ICS 27.100
P 62
Record No. J429—2005

DL

Electric Power Industry Standard of the People's Republic of China

P **DL / T** 5217 — 2005

Technical Code for Design of 220 kV-500 kV Compact Overhead Transmission Line

Issue Date: February 14, 2005 Implementation Date: June 1, 2005

Issued by the National Development and Reform Commission of the People's Republic of China

Electric Power Industry Standard of the People's Republic of China

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CHINA ELECTRIC POWER PRESS

BEIJING, 2012

图书在版编目（CIP）数据

DL/T 5217—2005 220kV～500kV 紧凑型架空送电线路设计技术规定= Technical Code for Design of 220 kV～500 kV Compact Overhead Transmission Line：英文 / 中华人民共和国国家发展和改革委员会发布. —北京：中国电力出版社，2012.3

ISBN 978-7-5123-2766-5

Ⅰ. ①D… Ⅱ. ①中… Ⅲ. ①架空线路：输电线路-设计规范-中国-英文 Ⅳ. ①TM726.3-65

中国版本图书馆 CIP 数据核字（2012）第 036801 号

中国电力出版社出版、发行

（北京市东城区北京站西街 19 号 100005 http://www.cepp.sgcc.com.cn）

北京博图彩色印刷有限公司印刷

各地新华书店经售

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2012 年 月第一版 2012 年 月北京第一次印刷

850 毫米×1168 毫米 32 开本 1.125 印张 25 千字

印数 0001—0000 册 定价 **0.00** 元

Foreword

As compared with the conventional overhead power transmission lines, compact overhead power transmission lines can considerably increase the natural power transmission, effectively reduce the size of line corridors, increase the power transmission capacity per unit of line corridors, thus contributing greatly to significant economic and social benefits.

This code is established in order to summarize the experiences in respect of scientific research, design, construction and operation of compact overhead power transmission lines in China, drive and guide the adoption of this new technology in construction of power grids in China. As a supplement to DL/T 5092—1999 *Technical Code for Designing 110 kV–500 kV Overhead Transmission Line*, it specifies the main technical design requirements for 220 kV–500 kV AC compact overhead transmission lines.

Appendix A and B to this code are normative.

This code is proposed by China Electricity Council.

This code is solely managed and interpreted by Technical Committee on Electric Power Planning and Engineering of Standardization Administration of Power Industry.

The code is drafted by North China Power Engineering Co., Ltd of China Power Engineering Consulting Group.

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This code is translated by SUNTHER Translation & Solutions under the authority of China Electric Power Planning & Engineering Association.

Contents

1 Scope

1.0.1 This code specifies the main design and technical requirements for 220 kV–500 kV AC compact overhead transmission lines.

1.0.2 This code is applicable to the design of 220 kV–500 kV compact overhead transmission lines (hereinafter referred to as compact lines).

1.0.3 This code is not applicable to the design of compact lines in heavy icing areas and those with a large span.

2 Normative References

The following normative documents contain provisions which, through reference in this text, constitute the provisions of this code. For dated references, subsequent amendments (excluding the contents of errata) to, or revision of, any of these publications do not apply. However, parties to agreements based on this code are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies.

DL/T 5092—1999 *Technical Code for Designing 110 kV–500 kV Overhead Transmission Line*

DL/T 5154—2002 *Technical Regulation of Design for Tower and Pole Structures of Overhead Transmission Line*

3 General

3.0.1 The construction of compact line shall be demonstrated in terms of the necessity, economic benefits and social benefits from the perspective of increase of the transmission capacity of power grids and save of line corridors.

3.0.2 The design of compact lines must be in compliance with the national basic construction strategy and economic policies and be safe, reliable, economic and reasonable.

3.0.3 This code is based on DL/T 5092—1999 and makes supplementary provisions on the technical design of compact lines. For the basic rules governing loads, materials, structural design, structure and foundation of towers, refer to DL/T 5092—1999.

3.0.4 In addition to the requirements stipulated in this code, relevant provisions specified in the current national standards and electric power industry standards shall also be complied with in the design of compact lines.

4 Terms and Symbols

4.1 Terms

The following terms and symbols are applicable to this part.

4.1.1

Compact overhead transmission line

Overhead transmission line for which grounding members between three-phase conductors have been eliminated through optimization of conductor configuration in order to improve the inherent transmission power, reduce the width of corridor and increase the transmission capacity per unit of the corridor.

4.1.2

Spacer between phases

Insulated spacer supporting two phases of conductors to control the clearance between them.

4.1.3

Heavy ice area

Areas with design ice thickness of 20 mm or above.

4.1.4

Everyday tension

The tension at the lowest point of sag of conductor or shield wire which is calculated under the annual average temperature.

4.1.5

Tension section

Line part between two tension towers.

4.1.6

Electrical clearance

Minimum clearance between any live part of a line and grounding parts.

4.1.7

Ground clearance

Minimum clearance between any live part of a line and the ground.

4.1.8

Residential area

Populated areas like industrial area, port, wharf, rail station and towns.

4.1.9

Nonresidential area

Areas other than residential area defined above. Nonresidential areas also include the areas with frequent presence of people, vehicles or agricultural mechanics but no or few houses.

4.2 Symbols

The following symbols are used in this code:

H—altitude, km;

K_1—safety coefficient of mechanical strength of insulators;

K_c—safety coefficient of conductor or shield wire;

L—span, m;

n—quantity of insulators at areas with the altitude below 1000 m, piece;

n_h—quantity of insulators at areas with high altitude, piece;

S—clearance between conductor and shield wire, m;

T_{max}—maximum tension at the lowest point of sag of conductor or shield wire, N;

T_P—tensile of conductor or shield wire, N;

T_R—ultimate design load of insulators, kN;

T—maximum working load, line breakage load, string breakage load or annual continuous load of insulators, kN.

5 Routing

5.0.1 The routing of compact line shall be made taking into account comprehensively such factors as construction, operation, traffic condition and length of the line and no less than two options shall be compared in terms of technical and economical indices to ensure safety, reliability and cost effectiveness.
5.0.2 Two circuits of compact lines passing through constrained areas should share the same tower provided that both the operating safety and reliability are fully ensured.
5.0.3 The length of a tension section of compact line should not be larger than 20 km and may be increased appropriately if both the construction and operating conditions permit. In hilly areas or areas with undesirable operating conditions, the length may be reduced appropriately.
5.0.4 The routing of compact line shall be made such that, to the maximum extent possible:

1 The line will not exhibit large span, large height difference and excessively large span difference between neighboring spans;

2 The line will not pass through the areas susceptible to ice coating;

3 The line will not pass through the areas where conductors are susceptible to gallop;

4 The line should run along leeward slope where it passes through mountainous areas.

6 Meteorological Conditions

6.0.1 The meteorological conditions for design shall be determined according to the following recurrence periods based on the meteorological information for the routing areas and the operating experiences obtained from the existing lines nearby:

500 kV compact line	30 years
220 kV–330 kV compact line	15 years

If the meteorological conditions along the route are similar to the typical conditions as mentioned in Table A.1, Appendix A, the data for typical meteorological conditions should be used.

6.0.2 The 10-minutes annual maximum wind speed from the local meteorological observatory shall be used as the sample to determine the maximum design wind speed, and, the extreme-value type I distribution should be used as the probability model.

The elevations for wind speed statistics are as follows:

500 kV compact line	Distance from the ground: 20 m
220 kV–330 kV compact line	Distance from the ground: 15 m

6.0.3 The maximum design wind speed for transmission lines shall be selected based on the statistic value of the maximum wind speed. For transmission line in mountainous area, it shall be 10% higher than the statistic value for nearby plain areas if reliable material is unavailable.

The maximum design wind speed for 220 kV–330 kV compact lines shall not be lower than 25 m/s and that for calculating tension and load of conductor and shield wire as well as tower load of 500 kV compact lines shall not be lower than 30 m/s.

6.0.4 In icing areas, check shall be done based on the rare icing condition if necessary.

7 Conductor and Shield Wire

7.0.1 Compact lines shall employ conductor bundles whose cross-sectional area shall not only be selected based on economic current density, but also be checked against the corona and radio interference conditions, and, where necessary, shall be checked in terms of audible noises. To increase the natural power transmission, the cross-sectional area of a conductor bundle and the number of the bundles shall be determined through technical and economic comparison.
7.0.2 The conductor shall be selected such that the electric charges on each sub-conductor are basically in equilibrium. The maximum and minimum electric charges non-uniformity coefficient of sub-conductors should not be larger than 1.05 or less than 0.95. The working capacitance of phase conductors should not differ by more than 0.25%.
7.0.3 The allowable temperatures of conductors for verifying the allowable current-carrying capacity are as follows: +80℃ for steel-reinforced aluminum stranded conductors and steel-reinforced aluminum alloy stranded conductors; +80℃ or a temperature determined based on the experiences for steel-reinforced aluminum cladded stranded steel conductors (including aluminum clad stranded steel conductors); +125℃ for stranded galvanized steel conductor. The ambient temperature shall be the maximum average temperature in the hottest month; the wind speed shall be 0.5 m/s; the sun radiation power density shall be 0.1 W/cm^2.
7.0.4 Compact lines shall employ conductor bundles and the sub-conductors should be arranged symmetrically and uniformly. In order to control subspan oscillation of conductor bundles, the ratio between the bundle spacing and the diameter of the sub-conductor should be

larger than 15.

Number of sub-conductors per phase:

500 kV compact line	should not be less than 6
330 kV compact line	should not be less than 4
220 kV compact line	should not be less than 3

7.0.5 The design safety coefficient of conductor and shield wire shall not be less than 2.5. The design safety coefficient of shield wire should be larger than that of conductor.

The maximum tension at the lowest point of sag of conductor or shield wire shall be calculated according to Equation 7.0.5:

$$T_{max} \leqslant \frac{T_P}{K_c} \quad (7.0.5)$$

Where:

T_{max}—maximum tension at the lowest point of sag of conductor or shield wire, N;

T_P—tensile capacity of conductor or shield wire, N;

K_c—safety coefficient of conductor or shield wire.

The tension at the attachment point of conductor or shield wire may be increased by 10% as compared with the maximum tension at the lowest point.

For the conductor and shield wire erected on pulley, the additional tension due to local bending at attachment points shall be calculated as well.

Under the meteorological condition with rare wind speed or rare ice thickness, the maximum tension at lowest point of sag shall not exceed 60% of the breakage tensile and that at the attachment points shall not exceed 66% of the breakage tensile.

7.0.6 The shield wire shall meet both mechanical and electrical operating condition requirements and stranded galvanized steel conductor or composite stranded conductor may be used. Alternatively, optical fiber composite overhead ground wire (OPGW) may be used depending upon the communication requirement. The allowable temperatures of shield wire for verifying short-circuit thermal stability are as follows: +200℃ for steel-reinforced aluminum conductor (ACSR) and aluminum-alloy conductor steel-reinforced (AACSR); +300℃ for steel-reinforced aluminum-clad steel stranded conductor (including aluminum-clad steel stranded conductor); +400℃ for stranded galvanized steel conductor; and guaranteed test value for OPGW. The calculation time and corresponding short-circuit current value shall be determined according to the specific system conditions. Where shield wire employs stranded galvanized steel wire, it shall has a nominal cross-sectional area of not less than 80 mm^2 for 500 kV compact lines and not less than 50 mm^2 for 220 kV and 330 kV compact lines.

7.0.7 Anti-vibration Measures for Conductor and Shield Wire

For aluminum conductor steel-reinforced or stranded galvanized steel conductor with a section ratio between aluminum and steel not less than 4.29, the upper limits of everyday tension and the corresponding anti-vibration measures shall conform to the requirements of Table 7.0.7. However, the restriction therein may be ignored if supported by years of operating experiences.

Table 7.0.7 Upper Limits of Everyday Tensions of Conductor and Shield Wire and Anti-Vibration Measures

Scenario	Anti-vibration Measures	Upper Limits of Everyday Tension (percentage of tensile capacity, %)	
		Steel-core Aluminum Conductor	Stranded Galvanized Steel Conductor
Open area where a span does not exceed 500 m	Not Required	16	12

Table 7.0.7 (continued)

Scenario	Anti-vibration Measures	Upper Limits of Everyday Tension (percentage of tensile capacity, %)	
		Steel-core Aluminum Conductor	Stranded Galvanized Steel Conductor
Areas rather than open area where a span does not exceed 500 m	Not Required	18	18
A span does not exceed 120 m	Not Required	18	18
Whatever the span is	Armour rods	22	—
Whatever the span is	Vibration damper (damping wire) or armour rods	25	25

Where it is necessary to employ damping spacers for quad-bundle conductors and above, the damping spacers should be arranged at unequally spaced intervals and asymmetrically. In cases where the conductor span is 500 m and below, other anti-vibration measures may be eliminated. The largest sub-span of conductors should not be excessively large and should be controlled within about 70 m. The sub-span of conductors at both ends should be controlled within 30 m–35 m.

7.0.8 The creep of conductor and shield wire after erection shall be determined based on the data provided by manufacturer or by tests. In case no such information is available, 1×10^{-4} may be taken for stranded galvanized steel wire, and the values listed in Table 7.0.8-1 may be used for ACSR.