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Electric traction overhead lines— Fittings

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Foreword

This translation has been made based on the original Japanese Industrial Standard revised by the Minister of Economy, Trade and Industry through deliberations at the Japanese Industrial Standards Committee, as the result of proposal for revision of Japanese Industrial Standard submitted by the Industrial Association of Overhead Traction Equipment (JAOTE)/ the Japanese Standards Association (JSA) with the draft being attached, based on the provision of Article 12 Clause 1 of the Industrial Standardization Law. Consequently **JIS E 2201 : 1997** is replaced with this Standard.

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Electric traction overhead lines—Fittings

1 Scope This Japanese Industrial Standard specifies the fittings used for electric traction overhead lines and feeder lines (including overhead return circuits) (hereafter referred to as “overhead line fittings”).

2 Normative references The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. The most recent editions of the standards indicated (including Amendments) shall apply.

- JIS B 0205 *ISO general purpose metric screw threads*
- JIS B 0207 *Metric fine screw threads*
- JIS B 0209 *ISO general purpose metric screw threads—Tolerances*
- JIS B 0211 *Limits of sizes and tolerances for metric fine screw threads*
- JIS B 1171 *Cup head square neck bolts*
- JIS B 1180 *Hexagon head bolts and hexagon head screws*
- JIS B 1181 *Hexagon nuts and hexagon thin nuts*
- JIS B 1251 *Spring lock washers*
- JIS B 1351 *Split pins*
- JIS C 3102 *Annealed copper wires for electrical purposes*
- JIS C 3105 *Hard-drawn copper stranded conductors*
- JIS C 3109 *Hard-drawn aluminium stranded conductors*
- JIS E 2001 *Electric traction overhead lines—Vocabulary*
- JIS E 2002 *Electric traction overhead lines—Fittings—Test methods*
- JIS E 2101 *Hard-drawn grooved trolley wires*
- JIS E 2220 *Electric traction overhead lines—Connecting sleeves of stranded conductors*
- JIS E 2301 *Insulator for electric overhead line*
- JIS G 3101 *Rolled steels for general structure*
- JIS G 3108 *Rolled carbon steel for cold-finished steel bars*
- JIS G 3201 *Carbon steel forgings for general use*
- JIS G 3444 *Carbon steel tubes for general structural purposes*
- JIS G 3445 *Carbon steel tubes for machine structural purposes*
- JIS G 3507 *Carbon steel wire rods for cold heading and cold forging*
- JIS G 3537 *Zinc-coated steel wire strands*
- JIS G 3539 *Carbon steel wires for cold heading and cold forging*
- JIS G 4051 *Carbon steels for machine structural use*
- JIS G 4303 *Stainless steel bars*
- JIS G 4305 *Cold rolled stainless steel plates, sheets and strip*

- JIS G 4309 *Stainless steel wires*
 JIS G 5502 *Spheroidal graphite iron castings*
 JIS G 5705 *Malleable iron castings*
 JIS H 3100 *Copper and copper alloy sheets, plates and strips*
 JIS H 3110 *Phosphor bronze and nickel silver sheets, plates and strips*
 JIS H 3250 *Copper and copper alloy rods and bars*
 JIS H 3270 *Copper beryllium alloy, Phosphor bronze and nickel silver rods, bars and wires*
 JIS H 4000 *Aluminium and aluminium alloy sheets and plates, strips and coiled sheets*
 JIS H 4040 *Aluminium and aluminium alloy rods, bars and wires*
 JIS H 4080 *Aluminium and aluminium alloys extruded tubes and cold-drawn tubes*
 JIS H 5120 *Copper and copper alloy castings*
 JIS H 8641 *Zinc hot dip galvanizings*
 JIS K 5627 *Zinc chromate anticorrosive paint*

3 Definitions For the purpose of this Standard, the definitions shall be in accordance with **JIS E 2001**.

4 Grouping, classification and symbol The grouping, classification and symbols of overhead line fittings are in accordance with their use and structure, and conform to Table 1.

Table 1 Grouping, classification and symbol

Grouping	Classification		Symbol	Use and structure	Remarks
Pull-off arms	Pull-off arm	CS6	PCS6	For simple catenary-type (for pull angle 6°)	See Attached Figs. 1 to 4
		CS11	PCS11	For simple catenary-type (for pull angle 11°)	
		CS15	PCS15	For simple catenary-type (for pull angle 15°)	
		CT	PCT	For twin simple catenary-type	
		CC	PCC	For compound catenary-type auxiliary catenary	
	Curve ear	D1	PD1	For single tramway-type (L-180 mm)	See Attached Figs. 5 to 7
		D2	PD2	For single tramway-type (L-110 mm)	
		D3	PD3	For single tramway-type (L-45 mm)	
	Curve hanger	D4	PD4	For single tramway-type	See Attached Fig. 8
Steady arms	Steady arm	CS	BCS	For simple catenary-type	See Attached Figs. 9 to 12
		CT	BCT	For twin simple catenary-type	
		CC	BCC	For compound catenary-type	

Table 1 (continued)

Grouping	Classification		Symbol	Use and structure	Remarks
Suspension clamps	Dropper grip	CD	HCD	For catenary-type	See Attached Fig. 13
	Hanger ear	CH	HCH	For catenary-type	See Attached Figs. 14 to 16
		D1	HD1	For single tramway-type (connection type)	
		D2	HD2	For single tramway-type (suspension type)	
Feeder fittings	Feeding fittings	CB	FCB	For catenary-type (for branch)	See Attached Figs. 17 to 21
		CR	FCR	For catenary-type (for cross)	
		D1	FD1	For single tramway-type (conductor screw cramp type)	
		D2	FD2	For single tramway-type (conductor solder cramp type)	
		D3	FD3	For single tramway-type (conductor cramp type)	
	Connectors	CC	FCC	For compound catenary-type	See Attached Figs. 22
Connectors	Double ear	C85	JC85	For catenary-type (for 85 in JIS E 2101)	See Attached Figs. 23 to 25
		C110	JC110	For catenary-type (for 110 or 150 in JIS E 2101)	
		C170	JC170	For catenary-type (for 170 in JIS E 2101)	
		D1	JD1	For single tramway-type	
		Triple ear	D2	JD2	For single tramway-type
Termination fittings	Strain clamp	BC325	ABC325	For strain (check bolt type) (H325 in JIS C 3105)	See Attached Figs. 27 to 29
		BA510	ABA510	For strain (check bolt type) (HA1510 in JIS C 3109)	
		PA200	APA200	For strain (compression type) (HA1200 in JIS C 3109)	
		PA300	APA300	For strain (compression type) (HA1300 in JIS C 3109)	
		PA510	APA510	For strain (compression type) (HA1510 in JIS C 3109)	
	Wire terminal	T90S	AT90S	For strain (JIS G 3537 4.0 mm 1×7 Class 2 or Class 3 Grade A)	See Attached Fig. 30 and Attached Fig. 31
		T90T	AT90T	For connection (JIS G 3537 4.0 mm 1×7 Class 2 or Class 3 Grade A)	
		T135S	AT135S	For strain (JIS G 3537 5.0 mm 1×7 Class 2 or Class 3 Grade A)	
		T135T	AT135T	For connection (JIS G 3537 5.0 mm 1×7 Class 2 or Class 3 Grade A)	
		Anchor ear	E85	AE85	For 85 in JIS E 2101

Table 1 (concluded)

Grouping	Classification		Symbol	Use and structure	Remarks
Wire clips	Wire clip	38-2	W38-2	For 2 wires (JIS G 3537 2.6 mm 1×7 Class 2 or Class 3 Grade A)	See Attached Fig. 33
		55-2	W55-2	For 2 wires (JIS G 3537 3.2 mm 1×7 Class 2 or Class 3 Grade A)	
		90-1	W90-1	For 1 wire (JIS G 3537 4.0 mm 1×7 Class 2 or Class 3 Grade A)	
		90-2	W90-2	For 2 wires (JIS G 3537 4.0 mm 1×7 Class 2 or Class 3 Grade A)	
		135-1	W135-1	For 1 wire (JIS G 3537 5.0 mm 1×7 Class 2 or Class 3 Grade A)	
		135-2	W135-2	For 1 wire (JIS G 3537 5.0 mm 1×7 Class 2 or Class 3 Grade A)	
Wire turnbuckles	Wire turnbuckle	4-1	T4-1	Standard used tension 4 kN for adjusting range 100 mm	See Attached Fig. 34 and Attached Fig. 35
		4-2	T4-2	Standard used tension 4 kN for adjusting range 200 mm	
		15-2	T15-2	Standard used tension 15 kN for adjusting range 200 mm	
		15-4	T15-4	Standard used tension 15 kN for adjusting range 400 mm	
		15-6	T15-6	Standard used tension 15 kN for adjusting range 600 mm	

5 Quality

5.1 Appearance The appearance of overhead line fittings shall be free from any detrimental defects for usage such as flaws, poor plating, cracks, remarkable thickness deviation. Moreover, the appearance of casting parts shall, when carrying out the test in accordance with 11.3.1, be free from any flaws, cracks, cavities, etc.

5.2 Performance The performance of overhead line fittings shall be as follows:

- a) **Endurable tensile load** When carrying out the tensile load test of overhead line fittings in accordance with 11.1.1, any destruction of each part, sliding of the electric wire under test, etc. shall not occur. However, the sliding within 3 mm of a wire clip may be allowed. Moreover, any permanent sets such as strain, elongation after removing load shall not exist there. However, permanent sets of a hanger may be allowed in the tensile load test of a hanger.
- b) **Endurable compressive load** When carrying out the compressive load test of pull-off arms and steady arms in accordance with 11.1.1, any destruction of each part, sliding of the electric wire under test, etc. shall not occur. Moreover, any permanent sets such as strain, elongation after removing load shall not exist there.
- c) **Endurable sliding load** When carrying out the sliding load test of pull-off arms (excluding those for auxiliary catenary), steady arms, hanger ears (to be limited to the catenary type), and fittings for feeder (to be limited to the catenary type) in accordance with 11.1.1, any destruction of each part, sliding of

the electric wire under test, etc. shall not occur. Moreover, any permanent sets such as strain, elongation after removing load shall not exist there.

- d) **Endurable torsional load** When carrying out the torsional load test of pull-off arms (excluding those for auxiliary catenary), curve ears, steady arms and hanger ears (to be limited to the catenary type) in accordance with 11.1.1, any destruction of each part, sliding of the electric wire under test, etc. shall not occur. Moreover, any permanent sets such as strain, elongation after removing load shall not exist there.
- e) **Maximum tensile load** The tensile load test of overhead line fitting shall be carried out in accordance with 11.1.2, and the maximum tensile load shall conform to Table 2 or Table 3.
- f) **The maximum compressive load** The compressive load test of pull-off arms and steady arms shall be carried out in accordance with 11.1.2, and the maximum compressive load shall conform to Table 2.
- g) **The maximum torsional load** The torsional load test of pull-off arms (excluding those for auxiliary catenary), curve ears, steady arms and hanger ears (to be limited to the catenary type) shall be carried out in accordance with 11.1.2, and the maximum torsion load shall conform to Table 2.
- h) **The maximum clamping torque** The clamping torque test of overhead line fitting shall be carried out in accordance with 11.1.3, and the maximum clamping torque shall conform to Table 3.

Table 2 Maximum load (pull-off arms, steady arms, and suspension clamps)

Grouping	Symbol	Maximum tensile load kN	Maximum torsional load N · m	Maximum compressive load kN
Pull-off arms	PCS6, PCS11, PCS15 and PCT	6.0 or over	60.0 or over	2.5 or over
	PD1, PD2 and PD3			—
	PCC (auxiliary catenary fastening fitting)		—	
	PCC (rod)	12.0 or over		
	PD4	7.5 or over		
Steady arms	BCS, BCT and BCC	6.0 or over	60.0 or over	2.5 or over
Suspension clamps	HCH	5.5 or over	30.0 or over	—
	HCD	8.0 or over	—	
	HD1 and HD2	7.0 or over		

Table 3 Maximum load (connectors, termination fittings, wire clips and wire turnbuckles)

Grouping	Symbol	Maximum tensile load kN	Maximum clamping torque N · m
Connectors	JC85	21.0 or over	150 or over
	JC110	26.0 or over	
	JC170	39.0 or over	
	JD1	17.0 or over	60 or over
	JD2	6.0 or over	
Termination fittings	ABC325	55.0 or over	140 or over
	ABA510	50.5 or over	110 or over
	APA200, APA 300 and APA 510	Not less than 90 % of the tensile load of the applicable electric wire	—
	AT90S, AT90T, AT135S and AT135T	Not less than 95 % of the tensile load of the applicable stranded steel wire	—
	AE85	7.0 or over	70 or over
Wire clips	W 38-2	9.0 or over	55 or over
	W 55-2	12.0 or over	65 or over
	W 90-1	7.0 or over	110 or over
	W 90-2	17.0 or over	
	W 135-1	7.0 or over	130 or over
	W 135-2	17.0 or over	
Wire turnbuckles	T4-1 and T4-2	24.0 or over	—
	T15-2, T15-4 and T15-6	86.0 or over	

i) **Endurable vibration performance**

- 1) After the test of pull-off arms (excluding those for auxiliary catenary), steady arms, hanger ears (to be limited to the catenary type), and fittings for feeder (to be limited to the ear section for the catenary type) is carried out in accordance with 11.1.4 for checking the presence of looseness, etc. of each part, the test on them in accordance with 11.1.1 is conducted. The results shall be confirmed that they shall be free from any destruction of each part, sliding of the electric wire under test, etc. However, breaking, etc. of element wires of conductors of fittings for feeder may be allowed.
- 2) After the test of double ears (to be limited to the catenary type) in accordance with 11.1.4 for checking the presence of looseness, etc. of each part, the test on them in accordance with 11.1.1 is conducted. The results shall be confirmed that they shall be free from any destruction of each part, sliding of trolley wires, etc.

- j) **Endurable bend performance** The test of the endurable bend performance of round wires used for hangers shall be in accordance with 11.1.5, and their cut and separation shall not occur under the number of cycles given in Table 4.

Table 4 Endurable bend performance of hanger

Item	Classification of materials	
	SUS304 in JIS G 4309	C5191B-1/2H in JIS H 3270
Number of cycles on reverse bend test	10	16

- k) **Adjusting torque** The test of the adjusting torque of wire turnbuckles shall be in accordance with 11.1.6 and the adjusting torque shall conform to Table 5.

Table 5 Adjusting torque

Unit : N · m

Symbol	Adjusting torque
T4-1 and T4-2	50 or under
T15-2, T15-4 and T15-6	90 or under

- l) **Joint electric resistance** The test of joint electric resistance of the feeder ear, connector and double ear shall be in accordance with 11.2.1, and the results shall conform to Table 6.
- m) **Differential temperature in the temperature rise test** The test of the temperature rise of the feeder ear, connector and double ear shall be in accordance with 11.2.2, and the results shall conform to Table 6.

Table 6 Electrical performance

Grouping	Symbol	Joint electric resistance	Differential temperature in the temperature rise test
Feeder fittings	FCB, FCR and FCC	Not exceeding the value of electric resistance of conductor of the same length as that of the distance between measuring points.	The differential temperature of ear and clamp shall not exceed that of conductor.
	FD1, FD2 and FD3	40 $\mu\Omega$ or under	40 °C or lower
Connectors	JC85, JC110, JC170 and JD1	Not exceeding the value of electric resistance of applicable electric wire of the same length as that of the joint section.	40 °C or lower

- n) **Withstand current in the overcurrent test** When carrying out the test in accordance with 11.2.3, the value of joint electric resistance of the feed ear (to be limited to the catenary type) after the overcurrent test shall not increase from the value before test by not less than 10 %.

- o) **Hardness of metal** The hardness of the aluminium bronze casting shall be 75 to 90 HRB.
- p) **Corrosion resistance** When carrying out the test of solution treatment in accordance with 11.3.3 for the corrosion resistance of SUS304 in JIS G 4309 used for the wire turnbuckle, the results shall show that the grain boundary has a step-like organization.

6 Structure The structure of overhead line fittings shall be as follows:

6.1 Matters in common

- a) There shall be no projecting, saw-toothed, etc. parts which may cause damage of electric wires in the parts of the trolley, electric wire, etc. (hereafter referred to as "electric wires") with which the ear, clip and clamp (excluding a strain clamp) make contact.
- b) Each piece of the ear and clamp (excluding a strain clamp) shall hold electric wires with each of them being in parallel.
- c) The joint section of the arm of pull-off arms and steady arms and the ear shall have the structure which is capable of rotating easily in the horizontal direction.
- d) The joint section of the arm of termination fittings (including pull-off arms which have the object of the same structure as that of steady arms) shall have the structure which is capable of rotating easily in the horizontal and vertical direction.
- e) The arm of the pull-off arm and steady arms shall not give hindrance to pushing up, inclination, etc. of the pantograph.

6.2 Pull-off arms

- a) The pull-off arm shall have the structure which is capable of tightening the ear to the trolley wire with bolts and nuts, wedges, socket head cap screws, etc. However, PCC and PD4 are excluded (see Attached Figs. 1 to 3 and Attached Figs. 5 to 7).
- b) PCT shall not have fittings in the circular range of radius of 50 mm when the center of the circle is at the point of 100 mm away from the center of the trolley wire horizontally with it being mounted.
- c) PCC shall have the auxiliary catenary fastening fittings which grip the auxiliary catenary with bolts, wedges, etc. and the structure which is capable of straining this with rods, arms, etc. (see Attached Fig. 4).
- d) In the case of PCS6, PCS11 and PCT, the rising angle of the arm (see Attached Fig. 1 and Attached Fig. 3) shall be sufficiently given.
- e) PD4 shall be 250 mm or under in length, 1 kg or under in mass, and shall be capable of holding the curve ear vertically, and shall have the structure which is easy to mount and adjust a curve (see Attached Fig. 8).

6.3 Steady arms

- a) The steady arms shall have the structure which is capable of tightening to the trolley wire or auxiliary catenary with bolts and nuts, wedges, etc. (see Attached Figs. 9 to 12).
- b) The pull fittings shall have the structure which is capable of tightening to the span wire or span rod with bolts and nuts, wedges, etc. and linking the arm.

6.4 Suspension clamps

- a) HCD shall have the structure which is capable of tightening the dropper clip to the catenary, auxiliary catenary, etc. with bolts and nuts, wedges, etc. and linking the dropper wire.

In addition, the catenary, auxiliary catenary, etc. shall be wrapped with a wire protector as required (see Attached Fig. 13).

- b) HCH shall have the structure which is capable of tightening the ear to the trolley wire with bolts and nuts, clamping levers, wedges, etc. and linking the hanger, and hanging from the catenary (see Attached Fig. 14).
- c) HD1 shall have the structure which is capable of tightening the hanger to the span wire with bolts and nuts, etc. and linking the hanger and hanging as well as tightening the ear to the trolley wire with the socket head cap screw (see Attached Fig. 15).
- d) HD2 shall have the structure which is capable of tightening the ear to the trolley wire with the socket head cap screw, linking the hanger and hanging from the span wire (see Attached Fig. 16).

6.5 Fittings for feeder

- a) The fittings of FCB, FCR and FCC shall have the structure which is capable of tightening the ear or clamp to the electric wire with bolts and nuts or socket head cap screw, and preventing the looseness through the double means of using spring washers and adding the preventive means of loosening (see Attached Fig. 17, Attached Fig. 18, and Attached Fig. 22).
- b) FCB shall have the structure of connecting 2 pieces of the ear with the Y branch sleeve in **JIS E 2220** through conductors.
- c) FCR shall have the structure of connecting 2 pieces of the ear through conductors.
- d) FCC shall have the structure of connecting the ear and the clamp through conductors.
- e) The connection between the ear, clamp of FCB, FCR and FCC and conductors shall be carried out by compression.
- f) The constitution of stranded wires of conductors used for FCB, FCR and FCC shall be 37 wires/14 wires/0.5 mm or 91 wires/1.2 mm.

The strand shall be made by twisting together in a concentric configuration in the opposite direction every each layer and the outermost layer shall be the right-handed twist.

- g) FD1 and FD2 shall have the structure which is capable of tightening the ear to the trolley wire with the socket head cap screw, FD3 shall have the structure which is capable of tightening the ear to the trolley wire and conductor with the socket head cap screw, and the conductor and ear shall be able to be attached by set screws, FD2 shall be able to be attached to the ear terminal by soldering (see Attached Figs. 19 to 21).

6.6 Connector

- a) The double ear shall have the structure which is capable of tightening the ear to 2 trolley wires with bolts and nuts and shall be connected (see Attached Figs. 23 to 25).
- b) The triple ear shall have the structure which is capable of tightening the ear to 3 trolley wires with bolts and nuts and shall be connected (see Attached Fig. 26).
- c) The ear outer piece and the bolt head section and nut shall be stuck fast with connectors attached to the applicable trolley wire.

6.7 Termination fittings

- a) ABC325 and ABA510 shall have the structure which is capable of tightening the main body of clamp to the applicable electric wire through the protective sleeve and protective plate with bolts and nuts, straining by the cotter bolt and eye link or strap.

In addition, the main body of clamp may have the corrugated unevenness to increase the gripping strength of the electric wires (see Attached Fig. 27 and Attached Fig. 28).

- b) APA200, APA300 and APA510 shall have the structure which is capable of connecting the main body of clamp with the applicable electric wire by compression, straining by the cotter bolt and eye link (see Attached Fig. 29).
- c) The eye link, etc. shall be capable of fixing in the suspension insulator 180C in **JIS E 2301**, and rotating by 60° or over toward both sides at the respective connecting section with it being connected to the main body of clamp and suspension insulator.
- d) The wire terminal shall have the structure which is capable of inserting the applicable stranded steel wire into the main body of wire terminal, folding back by pinching wedges, sticking the wire terminal fast with the stranded steel wire, and straining by the cotter bolt and eye link. Moreover, the wire terminal for connection shall consist of two main bodies of wire terminal and one eye link (see Attached Fig. 30 and Attached Fig. 31).

In addition, the main body of wire terminal shall be provided with the hole for checking wedges.

- e) The main body of clamp of the strain clamp shall be provided with the guiding part of jumper wires, and the interval between the guiding part and the cotter bolt shall be the dimension which is capable of bending jumper wires without an excessive force.
- f) The anchor ear shall have the structure which is capable of tightening the ear to the trolley wire with socket head cap screw, and straining with the stranded wire being attached to the circumference of ear (see Attached Fig. 32).