SLOVENSKI STANDARD
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Nadzemni vodi - Meteorološki podatki za ocenjevanje klimatskih obtežb

Overhead lines - Meteorological data for assessing climatic loads

Lignes aériennes - Données météorologiques pour calculer les charges climatiques

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Lignes aériennes – Données météorologiques pour calculer les charges climatiques

Overhead lines – Meteorological data for assessing climatic loads

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

OVERHEAD LINES – METEOROLOGICAL DATA FOR ASSESSING CLIMATIC LOADS

FOREWORD

1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, the IEC publishes International Standards. Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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The main task of IEC technical committees is to prepare International Standards.

In exceptional circumstances, a technical committee may propose the publication of a technical report of one of the following types:

- type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;
- type 2, when the subject is still under technical development or where for any other reason there is the future but no immediate possibility of an agreement on an International Standard;
- type 3, when a technical committee has collected data of a different kind from that which is normally published as an International Standard, for example "state of art".

Technical reports of types 1 and 2 are subject to review within three years of publication to decide whether they can be transformed into International Standards.

Technical reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

IEC 61774, which is a technical report of type 2, has been prepared by IEC technical committee 11: Overhead lines.

The text of this technical report is based on the following documents:

Committee draft	Report on voting
11/115/CDV	11/125/RVC

Full information on the voting for the approval of this technical report can be found in the report on voting indicated in the above table.

This document is being issued in the Technical Report (type 2) series of publication (according to subclause G.3.2.2 of the ISO/IEC Directives) as a "prospective standard for provisional application" in the field of *climatic load databases* because there is an urgent need for guidance on how standards in this field should be used to meet an identified need.

This document is not to be regarded as an "International Standard". It is proposed for provisional application so that information and experience of its use in practice may be gathered. Comments on the content of this document should be sent to the IEC Central Office.

A review of this Technical Report (type 2) will be carried out not later than three years after its publication with the options of: extension for another three years, conversion into an International Standard, or withdrawal.

Annexes A to J are for information only.

OVERHEAD LINES – METEOROLOGICAL DATA FOR ASSESSING CLIMATIC LOADS

1 Scope

This Technical Report (type 2) aims at providing advice on methods for developing climatic load databases.This is necessary for the implementation of IEC 60826 which provides the framework for National Standards on overhead line design. However, for its practical use, it is required that design engineers acquire and utilise climatic data, since sufficient information is often not available in existing building codes and standards. In particular there is a lack of information on ice loads.

The objective of this report is met by:

a) reporting on the availability and proper use of climatic data

b) recommending simple standardized measurement techniques

c) reviewing icing models for computing ice loads.

The details of each of the foregoing aspects of overhead line design loads are presented in the following clauses. Clause 3 describes the framework – or strategy – linking these separate aspects together.

2 Normative reference

The following normative document contains provisions which, through reference in this text, constitute provisions of this Technical Report. At the time of publication, the edition indicated was valid. All normative documents are subject to revision, and and parties to agreements based on this Technical Report are encouraged to investigate the possibility of applying the most recent edition of the normative document indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60826: 1991, *Loading and strength of overhead transmission lines*

3 General

3.1 Meteorological data

The purpose of clause 4 is to provide an introduction to the meteorological data referred to in IEC 60826, the weather elements and parameters from which they are derived, and an explanation of some of the terminologies used by meteorologists. Information about the availability of meteorological data for overhead line design obtained from questionnaires sent to several utilities and national meteorological institutions is presented in 4.3. In 4.4 recommendations concerning procedures for obtaining the data most appropriate to IEC 60826 are given.

3.2 Ice loads

3.2.1 Icing processes

Atmospheric icing is a complex phenomenon which can take a number of forms. It is essential both for the specification of measuring instruments and icing models that the distinguishing features of these different forms are recognized.

Atmospheric icing is a result of two main processes in the atmosphere which are named accordingly:

a) in-cloud icing,

b) precipitation icing.

The latter one occurs in several forms among which the most important are:

1) freezing rain,

2) wet snow accretion,

3) dry snow accretion.

There is a third process resulting in the formation of so-called "hoar frost" but this does not lead to significant ice loads on overhead lines and will not be considered further.

In-cloud icing is a process where suspended, supercooled droplets in a cloud (or fog) freeze immediately upon impact on an object exposed to the airflow, for instance, a high level power line above the cloud base.

The ice growth is said to be dry when the available heat transfer rate away from the object is greater than the release of the latent heat of fusion. The density of the accretion is a function of the flux of water to the surface and the temperature of the layer. The resulting accreted ice is called soft or hard rime according to the density. A typical density for soft rime is 300 kg/m^3 and 700 kg/m^3 for hard rime.

The ice growth is said to be wet when the heat transfer rate is less than the rate of latent heat release. The growth then takes place at the melting point, resulting in a water film on the surface. The accreted ice is called glaze with a density of 900 kg/m^3.

Precipitation icing can occur in several forms, including freezing rain, wet and dry snow. Freezing rain comprises supercooled droplets which freeze immediately upon impact on objects. The resulting accretion is also glaze. The ambient temperature is below the freezing point.

When snowflakes fall through a layer of air with temperatures slightly above the freezing point, the flakes may partly melt, become sticky and thus accrete on objects. This is called wet snow accretion. The density and the adhesion may vary widely. If the ambient temperature drops significantly below freezing after a wet layer of snow has accreted, the adhesive and mechanical strength of the layer may become very high. In exceptional cases, wet snow accretions are known to have occurred with ambient temperatures slightly below freezing.

Dry snow flakes may accrete at temperatures significantly below freezing and can, under very low wind speed conditions, accumulate on objects to form a dry snow accretion.

It should be noted that the accretion on a conductor may be the result of more than one process occurring during an icing event.

3.2.2 Icing measurements

Clause 5 deals with ice load measurements. This is a complex problem requiring careful interpretation of the results if they are to be applied reliably to overhead line design. Such interpretations require an understanding of the different types of icing and their associated meteorological conditions, the physical processes associated with ice accretion and their interaction with the mechanical characteristics of the conductor system. There is a range of conductor and overhead line parameters which should ideally be employed (conductor diameter, stranding, torsional stiffness, height above ground, etc) and a range of icing and meteorological parameters (ice weight, density, shape, precipitation, droplet size, wind speed, air temperature, etc) that should ideally be measured at a test site. The cost of a test site is often high and decisions have to be made between the merits of using basic measurement systems or more expensive test spans.

3.2.2.1 Basic icing measurements

To obtain icing data covering a range of locations – comparable to meteorological stations – basic, relatively inexpensive techniques that can be replicated have to be defined. Such techniques should allow measurements to be made so that they can be related to the ice loads which would be experienced by a real line at the measurement site. These techniques may also provide a means for assessing the comparative exposure to icing at the site, relative to other sites.

By defining certain minimum common requirements for the basic standard rigs, comparisons can be made between measurements recorded at different sites in different areas or countries. This will assist in validating the measurements, increase the confidence in the data and allow a better understanding of conductor icing in relation to location, climate and meteorology. In order to achieve this, minimum standard instrumentation and measurement requirements are also specified. Both manual and automatic measurement systems are described because, in some locations, manual data collection is either not practicable or may be more expensive.

In addition to the minimum requirements for the basic rigs, optional additional facilities and measurements are described. These can improve the quality of the data and make it more readily related to the specific lines under consideration.

3.2.2.2 Test spans

Test spans are an advantageous way of obtaining wind and ice load data as they more closely represent real overhead lines. Because test spans are expensive to build and maintain they are generally restricted to a few sites. Sometimes they are formed by building a few spans of unenergised line on wood poles. They may also be provided by instrumenting or making detailed observations of spans of in-service lines.

Organizations in a number of countries have operated test lines of varying complexity, reflecting different objectives and subject to constraints imposed by cost, manpower and location. It is not proposed to define a standard test span; a list of both "purpose-built" test spans and "real-line" test spans is provided in annex D, giving some information on their construction, location, instrumentation, etc.

However, it is strongly recommended that at each new or continuing test site, an ice rack meeting at least the minimum requirements, as introduced in 5.2.3, should be erected. By means of comparisons between the ice rack data and the test line data, transfer functions can be constructed to make allowance for the differences in, for example, torsional stiffness or diameter of the conductor and its height above ground.

3.2.3 Icing models

The use of icing models to provide ice load data is obviously attractive. Some icing models use relatively simple approaches and are restricted to a particular type of icing, while others start from more fundamental equations and can address a range of icing types. A review of some icing models is given in clause 6. Ice accretion involves complex processes in fluid mechanics and thermodynamics. Empirical data are usually required for certain aspects of the theory, for example the relationship between accretion density and windspeed, or the heat transfer characteristics of a surface.

Icing models may be used both to estimate ice loads for defined conditions and to compute icing statistics from a historical database of meteorological conditions. In most cases, the precise information required as input to icing models is not available from such database. For example, droplet size or snow intensity must be estimated from the available data.

Icing models enable transfer functions to be determined from ice measurements on rigs or test spans. These transfer functions enable ice loads to be estimated for lines employing conductors of different diameters, different mechanical characteristics and at sites with different intensities of icing conditions. In this way, the models and measurements interact with each other to improve the quality of such extrapolations and predictions.

3.3 Galloping (informative)

In addition to ice loads on conductors, ice accretion may also lead to a wind-induced oscillation of the conductors known as galloping. This phenomenon, which is quite distinct from aeolian vibration or sub-conductor oscillation, is a low frequency, mainly vertical oscillation of high amplitude. Frequencies range up to about 1 Hz and amplitudes usually range from a few metres to the sag of the span. The air temperatures are usually only a few degrees above or below zero and the wind speed may range between 5 m/s and 25 m/s. The ice accretion produces a conductor profile which generates both aerodynamic lift and moment. These characteristics may be such that the conductor becomes aerodynamically unstable and gallops. The start of the instability may often be observed in the middle of the span, and the intensity is mainly influenced by the wind speed, the wind direction, the torsional stiffness of the conductor and whether it is a single conductor or a bundle; in the case of bundles, other aspects such as the tower and hardware characteristics may also be important.

This icing-related phenomenon is mentioned for completeness, but no further consideration is given to it in this report.

3.4 Strategy for employing data and models

Figure 1 shows the general strategy for linking together the three aspects described in 3.2, 3.3 and 3.4 to provide the input data to IEC 60826. In the figure they are represented by the top three boxes and are the resources ideally available to the overhead line engineer.

A simple case exists if the overhead line is not subject to icing and extensive data on extreme wind speeds are available from the general meteorological database. Then the requirements of IEC 60826 are met without modification, except for the transfer of data from their sites of origin to the site of the overhead line.

The situation is far more complicated as soon as icing occurs. However, a second level of simplification would exist if an icing model or empirical equation of sufficient reliability for use with the general meteorological database was available: ice rack data would not then be necessary. On the other hand, if ice rack data were available to a sufficient extent, historically and geographically, there would be no need for icing models. In general, however, data acquired through the procedures indicated in figure 1 will be required.

The historical meteorological and icing data (top left and right boxes) need to be transferred from sites of origin to the site of the overhead line (local data). Theoretical icing data are then generated from the local meteorological data, using the icing model (top middle box). Since droplet size and liquid water content are not directly available from the historical meteorological data, they have to be evaluated from the other historical data before the calculation of icing data.

A comparison between the theoretical and measured icing data is needed to ensure that the experimental results can be correctly interpreted and that the theoretical models are realistic, thereby improving the quality of the transfer functions derived from each. This is indicated by a feedback from the "comparison box" to the icing model.

If the comparison turns out to be acceptable, the resulting icing data have to be further modified by taking conductor and span data into account. The final icing data can then be statistically processed to give the design data on ice load. In addition, together with the wind data, the wind force on iced conductors is obtained and can be statistically processed.

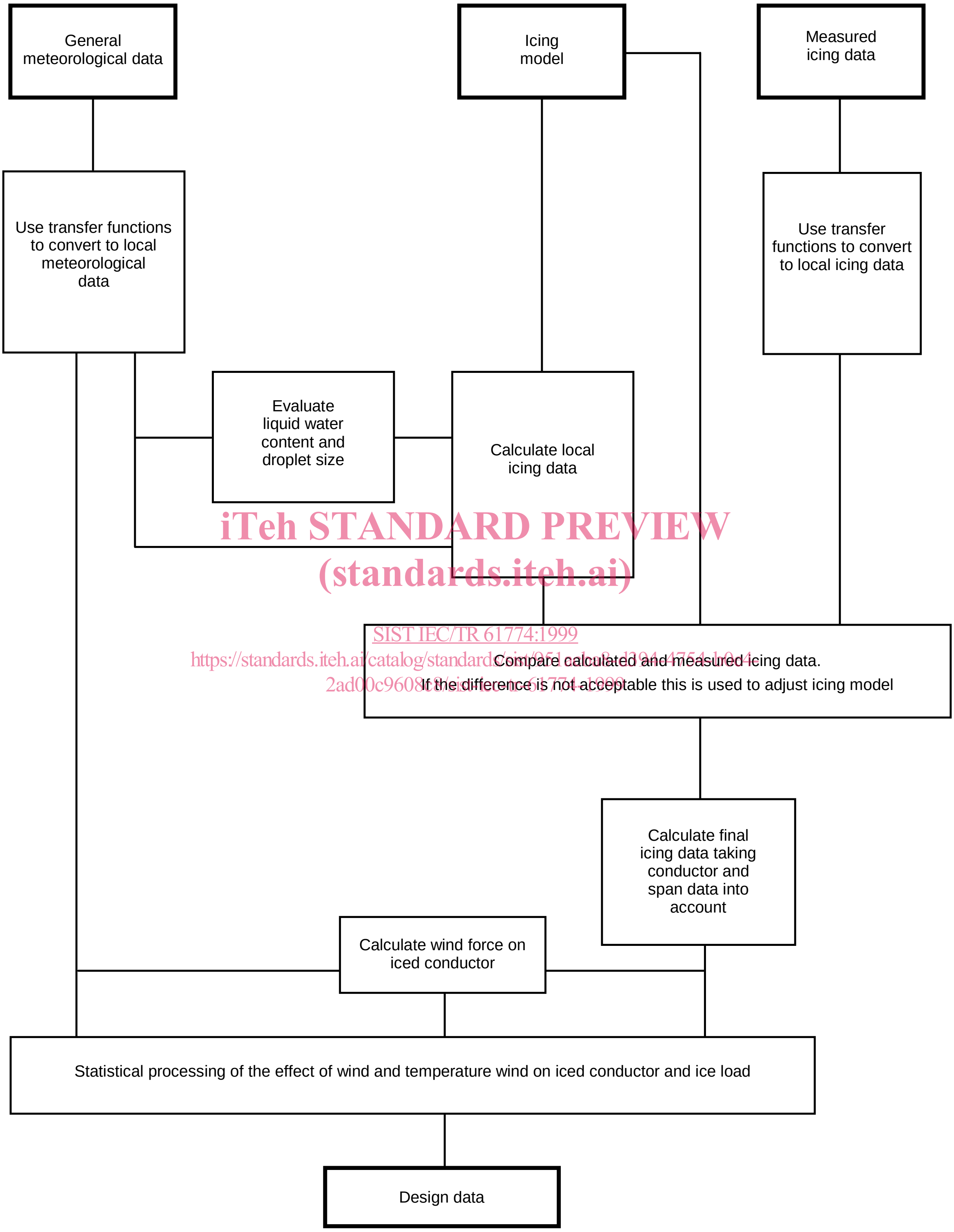

Figure 1 – Strategy flow chart