



SPECIFICATION SS-31/5

COPPER ALLOY (BRONZE) AND BIMETALLIC POWER CONNECTORS FOR S/S 150/20kV

I. SCOPE

The hereby specification covers the technical characteristics, design features and testing of copper alloy (Bronze) and bimetallic power clamp connectors, suitable for connecting multi-wire hard drawn copper conductors, copper tubes, copper tubes with aluminum conductors of ACSR type and multi-wire hard drawn copper conductors with aluminum conductors of ACSR type.

II. KEYWORDS

Connectors, Copper alloy (Bronze) connectors, bimetallic connectors, substation connectors.

III. USE

The copper alloy and bimetallic connectors shall be used in 150/20kV substations.

1. The Copper alloy (Bronze) connectors shall be used to connect:
 - a. Multi-wire copper conductors with cross - sections 185mm^2 , 240mm^2 and 400mm^2 .
 - b. Copper tubes with diameters of $\Phi 80/70\text{mm}$, $\Phi 60/52\text{mm}$, $\Phi 30/24\text{mm}$, and $\Phi 20/16\text{mm}$.
 - c. Copper tubes with multi-wire copper conductors.
2. The Bimetallic connectors shall be used to connect multi-wire copper conductors with cross-sections of 185mm^2 , 240mm^2 , 400mm^2 and copper tubes with ACSR conductors with diameters $\Phi 32.4\text{mm}$, $\Phi 25.04\text{mm}$, $\Phi 18.38\text{mm}$ and $\Phi 17.25\text{mm}$.

IV. OPERATING CONDITIONS

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|----------------------------------|---|
| 1. Installation | : Outdoors |
| 2. Limits of ambient temperature | : -20 °C to +45 °C |
| 3. Altitude | : Up to 1000m above sea level |
| 4. Weather conditions | : Snow, ice and fog |
| 5. Environmental pollution level | : Dust, salt and industrial contamination (medium to heavy depending on region) |

V. STANDARDS

The Copper (Bronze) alloy and bimetallic connectors shall be in accordance with the following ASTM standards

- ASTM B 154-95 & B 61-93
- ASTM B 505-97
- ASTM B 824-96
- ASTM B 208-96

VI. DESCRIPTION

The copper alloy (Bronze) and bimetallic connectors intend to hold mechanically and connect electrically two (2) or more parts of the network.

The Bronze connectors shall be manufactured with cast copper alloy, the chemical composition of which is indicated below and they intend to connect copper conductors or copper tubes.

The bimetallic connectors shall be manufactured with cast copper alloy for the part of the connector intended to connect with copper conductors and with aluminum for the part of the connector intended to connect with aluminum conductors.

A bimetallic sheet (CUPAL) of 1mm thickness shall be inserted between the surfaces in contact.

Is also permissible, the connectors intended to connect copper conductors with aluminum, to be made entirely of bronze, proven they withstand corrosion.

VII. ELECTRICAL REQUIRED CHARACTERISTICS

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| 1. Nominal (rated) voltage | : 150 kV |
| 2. Maximum operating voltage | : 170 kV |
| 3. Rated short time current | : 31.5 kA for 1 min |
| 4. Rated normal operating current | : according to the Table below |

Connector for copper tube of diameter $\Phi 80/70\text{mm}$	2000A
Connector for copper tube of diameter $\Phi 60/52\text{mm}$	1250A
Connector for copper tube of diameter $\Phi 30/24\text{mm}$	700A
Connector for copper tube of diameter $\Phi 20/16\text{mm}$	300A
Connector for multi-wire copper conductor 185mm^2	430A
Connector for multi-wire copper conductor 240mm^2	530A
Connector for multi-wire copper conductor 400mm^2	730A
Connector for aluminum multi wire (ACSR) conductor of diameter 32.4mm	1000A
Connector for aluminum multi wire (ACSR) conductor of diameter 25.04mm	730A
Connector for aluminum multi wire (ACSR) conductor of diameter 18.38mm	530A
Connector for aluminum multi wire (ACSR) conductor of diameter 17.25mm	430A

VIII. ALLOYS

1. COPPER ALLOY (bronze) connectors

The bronze connectors shall be manufactured with first melting copper alloy according to ASTM B 505-97 or EN 1982 or EN 12165, with the following preferable chemical composition:

Copper (Cu) : 85-90%
 Tin (Sn) : 5-7%
 Lead (Pb) : 1-2%
 Zinc (Zn) : 3-4%

The content of residual elements shall be according to standard recommendations, if such apply. Specifically, the impurities of the following metals shall not exceed the below indicated values:

Nickel (Ni) : <1%
 Iron (Fe) : <0.25%
 Antimony (Sb) : < 0.25%
 Phosphorus (Ph) : <0.05%
 Sulphur (S) : <0.05%
 Aluminum (Al) : <0.005%
 Silicon (Si) : <0.005%

The chemical composition of the alloy shall be declared and verified by chemical analysis. The selection of alloy by the manufacturer should fulfill both electrical and mechanical requirements as those are set in this specification and NEMA CC-1 standard rules. More specifically:

- Temperature rise
- Pullout strength test
- Corona/RIV

Mechanical properties of the copper alloy are the following:

Tensile strength	: 235 MPa
Elongation	: 24%
Yield point at 0.5% elongation	: 110MPa

Mechanical properties shall be checked via test bar castings produced from the same heat number. For each lot at least three (3) such bars shall be prepared during production and be available for inspection/quality control. The properties shall comply with the above minimum requirements (yield point, elongation, tensile strength and hardness) as applicable through standard requirements.

2. Aluminum alloy connectors

The bimetallic connectors shall be manufactured with first melting silicon aluminum alloy, of high strength, for the part of the connector intended to connect with aluminum conductors, with the following chemical composition:

Aluminum (Al) : 91-92%
Silicon (Si) : 6.5-7.5%
Magnesium (Mg): 0.25-0.45%

Impurities:

Iron (Fe) max 0.4%
Copper (Cu) max 0.1%
Zinc (Zn) max 0.1%
Lead (Pb) max 0.1%
Manganese (Mn) max 0.1%

Mechanical properties of the aluminum alloy are the following:

- Tensile strength : > 235 Mpa
- Elongation : >1.5%
- Yield point at 0.2 elongation : 165 Mpa
- Hardness : ≥ 65 HB
- Specific resistance : $4.8 \mu\Omega \times \text{cm}$

IX. TESTS

In accordance with ASTM B61-93.

1. Quality assurance tests (special tests)

The following tests shall be made in one piece from each casting lot.

- 1.1 Chemical analysis
- 1.2 Mechanical tests (simulate forces that result from short-circuit conditions)
- 1.3 Porosity test with non-destructive testing

2. Type tests

2.1 Temperature rise test

- a. The tests shall be carried-out indoors.
- b. The conductors of anticipated type and size shall be extended at least 1m from each side of the connector, up to the point of the connection is made to the electrical circuit.
- c. The values of currents for which the temperature rise test shall be carried-out, for the various types of connectors, shall be in accordance with the following:

Connector for copper tube of diameter $\Phi 80/70\text{mm}$	2000A
Connector for copper tube of diameter $\Phi 60/52\text{mm}$	1250A
Connector for copper tube of diameter $\Phi 30/24\text{mm}$	700A
Connector for copper tube of diameter $\Phi 20/16\text{mm}$	300A
Connector for multi-wire copper conductor 185mm^2	430A
Connector for multi-wire copper conductor 240mm^2	530A
Connector for multi-wire copper conductor 400mm^2	730A
Connector for aluminum multi wire (ACSR) conductor of diameter 32.4mm	1000A
Connector for aluminum multi wire (ACSR) conductor of diameter 25.04mm	730A
Connector for aluminum multi wire (ACSR) conductor of diameter 18.38mm	530A
Connector for aluminum multi wire (ACSR) conductor of diameter 17.25mm	430A

The temperature rise of the connectors shall not exceed the temperature rise of the conductors they intend to connect.

For the connectors that have branches of different size conductors, the selected value of current shall correspond to the smaller size conductor.

The specified currents shall be applied to the connectors until their temperature is stabilized at all points.

The hot-spot temperature rise shall not exceed the average temperature rise by more than 10 °C.

2.2 Electrical resistance measurement

The test measurement of the electrical resistance shall be made in conjunction with the temperature rise test. The test shall be performed for the conductor of the largest size for which the connector is intended. The measurement of the electrical resistance shall be at a distance of 30cm on either side of the junction of the connector and the deviation of the measured resistance after the test should not exceed the 1.2Ru. Ru is the resistance of the conductor before the temperature rise test.

2.3 Mechanical strength test

The mechanical strength test of a connector shall be performed for both the minimum and maximum size of conductor for which the connector is intended. The connector shall be fastened to the conductor and the bolts shall be tightened with a torque in the range of 1.2 Nm of the nominal tightened torque. The following minimum pull out values shall be considered in order that no slide of the conductor is observed.

Conductor Size	Minimum Pull-Out values
Stranded copper wire of cross section 185mm ²	4540 N
Stranded copper wire of cross section 240mm ²	6000 N
Stranded copper wire of cross section 400mm ²	12000 N
ACSR aluminum conductor with diameters Φ17.25 & Φ18.38	2500 N
ACSR aluminum conductor with diameters Φ 25.04 & Φ32.4	4500 N
Copper tube of diameter 20/16mm	2500 N
Copper tube of diameter 30/24mm	4500 N
Copper tube of diameter 60/52mm	9000 N
Copper tube of diameter 80/70mm	12000 N

X. ASSEMBLING COMPONENTS

All the assembling components, Bolts, Nuts and lock washers shall be made of stainless steel.

All connectors shall be delivered complete with the bolts, nut and lock washers.

XI. PACKING

The connectors shall be packed in robust wooden cases of maximum gross weight 200kg.

Each case shall be indelibly marked with the total weight, type of connector, number of connectors, contract number and year of manufacturing.

Each case shall contain only one type of connectors and the required amount of grease if deemed necessary.

XII. DATA TO BE SUBMITTED BY ALL BIDDERS

All bidders must submit in the technical offer the following:

1. Outline and cross section drawings of the clamp connectors with their dimensions and also symbolism of the roughness of the contact surface of the clamp.
2. Approximate weight of each assembled clamp connector
3. Chemical composition of the alloy which is to be used for the manufacturing of the conductors
4. Type of material of bolts, nuts, washers, lock washers and their strength.
5. All bidders must answer all items of attachment "A". Failure to comply or partial filling will result in rejection of the offer.
6. Any available type test certificates for the type tests of this hereby specification. Acceptance or not lies at the judgement of IPTO.
7. On the drawings shall be stated the type and the quality of special grease to cover the contact surface of the clamp with the conductor, if this deemed necessary by the manufacturer.
Also on the drawings shall be stated the rated torque of the bolts of the clamp.

ATTACHMENT "A"

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| 1. | Type or description of the offered connectors | : | |
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| 2. | Rated voltage | : | |
| 3. | Rated short-time current | : | |
| 4. | Rated normal operating current | | |
| 4.1 | Rated normal operating current for connectors for copper tube $\Phi 80/70\text{mm}$ | : | |
| 4.2 | Rated normal operating current for connectors for copper tube $\Phi 60/52\text{mm}$ | : | |
| 4.3 | Rated normal operating current for connectors for copper tube $\Phi 30/24\text{mm}$ | : | |

4.4	Rated normal operating current for connectors for copper tube Φ20/16mm	:	
4.5	Rated normal operating current for connectors for multi-wire conductor 185mm ²	:	
4.6	Rated normal operating current for connectors for multi-wire conductor 240mm ²	:	
4.7	Rated normal operating current for connectors for multi-wire conductor 400mm ²	:	
4.8	Rated normal operating current for connectors for Aluminum ACSR conductor 32.4mm	:	
4.9	Rated normal operating current for Connectors for Aluminum ACSR conductor 25.04 mm	:	
4.10	Rated normal operating current for connectors for Aluminum ACSR conductor 17.25 mm	:	
5.	Type of alloy for bronze connectors	:	
6.	Chemical composition of copper alloy		
	-Copper (Cu)	:	
	-Tin (Sn)	:	
	-Lead (Pb)	:	
	-Zinc (Zn)	:	
7.	Type of aluminum alloy for bimetallic connectors	:	
8.	Chemical composition of aluminum alloy		
	-Aluminum (Al)	:	
	-Silicon (Si)	:	
	-Magnesium (Mn)	:	

9. Material of assembling components :
10. For bronze connectors
- a. Tensile strength :
- b. Elongation :
- c. Yield point at 0.5% elongation :
11. For alluminum alloy connectors
- a. Tensile strength :
- b. Elongation :
- c. Yield point at 0.2% elongation :
- d. Hardness :
- e. Specific resistance. :
12. Is necessary to use special grease to cover the contact surface of the clamp?
If yes indicate the type and quality. :