



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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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

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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 shaped 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.

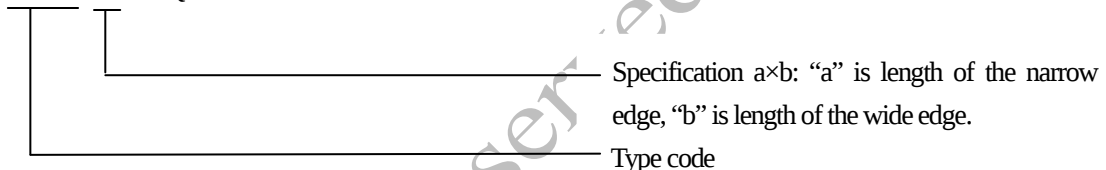
3.6 Metallurgical Bonding

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



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 performance 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.

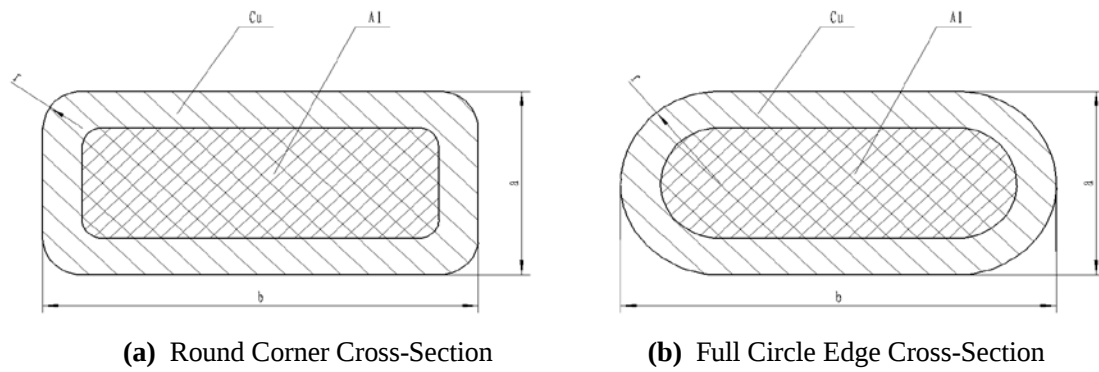


Fig.1 Cross-sectional shape of CCAC bus

5.3 Surface Quality

The surface of CCAC bus shall be smooth, flat, bumpy 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 $3 \text{ mm} \leq a \leq 35 \text{ mm}$; $30 \text{ mm} \leq B \leq 300 \text{ mm}$. 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 correlated 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) :

$$S = a \times b - 0.858 \times r^2 \quad \dots\dots\dots (1)$$

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

$$S = a \times b - 0.214 \times a^2 \quad \dots\dots\dots (2)$$

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.

$$V_{Cu} = \left[\frac{m \times 10^3}{6.187l(a \times b - 0.858r^2)} - 0.437 \right] \times 100\% \quad \dots (3)$$

$$V_{Cu} = \left[\frac{m \times 10^3}{6.187l(a \times b - 0.214a^2)} - 0.437 \right] \times 100\% \quad \dots (4)$$

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/dm³);

Density of aluminum: 2.703 (kg/dm³).

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 flattening, 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.

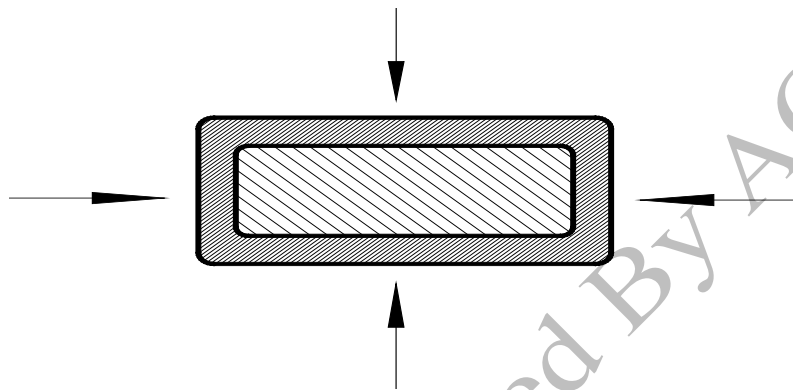


Fig.2. Method of thickness measurement

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”
$3.00 \leq a \leq 6.00$	12
$6.00 < a \leq 12.00$	24
$12.00 < a \leq 20.00$	36
$20.00 < a \leq 30.00$	45

5. 11 Electrical Properties

5. 11. 1 The DC resistivity of CCAC bus at 20 °C shall be not greater than $0.02480\Omega \cdot \text{mm}^2/\text{m}$, 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 ± 0.1 mm, 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 not exceed 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) .

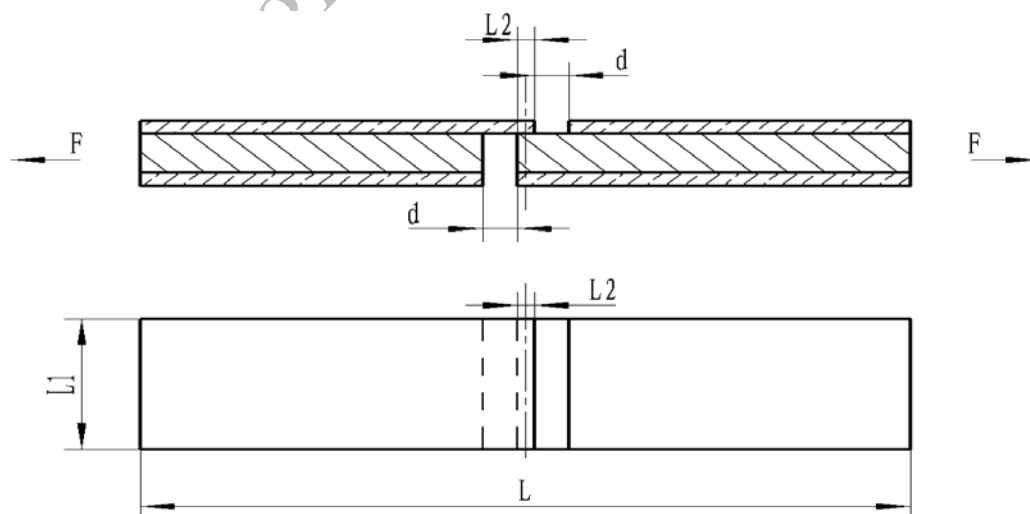


Figure 3. Schematic diagram of sample preparation for interfacial bonding strength (shear strength) test of CCAC bus



$$P = F_{\max} / S_b \quad \dots\dots\dots (5)$$

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 “mm²”

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 $d=18\text{mm}$ 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 $d_1=20\text{mm}$, $d_2=22\text{mm}$ without damage to the aluminum core. Meanwhile, make a die in pie shape with 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) .

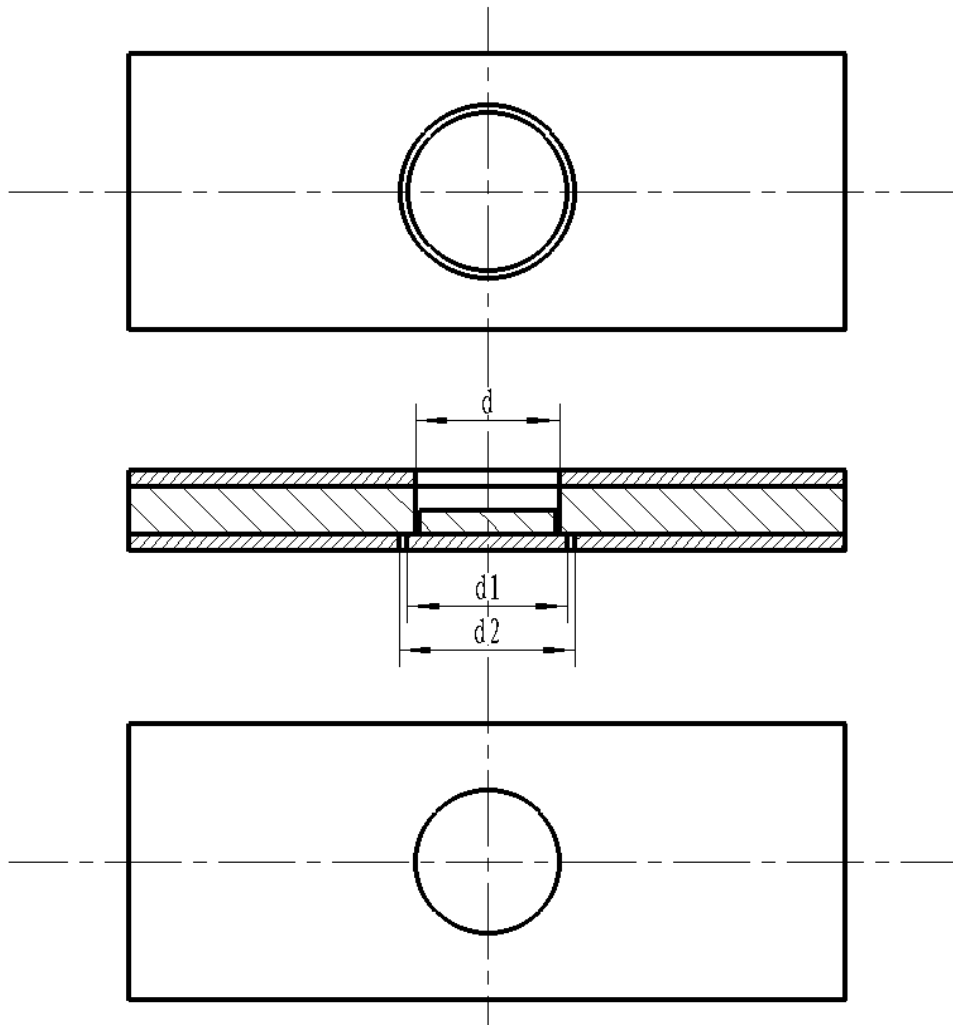


Figure 3. Schematic diagram of sample preparation for interfacial bonding strength test of CCAC bus

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

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, $S_a = \pi(d_1^2 - d_2^2)/4$, the unit is “mm²”

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 tagged which marks:

- Manufacturer name and trademark;
- Product name;
- Product model, specification;
- Product batch number;
- Gross and net weight, length, number of pieces;
- Delivery Date: year / month / day
- 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	355	388	404	420	434
4×40	428	469	488	507	524
4×50	502	550	572	593	614
5×40	494	541	564	585	605
5×50	581	637	663	688	712
6×60	715	783	816	846	877
6×80	923	1011	1052	1093	1132
6×100	1075	1177	1226	1272	1317
6×120	1265	1385	1442	1497	1551
6×140	1399	1532	1594	1655	1714
6×160	1621	1775	1857	1917	1986
8×60	820	899	935	970	1005
8×80	1026	1124	1170	1214	1258
8×100	1220	1336	1390	1443	1495
8×120	1424	1560	1624	1685	1745
8×140	1627	1783	1856	1926	1995
8×160	1832	2007	2088	2168	2245
10×100	1388	1521	1583	1642	1701
10×120	1616	1770	1842	1912	1980
10×140	1849	2025	2108	2188	2266
10×160	2082	2281	2374	2464	2552
12×100	1538	1694	1754	1820	1885
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 18%.					

Appendix B

(Informative Annex)

Comparison Table of Current-Carrying-Capacity of Copper vs. CCAC Bus (Calculation Value)

Table B presents the calculation value of Current-Carrying-Capacity of copper bus vs. CCAC bus with the ambient temperature at 40°C.

Table B. Comparison Table of Current-Carrying-Capacity of Copper vs. CCAC Bus

Copper Bus			CCAC Bus		
Apecification (a×b) mm	Weight Per Meter kg/m	Current- Carrying- Capacity(A)	Apecification (a×b) mm	Weight Per Meter kg/m	Current- Carrying- Capacity (A)
4×30	0.207	360	4.70×30	0.537	360
4×40	0.278	480	4.70×40	0.722	480
4×50	0.350	600	4.70×50	0.907	600
5×40	0.346	520	5.80×40	0.886	520
5×50	0.435	650	5.80×50	1.115	650
5×60	0.524	780	5.80×60	1.343	780
6×60	0.626	840	7.00×60	1.614	840
6×80	0.840	1120	7.00×80	2.165	1120
6×100	1.053	1400	7.00×100	2.717	1400
6×120	1.266	1680	7.00×120	3.269	1680
6×140	1.480	1960	7.00×140	3.820	1960
6×160	1.693	2240	7.00×160	4.372	2240
8×60	0.829	960	9.30×60	2.126	960
8×80	1.114	1280	9.30×80	2.859	1280
8×100	1.398	1600	9.30×100	3.592	1600
8×120	1.683	1920	9.30×120	4.324	1920
8×140	1.967	2240	9.30×140	5.057	2240
8×160	2.251	2560	9.30×160	5.791	2560
10×100	1.740	1800	11.70×100	4.495	1800
10×120	2.096	2160	11.70×120	5.423	2160
10×140	2.451	2520	11.70×140	6.339	2520
10×160	2.807	2880	11.70×160	7.261	2880
12×100	2.079	2000	14.00×100	5.352	2000

Note 1.The Current-carrying capacity of copper bus is calculated based on the ambient temperature at 40°C.;

Note 2.The Current-carrying capacity of CCAC bus is calculated by referring to copper bus under the same condition and equal conversion into the theoratical specifications;

Note 3. During calculation, the volume ratio of cladding copper in CCAC bus is set as 20%.

Note 4. The Current-carrying capacity of CCAC bus in table B is calculated based on single bar placed flat.