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Shear Bolt Connector (185~400mm^2) Design Test Report

Report Number:	Test Start Date:	Test Complete Date:
RN-R3102	2016 / 02 / 15	2016 / 09 / 05

Chardon Taiwan
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1. Current cycling test of the aluminum cable

Object

To verify the terminal connectors meet ANSI/IEEE Std C119.4-2003 requirement of current cycling test.

Testing Samples

Connector	SBC-A-185-400-16/3/C	4 PCS

Mating Parts

Insulating Plug	25-IP600	4 PCS
Stud	25-STUD600	4 PCS
Cable Conductor Type	750kcmil Aluminum Cable	
Cable Insulation Thickness	260 mil	
Equalizers Aluminum	150mm(L), 41.1mm(OD), 26.4mm(ID)	
Bushing Bus Aluminum	1220mm(L),50.8mm(W),19.05mm(T)	

Procedure

Current cycle tests shall be conducted on connectors assembled in series in a loop in accordance with clauses 5 and 6.2 through 6.12.2. An accelerated current cycle test method, referred to as the current cycle submersion test (CCST) is offered as an alternate test method used primarily to quickly assess connector performance. The current cycle test (CCT) remains the preferred test method recommended for the qualification of a connector.

Conductor combinations shall be selected to maximize current through the connector. If the connector is recommended for use between aluminum-to-aluminum and aluminum-to-copper conductors, it shall be tested on both combinations.

The current cycle submersion test current shall be adjusted during the current-ON period of the first five cycles to result in a steady-state temperature rise on the control conductor of 100℃ to 105℃ over ambient temperature. This current shall then be used during the remainder of the test current-ON periods, regardless of the temperature of the control conductor.

To provide equipotential planes for resistance measurements and to prevent the influence of one connector on another, equalizers shall be installed in stranded conductor on each side of each connector in the current cycle loop, except where two terminal connectors are tested tang-to-tang (pad-to-pad).

Equalizers are not required on solid conductors. Any form of equalizer that ensures permanent contact among all the conductor strands for the test duration may be used.

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In addition, where connector design permits, the conductor end shall project 1/2 inch (12.7 mm) beyond the connector contact groove. The equalizers at each end of the current cycle loop shall be joined to the power source with additional lengths of the test conductor to be not less than the lengths specified in Table 4.

The exposed length of stranded conductor between the connector and the equalizer, or between the connectors of solid conductors in the current cycle loop, shall be in accordance with Table 4. If a flat bus bar is used between terminal connectors, its length shall be twice that shown in table 4 for the stranded conductor size being used in the terminal, or the same length of the solid conductor being used in the terminal. The conductor length in Table 4 does not include the length within the connector or equalizer.

A control conductor, for determining test current, shall be installed in the current cycle loop (between two equalizers for stranded conductors). The control conductor shall be the same type and size as the conductor in the current cycle loop that would be at the highest temperature. Its length shall be twice that given in Table 4. For Class AA, when the control conductor is copper, see 6.5.2.

Resistance measurements shall be made at the end of a current-OFF period with all connectors thermally stabilized at the room ambient temperature. Thermal stability is defined as not more than a variation of 2℃ between any two of three readings taken at not less than 10 min intervals. Resistance measurements shall be made across each connector, between potential points located either on the equalizers a maximum of one conductor diameter from the edge adjacent to the conductor or at the midpoint of a solid conductor. A low magnitude direct current not to exceed 12A shall be used for these measurements. Ambient temperature shall be measured within 2 ft (610 mm) of the test loop at a location that minimizes the effect of thermal convection. The ambient temperature shall be recorded at the time of each set of resistance measurements. The resistance of each connector assembly shall be corrected from the measured temperature to 20℃. The corrected resistance values shall be used to evaluate the performance of the connectors.

$$R20 = Rm / [1 + \alpha (Tm - 20)]$$

Where Rm is the measured resistance, Tm is the temperature (℃) of the connector and α is the resistance variation coefficient with the temperature. This coefficient can be taken equal to:

$$\alpha = 4 \text{ X } 10\text{-}3/℃ \text{ for copper and ACSR}$$

$$\alpha = 3.6 \text{ X } 10\text{-}3/℃ \text{ for aluminum}$$

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Results

Temperature Data Unit :℃

Date	Cycle	Sample Number								Cable Tem	Room Tem
		1		2		3		4			
		1a	1b	2a	2b	3a	3b	4a	4b		
2/6	28	87.2	88.0	86.4	86.8	86.4	87.3	87.3	87.6	101.2	17.6
2/9	49	87.5	87.9	87.1	87.6	86.8	87.5	87.1	88.6	102.4	17.4
2/12	73	88.1	89.3	87.9	89.2	88.7	89.6	88.9	90.4	102.8	21.6
2/15	97	85.3	86.7	85.5	86.2	84.6	85.6	85.6	87.4	101.8	16.2
2/18	121	87.9	89.1	87.5	88.7	87.2	88.4	87.8	89.3	102.2	19.0
2/23	161	86.1	87.5	86.4	87.8	85.6	86.8	86.7	88.5	101.8	17.8
2/29	209	85.1	85.6	85.3	85.9	84.8	85.2	85.2	86.1	101.6	16.2
3/5	249	86.8	87.4	87.1	87.8	86.6	87.9	87.5	88.8	102.1	19.9
3/14	322	85.6	86.5	86.1	86.7	85.7	86.5	85.9	87.6	101.9	16.6
3/24	401	84.3	85.9	83.6	84.8	84.2	85.4	85.5	87.0	101.5	15.8
4/5	497	87.5	88.6	87.7	88.4	87.2	88.1	87.8	89.5	102.6	22.4
Average		86.5	87.5	86.4	87.3	86.2	87.1	86.8	88.3	102.0	18.2

Resistance Data Unit : mΩ

Date	Cycle	Sample Number								Room Tem
		1		2		3		4		
		RT	20℃	RT	20℃	RT	20℃	RT	20℃	
2/6	28	0.08	0.081	0.07	0.071	0.08	0.081	0.10	0.101	17.6
2/9	49	0.07	0.071	0.08	0.081	0.09	0.091	0.08	0.081	17.4
2/12	73	0.12	0.119	0.11	0.109	0.09	0.089	0.13	0.129	21.6
2/15	97	0.08	0.081	0.08	0.081	0.07	0.071	0.09	0.091	16.2
2/18	121	0.12	0.120	0.09	0.090	0.10	0.100	0.12	0.120	19.0
2/23	161	0.09	0.091	0.08	0.081	0.11	0.111	0.13	0.131	17.8
2/29	209	0.07	0.071	0.09	0.091	0.08	0.081	0.11	0.112	16.2
3/5	249	0.11	0.110	0.10	0.100	0.09	0.090	0.10	0.100	19.9
3/14	322	0.08	0.081	0.07	0.071	0.10	0.101	0.09	0.091	16.6
3/24	401	0.09	0.091	0.10	0.102	0.08	0.081	0.11	0.112	15.8
4/5	497	0.13	0.129	0.11	0.109	0.09	0.089	0.12	0.119	22.4
Average			0.0950		0.0896		0.0896		0.1079	18.2

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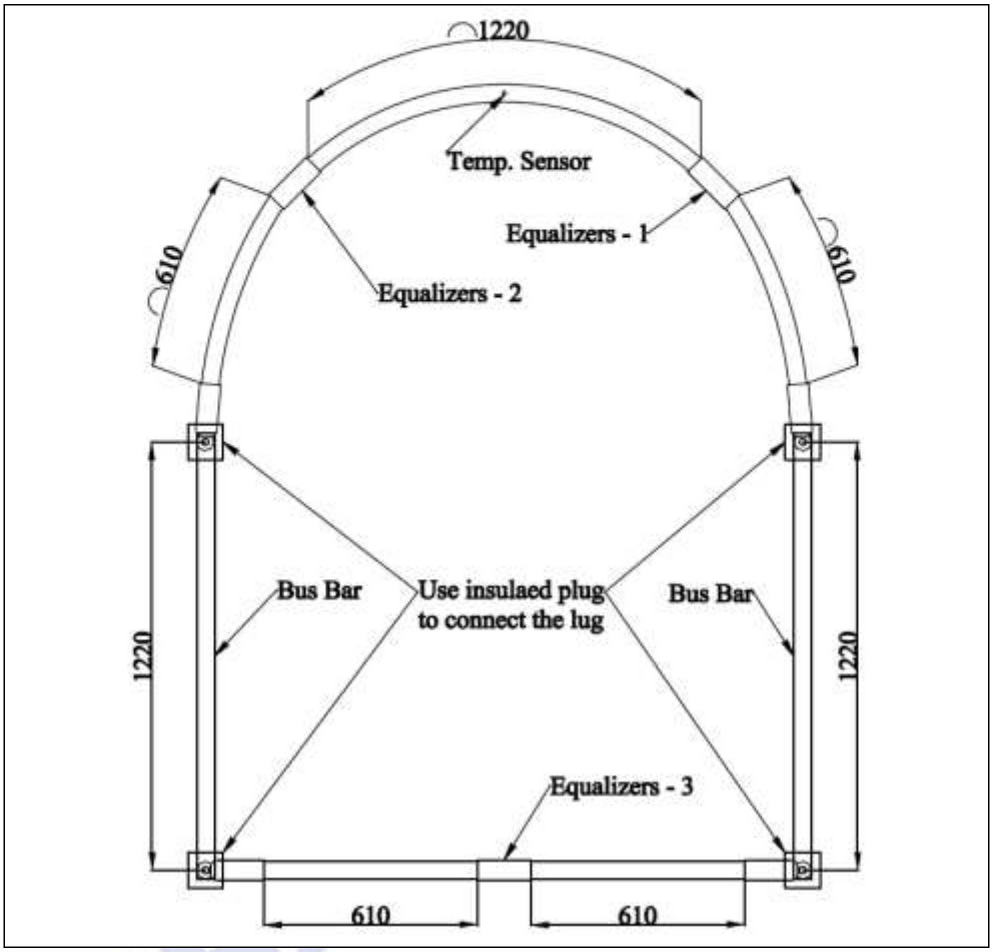

Test circuit - I

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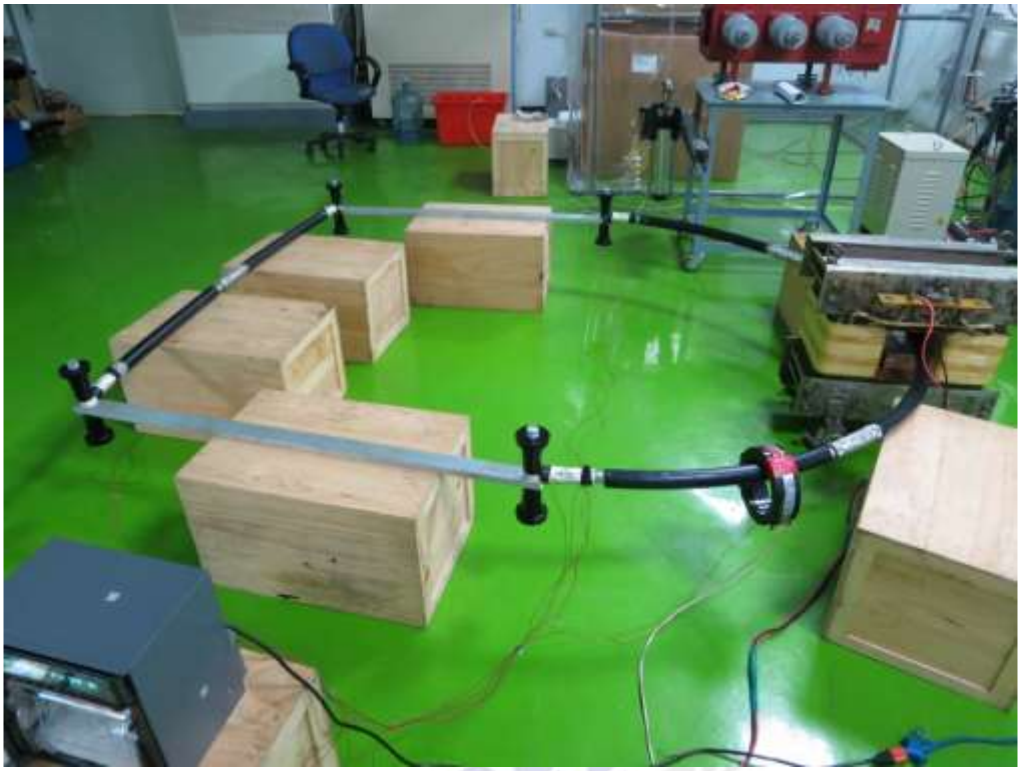

Test circuit - II

Current On

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2. Current cycling test of the copper cable

Object

To verify the terminal connectors meet ANSI/IEEE Std C119.4-2003 requirement of current cycling test.

Testing Samples

Connector	SBC-A-185-400-16/3/C	4 PCS

Mating Parts

Insulating Plug	25-IP600	4 PCS
Stud	25-STUD600	4 PCS
Cable Conductor Type	500MCM copper cable	
Cable Insulation Thickness	220 mil	
Equalizers Aluminum	150mm(L), 41.1mm(OD), 26.4mm(ID)	
Bushing Bus Aluminum	1220mm(L),50.8mm(W),19.05mm(T)	

Procedure

Current cycle tests shall be conducted on connectors assembled in series in a loop in accordance with clauses 5 and 6.2 through 6.12.2. An accelerated current cycle test method, referred to as the current cycle submersion test (CCST) is offered as an alternate test method used primarily to quickly assess connector performance. The current cycle test (CCT) remains the preferred test method recommended for the qualification of a connector.

Conductor combinations shall be selected to maximize current through the connector. If the connector is recommended for use between aluminum-to-aluminum and aluminum-to-copper conductors, it shall be tested on both combinations.

The current cycle submersion test current shall be adjusted during the current-ON period of the first five cycles to result in a steady-state temperature rise on the control conductor of 100℃ to 105℃ over ambient temperature. This current shall then be used during the remainder of the test current-ON periods, regardless of the temperature of the control conductor.

To provide equipotential planes for resistance measurements and to prevent the influence of one connector on another, equalizers shall be installed in stranded conductor on each side of each connector in the current cycle loop, except where two terminal connectors are tested tang-to-tang (pad-to-pad).

Equalizers are not required on solid conductors. Any form of equalizer that ensures permanent contact among all the conductor strands for the test duration may be used.

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In addition, where connector design permits, the conductor end shall project 1/2 inch (12.7 mm) beyond the connector contact groove. The equalizers at each end of the current cycle loop shall be joined to the power source with additional lengths of the test conductor to be not less than the lengths specified in Table 4.

The exposed length of stranded conductor between the connector and the equalizer, or between the connectors of solid conductors in the current cycle loop, shall be in accordance with Table 4. If a flat bus bar is used between terminal connectors, its length shall be twice that shown in table 4 for the stranded conductor size being used in the terminal, or the same length of the solid conductor being used in the terminal. The conductor length in Table 4 does not include the length within the connector or equalizer.

A control conductor, for determining test current, shall be installed in the current cycle loop (between two equalizers for stranded conductors). The control conductor shall be the same type and size as the conductor in the current cycle loop that would be at the highest temperature. Its length shall be twice that given in Table 4. For Class AA, when the control conductor is copper, see 6.5.2.

Resistance measurements shall be made at the end of a current-OFF period with all connectors thermally stabilized at the room ambient temperature. Thermal stability is defined as not more than a variation of 2℃ between any two of three readings taken at not less than 10 min intervals. Resistance measurements shall be made across each connector, between potential points located either on the equalizers a maximum of one conductor diameter from the edge adjacent to the conductor or at the midpoint of a solid conductor. A low magnitude direct current not to exceed 12A shall be used for these measurements. Ambient temperature shall be measured within 2 ft (610 mm) of the test loop at a location that minimizes the effect of thermal convection. The ambient temperature shall be recorded at the time of each set of resistance measurements. The resistance of each connector assembly shall be corrected from the measured temperature to 20℃. The corrected resistance values shall be used to evaluate the performance of the connectors.

$$R20 = Rm / [1 + \alpha (Tm - 20)]$$

Where Rm is the measured resistance, Tm is the temperature (℃) of the connector and α is the resistance variation coefficient with the temperature. This coefficient can be taken equal to:

$$\alpha = 4 \times 10^{-3}/℃ \text{ for copper and ACSR}$$

$$\alpha = 3.6 \times 10^{-3}/℃ \text{ for aluminum}$$

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Results

Temperature Data

Unit :℃

Date	Cycle	Sample Number								Cable Tem	Room Tem
		1		2		3		4			
		1a	1b	2a	2b	3a	3b	4a	4b		
7/7	25	84.2	86.9	85.3	87.2	84.8	87.0	86.1	89.4	101.2	29.4
7/10	49	86.1	88.7	86.1	89.2	86.3	90.1	86.9	89.4	102.1	30.2
7/13	72	83.6	86.4	83.7	87.1	84.8	87.9	85.2	89.4	100.1	30.3
7/16	96	85.0	89.2	85.0	89.3	85.3	91.2	86.2	91.9	100.5	33.5
7/19	120	82.4	85.6	82.7	86.2	82.5	85.9	83.3	87.2	100.2	31.7
7/24	161	82.5	86.7	83.7	88.0	82.6	87.2	84.9	88.4	102.0	32.4
7/30	209	83.1	86.4	85.3	87.8	83.4	87.2	86.1	89.1	101.9	30.0
8/4	249	84.6	87.7	84.7	87.5	85.2	87.7	86.3	89.8	102.1	31.2
8/13	321	84.1	87.9	83.4	88.1	87.0	89.3	87.1	89.5	101.7	28.9
8/23	401	81.5	82.3	81.6	82.4	80.9	83.7	81.4	83.2	100.1	28.7
9/4	497	82.8	86.8	82.6	87.2	86.3	87.9	86.1	89.2	101.2	28.3
Average		83.6	86.8	84.0	87.3	84.5	87.7	85.4	88.8	101.2	30.4

Resistance Data

Unit : mΩ

Date	Cycle	Sample Number								Room Tem
		1		2		3		4		
		RT	20℃	RT	20℃	RT	20℃	RT	20℃	
7/7	25	0.07	0.068	0.08	0.077	0.08	0.077	0.08	0.077	29.4
7/10	49	0.08	0.077	0.08	0.077	0.08	0.077	0.09	0.087	30.2
7/13	72	0.07	0.067	0.07	0.067	0.08	0.077	0.07	0.067	30.3
7/16	96	0.08	0.076	0.08	0.076	0.08	0.076	0.08	0.076	33.5
7/19	120	0.07	0.067	0.07	0.067	0.07	0.067	0.07	0.067	31.7
7/24	161	0.07	0.067	0.07	0.067	0.07	0.067	0.08	0.077	32.4
7/30	209	0.07	0.068	0.08	0.077	0.07	0.068	0.08	0.077	30.0
8/4	249	0.08	0.077	0.08	0.077	0.08	0.077	0.09	0.087	31.2
8/13	321	0.08	0.078	0.07	0.068	0.09	0.087	0.07	0.068	28.9
8/23	401	0.07	0.068	0.07	0.068	0.07	0.068	0.08	0.078	28.7
9/4	497	0.07	0.068	0.07	0.068	0.08	0.078	0.08	0.078	28.3
Average			0.071		0.072		0.074		0.076	30.4

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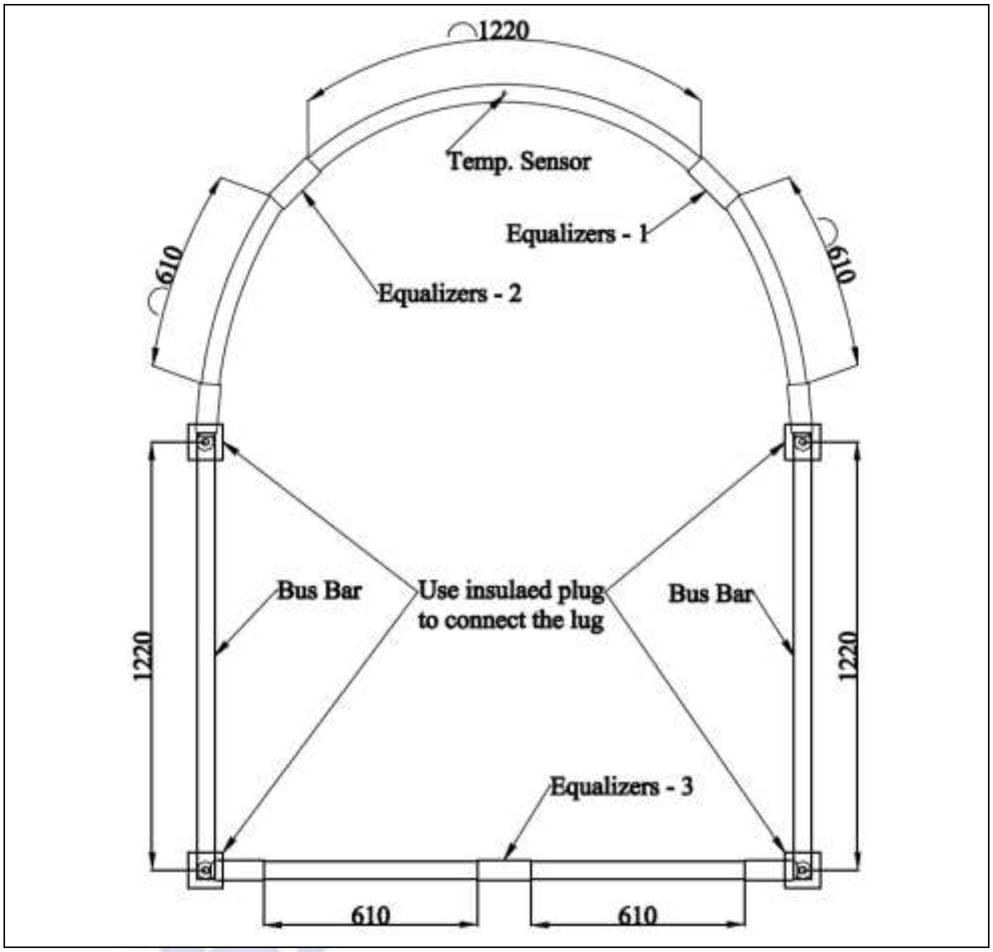

Test circuit - Ⅰ

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Test circuit - Ⅱ

Current On

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3. Pullout test

Object

To verify the terminal connectors meet ANSI/IEEE Std C119.4-2003 & BS-EN-61238-1-2003 requirement of cable pullout test.

Testing Samples

Connector	SBC-A-185-400-16/3/C	4 PCS

Mating Parts

Cable Conductor Type	750kcmil Aluminum Cable
Cable Insulation Thickness	260 mil (1mm=39.37mil)

Procedure

Pullout strength tests shall be performed on the following two conductor combinations for which the connector is designed:
(1) The highest rated tensile strength conductor and
(2) The smallest diameter conductor of the highest rated tensile strength.

If the connectors can be used on different construction and/or materials, the test shall be run on each conductor category such as ACSR, AAC, AAC/TW, etc.
The same samples shall be used for both the sustained load testing and maximum load testing. Relaxation of tension between tests is permissible.

Class 1, full-tension connectors of the type that do not have separately installed gripping means for the different metals of composite conductors, or which use nonferrous means on ferrous conductors or cores, shall first be tested by installing the connectors in assemblies as described in 7.3.3.1.2. A constant tensile load equal to 77% ± 5% of the rated strength of the conductor, as determined in 4.4.2, shall be applied and maintained on the assemblies for a minimum of 168 hours.

The length of the exposed conductor in the test assembly between each gripping means and each connector shall be at least 12 ft (3.66 meters). The gripping means may be any device capable of securely gripping all strands without slippage for the duration of the test. If another connector of the same type as the connector being tested is used, it may also be considered as a test connector.

When conducting the tensile strength test, care shall be taken to ensure that all strands of the conductor are loaded simultaneously.

The load shall be applied at a cross-head speed not exceeding 1/4 in. per min per ft (20.8 mm per min per m) of the total length of the exposed conductor between jaws.

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Minimum values indicated in 4.4.3 are required:

The tensile strength shall be equal to or greater than 95% of the rated conductor strength of the weaker of the conductors being joined. A conductor shall be considered as a failure when at least one strand breaks. For connectors of the type that do not have separate gripping means for the different metals of composite conductors or that use nonferrous means on ferrous conductors or cores, they shall first be tested in accordance with 7.3.3.1 without slippage or breakage.

If the connector is tested electrically for conductors with a different cross-sectional area, the different connectors shall be tested individually, in accordance with Table 3.

Conductor material	Tensile force N
Aluminium	40 × A [a]; maximum 20000
Copper	60 × A [a]; maximum 20000
[a] A = nominal cross-sectional area (mm^2).	

Results

Date: 2016/04/25

Sample No.	Tensile Strength (40 * 400 = 16000N)
1	19282 N
2	19276 N
3	19298 N
4	19309 N
Average	19291.25 N

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Test Sample

Pullout Test

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Before the Test

After the Test