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Technical Code for Designing of Overhead Transmission Line in Medium & Heavy Icing Area

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Contents

Foreword

This code is prepared in accordance with the arrangement of *Notice on Issuance of Plan for Development of Electric Power Industry Standards in 2008* issued by the General Office of National Development and Reform Commission (FGBGY [2008] Document No. 1242).

Appendix A of this code is a normative appendix.

This code is proposed by China Electricity Council.

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

This code is drafted by China Power Engineering Consulting Group Corporation and Southwest Electric Power Design Institute with the participation of Central Southern China Electric Power Design Institute.

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

The comments and suggestions proposed during the implementation of this code are to be referred to the Standardization Center of China Electricity Council at the following address: No. 1 Ertiao Lane, Baiguanglu Rd., Beijing 100761 China.

1 Scope

This code specifies the technical requirements for the routing, selection and configuration of conductors and shield wires, type and load of towers and crossing, taking into account the characteristics of heavy icing lines.

This code is applicable to the design of 110kV–750kV heavy icing transmission lines. It can also be used as a reference standard for the DC/AC heavy icing transmission lines at other voltage levels.

2 Normative References

The following normative documents contain provisions which, through reference in this text, constitute 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.

GB 50545 *Code for Design of 110kV–750kV Overhead Transmission Line*

DL/T 5158—2002 *Technical Code of Meteorological Surveying for Electrical Power Projects*

3 General

3.0.1 Heavy icing lines include the transmission lines erected in medium and heavy icing areas.

3.0.2 In addition to this code, the design of heavy icing lines shall observe the requirements as specified in *Code for Design of 110kV–750kV Overhead Transmission Line*.

3.0.3 When designing heavy icing lines, the measures for avoiding icing or anti-icing shall be given priority. In areas where conditions permit, the measures for melting and preventing icing may be used if justified through technical and economic comparison. For the lines designed with ice melting and prevention measures, design ice thickness shall be selected appropriately to ensure that they have a certain anti-icing capability.

3.0.4 In parallel with the design of heavy icing lines, ice observation stations (points) shall be established and on-line icing monitoring shall be conducted for transmission lines if conditions permit so as to collect the data at ice observation stations and summarize the design and operation experiences.

3.0.5 For the purpose of this code, transmission lines are divided into three categories in terms of voltage levels.

Category 1: lines operating at 750kV, 500kV, and critical lines operating at 330kV;

Category 2: lines operating at 330kV, and critical lines operating at 220kV;

Category 3: lines operating at 220kV and 110kV.

4 Terms and Symbols

4.1 Terms

The following terms are applicable to this code.

4.1.1

Glaze

A coating of ice with a high specific gravity, generally clear, hard and strongly adhesive, often being accompanied with icicles, formed on objects in the manner of wet growth when supercooled water droplets of a large size hit the object surface, then dispersed into a film, and finally frozen.

4.1.2

Soft rime

A coating of ice with a low specific gravity, generally white, loose and poorly adhesive, formed on objects in the manner of dry growth instantly when supercooled water droplets of a small size drifting with air flow hit the object surface. The soft rime usually develops on the windward side of objects.

4.1.3

Hard rime

A semi-opaque coating of ice with a medium specific gravity, formed on objects partially in the manner of dry growth and partially in the manner of wet growth instantly when supercooled water droplets of different sizes drifting with air flow hit their surface. The hard rime usually develops on the windward side and has a certain adhesion.

4.1.4

Wet snow

Snow which is originally frozen, becomes tentatively damp and melting when passing a warm layer during the falling process, finally stacked and frozen on objects. The wet snow has a low specific gravity and relatively poor adhesion.

4.1.5

Precipitation icing

A process of icing by which supercooled water droplets of a large size falling under gravity are deposited on the objects and frozen into glaze or hard rime.

4.1.6

In-cloud icing

A process of icing by which supercooled water droplets of a small size drifting with air flow are deposited on the objects and frozen into soft or hard rime.

4.1.7

Air flow in icing

An air mass that contains a certain quantity of supercooled water droplets having the potential of causing large-scale icing.

4.1.8

Medium icing area

An area with design ice thickness ranging from 10mm to 20mm.

4.1.9

Heavy icing area

An area with design ice thickness of 20mm and above.

4.1.10

Design ice thickness

Ice thickness equivalent to an ice density of 0.9g/cm^3 as per recurrence reoccurrence period as specified in design.

4.1.11

Check ice thickness

Rare ice thickness with rarely-occurring probability (ice density of 0.9g/cm^3).

4.1.12

Design ice load

Ice load determined based on design ice thickness.

4.1.13

Check ice load

Ice load determined based on rarely-occurring icing.

4.1.14

Condensation level

Elevation of the areas with ground temperature at 0℃ and below during the freezing period in winter.

4.2 Symbols

The following symbols are used in this code.

A_s —calculated projected area of the wind pressure bearing parts of members, m^2;

A_I—calculated wind pressure bearing area of insulator strings, m^2;

B_1 —wind load increase coefficient of conductors, shield wires and insulators after being coated with ice;

B_2 —wind load increase coefficient of members when being coated with ice;

d —outer diameter of conductors or shield wires, or their calculated outer diameter when coated with ice. For a conductor bundle, its outer diameter shall be the sum of outer diameters of all sub-conductors, m;

K_I —safety coefficient of mechanical strength of insulators;

L_p —wind span of towers, m;

T —maximum working load, line breakage load, string breakage load and check load of insulators when coated with ice, kN;

T_R—rated mechanical failing load of insulators, kN;

W_0 —characteristic value of reference wind pressure, kN/m^2;

W_s —characteristic value of tower wind load, kN;

W_x—characteristic value of horizontal wind load perpendicular to direction of conductors and shield wires, kN;

W_I —characteristic value of wind load of insulator strings, kN;

α —non-uniform coefficient of wind pressure;

β_c—adjustment coefficient of wind load applied on conductors and shield wires;

β_z —adjustment coefficient of wind load applied on towers;

θ—angle between the wind direction and line direction wires, (°);

μ_s—shape coefficient of members;

μ_{sc} —shape coefficient of conductors or shield wires;

μ_z —coefficient of wind pressure change as a function of elevation;

ψ —combination coefficient of variable load.

5 Routing

5.0.1 The routing of lines shall be made through technical and economic analysis provided that the safety is ensured and shall be kept clear of severe icing areas as practical as possible.

5.0.2 Routing shall be made such that, to the maximum extent possible:

1 The lines are kept clear of severely icing or polluted areas determined through investigation;

2 The lines run along terrains which are less rugged;

3 The lines do not cross passes, wind gap, or lakes, reservoirs and other areas prone to icing;

4 The line will not exhibit large span and large height difference;

5 The lines should run along leeward slopes or sunny slopes when crossing mountainous areas;

6 The length of tension sections should not be excessively large, in particular, not exceeding 5km in medium icing areas and not exceeding 3km in heavy icing areas;

7 The line angle should not be excessively large.

6 Meteorological Conditions of Icing

6.0.1 The design ice thickness of overhead transmission lines is determined based on the following recurrence periods:

750kV, 500kV transmission lines and sections with large spans: 50years;

110kV–330kV transmission lines and sections with large spans: 30years.

6.0.2 Where sufficient icing observation data is available and confirmed effective, the design ice thickness of lines shall be determined by using probabilistic method, with extreme value type I distribution being employed as the probabilistic model. If icing observation data is rarely available or even unavailable, the design ice thickness of lines shall be determined through investigation and analysis on the icing conditions of the existing lines nearby.

6.0.3 The data of icing shall be collected from the weather stations, icing observation stations, power lines, weak current lines and microwave towers along the lines, and the field investigation is required so as to be aware of the icing conditions, nature of icing and freezing levels over years, as well as the years when severe icing occurs and its recurrences.

6.0.4 With the information and data collected, a comprehensive analysis shall be performed by simultaneously considering the landform, land feature of the areas where the lines run and those of the surrounding areas, the relative height difference, routing direction, erection height of lines, the meteorological factors including wind velocity, direction and humidity during icing period as well as the operating conditions of the existing lines nearby. Attention shall be paid to the effects of micro-topography and micro-climate on increased icing so as to reasonably determine the design ice thickness and classify the ice zones.

6.0.5 Generally, the values listed in Table 6.0.5-1 and Table 6.0.5-2 can be taken as a reference for the meteorological conditions of icing.

Table 6.0.5-1 Ice Zone of Lines in Medium Icing Area

Ice Zone	I	II
Design ice thickness mm	15	20
Accompanying wind velocity m/s	10	
Accompanying ambient temperature ℃	5	
Ice density g/cm^3	0.9	

Table 6.0.5-2 Ice Zone of Lines in Heavy Icing Area

Ice Zone	III	IV	V	VI
Design ice thickness mm	20	30	40	50
Wind velocity m/s	15			
Ambient temperature ℃	5			
Ice density g/cm^3	0.9			
Note: The accompanying wind velocity actually measured, if available, shall be used.				

6.0.6 The ice thickness that can be borne by shield wires shall be at least 5mm greater than that of conductors.

6.0.7 If rarely-occurring heavy ice is encountered in severe icing area during investigation, it should be checked by using the ice thickness of rare occurrence.

7 Conductor and Shield Wire

7.0.1 The conductor and the number of sub-conductors for heavy icing lines shall be selected based on technical and economic analysis and operating experience provided that the safe operation is ensured.

7.0.2 The design safety coefficient of conductors and shield wires including OPGW (optical ground wires) at the lowest point of the sag shall not be less than 2.5 and shall not be less than 2.25 at suspension points. The design safety coefficient of shield wires shall be larger than that of conductors.

7.0.3 When applied with the check ice load, the maximum tension at the lowest point of the sag of conductors and shield wires shall not exceed 70％ of the tensile strength. The maximum tension at the attachment points of conductors and shield wires shall not exceed 77％ of the breakage tensile.

7.0.4 Where stranded galvanized steel wires are used for the shield wires of transmission lines operating at 500kV and above, the nominal cross-section area thereof should not be less than $100mm^2$.

7.0.5 If OPGW is used, the requirements on mechanical strength thereof imposed by ice-shedding induced jumping and an overload shall be satisfied.

8 Insulator and Fittings

8.0.1 The safety coefficient of mechanical strength of insulators shall not be less than the values as shown in Table 8.0.1. For a double-and multiple-insulator string, the mechanical strength thereof following breakage of one insulator shall be checked, and the load and safety coefficient thereof shall be considered by assuming that the string breaks.

Table 8.0.1 Safety Coefficients of Mechanical Strength of Insulators

Scenarios	Maximum Working Load		Line Breakage	String Breakage	Check Load
	Disc Type	Rod Type			
Safety Coefficient	2.7	3.0	1.8	1.5	1.5

The safety coefficient K_I of the mechanical strength of insulators shall be calculated according to the equation below:

$$K_I=T_R/T \qquad (8.0.1)$$

Where:

T_R—the rated mechanical failing load of insulators, kN;

T—the maximum working load, line breakage load, string breakage load or check load of insulators, kN.

The meteorological condition for line breakage load and check load corresponds to the condition of icing, no wind, –5℃, and that for string breakage load corresponds to the condition of no icing, no wind and –5℃. Refer to Article 12.0.5 for the ice coating rate and tension of line in case of line breakage.

8.0.2 The safety coefficients of the mechanical strength of the fittings shall not be lower than:

2.5 for the maximum working load;

1.5 for line breakage, string breakage and check load scenarios.

8.0.3 The conductors should be protected with preformed armor rods in order to mitigate or prevent the damage thereof caused by the unbalanced tension, ice-shedding induced jumping and galloping of the conductors.

Non-fixing clamps shall not be used.

The counter-weight used on conductors shall be of fixed type.

8.0.4 Conductor spacers shall give full consideration to the operating characteristics of lines in heavy icing area in order to minimize sub-span and increase torsional strength.

9 Insulation Coordination and Lightning Protection

9.0.1 The insulation coordination for transmission lines shall ensure that transmission lines can operate safely and reliably under various conditions, including power frequency voltage, switching over-voltage and lightning over-voltage. In addition, heavy icing lines shall be checked in terms of power-frequency withstand voltage strength under pollution and wet condition when the insulator strings are coated with ice.

9.0.2 Tension towers erected in heavy icing area shall be equipped with jumper insulator strings.

9.0.3 In the case of single-circuit towers erected at heavy icing area, the shielding angle of the shield wire relative to the side phase conductor should not be larger than 15° for 750kV and 500kV transmission lines, and around 20° for 220kV transmission lines with double shield wires and 330kV transmission lines, and around 25° for 110kV transmission lines with a single shield wire in mountainous areas. In the case of double-circuit or multiple-circuit towers erected at medium icing area, the shielding angle should not exceed 0° for the transmission lines operating at 220kV and above, and not exceed 10° for 110kV transmission lines. In the case of single-circuit structures erected at medium icing area, the shielding angle of the shield wire relative to the side phase conductor should not be larger than 10° for 750kV and 500kV transmission lines, and around 15° for 220kV transmission lines with double shield wires and 330kV transmission lines, and around 20° for 110kV transmission lines with a single shield wire in mountainous areas.

9.0.4 In order to minimize the flashovers between conductors and shield wires of 110kV lines, the shield wires erected at heavy icing area may be insulated based on the operating phase-to-ground voltage. After the freezing period elapses, the shield wires shall be restored to earth directly.

9.0.5 For transmission lines of 220kV and above erected in heavy icing area, the shield wires should not be insulated as described above.