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TECHNICAL SPECIFICATION

Selection and dimensioning of high-voltage insulators intended for use in polluted conditions –
Part 4: Insulators for d.c. systems

colour inside

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CONTENTS

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SELECTION AND DIMENSIONING OF HIGH-VOLTAGE INSULATORS INTENDED FOR USE IN POLLUTED CONDITIONS –

Part 4: Insulators for d.c. systems

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- 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.

Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC 60815-4, which is a technical specification, has been prepared by technical committee 36: Insulators.

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

DTS	Report on voting
36/382/DTS	36/390/RVC

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

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 60815 series, published under the general title *Selection and dimensioning of high-voltage insulators intended for use in polluted conditions*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

Work has been going on in CIGRE C4.303 and the IEC to produce d.c. pollution design guides that represent the current state of the art. The CIGRE work has resulted in an HV d.c. Pollution Application Guidelines brochure [1] and the IEC work in this final part of IEC 60815 – *Selection and dimensioning of high-voltage insulators intended for use in polluted conditions – Part 4: Insulators for d.c. systems*.

The work represents a huge accumulation of pollution performance knowledge from various sources (both published and unpublished) never before collated into a single opus.

Contrary to the parts of IEC 60815 dealing with a.c., this technical specification covers both polymeric and glass and porcelain insulators for d.c. systems in a single publication. It also covers hybrid insulators (the ceramic core is fully covered by a polymer).

NOTE The present document does not apply to insulators with coatings, due to the variety of coatings to be considered. This may be reconsidered at the next revision of this technical specification, after gaining more knowledge and experience and a better definition of the coating characteristics and requirements.

The approach for d.c. insulator design and selection with respect to pollution given in this part is different to that used for a.c. The key differences are:

- A simplified approach is presented which is intended for preliminary design. However, since under d.c. pollution build-up and its effects can be more severe than under a.c., the final design should be based as much as possible on a direct pollution severity measured under d.c. for the site being studied. Equally direct evaluation of the insulators selected by this process should be considered. (A statistical design approach is available in the CIGRE guidelines for d.c. pollution [1]);
- Two approaches are considered to estimate pollution severity: one using prior d.c. site severity experience, the other using site severity measurements on a.c. or unenergised insulators;
- Correction of site severity for specific parameters that have an influence under d.c. (e.g. pollution uniformity ratio, effect of diameter on pollution accumulation, NSDD) are considered;
- Direct transfer from corrected site pollution severity to necessary USCD without any use of discrete site severity classes (as made in IEC 60815 Parts 2 and 3);
- Recognition is made of the improved performance of Hydrophobicity Transfer Materials (HTM) as a practical solution for many designs, notably at UHV, while taking into account potential hydrophobicity loss;
- Importance of the influence of altitude;
- Distinct diameter correction for flashover performance.

Although there is some positive experience with validation by testing of traditional glass and porcelain insulators, the full translation of such test results to service conditions is still under consideration. Any such experience is mainly lacking for composite insulators, since an agreed standardised testing procedure is not yet available. The problem is accentuated to porcelain/glass as well composite technology by the continuing rise in system voltages where over-design may result in unrealistic insulator lengths or heights. Hence for this first edition the verification of a chosen insulator solution by testing is entirely subject to agreement.

For polymeric, notably HTM, the pollution withstand may not be the only necessary design information. The design stress should be selected not only to avoid flashover, but also to assure a limited ageing of the insulators in service. This item is however out of the scope of the present specification.

Applications with controlled indoor environment are not included in the scope of this document.

SELECTION AND DIMENSIONING OF HIGH-VOLTAGE INSULATORS INTENDED FOR USE IN POLLUTED CONDITIONS –

Part 4: Insulators for d.c. systems

1 Scope

This part of IEC 60815, which is a Technical Specification, is applicable as first approach for the determination of the required d.c. Unified Specific Creepage Distance for insulators with respect to pollution. To avoid excessive over or under design, existing operation experience should be compared and eventually additional appropriate tests may be performed by agreement between supplier and customer.

It is applicable to:

- Glass and porcelain insulators;
- Composite and hybrid insulators with an HTM or non-HTM housing.

This part of IEC 60815 gives specific guidelines and principles to arrive at an informed judgement on the probable behaviour of a given insulator in certain pollution environments.

The structure and approach of this part of IEC 60815 are similar to those explained in Part 1, but adapted for the specific issues encountered with polluted HV d.c. insulation.

The aim of this Technical Specification is to give the user simplified means to:

- Identify issues specific to d.c. applications that can affect the choice and design process;
- Determine the equivalent d.c. Site Pollution Severity (SPS) from measurements, correcting for electrostatic effects, diameter, pollution distribution and composition;
- Determine the reference USCD for different candidate insulating solutions, taking into account materials, dimensions and risk factors;
- Evaluate the suitability of different insulator profiles;
- Discuss the appropriate methods to verify the performance of the selected insulators, if required;

This simplified process is intended to be used when comparable operational experience from existing d.c. system is incomplete or not available.

The simplified design approach might result in a solution that exceeds the physical constraints of the project. More refined approaches for such cases, e.g. using a statistical approach, are given in the CIGRE d.c. guidelines [1]. In extreme cases, e.g. for exceptionally severe site conditions, alternative solutions such as changing the line route, relocation of converter stations or using an indoor d.c. yard may need to be considered.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC TS 61245, *Artificial pollution tests on high-voltage ceramic and glass insulators to be used on d.c. systems*

IEC TS 60815-1:2008, *Selection and dimensioning of high-voltage insulators intended for use in polluted conditions – Part 1: Definitions, information and general principles*

IEC TS 60815-2, *Selection and dimensioning of high-voltage insulators intended for use in polluted conditions – Part 2: Ceramic and glass insulators for a.c. systems*

IEC TS 60815-3, *Selection and dimensioning of high-voltage insulators intended for use in polluted conditions – Part 3: Polymer insulators for a.c. systems*

IEC TS 62073, *Guidance on the measurement of hydrophobicity of insulator surfaces*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-471:2007 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1.1
Unified Specific Creepage Distance
USCD
creepage distance of an insulator divided by the maximum operating voltage across the insulator. It is generally expressed in mm/kV

Note 1 to entry: For d.c. the maximum operating voltage is the d.c. system voltage as defined in IEC 60071-5.

3.1.2
Reference d.c. Unified Specific Creepage Distance
RUSCDdc
value of Unified Specific Creepage Distance for a d.c. system at a pollution site determined from ESDD and NSDD values corrected for NSDD, CUR, etc. according to this document

Note 1 to entry: This is generally expressed in mm/kV.

3.1.3
Contamination Uniformity Ratio
CUR
ratio of the pollution deposit density on the lower surface of insulators to that of the upper surface

Note 1 to entry: Referred to as Pollution Uniformity Ratio (PUR) in some countries.

Note 2 to entry: This is referred to as Contamination Uniformity Ratio in some countries.

3.1.4
Hydrophobicity Transfer Material
HTM
polymer materials which exhibit hydrophobicity and the capability to transfer hydrophobicity to the layer of pollution

Note 1 to entry: Further information on HTM is given in Annex A.

3.2 Abbreviated terms

CF	Creepage Factor
ESDD	Equivalent Salt Deposit Density
HTM	Hydrophobicity Transfer Material
NSDD	Non Soluble Deposit Density
SDD	Salt Deposit Density
SES	Site Equivalent Salinity
SPS	Site Pollution Severity
USCD	Unified Specific Creepage Distance
RUSCD	Reference Unified Specific Creepage Distance
CUR	Pollution (Contamination) Uniformity Ratio
RUSCDdc	Reference d.c. Unified Specific Creepage Distance

4 Principles

4.1 General

The overall process of insulation selection and dimensioning can be summarised as follows:

- Determination of the appropriate approach (deterministic, statistical etc.) as a function of available knowledge, time and resources as recommended in IEC TS 60815-1. The following steps concern the simplified, deterministic approach as described in IEC TS 60815-1; if the statistical approach is chosen, please refer to IEC TS 60815-1 for full details.

Therefore, using IEC TS 60815-1:

- collection of the necessary input data, notably system voltage, insulation application type (line, post, bushing, etc.);
- collection of the necessary environmental data, notably site pollution severity.

At this stage, a preliminary choice of possible candidate insulators suitable for the applications and environment may be made.

Then, using this document for:

- determination of the d.c. site severity by application of correction factors;
- determination of the reference d.c. USCD (RUSCD);
- correction of the RUSCD for each candidate insulator;
- checking the profile parameters;
- verification.

It is to be noted that in the following the USCD and the correction factors are based on a median behaviour derived from widely spread results (see [1][1]). Despite this, when the process is benchmarked against service experience the results are consistent enough to give useful orientation to identify a range of preliminary solutions (see [1]).

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[1] Numbers in square brackets refer to the bibliography.

4.2 Overall design process

The overall design process is shown in the flowcharts in Figures 1 and 2. From these flowcharts it can be seen that the creepage distance is only selected after multiple steps to correct site pollution measurements for the factors which can influence d.c. performance and which often have a more pronounced effect under d.c. than for a.c. The design process is complicated by several factors:

- d.c. energised insulators exhibit a greatly different pollution accumulation behaviour compared to a.c. and un-energised insulators due to electrostatic effects, this accumulation is affected by wind, particle size etc.;
- composition of the pollution (low solubility or slow-dissolving salts);
- effect of the amount of non-soluble deposit;
- CUR “Contamination Uniformity Ratio”;
- effect of diameter on pollution accumulation;
- non-uniformity of the pollution layer along or around the insulator;
- effect of diameter on pollution performance;
- effect of insulator material on pollution performance.

These points are described in more detail in Figures 1 and 2.

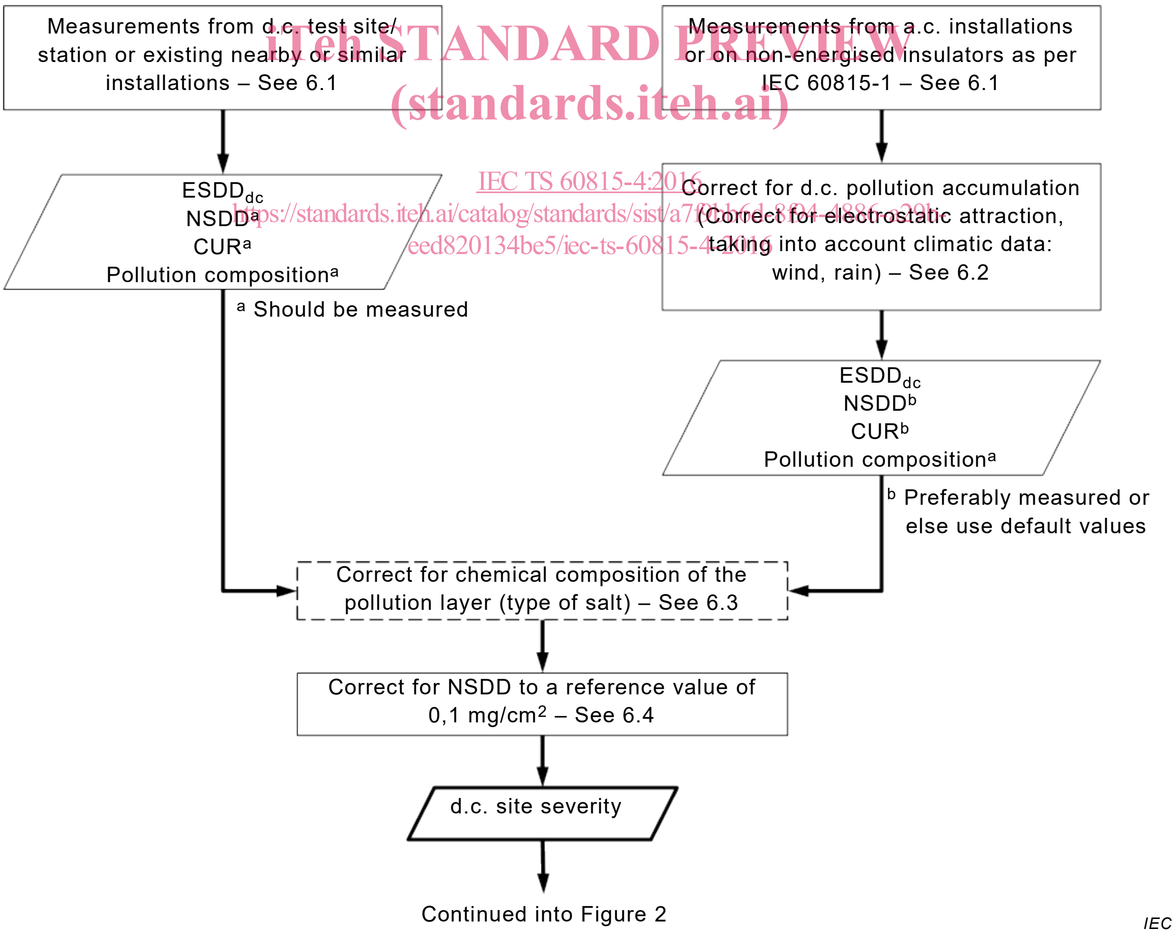

Figure 1 – Overall design process for d.c. insulation – determination of d.c. Site Pollution Severity