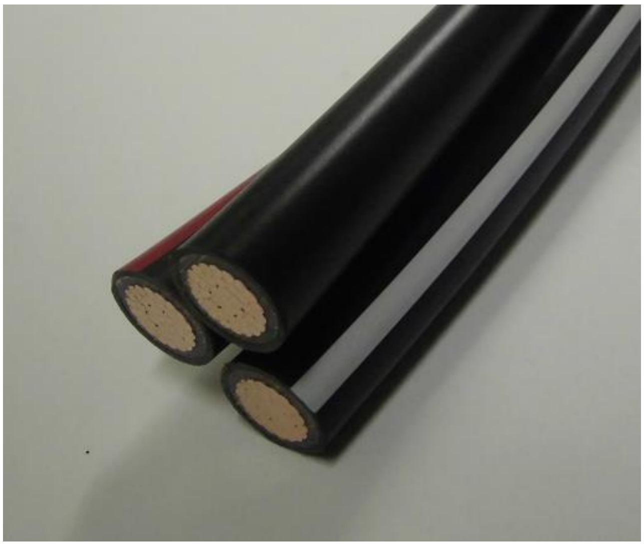
6A-089: 600-V CV Cables

(Rank C)



Established: December 4, 2014

Enforced: January 4, 2015

Power Distribution Department

TEPCO Power Grid, Incorporated

1. Scope of Application

This standard applies to cross-linked-polyethylene-insulated polyvinyl-chloride-sheathed cables used or circuits of 600 V or less.

2. Related Standards

2.1. Japanese Industrial Standards (JIS)

JIS C 3005 (2014): Test methods for rubber or plastic insulated wires and cables

JIS C 3605 (2002): 600-V polyethylene insulated cables

JIS C 3102 (1984): Annealed copper wires for electrical purposes

3. Type

The product is available in the following three types: single-conductor type, stranded-double-conductor type, and stranded-triple-conductor type. The types are classified according to the number of cable conductors and nominal cross-section area as shown in Tables 1, 2, and 3. The abbreviations and the sizes shall be as per Table 1.

Table 1

Type	Abbreviation	Conductor size
Single conductor	CV	8 mm^2, 14 mm^2, 22 mm^2, 38 mm^2, 60 mm^2, 100 mm^2, 150 mm^2
Stranded double conductors	CVD	8 mm^2, 14 mm^2, 22 mm^2, 38 mm^2, 60 mm^2, 100 mm^2, 150 mm^2
Stranded triple conductors	CVT	8 mm^2, 14 mm^2, 22 mm^2, 38 mm^2, 60 mm^2, 100 mm^2, 150 mm^2

Note: CV stands for <u>C</u>ross-linked Polyethylene insulated Poly<u>v</u>inyl chloride sheathed Cables.

CVD stands for <u>D</u>uplex type <u>C</u>ross-linked Polyethylene insulated Poly<u>v</u>inyl chloride sheathed Cables.

CVT stands for <u>T</u>riplex type <u>C</u>ross-linked Polyethylene insulated Poly<u>v</u>inyl chloride sheathed Cables.

4. Structure and Material

4.1. General

The product shall be a 600-V cable with a single copper conductor or stranded double or triple copper conductors insulated with cross-linked polyethylene and sheathed with a compound based on polyvinyl chloride resin (hereafter referred to as PVC). The insulating layer shall be sufficiently insulative and free of cracks, air bubbles, and other defects.

The sheath shall be flexible, waterproof, and durable, and shall not crack or peel off.

4.2. Conductor

The conductor shall be the annealed copper wire defined by JIS C 3102 (Annealed copper wires for electrical purposes) or an elemental wire similar to it. Conductors of 8 mm^2 and 14 mm^2 shall be concentric lay cables or stranded circularly compressed wires, 22mm^2 to 150mm^2 shall be stranded circularly compressed wires. Concentric lay cables shall be elemental wires concentrically S-twisted (right-hand laid) with a pitch not larger than 20 times the pitch diameter of the outermost layer. Stranded compressed circular wires shall be elemental wires with the outmost layer concentrically S-twisted (right-hand laid) then circularly compressed.

4.3. Insulator

The conductor shall be sheathed with cross-linked polyethylene with a thickness as defined in the table in a manner such that the cross-linked polyethylene will be concentric with the conductor. The cross-linked polyethylene shall not be depressed into the conductor. To prevent this, the section that contacts the conductor may be provided with a separator. The average thickness of the insulator shall not be less than 90% of the value indicated in the table and the lowest measured value shall be acceptable if it is not less than 80% of the value indicated in the table. The surface of the insulator shall be free of detrimental flaws and air bubbles. As the insulator, a material may be used made by heat plasticizing a cross-linked polyethylene sheath of a cable dismounted from our distributor (hereafter referred to as recycled XLPE material) and mixing it with raw polyethylene material. If this is the case, the combination ratio of the recycled XLPE material shall be between 15% and 25% and the actual mixing ratio shall be clearly indicated on the fabrication specification and quality management flowchart.

4.4 Identification of Conductors

The conductors shall be identified in a manner such that the phases can be identified with reliability, using the following colors:

Black and black/white for double-conductor cables

Black, black/white, and black/red for triple-conductor cables

For the black/white combination, black represents the sheath and white the line.

[Explanation]

As a guideline, the phase identification is reliable if there are two or more successive lines facing each other along the wire longitudinal direction.

4.5. Sheath

The conductor(s) shall be sheathed with a black weather-resistant PVC material with a thickness as shown in the table. The average thickness of the sheath shall not be less than 90% of the value indicated in the table and the lowest measured value shall be accepted if it is not less than 85% of the value indicated in the table. The surface of the insulator shall be free of detrimental flaws and air bubbles.

As the PVC material, a recycled PVC material from our distributor may be used. If this is the case, the mixing ratio of the recycled material shall be clearly indicated on the fabrication specification, QC flowchart, and test reports.

4.6. Twisting

Each of the PVC-sheathed conductors shall be S-twisted (right-hand laid).

4.7. Designation

The product shall be designated as indicated in the following example:

Example: 600-V power cable with stranded triple copper conductors insulated with cross-linked polyethylene and sheathed with PVC (3 x 100 mm^2)

Or 600-V CVT 100 mm^2

4.8. Dimensions

The dimensions shall be basically as per the table.

5. Performance Requirements

The cable shall undergo the tests defined in Section 7 to demonstrate that its performance satisfy the requirements defined in Table 2.

Table 2

<table>
<tr><th colspan="3">Item</th><th colspan="2">Requirement</th></tr>
<tr><td colspan="3">Conductor resistance</td><td colspan="2">The resistance is not higher the value indicated in the table.</td></tr>
<tr><td colspan="2">Withstand voltage</td><td>Underwater</td><td colspan="2">The product withstands the test voltage indicated in the table for 1 minute.</td></tr>
<tr><td colspan="3">Insulation resistance</td><td colspan="2">The resistance is higher than the value indicated in the table.</td></tr>
<tr><td rowspan="8">Tensile strength and elongation</td><td rowspan="4">Cross-linked polyethylene insulator</td><td rowspan="2">Room temperature</td><td>Tensile strength</td><td>10 MPa</td></tr>
<tr><td>Elongation</td><td>200% or more</td></tr>
<tr><td rowspan="2">Retention after heated</td><td>Tensile strength</td><td>80% or more of the value before heated</td></tr>
<tr><td>Elongation</td><td>80% or more of the value before heated</td></tr>
<tr><td rowspan="4">PVC sheath</td><td rowspan="2">Room temperature</td><td>Tensile strength</td><td>10 MPa</td></tr>
<tr><td>Elongation</td><td>120% or more</td></tr>
<tr><td rowspan="2">Retention after heated</td><td>Tensile strength</td><td>85% or more of the value before heated</td></tr>
<tr><td>Elongation</td><td>80% or more of the value before heated</td></tr>
<tr><td colspan="2" rowspan="2">Resistance to heat deformation</td><td rowspan="2">Thickness reduction</td><td>Insulator</td><td>Not higher than 40%</td></tr>
<tr><td>PVC sheath</td><td>Not higher than 50%</td></tr>
<tr><td colspan="3">Cold resistance</td><td>PVC</td><td>The test piece does not break.</td></tr>
<tr><td colspan="3">Incombustibility</td><td>PVC</td><td>The PVC does not burn with flames disappearing within 60 seconds.</td></tr>
</table>

6. Cable Markings

The cable shall be seamlessly and permanently marked with the following information. If the cable uses a recycled XLPE or recycled PVC material, the product abbreviation CV/R shall be used.

a. Nominal voltage (e.g., 600 V)

b. Abbreviated article name (e.g., CV)

c. Nominal cross-sectional area (e.g., 150 mm^2)

d. Manufacturer or its abbreviation

e. Year of manufacture (e.g., 2014)

f. Statement that the product is subject to the Electrical Appliances and Material Safety Act (if applicable)

7. Test and Inspection Methods

7.1. Appearance inspection

The product shall be checked, for example, visually or by touch to determine that no flaw is found, the surface is smooth, and the cables are properly color coded.

7.2. Structural Inspection

Samples with an appropriate length shall be taken and inspected according to Section 4.3 of JIS C 3005 (Test methods for rubber or plastic insulated wires and cables).

7.3. Conductor Resistance Test

The conductor resistance test shall be conducted according to Section 4.4 of JIS C 3005 (Test methods for rubber or plastic insulated wires and cables).

7.4 Insulation Resistance Test

The insulation resistance test shall be conducted according to Section 4.7 of JIS C 3005 (Test methods for rubber or plastic insulated wires and cables).

7.5. Withstand Voltage Test

The withstand voltage test shall be conducted according to "Section 4.6 a) Underwater" of JIS C 3005 (Test methods for rubber or plastic insulated wires and cables).

7.6. Insulator Tests

(1) Tensile tests

a. Room-temperature test

The room-temperature test shall be conducted according to Section 4.16 of JIS C 3005 (Test methods for rubber or plastic insulated wires and cables). The tension speed shall be as per B of Table 4 (200 mm/minute).

b. Heating test

The heating test shall be conducted according to Section 4.17 of JIS C 3005 (Test methods for rubber or plastic insulated wires and cables). The tension speed shall be as per B of Table 4 (200 mm/minute). A test piece shall be heated at 120 ± 3°C under an air-circulating environment. Next, it shall be allowed to sit at room temperature for 4 hours and shall undergo the test defined in Section 7.6 (1) a. within 96 hours.

(2) Heat-deformation test

The heat-deformation test shall be conducted according to Section 4.23 of JIS C 3005 (Test methods for rubber or plastic insulated wires and cables). The load to be applied to the parallel plate shall be as follows:

Nominal cross-sectional area (mm^2)	Load (N)
8 to 14	10
22 to 38	15
60	20
100 to 150	25

7.7. Sheath Tests

(1) Tensile tests

a. Room-temperature test

The room-temperature test shall be conducted according to Section 7.6 (1). The tension speed shall be 500 mm/min.

b. Heating test

The heating test shall be conducted according to Section 7.6 (1). The test piece shall be heated at 100 ± 2°C for 48 hours.

(2) Heat-deformation test

The heat-deformation test shall be conducted according to Section 7.6 (2). The load to be applied shall be as follows:

Nominal cross-sectional area (mm^2)	Load (N)
8 to 22	7
38 to 150	10

(3) Cold-resistance test

The cold-resistance test shall be conducted according to Section 4.22 of JIS C 3005 (Test methods for rubber or plastic insulated wires and cables).

(4) Flame retardance test

The flame retardance test shall be conducted according to Section 4.26.2 b) (Inclining test) of JIS C 3005 (Test methods for rubber or plastic insulated wires and cables).

7.8. Cross-linking-degree Test

If a recycled XLPE material is used as the insulator, a cross-linking-degree test shall be conducted on a heat-plasticized XLPE material. The cross-linking-degree test shall be conducted according to Section 4.25 of JIS C 3005 and the degree of cross-linking shall not be higher than 40%.

8. Test and Inspection

8.1. General

The product shall undergo the “type test” defined in Section 8.2, “manufacturing process inspection” defined in Section 8.3, and “acceptance inspection” defined in Section 8.4 according to the test methods defined in Section 7 and shall satisfy all the requirements.

8.2. Type Test

For the purpose of checking the quality level of the manufacture, the type test shall be conducted on the following items and the product shall satisfy the requirements defined in Sections 4 and 5. The test piece shall be a drum of cable with a length of 100 m or more.

(1) Appearance inspection

(2) Structural inspection

(3) Conductor resistance test

(4) Insulation resistance test

(5) Withstand voltage test

(6) Insulator tests

a. Tensile tests

(a) Room-temperature test

(b) Heating test

b. Heat-deformation test

(7) Sheath tests

a. Tensile tests

(a) Room-temperature test

(b) Heating test

b. Heat-deformation test

c. Cold-resistance test

d. Flame retardance test

(8) Cross-linking-degree test (to be conducted on any recycled XLPE material)

8.3. Manufacturing Process Test

For the purpose of checking that production processes are established that ensure that products completely the same as the type-test product are produced, the type test shall be conducted as a rule to inspect the materials used, quality control items, quality control methods, countermeasures against problems, quality management system, etc.

8.4 Acceptance Inspection

The acceptance inspection shall be conducted in the presence of the customer according to the method defined in 8.2 "Type Test" if the customer has instructed to do so. The specific test items and sampling rate shall be determined in consultation with the customer. If the acceptance inspection is not conducted in the presence of the customer, the manufacturer shall conduct the internal test preliminarily defined in consultation with us and submit the test results as a test report to the customer.

9. Other

9.1. General

(1) Any requirements that are not defined in this specification shall be defined in consultation with us if they are needed to satisfy the required product performance and functions.

(2) If modifying part of this specification substantially benefits in terms of use or manufacturing, the appropriate part can be modified with approval from us.

(3) An on-the-spot process inspection, material inspection, etc. may be conducted if we determine that they are necessary.

9.2 Packing

(1) Inventory products shall be packed individually bundled or wound around the plastic drum specified by us as shown in the attached table that that they will not be damaged during transportation. If it is determined that the plastic drum specified by us is difficult to use, the wooden drum defined by the Japanese Cable Makers' Association Standard (JCS) may be used in consultation with us.

(2) The plastic drum must bear the label that conforms to Figure 1.

(3) The wooden drum shall be permanently marked on the sides with the information shown in Figure 1.

(4) Each bundled wire shall be printed at an appropriate position with the following information or shall bear two

or more tags bearing the following information:

a. Designation

b. Nominal voltage

c. Number of conductors

d. Nominal cross-sectional area

e. Length

f. Net mass

g. Marking indicating that the compliance test has been conducted according to the Electrical Appliances and Material Safety Act

h. Gross mass

i. Manufacturer or its abbreviation and its registered trademark

j. Month and year of manufacture

9.3. Preparation of Samples

The supplier or inspection applicant shall prepare the products and test pieces to be used in the tests and bear the costs for conducting the tests.

9.4. Documents to be Submitted

9.4.1. Fabrication Specification

The fabrication specification shall be filled out with information items (1) to (5) shown below required for us to examine whether the product conforms to this specification and shall be submitted together with drawings that indicate dimensional tolerances and materials. As required, the fabrication specification shall also come with technical materials that complement the specification.

(1) Information about the conductor: Material, structure, outside diameter, performance, and pitch

(2) Information about the insulator: Material and performance

(3) Information about markings: Marking method

(4) Information about cabling: Outside diameter of the conductor and cabling pitch

(5) Information about the type of packing: Method, dimensions, and markings

9.4.2. Test Report

The test report shall be filled out with the results and conditions of the type test conducted according to Section 8.2.

9.4.3. Quality Management Reports

A quality management flowchart, management report on subcontractors and suppliers, and other reports shall be used to indicate concrete information about the materials used, quality control points in each production process, quality control method for quality, actions taken against problems, quality management system, etc. If a main production processes are outsourced, a report on management of outsourced processes (a document to indicate how the processes are managed at the subcontractor(s), which must be filled out with information according to the formant of the quality management flowchart) shall be submitted. The information that must be provided shall be defined in consultation with us.

9.4.4. Technical Data

Type examination may the submission of the following technical data so that we can sufficiently and appropriately assess the performance and quality of the product. The submission of more technical data in addition to the following may be required.

(1) If a recycled XLPE material is used as the insulator, technical information about the following is required.

(a) Heat-plasticization conditions

(b) Quality assurance for a material recycled several times

(c) Technical data about elimination of foreign matters and/or impurities from recycled materials

(2) If a recycled PVC material is used as the material for the sheath, technical information about the following is required.

(a) Grounds for determining the mixing ratio of the recycled material

(b) Quality assurance for a material recycled several times

Table 1: Structures of 600-V Single-conductor (CV) Cables

Number of conductors		1								
Conductor	Nominal cross-sectional area (mm^2)	8		14		22	38	60	100	150
	Shape or number of elemental wires/elemental wire diameter	7/1.2	Circular compression	7/1.6	Circular compression	Circular compression	Circular compression	Circular compression	Circular compression	Circular compression
	Outside diameter (mm)	3.6	3.4	4.8	4.4	5.5	7.3	9.3	12.0	14.7
Insulator thickness (mm)		1.0	1.0	1.0	1.0	1.2	1.2	1.5	2.0	2.0
Outside diameter of the insulated cable (mm)		5.6	5.4	6.8	6.4	7.9	9.7	12.3	16.0	18.7
Sheath thickness (mm)		1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Outside diameter of the finished (sheathed) cable (approx. size in mm)		8.6	8.4	9.8	9.4	10.9	12.7	15.3	19.0	21.7
Electrical test	Conductor resistance at 20°C (Ω/km)	2.31	2.29	1.30	1.31	0.832	0.481	0.305	0.183	0.122
	Test voltage (V)	1500	1500	2000	2000	2000	2500	2500	2500	3000
	Insulation resistance (MΩ km)	2000	2000	1500	1500	1500	1500	1500	1500	1000
Approximate mass (kg/km)		140	140	200	200	290	460	690	1120	1610
Standard wire length (m)		300		200		1500	1000	700	500	350
Packing	Plastic drum (specified by us)	Bundle		Bundle		RP6-6	RP6-6	RP6-6	RP6-6	RP6-6
	Wooden drum (Japanese Cable Makers' Association Standard)					L6-6	L6-6	L6-6	L6-6	L6-6

* Bundle size: Inside diameter of 300 mm or more, width of 200 mm or less, and outside diameter of 680 mm or less

Table 2: Structure of 600-V, Stranded-double-conductor (CVD) Cables

Number of conductors		2								
Conductor	Nominal cross-sectional area (mm^2)	8		14		22	38	60	100	150
	Shape or number of elemental wires/elemental wire diameter	7/1.2	Circular compression	7/1.6	Circular compression	Circular compression	Circular compression	Circular compression	Circular compression	Circular compression
	Outside diameter (mm)	3.6	3.4	4.8	4.4	5.5	7.3	9.3	12.0	14.7
Insulator thickness (mm)		1.0	1.0	1.0	1.0	1.2	1.2	1.5	2.0	2.0
Outside diameter of the insulated cable (mm)		5.6	5.4	6.8	6.4	7.9	9.7	12.3	16.0	18.7
Sheath thickness (mm)		1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Outside diameter of the sheathed cable (approx. size in mm)		8.6	8.4	9.8	9.4	10.9	12.7	15.3	19.0	21.7
Outside diameter of the finished (stranded) cable (approx. size in mm)		17.5	17.0	20.0	19.0	22.0	26.0	31.0	38.0	44.0
Electrical test	Conductor resistance at 20°C (Ω/km)	2.36	2.34	1.33	1.34	0.849	0.491	0.311	0.187	0.124
	Test voltage (V)	1500	1500	2000	2000	2000	2500	2500	2500	3000
	Insulation resistance (MΩ·km)	2000	2000	1500	1500	1500	1500	1500	1500	1000
Approximate mass (kg/km)		280	280	420	410	600	930	1400	2260	3250
Standard wire length (m)		150		500		350	400	300	200	150
Packing	Plastic drum (specified by us)	Bundle		RP6-6		RP6-6	RP8-6	RP8-6	RP8-6	RP8-6
	Wooden drum (Japanese Cable Makers' Association Standard)			L6-6		L6-6	L8-6	L8-6	L8-6	L8-6

* Bundle size: Inside diameter of 300 mm or more, width of 200 mm or less, and outside diameter of 680 mm or less

Table 3: Structure of 600-V, Stranded-triple-conductor (CVT) Cables

Number of conductors		3								
Conductor	Nominal cross-sectional area (mm^2)	8		14		22	38	60	100	150
	Shape or number of elemental wires/elemental wire diameter	7/1.2	Circular compression	7/1.6	Circular compression	Circular compression	Circular compression	Circular compression	Circular compression	Circular compression
	Outside diameter (mm)	3.6	3.4	4.8	4.4	5.5	7.3	9.3	12.0	14.7
Insulator thickness (mm)		1.0	1.0	1.0	1.0	1.2	1.2	1.5	2.0	2.0
Outside diameter of the insulated cable (mm)		5.6	5.4	6.8	6.4	7.9	9.7	12.3	16.0	18.7
Sheath thickness (mm)		1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Outside diameter of the sheathed cable (approx. size in mm)		8.6	8.4	9.8	9.4	10.9	12.7	15.3	19.0	21.7
Outside diameter of the finished (stranded) cable (approx. size in mm)		19.0	18.5	22.0	21.0	24.0	28.0	33.0	41.0	47.0
Electrical test	Conductor resistance at 20°C (Ω/km)	2.36	2.34	1.33	1.34	0.849	0.491	0.311	0.187	0.124
	Test voltage (V)	1500	1500	2000	2000	2000	2500	2500	2500	3000
	Insulation resistance (MΩ·km)	2000	2000	1500	1500	1500	1500	1500	1500	1000
Approximate mass (kg/km)		420	420	630	620	890	1400	2100	3430	4870
Standard wire length (m)		100		350		290	350	250	150	120
Packing	Plastic drum (specified by us)	Bundle		RP6-6		RP6-6	RP8-6	RP8-6	RP8-6	RP8-6
	Wooden drum (Japanese Cable Makers' Association Standard)			L6-6		L6-6	L8-6	L8-6	L8-6	L8-6

* Bundle size: inside diameter of 300 mm or more, width of 200 mm or less, and outside diameter of 680 mm or less

10 cm

10 cm

東京電力用品（□□□）	
品名　CVT	
サイズ　○○○mm^2	
製造年月　2014.12	条長　m
質量　kg	総重量　kg
公称電圧　V	認可番号
製造No.　12345	No.　67890

○○○○株式会社

Figure 1

Notes: 1. Labels must be affixed to both sides of the drum.
2. The label must be purple in color.
3. The label must clearly indicate its color and markings and remain adhered even after it is left outdoors for three months after the delivery.