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Outline for part 3: Polymer insulators
INTERNATIONAL ELECTROTECHNICAL COMMISSION

IEC 60815: Selection and dimensioning of high-voltage insulators for polluted conditions -

Part 3: Polymer insulators for a.c. systems

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.

2) The formal decisions or agreements of the IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested National Committees.

3) The documents produced have the form of recommendations for international use and are published in the form of standards, technical specifications, technical reports or guides and they are accepted by the National Committees in that sense.

4) In order to promote international unification, IEC National Committees undertake to apply IEC International Standards transparently to the maximum extent possible in their national and regional standards. Any divergence between the IEC Standard and the corresponding national or regional standard shall be clearly indicated in the latter.

5) The IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with one of its standards.

6) Attention is drawn to the possibility that some of the elements of this technical specification may be the subject of patent rights. The IEC shall not be held responsible for identifying any or all such patent rights.

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 specification when

• the required support cannot be obtained for the publication of an International Standard, despite repeated efforts, or
• 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 60815-3, 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:

<table>
<thead>
<tr>
<th>Enquiry draft</th>
<th>Report on voting</th>
</tr>
</thead>
<tbody>
<tr>
<td>XX/XX/DTS</td>
<td>XX/XX/RVC</td>
</tr>
</tbody>
</table>

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

The committee has decided that the contents of this publication will remain unchanged until ______. At this date, the publication will be

• reconfirmed;
• withdrawn;
• replaced by a revised edition, or
• amended.
Introduction from the Project Leader

The revision of IEC 60815:1986 to take into account current experience, knowledge and practice related to polluted insulators in general, and specifically to include polymer insulators and to cover d.c. systems, requires subdivision of the Technical Specification into the following five parts:

- Part 1: Definitions, information and general principles
- Part 2: Ceramic and glass insulators for a.c. systems
- Part 3: Polymer insulators for a.c. systems
- Part 4: Ceramic and glass insulators for d.c. systems
- Part 5: Polymer insulators for d.c. systems

As work on part 1 has progressed, it has become evident that the requirements for evaluation and measurement of site severity were a major concern. The content of part 1 now principally covers site pollution severity determination, description of the flashover mechanism, approaches for selection and dimensioning and testing techniques. The second draft of part 1 of IEC 60815 is being circulated at the same time as this draft.

The basic principle of selection has changed with respect to IEC 60815:1986 in that it is no longer a simple GO/NO-GO process. The reader of this draft will discover that the information gathered on the pollution at the projected site (from IEC 60815-1) is used to determine a reference creepage distance, which is then corrected as a function of the suitability of candidate insulators for the type of pollution. Other factors, which take into account the influence of profile parameters (e.g. diameter, shed spacing etc.), are also applied to this creepage distance or are used to determine the suitability of the candidate insulators.

Additionally the user of the publication is now given means by which the selection process can be confirmed – with a given degree of confidence – by use of relatively simple artificial pollution withstand test.

It is hoped that this revision of IEC 60815 will also result in the reduction of risk of over-design, in more freedom in designing insulators for specific pollution problems or for unusual geometric constraints and in a better comprehension of the factors affecting the behaviour of insulation in polluted conditions.

The final details of the statistical procedure for determining the parameters for confirmation by artificial pollution tests is still under development by CIGRE TF C4.13.01. This information should be available by the end of 2005. Consequently clause 13 may be modified at that time.
IEC 60815: Selection and dimensioning of high-voltage insulators for polluted conditions -

Part 3: Polymer insulators for a.c. systems

1 Scope and object

This Technical Specification is applicable to the selection of polymer insulators for a.c. systems, and the determination of their relevant dimensions, to be used in high voltage systems with respect to pollution.

NOTE Ceramic and glass insulators have an insulating part manufactured either of glass or porcelain, whereas the insulating surface of polymeric insulators is manufactured of polymers or other organic materials.

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.

This structure is based on that used in CIGRE 33.13 TF 01 documents [1, 2], which form a useful complement to this Technical Specification for those wishing to study in greater depth the performance of insulators under pollution.

This Technical Specification does not deal with the effects of snow or ice on polluted insulators. Although this subject is dealt with by CIGRE [3], current knowledge is very limited and practice is too diverse.

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

- Determine the reference Unified Specific Creepage Distance (USCD) from Site Pollution Severity (SPS) class;
- Choose appropriate profiles;
- Apply correction factors for altitude, insulator shape, size and position etc. to the reference USCD.

2 Normative references

The following referenced documents are indispensable for the application 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 60507  Artificial pollution tests on high voltage insulators to be used on a.c. systems
IEC 60815-1 Selection and dimensioning of high-voltage insulators for polluted conditions - Part 1: Definitions, information and general principles

3 Definitions

For the purpose of this publication, the following definitions apply. The definitions given below are those which either do not appear in IEC 60050(471) or differ from those given in IEC 60050(471)

3.1 Unified Specific Creepage Distance (USCD) (repeated from IEC 60815-1 for clarity)

The creepage distance of an insulator divided by the maximum operating voltage across the insulator (for a.c. systems usually $U_{m}/\sqrt{3}$) It is generally expressed in mm/kV.

NOTE This definition differs from that of Specific Creepage Distance where the phase-to-phase value of the highest voltage for the equipment is used. For phase to earth insulation, this definition will result in a value that is $\sqrt{3}$ times that given by the definition of Specific Creepage Distance in IEC 60815 (1986). See Annex I for details.
3.2 Reference Unified Specific Creepage Distance

The initial value of Unified Specific Creepage Distance for a pollution site before correction for size, profile, mounting position etc. according to this publication.

4 Abbreviations

CF Creepage Factor
SES Site Equivalent Salinity
SPS Site Pollution Severity
USCD Unified Specific Creepage Distance

5 Principles

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

Firstly, using IEC 60815-1:

- Determination of the appropriate approach A, B or C as a function of available knowledge, time and resources;
- Collection of the necessary input data, notably whether a.c. or d.c. energisation, system voltage, insulation application type (line, post, bushing etc.);
- Collection of the necessary environmental data, notably site pollution severity and class;

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

Then, using this publication:

- Refining choice of possible candidate ceramic or glass insulators suitable for the environment;
- Determination of the reference Unified Specific Creepage Distance for the insulator types and materials, either using the indications in the this Technical Specification, or from service or test station experience in the case of Approach A (Clause 8);
- Choice of suitable profiles for the type of environment (Clause 9);
- Verification that the profile satisfies certain parameters, with correction or action according to the degree of deviation (Clause 10);
- Modification, where necessary (Approaches B and C), of the reference USCD by factors depending on the size, profile, orientation etc. of the candidate insulator (Clauses 11 & 12);
- Verification that the resulting candidate insulators satisfies the other system and line requirements such as those in Table 2 of IEC 60815-1 (e.g. imposed geometry, dimensions, economics);
- Verification of the dimensioning, if required in the case of Approach B, by laboratory tests (see Clause 13).

NOTE Without sufficient time and resources (i.e. using approach C), the determination of the necessary USCD will have less accuracy.
6 Materials

Present practice is to use housings manufactured from several base polymers for instance silicone rubbers based on dimethyl siloxane, cross linked polyolefins, like epdm rubber, or semicrystalline ethylene copolymers, like EVA, or rigid highly cross linked epoxy resins based on cycloaliphatic components. None of these polymers will work in an outdoor environment without a sophisticated additive package to modify their behaviour (e.g. antitracking agents, UV screens and stabilisers, antioxidants, ionic scavengers etc.) With a well developed additive package, all the above base polymers can be made to work in a wide variety of environments. Nevertheless, experience shows that each base polymer gives particular strengths or weaknesses, which may be significant in specific conditions. Mitigation required for poor resistance to discharge products.

Silicone rubbers: UV resistance, ozone resistance, thermal rating, exhibits surface hydrophobicity and transfer capability in many environments, several formulations with very long and excellent service experience. Weaker mechanicals so susceptible to mechanical damage or bird/rodent/insect attack; hydrophobicity may be temporarily lost in certain conditions; high moisture vapour transmission rate.

EPDMs: hydrophilic; low moisture vapour transmission rate, good dry band arc, tracking and erosion resistance and high dielectric strength with correct filler package. Reasonable mechanicals, little history of bird/insect attack. Moderate UV resistance, higher leakage currents compared to silicones;

Cross linked EVA: hydrophilic; Low moisture vapour transmission rate, Reasonable mechanicals, good dry band arc, tracking and erosion resistance and high dielectric strength. Very long service experience. Correct additive package required.

Epoxy resins: hydrophilic, higher mechanical strength and rigidity; low moisture vapour transmission rate, bird and animal proof. Needs excellent UV stabiliser package, and has high leakage currents. Can be prone to hydrolysis. Lower tracking and erosion resistance.

Note: Some polymer insulators sometimes collect more pollutants compared to the ceramic and glass insulators due to their surface characteristics.

Define HTM plus refs to IEC 62073 and CIGRE D1.14

7 Site severity determination

For the purposes of standardisation, five classes of pollution characterising the site severity are qualitatively defined in IEC 60815-1, from very light pollution to very heavy pollution, as follows:

   a – Very light
   b – Light
   c – Medium
   d – Heavy
   e – Very heavy.

NOTE These letter classes do not correspond directly to the previous number classes of IEC 60815:1986.

The SPS class for the site is determined according to IEC 60815-1 and is used to determine the reference USCD for glass and ceramic insulators.
8 Determination of the reference USCD

Figure 1 shows the relation between SPS class and reference USCD for polymer insulators. The bars are preferred values representative of a minimum requirement for each class and are given for use with approach C as described in IEC 60815-1. If the estimation of SPS class tends towards the neighbouring higher class, then the curve may be followed.

If exact SPS measurements are available (approach A or B), it is recommended to take a reference USCD which corresponds to the position of the SPS measurements within the class by following the curve in figure 1.

In cases of exceptionally high SPS in class e the minimum reference USCD may not be adequate. Depending on service experience and/or laboratory test results a higher USCD can be used; in some instances mitigation may be useful (see IEC 60815-1, 10.4.5).

NOTE – It is assumed that the final USCD resulting from the application of the corrections given hereafter to the reference USCD will not correspond exactly to a creepage distance available for catalogue insulators. Hence it is preferred to work with exact figures and to round up to an appropriate value at the end of the correction process.

![Figure 1 – Reference USCD as a function of SPS class](image)

9 Choice of profile

9.1 General recommendations for polymer profiles (adapted from IEC 60815-1)

C.E. : to provide a paragraph describing issues governing the selection of profiles especially during heavy rain.

Aerodynamic or open profiles (Figure 2) prove to be beneficial in areas where the pollution is deposited onto the insulator by wind, such as deserts, heavily polluted industrial areas or coastal areas. This type of profile is especially effective in areas that are characterised by extended dry periods. Open profiles have good self-cleaning properties and are generally acceptable in all types of environmental conditions

The use of anti fog profiles with under-ribs, (Figure 3) provide protected additional creepage.
Alternating shed arrangements (Figure 4) are in general feasible for all profiles. They offer increased creepage distance per unit with improved performance in heavy rain.

Bob Hill: expand the text on profiles to highlight advantages. Table would then be deleted.
9.2 Profile suitability

Table 2 gives simple merit values for insulator profiles. In each case the merit value of each profile for use in specific areas is given as follows:

--- Unsuitable, avoid this choice if possible
- Unsuitable, but can be used
0 No particular advantage or disadvantage
+ Suitable
++ Suitable, best choice

The choice of profiles is often not determined by pollution alone. The insulator material, design, manufacturing process or application may preclude certain profiles. Hence the optimal profile may not be available for the combination of insulator/pollution type. Therefore the choice or use of a less suitable profile is not excluded.

If an unsuitable profile is chosen, then it is recommended that the reference USCD be chosen from figure 1 towards the upper end of the SPS class or even for the next higher class, unless such a change would cause, or aggravate, deviation of the profile parameters in clause 10. If an unsuitable profile is chosen which also has a minor deviation in profile parameters, then it is recommended to treat this profile as if it has a major deviation in profile parameters (see 10).
### Table 2 – Profile suitability for polymer insulators

<table>
<thead>
<tr>
<th>Pollution area</th>
<th>Profile suitability</th>
<th>Standard profile Disc &amp; Post/Barrel</th>
<th>Open profile&lt;sup&gt;2)&lt;/sup&gt;</th>
<th>Anti-fog profile Post/Hollowcore</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desert</td>
<td>--</td>
<td>Disc</td>
<td>Post</td>
<td>Hollowcore</td>
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<tr>
<td></td>
<td>0</td>
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<tr>
<td>Coastal</td>
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<td>Industrial</td>
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<td>Agricultural</td>
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<td>0</td>
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<td>++</td>
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<tr>
<td>Inland (low pollution)</td>
<td>--</td>
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<td></td>
<td>0</td>
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<td>++</td>
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</tr>
</tbody>
</table>

**KEY**
- Type A pollution
- Type B pollution

**NOTES**
1. The table shows suitability assuming same creepage distance per unit.
2. Alternating shed arrangements are mainly categorized in open profile.
3. For the areas where rapid pollution due to typhoons or the like is anticipated, an open profile will collect more pollutants in a short period than standard or anti-fog profile, hence its suitability becomes lower.

---

### 10 Checking the profile parameters

The following profile parameters have a normal (white) range, a grey range where they can reduce performance (minor deviation) and a black range where they can have a serious effect on performance under pollution (major deviation). Each parameter shall be calculated and checked according to the following. It is allowed for one parameter to deviate into a grey area, i.e. to have a minor deviation. In the case of a minor deviation, it is recommended that the reference USCD be chosen from figure 1 towards the upper end of the SPS class or even for the next higher class, unless such a change would further aggravate the deviation. If more than one parameter is in a grey area, or any parameter in a black area, then this is considered as a major deviation and it is recommended to do one of the following:

- Consult data from service or test station experience to confirm the performance of the profile;

---

Outline for part 3: Polymer insulators
— Find an alternative profile or insulator technology;
— Verify the performance of the profile by testing (see 13).

10.1 Spacing versus shed overhang

Not applicable to cap and pin insulators or multi-shed pin insulators.

Clive: to review and propose what is acceptable for polymer.

10.2 Creepage distance versus clearance

\( d \) is the straight air distance between two points on the insulating part or between a point on the insulating part and another on a metal part.

\( l \) is the part of the creepage distance measured between the above two points.

\( l/d \) is the highest ratio found on any section, for example on the underside of a cap and pin insulator.

Clive: to review and propose what is acceptable for polymer.

10.3 Shed overhang and spacing

Not applicable to cap and pin insulators. Only for alternating sheds.

Clive and Jens: to review and propose what is acceptable for polymer. Review if Washington comment for part 2 is still applicable to part 3.

For small values of \( p_1-p_2 \) (less than 5% of the maximum shed diameter) the profile cannot be considered as being alternating.

From Washington
Outline for part 3: Polymer insulators

Define \( p_1-p_2 > 15 \text{mm} \) independently of spacing \( c \) as in existing IEC 60815:1986. Clause 10.3 will be reviewed and revised by the WG.

### 10.4 Shed angle

For rounded sheds, \( \alpha \) is measured at the mid-point.

Review shed angle in general for horizontal and vertical use. Note that 0 angle is not recommended (large shed + rain, cascading runoff) for vertical application and possibly 25 degrees and above not recommended for horizontal application.

### 10.5 Creepage factor

CF is equal to \( \frac{l}{S} \) where:

- \( l \) is the total creepage distance of the insulator
- \( S \) is the arcing distance of the insulator

For cap and pin insulators, CF is determined for a string of 5 insulators or more.

Clive and Jens; to review the ratios and minor vs major deviations for polymer. Check if other parameters (clauses 10.1-10.4) can still be respected.
11 Correction of the reference USCD

If the insulator satisfies clause 10 above, then the following corrections shall be applied to the reference USCD where applicable. All the factors are multipliers.

11.1 Correction for altitude $K_a$

The influence of altitude on impulse withstand voltages is generally much greater than on pollution withstand performance. In general, the increase in insulation length necessary for impulse voltages at higher altitudes results in more than sufficient increase in creepage distance.

NOTE – If, nevertheless, correction is required, notably for altitudes above 1 500 m where there is no previous operating experience, then correction can be used based on [1].
11.2 Correction for insulator diameter $K_{ad}$

For long rod, post and hollow core insulators correct for average diameter $D_a$ by:

- $K_{ad} = 1$ when $D_a$ is smaller than 300 mm.
- $K_{ad} = 0.001D_a + 0.7$ when $D_a$ is equal to or larger than 300 mm

Dong WU: suggest to review this aspect from experience in the field

12 Determination of the final minimum creepage distance

Once the reference USCD has been corrected according to clause 11, the final minimum creepage distance is determined for the candidate insulator by rounding up to the nearest creepage distance available for that type of insulator within the constraints (system, dimensional etc.).

Russian NC will submit example.

13 Confirmation by testing

There are no available testing methods for polymer from Cigre at the present time [4] although further work is underway. In the absence of recommended tests, tests can be agreed between utility and manufacturer.
FIGURES

**Figure 2 – Typical “standard” profiles**

Polymeric long rod, post and housing

**Figure 2 – Typical “open” profiles**

Steep polymeric long rod, housing, posts  
Under-ribs on polymeric long rod, post and housings

**Figure 3 – Typical “anti-fog” profiles**

b) Alternating Sheds on polymeric long rod, posts, housing

**Figure 4 – Typical “alternating” profiles**
Annex A
Bibliographic References

1. CIGRE Taskforce 33.04.01 – “Polluted insulators: A review of current knowledge”, CIGRE brochure N° 158-2000

2. CIGRE Taskforce C4.13.01 – Guidelines for the selection and dimensioning of insulators for outdoor applications, CIGRE brochure N° ???-2003


4. CIGRE Report 142 Natural and artificial ageing and pollution testing of polymeric insulators, WG33-04-07 june 1999