the provisions of GB/T 4909.3-2009, it should be the overall tensile.

5. 10. 2 Bending

5. 10. 2. 1 When bend the broad-side 90°, the cladding copper shall has no crack, the cladding copper and the aluminum s core should not be separated.

5. 10. 2. 2 The bending test shall be carried out in accordance with the provisions of GB/T 4909.6-2009, the diameter "d" of the bending cylinder shall comply with the provisions of table 5.

Table 5. Diameter of Bending Cylinder Unit: mm

Thickness "a"	Diameter of Bending Cylinder "d"
a = 3.00	12
a = 4.00	16
a = 5.00	20
a = 6.00	24
a = 8.00	32
a = 10.00	40
a = 12.00	48

5. 11 Electrical Properties

5. 11. 1 The DC resistivity of CCAC bus at 20 ℃ shall be not greater than 0.02480Ω·mm^2/m, that is the conductivity equivalent to 69.5%IACS.

5. 11. 2 The resistivity test of CCAC bus shall be carried out in accordance with the provisions of GB/T 3048.2-2009.

5. 11. 3 The calculation reference of current-carrying-capacity for typical CCAC bus specifications refers to appendix A and appendix B, the current-carrying-capacity data in the table is calculated based on flat placed single bus.

5. 12 Interfacial Bonding Strength

5. 12. 1 The interfacial bonding strength (shear strength) of CCAC shall be great than the shear strength of aluminum (50MPa ~ 80MPa under normal condition).

5. 12. 2 The measurement method of interfacial bonding strength (shear strength) of CCAC bus as of: preparing a length of 150mm, width "L1" of 20±1 mm CCAC sample, removing one side of cladding copper and aluminum core at point "A" through mechanical process or electric spark cutting without damage to the other side of cladding copper; removing other side of cladding copper at point "B" without damage to the aluminum core. At the time of the operation, the width of the groove "d" should not exceed 4 mm, the distance "L2" between the two grooves should be 2± 0.1mm, as shown in Fig.3, it should take not less than three samplings for same specifications. The sample undergoes tensile test through the tensile testing machine. Prior to the tensile test, measures the actual width "L1" and "L2" of the sample by vernier caliper; during the test, the tensile speed should between 20mm/min~200mm/min, to stretch the sample till complete separation of the cladding copper and aluminium core, to record the maximum tensile F_{max} and calculate the interfacial bonding strength (shear strength) "P" according to the formula (5) .

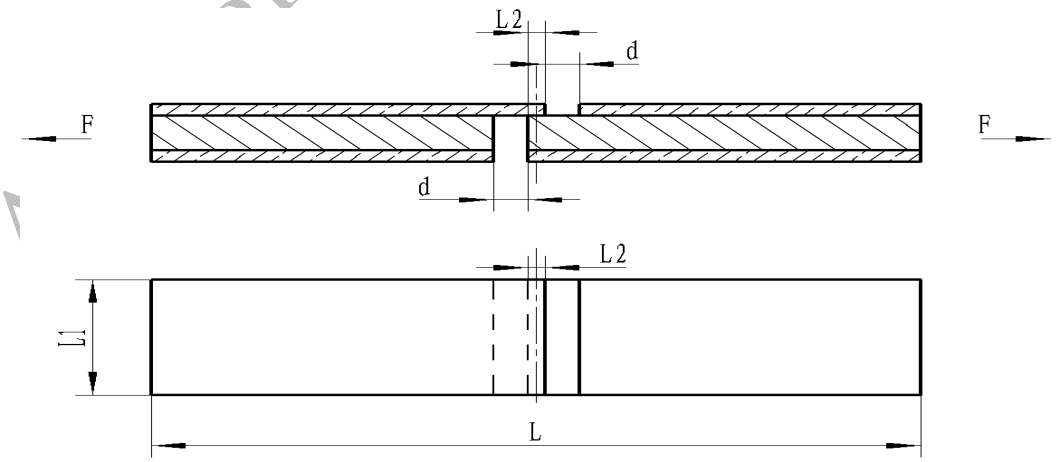


Figure 3. Schematic diagram of sample preparation for interfacial bonding shear strength test of CCAC bus

$$P = F_{\max} / S_b \qquad \cdots\cdots\cdots\cdots\cdots\cdots (5)$$

Amongst:

P ——Interfacial Bonding Strength, the unit is "MPa";

F_{max}——The maximum tensile stress during the tensile test, the unit is "N";

S_b ——The measured interfacial bonding area $L_1 \times L_2$, the unit is "mm^2"

5. 12. 3 Auxiliary Measuring Methods of Interfacial Bonding Strength

5.12.3.1 Auxiliary Method 1. The test standard used ASTM D4541-09e1 Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers.

5.12.3.2 Auxiliary Method 2. Preparing both length and width great than 50 mm CCAC bus sample, removing one side of cladding copper and aluminum core to form a diameter d=18mm round well at point "A" through mechanical process or electric spark cutting without damage to the other side of cladding copper; removing other side of cladding copper at point "A" to form a ring with inner and outer diameter d_1=20mm, d_2=22mm without damage to the aluminum core. Meanwhile, make a die in pie shape wirh diameter of 17mm, thickness of 3mm, as shown in Fig.4. The sample undergoes momentum test through the momentum testing machine. During the test, the momentum speed should not less than 10m/sec, till complete separation of the cladding copper and aluminium core, record the minimum momentum F_{min} and calculate the interfacial bonding strength "P" according to the formula (6) .

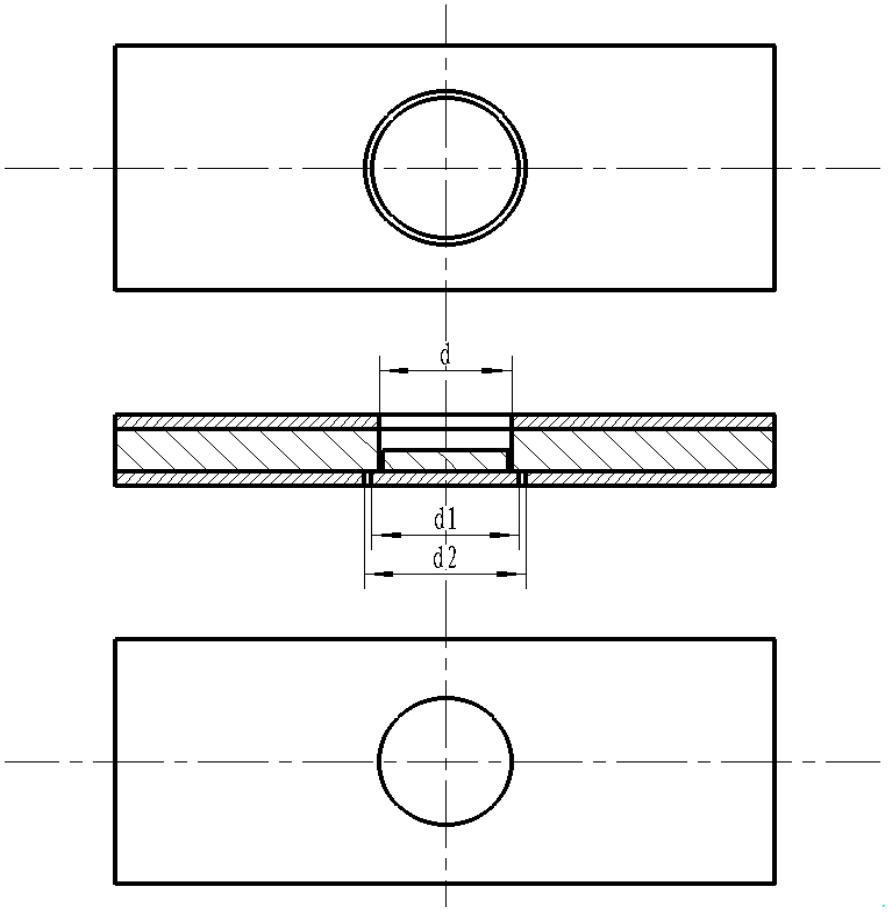


Figure 3. Schematic diagram of sample preparation for interfacial bonding strength test of CCAC bus

$$P = F_{min} / S_a \quad \cdots\cdots\cdots\cdots (6)$$

Amongst:

P —— Interfacial Bonding Strength, the unit is "MPa";

F_{min} ——The maximum tensile stress during the tensile test, the unit is "N";

S_a —— The measured interfacial bonding area, $S_a = \pi(d_1^2 - d^2)/4$, the unit is "mm^{2}"

6 Length by Delivery

The standard delivery length of CCAC bus is 6m each for domestic market, 5.5m (or 5m) each for global market. By negotiation, any delivery length is permitted, and 100% fixed.

7 Test

7.1 Test Classification

7.1.1 Type Test

Type test (T) conducts the comprehensive assessment of product quality. When design new CCAC bus or utilize new technology to the fabrication process, the type test is necessary.

Type test is only for the CCAC bus which is in compliance with all relevant sampling test requirements.

7.1.2 Sampling Test

Sampling test (S) is used to ensure the quality and requirements of CCAC bus to this standard.

7.1.3 Sampling Rule

Sampling rule shall set the sampling time during processing for the continuous production line system, Sampling rule shall conform to the requirements specified in table 6.

Table 6. Sampling Rules

Processing Time Hour(s)	Number for Sampling "n" Piece(s)
3	3
6	6
9	9
12	12

7.2 Test Requirements

CCAC buss should be tested in accordance with the provisions of table 7.

Table 7. Test Requirements

No.	Test Contents	Technical Requirements	Inspection Type	Test Methods
1	Surface Quality	5.3	T, S	Normal Visual Inspection
2	Size & Deviation	5.4	T, S	GB/T 4909.2—2009
3	Round Corner & Full Circle Edge Cross-Section	5.5	T, S	GB/T 4909.2—2009
4	Flatness	5.7	T, S	5.7.3
5	Volume Ratio of Cladding Copper	5.8.1	T, S	5.8.2
6	Thickness of Cladding Copper	5.9.1	T, S	5.9.2
7	Tensile Strength & Elongation	5.10.1.1	T, S	5.10.1.2
8	Bending	5.10.2.1	T, S	5.10.2.2
9	Resistivity	5.11.1	T, S	5.11.2
10	Interfacial Bonding Strength	5.12.1	T, S	5.12.2

8 Certificate, Packaging, Mark, Transportation and Storage

8.1 Certificate

Each package should be accompanied the certificate of product issued by quality inspection department of the supplier; each batch of products should be accompanied the factory inspection report issued by quality inspection department of the supplier.

8.2 Packaging

The product surface is coated antioxidant and wrapped by thin insulating plastic film. The antioxidant life is great than 180 days under the normal temperature and humidity condition.

CCAC bus should be a bundle or box packaging, packaging surface should be clearly identified; Each package shall be of the same type, same specifications. If there is a short segment, the length and number of short segments shall be marked.

The product should be packed properly, the packaging material shall conform to the requirement of anti-humidity, anti-corrosion and prevention of mechanical damage.

8.3 Mark

Each package should be taged which marks:

a) Manufacturer name and trademark;
b) Product name;
c) Product model, specification;

d) Product batch number;
e) Gross and net weight, length, number of pieces;
f) Delivery Date: year / month / day
g) QB/ACM 01.01—2014。

8.4 Transportation and Storage

During transportation, CCAC bus should be moisture-proof, anti-corrosive, prevent damage from loading and unloading, handling, storage and transportation. The CCAC buss should be properly stored in warehouse which has dry and ventilated, rain-proof, waterproof, no alkaline substances or hazardous gases.

Appendix A

（Informative Annex）

Current-Carrying-Capacity Table of CCAC Bus

(Reference Data)

The reference value of Current-Carrying-Capacity of CCAC bus under different temperature condition are presented in table A with the ambient temperature not great than +40℃.

Table A.

Table of Current-Carrying-Capacity of CCAC bus

(Reference Data)

Specification (a×b) mm	**Current-Carrying-Capacity** (A)				
	50K	60K	65K	70K	75K
4×30	358	391	407	423	437
4×40	431	473	492	511	528
4×50	506	554	576	598	619
5×40	498	545	568	590	610
5×50	585	642	668	694	718
6×60	721	789	823	853	884
6×80	930	1019	1060	1102	1141
6×100	1084	1186	1236	1282	1328
6×120	1275	1396	1453	1509	1563
6×140	1410	1544	1607	1668	1728
6×160	1634	1789	1872	1932	2002
8×60	826	906	942	978	1013
8×80	1034	1133	1179	1224	1268
8×100	1230	1347	1401	1455	1507
8×120	1435	1572	1637	1698	1759
8×140	1640	1797	1871	1941	2011
8×160	1847	2023	2105	2185	2263
10×100	1399	1533	1596	1655	1715
10×120	1629	1784	1857	1927	1996
10×140	1864	2041	2125	2206	2284
10×160	2099	2299	2393	2484	2572
12×100	1550	1707	1768	1835	1900

Note 1. The Current-carrying capacity of CCAC bus is derived based on single bar placed flat, the test condition is under nosunshine, no wind, the CCAC bus is without coating.

Note 2. During calculation, the volume ratio of cladding copper in CCAC bus is set as of 20%.

Appendix B. SPECIFICATION

COPPER BUS			CCAC BUS		
Spec.(axb) mm	kg/m	Kg/Ea.	Spec.(axb) mm	kg/m	Kg/Ea.
4×30	1. 036	6. 217	4×30	0. 459	2. 754
4×40	1. 392	8. 351	4×40	0. 616	3. 699
4×50	1. 748	10. 485	4×50	0. 774	4. 644
4×60	2. 103	12. 618	4×60	0. 932	5. 589
5×40	1. 730	10. 381	5×40	0. 766	4. 599
5×50	2. 175	13. 048	5×50	0. 963	5. 780
5×60	2. 619	15. 715	5×60	1. 160	6. 961
5×80	3. 508	21. 049	5×80	1. 554	9. 324
5×100	4. 397	26. 383	5×100	1. 948	11. 687
6×60	3. 132	18. 790	6×60	1. 387	8. 323
6×80	4. 198	25. 190	6×80	1. 860	11. 159
6×100	5. 265	31. 591	6×100	2. 332	13. 994
6×120	6. 332	37. 992	6×120	2. 805	16. 829
6×140	7. 399	44. 393	6×140	3. 277	19. 665
6×160	8. 466	50. 793	6×160	3. 750	22. 500
6×180	9. 532	57. 194	6×180	4. 223	25. 335
6×200	10. 599	63. 595	6×200	4. 695	28. 171
8×60	4. 145	24. 869	8×60	1. 836	11. 016
8×80	5. 567	33. 404	8×80	2. 466	14. 797
8×100	6. 990	41. 938	8×100	3. 096	18. 577
8×120	8. 412	50. 472	8×120	3. 726	22. 358
8×140	9. 834	59. 007	8×140	4. 356	26. 180
8×160	11. 257	67. 541	8×160	4. 986	29. 919
8×180	12. 679	76. 076	8×180	5. 617	33. 699
8×200	14. 102	84. 610	8×200	6. 247	37. 480
10×100	8. 699	52. 193	10×100	3. 853	23. 120
10×120	10. 477	62. 861	10×120	4. 641	27. 846
10×140	12. 255	73. 529	10×140	5. 426	32. 571
10×160	14. 033	84. 197	10×160	6. 216	37. 297
10×180	15. 811	94. 865	10×180	7. 004	42. 022
10×200	17. 589	105. 533	10×200	7. 791	46. 748
12×100	10. 393	62. 357	12×100	4. 604	27. 622
12×120	12. 526	75. 158	12×120	5. 549	33. 293
12×140	14. 660	87. 960	12×140	6. 464	38. 964
12×160	16. 794	100. 791	12×160	7. 439	44. 634
12×180	18. 927	113. 563	12×180	8. 384	50. 305
12×200	21. 061	126. 365	12×180	9. 329	55. 976

Note 1.The current-carrying capacity of CCAC equivelent to 86% of copper bus;

Note 2.Tthe volume ratio of copper is 20%, density 3.938g/cm³ , full circle edge cross-section, length of 6m/each.