# GB

NATIONAL STANDARD

OF THE PEOPLE'S REPUBLIC OF CHINA

ICS 29.060.20

K 13

**GB/T 33594-2017**

# Charging cables for electric vehicles

电动汽车充电用电缆



**Issued on: May 12, 2017** **Implemented on: December 01, 2017**

**Issued by: General Administration of Quality Supervision, Inspection and Quarantine of the People's Republic of China;**

**Standardization Administration of the People's Republic of China.**

# Table of Contents

# Foreword

This standard was drafted in accordance with the rules given GB/T 1.1-2009.

This standard was proposed by the China Electrical Equipment Industry Association.

This standard shall be under the jurisdiction of the National Power Cable Standardization Technical Committee (SAC/TC 213).

The drafting organizations of this standard: Shanghai Electric Cable Research Institute, Shanghai National Cable Testing Center Co., Ltd., China Quality Certification Center, Wuxi Xinhongye Special Plastic Cable Co., Ltd., Guangdong OMG Conducting Technology Co., Ltd., Hengyang Hengfei Cable Co., Ltd., Zhongtian Technology and Equipment Cable Co., Ltd., Wuxi Pearl Cable Co., Ltd., Zhongli Technology Group Co., Ltd., Jinbei Electric Co., Ltd., Jinlongyu Group Co., Ltd., Shenzhen WOER Heat-Shrinkage Material Co., Ltd., Jiangsu Hengtong Power Cable Co., Ltd., Guangzhou Nanyang Cable Co., Ltd., Far East Cable Co., Ltd., Zhejiang Wanma Co., Ltd., Jiangsu Shangshang Cable Group Co., Ltd., Changzhou Marine Cable Co., Ltd., Yangzhou Yaguang Cable Co., Ltd., DEKRA Quality Certification (Shanghai) Co., Ltd., Guangdong Institute of Product Quality Supervision and Inspection, Hunan Changgao High Voltage Switchgear Corporation.

The main drafters of this standard: Li Na, Zhu Yonghua, Qu Wenbo, Xiao Jidong, Yang Juanjuan, Xie Zhiguo, Guan Lili, Guan Yong, Liu Yaoxun, Wang Fushan, Xu Pengfei, Yu Jinhua, Sun Jianyu, Yang Zhiqiang, Lu Zhicai, Zhang Qiang, Guan Xinyuan, Wang Zhihui, Wang Chuanbin, Liu Huanxin, Zhu Jun, Gao Jun, Jia Yunpeng, Hong Jian, Liu Weihai, Lu Shenggan, Wang Can.

# Charging cables for electric vehicles

## 1 Scope

This standard specifies the use characteristics, expression methods, technical requirements, marking, test methods and requirements, inspection rules and cable packaging, transportation and storage of charging cables for electric vehicles.

This standard applies to the charging cables (which may include the signal or control core) having a rated voltage AC 450/750 V and below and DC 1.0 kV and below for the conductive charging device of electric vehicles.

## 2 Normative references

The following documents are essential to the application of this document. For the dated documents, only the versions with the dates indicated are applicable to this document; for the undated documents, only the latest version (including all the amendments) are applicable to this Standard.

GB/T 1690-2010 Rubber, vulcanized or thermoplastic - Determination of the effect of liquids

GB/T 2423.3-2006 Environmental testing for electric and electronic products - Part 2: Testing method test Cab: Damp heat steady state

GB/T 2951.11-2008 Common test methods for insulating and sheathing materials of electric and optical cables - Part 11：Methods for general application - Measurement of thickness and overall dimensions

GB/T 2951.12-2008 Common test methods for insulating and sheathing materials of electric and optical cables - Part 12: Methods for general application - Thermal ageing methods

GB/T 2951.13-2008 Common test methods for insulating and sheathing materials of electric and optical cables - Part 13: Methods for general application - Measurement for determining the density - Water

GB/T 2951.14-2008 Common test methods for insulating and sheathing materials of electric and optical cables - Part 14: Methods for general application - Test at low temperature

GB/T 2951.21-2008 Common test methods for insulating and sheathing materials of electric and optical cables - Part 21: Methods specific to elastomeric compounds - Ozone resistance, hot set and mineral

GB/T 2951.31-2008 Common test methods for insulating and sheathing materials of electric and optical cables - Part 31: Methods specific to PVC compounds - Pressure test at high temperature - Test for cracking resistance

GB/T 3048.4-2007 Test methods for electrical properties of electric cables and wires - Part 4: Test of DC resistance of conductors

GB/T 3048.5-2007 Test methods for electrical properties of electric cables and wires - Part 5: Test of insulation resistance

GB/T 3048.8-2007 Test methods for electrical properties of electric cables and wires - Part 8: AC voltage test

GB/T 3048.9-2007 Test methods for electrical properties of electric cables and wires - Part 9: Spark test of insulated cores

GB/T 3048.14-2007 Test methods for electrical properties of electric cables and wires - Part 14: DC voltage test

GB/T 3956-2008 Conductors of insulated cables

GB/T 4909.2 Test methods for bare wires - Part 2: Measurement of dimensions

GB/T 5013.2-2008 Rubber insulated cables of rated voltages up to and including 450/750V - Part 2: Test methods

GB/T 16422.2-2014 Plastics - Methods of exposure to laboratory light sources - Part 2: Xenon-arc sources

GB/T 17650.1-1998 Test on gases evolved during combustion of materials from cables - Part 1: Determination of the amount of halogen acid gas

GB/T 17650.2-1998 Test on gases evolved during combustion of materials from cables - Part 2: Determination of degree of acidity of gases by measuring pH and conductivity

GB/T 17737.1-2000 Radio-frequency cables - Part 1: Generic specification - General, definitions, requirements and test methods

GB/T 18380.12-2008 Test on electric and optical fiber cables under fire conditions - Part 12: Test for vertical flame propagation for a single insulated wire or cable - Procedure for 1kW pre-mixed flame vertical spread test method

GB 29518-2013 Diesel engines NOx reduction agent - Aqueous urea solution (AUS 32)

JB/T 8137 (all parts) Delivery drums for electric wires and cables

JB/T10696.6-2007 Test methods for determining mechanical physical and chemical properties of electric cables and wires - Part 10: Rat gnawing test

ISO 48:2010 Rubber, vulcanized or thermoplastic - Determination of hardness (hardness between 10 IRHD and 100 IRHD)

IEC 60684-2: 2011 Flexible insulation sleeving - Part 2: Methods of test

# 3 Terms and definitions

The terms and definitions as defined in GB/T 2900.10 AND the following terms and definitions apply to this document.

**3.1**

**Nominal value**

It refers to the specified magnitude which is often used in forms.

Note: In this standard, the magnitude which is usually introduced by the nominal value is verified through measurement under the consideration of the specified tolerance.

**3.2**

**Median value**

It refers to the middle value of the several values obtained from test AND arranged in the order of ascending (or descending) if the number of values is odd, OR the average of the middle two values if the number of values is even.

**3.3**

**Rated voltage**

It refers to the reference voltage which is used for cable design, use and electrical performance test.

# 5 Code, model and product expression method

## 5.1 Code

### 5.1.1 Product code

EV: electric vehicle

AC (can be omitted): for AC charging

DC: for DC charging

### 5.1.2 Conductor structure

(Omitted): the fifth copper conductor

R: the 6th copper conductor

### 5.1.3 Insulation material code

S: Thermoplastic elastomer at continuous working temperature 70 °C (TPE)

S90: Thermoplastic elastomer at continuous working temperature 90 °C (TPE)

E: The ethylene-propylene rubber or similar synthetic rubber at continuous working temperature 90 °C

EY: Rigid ethylene-propylene rubber or similar halogen-free synthetic material

### 5.1.4 Sheath (inner sheath) material code

S: Thermoplastic elastomer at continuous working temperature 70 °C (TPE)

S90: Thermoplastic elastomer at continuous working temperature 90 °C (TPE)

F: Thermoset elastomer composite material

U: Polyurethane elastomer material

YJ: Halogen-free cross-linked polyolefin or similar materials

### 5.1.5 Structural characteristics code

P: Copper wire braided overall shield

(P): Signal or control wire core braided shield

### 6.4.4 Spark test

Insulation cores shall be subjected to the spark test as required by 6.3.4.

## 6.5 Cable core and filler

### 6.5.1 Structure

All insulated cores (which may include signals or control cores) shall be twisted together. The signal or control cores may be twisted into a unit that is stranded with the other cores, BUT they shall not be in the center of the cable core.

It is allowed to use fillers when stranding the insulated cores.

### 6.5.2 Filler material

The material used as the filler shall be suitable for the operating temperature of the cable AND compatible with the insulation and sheathing material of the cable. In the case of halogen-free cables, the filler shall comply with the halogen content assessment in Table 13.

## 6.6 Inner sheath

### 6.6.1 Structure

If there is an overall shield, the cable core outside shall have extruded inner sheath.

Extruded inner sheath shall be wrapped around the cable core AND make the cable round and neat, AND the extruded inner sheath shall not stick to the insulated core.

Before extruding the inner sheath, it is allowed to use appropriate belt to tie it tightly.

### 6.6.2 Materials

At working temperature, the inner sheath material shall be suitable for the operating temperature of the cable AND be compatible with the insulation and sheathing materials of the cable.

Mechanical and physical properties of the inner sheath shall comply with the requirements of Table 14 (except for mineral oil resistant, acid and alkali resistance, hydrolysis resistance, and tear resistance test).

### 6.6.3 Thickness

Except for cores identified in green/yellow color combinations, only one color per insulated core of the cable shall be used. Green and yellow cannot be used as independent colors.

#### 8.2.2 Color chromatography

The coloring of the cable main insulated core shall give preference to the chromatography as follows:

- Two-core cable: blue, brown;
- Three-core cable: green/yellow, blue, brown;
- Four-core cable: green/yellow, blue, brown, gray;
- Five-core cable: green/yellow, blue, brown, black, gray.

Various colors shall be clearly identifiable and endurable.

For auxiliary power cores, signal or control cores and other extension cores etc., which are identified with color, there is no requirement for the coloring, BUT the color shall be clearly identifiable AND be different from the color of the main insulated core.

#### 8.2.3 Green/yellow combination

The core color distribution of the green/yellow combination shall comply with the following requirements: for each insulated core of 15 mm in length, one of the colors shall cover at least 30% and not more than 70% of the surface of the insulated core AND the other color shall cover the rest of the insulated core.

NOTE: descriptions on the use of green/yellow combination color: When using a combination of green/yellow as defined above, it is intended to be used exclusively as an insulated core that identifies the connection to grounding or similar protective purposes.

### 8.3 Number identification

#### 8.3.1 General requirements

Auxiliary power cable cores, signal or control cores and other extension cores can use number identification.

The core insulation shall be of the same color and arranged in numerical order, except for the green/yellow core (if any).

The number shall start with the number 1.

The conductor DC resistance at 20 °C of each conductor shall not exceed the corresponding maximum value as specified in GB/T 3956-2008.

### 9.2 Voltage test

Voltage test shall be carried out at ambient temperature, AC charging cable shall be tested in accordance with the requirements of GB/T 3048.8-2007, AND the DC charging cable shall be tested in accordance with the requirements of GB/T 3048.14-2007.

Voltage test is performed in accordance with the following requirements:

- AC charging cable: APPLY the 3.5 kV AC voltage in between each main insulation conductor and the rest conductors and the braided shield (if any) in order, for a period of 15 min; then APPLY the 1.5 kV AC voltage in between each signal or control core and the rest conductors and the braided shield (if any), for a period of 15 min; AND the cable insulation shall be free from breakdown;

- DC charging cable: APPLY the 8.4 kV DC voltage between each insulated conductor (including grounding core conductor, auxiliary core conductor, etc.) and the rest conductors and braided shield (if any) in order, for a period of 15 min; then APPLY the 3.6 kV voltage in between each signal or control core and the rest conductors and the braided shield (if any), for a period of 15 min; AND the cable insulation shall be free from breakdown.

### 9.3 Spark test

Insulated core shall be subjected to spark test in accordance with 6.3.4 and 6.4.4.

## 10 Sample test

### 10.1 Sampling frequency

#### 10.1.1 Conductor inspection and dimensional inspection

Conductor inspection and dimensional inspection shall be performed on one cable of the same model and specification and manufacturing length, BUT the number of inspections shall be limited to no more than 10% of the contracted quantity.

#### 10.1.2 Other test items

The insulation resistance constant $K_i$ is calculated from the measured insulation resistance in accordance with the formula (3).

$$K_i = \frac{L \times R \times 10^{-11}}{\lg(D/d)} \quad \cdots\cdots\cdots\cdots (3)$$

Where:

$K_i$ - Insulation resistance constant, in megaohm • kilometer (MΩ • km);

L - Cable length, in centimeters (cm);

R - Measured insulation resistance, in ohms (Ω);

D - Insulation outer diameter, in millimeters (mm);

d - Insulation inner diameter, in millimeters (mm).

The value calculated from the formula (3) shall not be less than the value specified in Table 12.

**11.2.6 Sheath surface resistance**

CUT three sections of finished cable samples; AND the length of each sample section is about 250 mm.

USE industrial alcohol to clean the surface of the cable sheath. USE a thin copper wire with a diameter of 0.2 mm ~ 0.6 mm to wind around two electrodes on each sample; AND the distance between the two electrodes is (100 ± 2) mm. After the winding is completed, CLEAN thoroughly the cable sheath surface between the two electrodes again.

PLACE the sample with the electrode in a test chamber at a temperature of (20 ± 2) °C AND a humidity of (65 ± 5) % for 24 h.

TAKE the sample out from the test chamber; immediately APPLY the 100 V ~ 500 V DC voltage between the two electrodes; after 1 min, MEASURE the resistance; AND the measurement result is calculated in accordance with the formula (4).

$$R_S = R \times a / 100 \quad \cdots\cdots\cdots\cdots (4)$$

Where:

$R_S$ - Surface resistance, in ohms (Ω);

When required by the user or the manufacturer, the finished cables may be subjected to high and low temperature cycling tests.

PERFORM the test in a test chamber at a low temperature of (-40 ± 2) °C [(-25 ± 2) °C for the 70 °C thermoplastic elastomer material)] and a high temperature of (100 ± 2 °C) [(85 ± 2) °C for the 70 °C thermoplastic elastomer material].

After the sample is placed in a low temperature environment for a minimum of 30 minutes, INCREASE the temperature of the test chamber to a corresponding high temperature within 30 minutes; PLACE the sample at high temperature for 6 h; REDUCE the temperature of the test chamber to the low temperature environment within 1 h, which forms a cycle.

Except as otherwise provided by the user or manufacturer, it is recommended to perform 40 cycles.

After the test, the cable insulation core shall not be adhesive, AND the insulated core and sheath surface shall be free from visible cracks.

**11.5.7 Mechanical strength test of finished cable**

**11.5.7.1 Deflection test**

Except as otherwise provided by the user or manufacturer, the cable with overall shielding structure AND the cable without overall shielding structure having a conductor cross-sectional area in excess of 4 mm$^2$ shall not be subjected to this test.

Test is performed in accordance with the methods as specified in clause 3.1 of GB/T 5013.2-2008; after 30000 reciprocating motions, that is, after 60000 one-way movement, there shall be neither current open circuit nor short circuit between conductors.

After the cable test, it shall strip off the sheath, AND follow the requirements of 11.2.3 to perform voltage withstanding test on the insulated core, AND the insulation shall not be breakdown.

**11.5.7.2 Extrusion resistance test**

Test equipment shall include the following parts (test diagram as shown in Figure 4):

- Pressure testing machine, with a pressure measuring equipment, AND the mechanical transmission speed of the testing machine is (10 ± 1) mm/min;

- Two flat steel plates of 50 mm × 150 mm;

- A solid steel bar with smooth surface and 20 mm diameter placed on one piece of steel plate;

- Connected signal device, which can provide 30 V or less DC power supply, AND is used to connect the sample conductors and between the conductor and the steel plate or steel bar.

The sample is the finished cable, having a minimum length of 3000 mm, AND conductor is exposed at one end of the sample.

Between the sample exposed copper conductors AND between the copper conductor and the steel plate or steel bar on the tensile testing machine, respectively CONNECT the DC power supply.

INSTALL the two steel plates in parallel onto the pressure testing machine. The longitudinal axis of the two plates shall be in the same vertical plane. The samples, equipment and the surrounding environment shall reach heat balance at room temperature.

The first test point on the sample shall be in the center of the lower steel plate, the upper steel plate shall be moved downwards at a speed of (10 ± 1) mm/min until it contacts the surface of the sample, AND continue to move downward until the indicating signal is turned on.

RECORD the pressure value indicated by the pressure testing machine when the signal is on.

PERFORM the above test for 10 times along the sample length direction, AND the test points for each test shall be uniformly distributed along the sample length direction.

The distance between the test points shall be at least 250 mm AND at least 125 mm from the end of the sample.

The minimum average extrusion force of finished cable shall comply with the following requirements (S is the conductor nominal cross-sectional area):

a) $S \leq 4mm^2$, 4.0 kN;

b) $4\ mm^2 < S \leq 35\ mm^2$, 11.0 kN;

c) $S > 35\ mm^2$, 15.0 kN.

# 13 Packaging, transportation and storage

**13.1** The cables in coil shall be neatly winded AND appropriately packaged. Cable tray shall comply with the provisions of JB/T 8137. The two ends of the cable shall have a reliable waterproof or moisture-proof seal, AND the end of the coiled cable running out of the tray shall be firmly secured to the cable tray.

**13.2** Each loop or coil of exit-factory cable shall be attached with the product inspection certificate. AND the product inspection certificate shall be placed in a watertight plastic bag.

**13.3** Each loop or coil of cable shall be marked with the following information:

- Manufacturer's name or trademark;
- Cable rated voltage, model and specifications;
- Cable length, m;
- Gross weight, kg;
- Date of manufacture;
- Standard number or certification mark;
- Correct rotation direction of winding cable drum.

**13.4** Transportation and storage shall comply with the following requirements:

- Cable shall be kept in the open air, AND cable tray shall not be flatly placed;
- During transportation, it shall not push down the cable tray from height, AND it shall not damage the cable mechanically;
- When lifting the packaged parts, it is not allowed to lift multiple coils at the same time. On the transportation means such as vehicles and ships, the cable tray shall be placed stably and fixed by appropriate method, to avoid it from collisions or overturning.

# Appendix A

## (Normative)

### Insulation hardness determination

**A.1 Sample**

The sample shall be a length of finished cable with all sheath; the sample shall be peeled carefully to the measurement surface of the EY insulation; AND it may also use a section of insulated core as the sample.

**A.2 Measurement procedures**

**A.2.1 Large curvature surface**

The measuring device shall comply with the requirements of ISO 48:2010 AND shall be such as to allow the instrument to be placed stably on the EY insulation, with the pressing foot and head in vertical contact with the insulation surface, AND this can be achieved by one of the following methods:

a) The instrument is equipped with an easy-to-adjust universal joint movable foot, which can be adapted to the insulation curved surface;

b) The instrument is fixed by two parallel rods A and A' on the bottom plate, the distance between which is determined by the degree of surface curvature (as shown in Figure A.1).

These methods are applicable to surfaces with a radius of curvature of 20 mm above.

For the instruments to measure the EY insulation thickness of less than 4 mm, it shall use the measurement methods in ISO 48:2010 for small test samples.

**A.2.2 Small curvature surface**

For the surface with a small radius of curvature, the measuring procedure is the same as that specified in A.2.1. The sample and the measuring instrument shall be fixed by the same rigid baseplate. This ensures that the insulation will move as little as possible when the pressure from the pressing head increases, AND meanwhile it can make the pressing head perpendicular to the sample axis.

Measurement procedures are as follows:

Note 2: Due to the relatively small outer diameter of the cable and the nature of the material, it is not possible to produce a perfectly flat test piece.

**Figure B.1 -- Tear resistance test piece**

USE a sharp blade to cut the axisymmetric incision perpendicular to the width of the test piece, as shown in Figure B.1, to ensure that the incision is at the thinnest point of the groove created by the core. At the three equidistant points in the direction of the incision length, USE the pointer thickness gauge to measure the test piece thickness; TAKE the median value; RETAIN two decimal places.

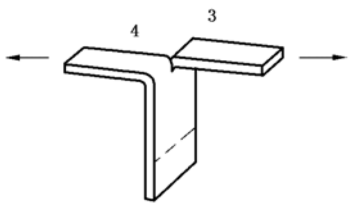
## B.3 Test preparation

All test pieces shall be stored at a temperature of (20 ± 5) °C for at least 3 h before starting the test.

## B.4 Test procedure

Respectively CLAMP the both sides of the cutting end of the test piece onto the upper fixture and the lower fixture of the tensile testing machine, as shown in Figure B.2; TEAR the test piece at the speed of (250 ± 50) mm/min.

READ out the maximum tearing force when the test piece is torn to the mark line; TAKE one decimal place.




Description:

3 - Upper clamping position;

4 - Lower clamping position.

**Figure B.2 -- Test piece before placed into the tensile testing equipment opening**

## B.5 Test results

If the tear opening reaches the mark line as shown in Figure B.1, the result is considered valid. If the tear opening reaches one side of the test piece before it reaches the mark line, the result is invalid. It shall obtain at least 3 valid results, otherwise it is required to prepare more test pieces.

# Appendix C

## (Normative)

## Saponification test

### C.1 Definition

### C.1.1 Saponification

The formation of alkali metal salts, irrespective of the formation of the corresponding acid.

### C.1.2 Saponification value

The milligrams of potassium hydroxide as required to saponify 1 g of sample.

### C.2 Test equipment and materials

Test equipment and materials are as follows:

- Conical flask: capacity 250 mL, made of alkali-resistant glass, with grinding mouth;
- Reflux condenser tube: with frosted glass connector to connect conical flask;
- Burette;
- Analytical balance: accurate to 0.1 mg;
- Natural ventilation electric heating box;
- Water bath
- Potassium hydroxide solution, 0.5 mol/L;
- Hydrochloric acid solution, 0.5 mol/L;
- 1% phenolphthalein ethanol solution;
- Tetrahydrofuran;
- Zeolite
- Distilled or deionized water.