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Guide for the selection of insulators in respect of polluted conditions

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et pour les appareils électromédicaux,

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- IEC 27: *Letter symbols to be used in electrical technology;*
- IEC 417: *Graphical symbols for use on equipment. Index, survey and compilation of the single sheets;*
- IEC 617: *Graphical symbols for diagrams;*

and for medical electrical equipment,

- IEC 878: *Graphical symbols for electromedical equipment in medical practice.*

The symbols and signs contained in the present publication have either been taken from IEC 27, IEC 417, IEC 617 and/or IEC 878, or have been specifically approved for the purpose of this publication.

IEC publications prepared by the same technical committee

The attention of readers is drawn to the end pages of this publication which list the IEC publications issued by the technical committee which has prepared the present publication.

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Guide for the selection of insulators in respect of polluted conditions

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

GUIDE FOR THE SELECTION OF INSULATORS IN RESPECT OF POLLUTED CONDITIONS

FOREWORD

1) The formal decisions or agreements of the IEC on technical matters, prepared by Technical Committees on which all the National Committees having a special interest therein are represented, express, as nearly as possible, an international consensus of opinion on the subjects dealt with.

2) They have the form of recommendations for international use and they are accepted by the National Committees in that sense.

3) In order to promote international unification, the IEC expresses the wish that all National Committees should adopt the text of the IEC recommendation for their national rules in so far as national conditions will permit. Any divergence between the IEC recommendation and the corresponding national rules should, as far as possible, be clearly indicated in the latter.

PREFACE

This report has been prepared by IEC Technical Committee No. 36: Insulators.

The text of this report is based upon the following documents:

Six Months' Rule	Report on Voting	Two Months' Procedure	Report on Voting
36(CO)64	36(CO)66	36(CO)67	36(CO)68

Further information can be found in the relevant Reports on Voting indicated in the table above.

The following IEC publications are quoted in this report:

Publications Nos. 71-2 (1976): Insulation Co-ordination, Part 2: Application Guide.
273 (1979): Dimensions of Indoor and Outdoor Post Insulators and Post Insulator Units for Systems with Nominal Voltages Greater than 1 000 V.
305 (1978): Characteristics of String Insulator Units of the Cap and Pin Type.
433 (1980): Characteristics of String Insulator Units of the Long Rod Type.
507 (1975): Artificial Pollution Tests on High-voltage Insulators to be Used on A.C. Systems.
720 (1981): Characteristics of Line Post Insulators.

GUIDE FOR THE SELECTION OF INSULATORS IN RESPECT OF POLLUTED CONDITIONS

1. Scope

This guide is mainly applicable to three-phase systems up to 525 kV (phase-to-phase). For higher voltages the possible non-linear performance of insulators is still under study.

This guide is applicable to outdoor ceramic and glass insulators, used in a.c. systems, of the following types:
- long-rod and traction line insulator;
- cap and pin insulator;
- pedestal type post and rigid pin insulator;
- substation and line post insulator;
- hollow insulator;
- bushing.

This guide cannot directly be used for special types of insulators such as insulators with conductive glaze, or covered, during the manufacturing, with any insulating material, for surge arresters and also for longitudinal insulation for open circuit-breakers. This guide does not deal with radio interference voltage, television interference voltage and audible noise, the intensity of which may be increased on some polluted insulators.

2. Object

The performance of insulators in polluted conditions has been the subject of many studies that permit the specification of the required insulation when the site pollution is known, or by experience of insulator performance in the same region which has been operating at the same or at a different system voltage. The approach based on laboratory simulation of natural pollution consists consequently of the following steps:

1) evaluation of type and severity of the pollution at the site;
2) specification of a laboratory test as representative of the pollution of the site as possible (in particular, see I E C Publication 507: Artificial Pollution Tests on High-voltage Insulators to be Used on A.C. Systems);
3) selection of insulators which would show a good behaviour under this test.

This method of selection and specification of the required insulation should be adopted whenever circumstances permit.

Obviously, this approach has some limitations, for instance, when a natural site cannot be represented in a satisfactory way by an artificial pollution test in the laboratory.

The aim of the present guide is to give, on the basis of the experience in service and numerous test results in naturally and artificially polluted conditions, *simple general rules that should assist in choosing the insulator which should give satisfactory performance under polluted conditions.*

These rules are essentially based upon *minimum creepage distance* requirements associated with a few other geometrical parameters, which generally do not limit the design of the insulator itself. They provide an easily accomplished way to choose insulators based on the predicted severity of the site where these insulators are to be installed. The above requirements are based on insulators having an acceptable risk of flashover when operating under such polluted conditions.

Note. — Suitable testing carried out in the laboratory or direct experience obtained in natural conditions may allow the minimum creepage distances specified in this guide to be reduced (for instance, for insulators specially designed for polluted conditions).

This guide describes the method of insulator selection by:

- evaluating qualitatively the severity of the pollution of the site (see Clause 4, Table I and Appendix A);
- choosing insulator dimensions with regard to the specific nominal creepage distance (Table II) within the limits stated in Clause 5.

In special cases, washing or greasing of insulators can be used (see Appendix B).

The guide also indicates, by way of information:

- different methods for measuring the pollution severity that make it possible to check, or to know with greater accuracy, the actual pollution severity of a site, while bearing in mind that valid information often calls for several years of measurements (see Clause 7);
- relations between pollution levels and artificial pollution tests (see Appendix C).

3. Pollution severity levels

For the purposes of standardization, four levels of pollution are qualitatively defined, from light pollution to very heavy pollution.

Table I gives, for each level of pollution, an approximate description of some typical corresponding environments. Other extreme environmental conditions exist which merit further consideration, e.g. snow and ice in heavy pollution, heavy rain, arid areas.

Note. — This table is intended to replace Table I of I E C Publication 71-2 : Insulation Coordination, Part 2 : Application Guide.

TABLE I

Pollution level	Examples of typical environments
I - Light	— Areas without industries and with low density of houses equipped with heating plants — Areas with low density of industries or houses but subjected to frequent winds and/or rainfall — Agricultural areas [1] — Mountainous areas All these areas shall be situated at least 10 km to 20 km from the sea and shall not be exposed to winds directly from the sea [2]
II - Medium	— Areas with industries not producing particularly polluting smoke and/or with average density of houses equipped with heating plants — Areas with high density of houses and/or industries but subjected to frequent winds and/or rainfall — Areas exposed to wind from the sea but not too close to the coast (at least several kilometres distant) [2]
III - Heavy	— Areas with high density of industries and suburbs of large cities with high density of heating plants producing pollution — Areas close to the sea or in any case exposed to relatively strong winds from the sea [2]
IV - Very heavy	— Areas generally of moderate extent, subjected to conductive dusts and to industrial smoke producing particularly thick conductive deposits — Areas generally of moderate extent, very close to the coast and exposed to sea-spray or to very strong and polluting winds from the sea — Desert areas, characterized by no rain for long periods, exposed to strong winds carrying sand and salt, and subjected to regular condensation

[1] Use of fertilizers by spraying, or the burning of crop residues, can lead to a higher pollution level due to dispersal by wind.

[2] Distances from sea coast depend on the topography of the coastal area and on the extreme wind conditions.

4. Relation between the pollution level and the specific creepage distance

For each level of pollution described in Table I, the corresponding minimum nominal specific creepage distance, in millimetres per kilovolt (phase-to-phase) of the highest voltage for equipment is given in Table II. This table is intended to replace Table II of IEC Publication 71-2.

Experience has shown that the criterion of "minimum specific creepage distance", which implies linearity under pollution between withstand voltage and creepage distance, applies to most insulators used on existing systems.

Some insulators specially shaped for particular kinds of pollution may not satisfy these conditions even though they perform satisfactorily in service.

TABLE II

Pollution level	Minimum nominal specific creepage distance [1] (mm/kV [2])
I - Light	16
II - Medium	20
III - Heavy	25
IV - Very heavy	31

[1] For the actual creepage distance, the specified manufacturing tolerances are applicable (see IEC Publication 273: Dimensions of Indoor and Outdoor Post Insulators and Post Insulator Units for Systems with Nominal Voltages Greater than 1 000 V, IEC Publication 305: Characteristics of String Insulator Units of the Cap and Pin Type, IEC Publication 433: Characteristics of String Insulator Units of the Long Rod Type, and IEC Publication 720: Characteristics of Line Post Insulators).

[2] Ratio of the leakage distance measured between phase and earth over the r.m.s. phase to phase value of the highest voltage for the equipment (see IEC Publication 71-1).

Notes 1. — In very lightly polluted areas, specific nominal creepage distances lower than 16 mm/kV can be used depending on service experience. 12 mm/kV seems to be a lower limit.

2. — In the case of exceptional pollution severity, a specific nominal creepage distance of 31 mm/kV may not be adequate. Depending on service experience and/or on laboratory test results, a higher value of specific creepage distance can be used, but in some instances the practicability of washing or greasing (see Appendix B) may have to be considered.

5. Application of the "specific creepage distance" concept

In order to successfully apply the "specific creepage distance" concept, certain dimensional parameters characterizing the insulator shall be taken into account.

These parameters, based on service experience and on laboratory tests, mainly relate to the shed shape or to the profile of the insulator, but also to the diameter and the position in service of the insulator.

The following parameters are not intended to limit the future development of insulator design. They simply recommend certain limits (indicated in Appendix D) which must be interpreted flexibly in order to provide a high probability of satisfactory performance in service.

Based on past experience the important parameters which have to be taken into account are:

5.1 *Parameters characterizing the profile* (see Appendix D)

The profile of an insulator is characterized by the following parameters:
- minimum distance, c, between sheds;
- ratio s/p between spacing and shed overhang;
- ratio l_d/d between creepage distance and clearance;
- alternating sheds (see Figures 2, page 19 and D3b, page 37);
- inclination of sheds;
- parameters characterizing the entire insulator:
  - creepage factor C.F.
  - profile factor P.F.

Appendix D gives the definition of these parameters and an indication of their value.

5.2 *Influence of the position of insulators*

There is normally some change in the pollution performance of insulators designed for use in the vertical position when they are used in an inclined or horizontal position. Generally the change is for an improvement in performance, but in certain cases a reduction may result, due for example to the cascade effect of heavy rain.

Unless specific data showing significantly improved performance is available, any change in performance due to position should be neglected.

Note. — If insulators are designed for use in an inclined or horizontal position, the performance under polluted conditions can be checked by laboratory or field tests in the position for which they are designed.

5.3 *Influence of the diameter*

Various laboratory tests appear to indicate that the pollution performance of post insulators and hollow insulators decreases with increasing average diameter.

The following values for k_D are proposed, k_D being a factor to increase the creepage distance with average diameter D_m in millimetres.
- average diameter $D_m < 300$ mm: $k_D = 1$
- $300 \leqslant D_m \leqslant 500$ mm: $k_D = 1.1$
- $D_m > 500$ mm: $k_D = 1.2$

However, these values may differ according to the origin of different results (field results or laboratory tests). This factor should therefore be used with caution.

For a given profile, the average diameter D_m is given by:

$$D_m = \frac{\int_0^{l_t} D(l)\,\mathrm{d}l}{l_t}$$

where:

l_t is the total creepage distance of the insulator

$D(l)$ is the value of the diameter at a creepage distance l, measured from one electrode

The above formula may be approximated in general by the following simple relations:

1) regular sheds $D_m = \frac{D_e + D_i}{2}$ (Figure 1, page 19),

2) alternating sheds $D_m = \frac{D_{e1} + D_{e2} + 2D_i}{4}$ (Figure 2, page 19).

6. Determination of the creepage distance

The minimum nominal creepage distance of an insulator situated between phase and earth is determined, according to the pollution level of the site, by the relation:

minimum nominal creepage distance = minimum specific creepage distance (Table II) × highest system voltage phase-to-phase for the equipment × k_D

where:

k_D is the correction factor due to diameter (see Sub-clause 5.3)

If insulators are to be used between phases (phase-spacers for instance), the creepage distance should be multiplied by $\sqrt{3}$ (for a three-phase system).

7. Evaluation of pollution severity

The application of this guide is directly related to the knowledge of the pollution severity of the site where the insulators are to be installed.

The evaluation of the pollution severity can be made with an increasing degree of confidence:

- qualitatively from indications given in Table I,
- from information on the behaviour of insulators from lines and substations already in service on that site (see Appendix A), for evaluation by experts in this field,
- from measurements *in situ*.

For measurements *in situ*, different methods are generally used. They are:

1) volume conductivity for the pollutant collected by means of directional gauges;
2) Equivalent Salt Deposit Density on the insulator surface (ESDD method);
3) total number of flashovers of insulator strings of various lengths;
4) surface conductance of sample insulators;
5) leakage current of insulators subjected to service voltage (highest current values during subsequent time intervals, I_H).

The first two methods do not require expensive equipment and can be easily performed. The volume conductivity method gives no direct information by itself on the frequency and on the severity of the contamination events on a natural site. The ESDD method characterizes the pollution severity of the site. Information on wetting shall be separately obtained.

The accuracy of these methods depends upon the frequency of measurement. However, for the ESDD method, an automatic measuring system has been developed and therefore pollution severity can be measured continuously, in order to find, for example, the suitable timing of washing.

The method based on total flashovers needs expensive test facilities. Reliable information can be obtained only for insulators having a length close to the actual length and flashing over at a voltage near the operating voltage.

The last two methods which need a power source and special recording equipment have the advantage that the effects of pollution are continuously monitored. These techniques have been developed for assessing the pollution rate and the results, when related to test data, are used to indicate that the pollution is still at a level known to be safe for operational service or whether washing or re-greasing is required.

Note. — For more information on these different methods see "Electra" No. 64 - May 1979, page 101 and the following.

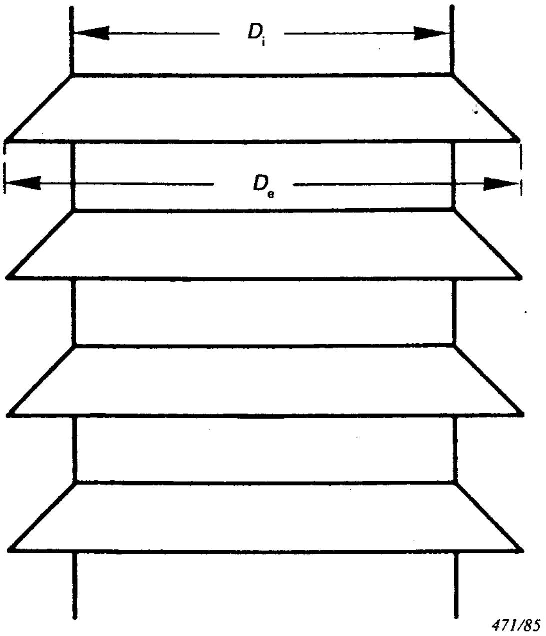

FIG. 1. — Regular sheds.

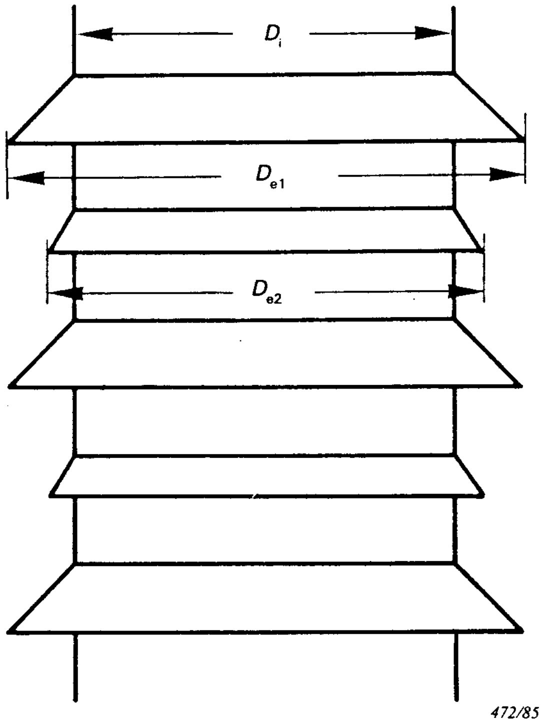

FIG. 2. — Alternating sheds.

APPENDIX A

EXAMPLE OF A QUESTIONNAIRE TO COLLECT INFORMATION ON THE BEHAVIOUR OF INSULATORS IN POLLUTED AREAS

Company:	Country:
Identification of project and/or location: Line or substation:	
Person to consult for complementary information, address, telex, telephone:	

A1. General information

— Nominal voltage of the system and highest voltage for equipment

— Date of construction
— Type of system
— Maintenance (not involving changes of insulator)

— Date of energizing
— Cleaning — yes or no — frequency...
— Washing — yes or no — frequency...
— Greasing — yes or no — frequency...

— *For overhead lines*
— Type of tower (sketch)
— Number of circuit
— Ground clearance of string
— Type of insulator sets
— Insulator protective fittings

— *For substations*
— Type of apparatus:
  - circuit-breaker
  - disconnector
  - instrument transformer
  - lightning arrester
  - bus-bar insulator
— Clearance between base of insulator and ground

A2. Information on the site

— Map of areas crossed and routing of the line
— For polluted areas only, the different climatic zones crossed by the line (mark them on the map)
— For substations, place, orientation and altitude

A3. Information on weather conditions

— Type of climate: temperate, tropical, equatorial, continental...
— Time without rainfall, in months
— Annual rainfall, in millimetres
— Dominant wind: direction, average speed in kilometres per hour
— Dew: sometimes, often, never
— Fog: sometimes, often, never

A4. Information on pollution

For example:

- Seaborne pollution (high percentage of salt) — small amount of insoluble matter
- Saline pollution other than coastal — small amount of solids
- Sand-based pollution or ground dust (e.g. desert...)
- Industrial pollution with large amounts of solid deposits (except cement)
- Industrial pollution with large amounts of cement
- Chemical industrial pollution (gas, smoke...)
- Mixed pollution (indicate in this case the main components, for example for coastal cement factories)
- ...

A5. Data on insulation

- *For overhead lines*
- Position of string
  - vertical (suspension)
  - horizontal (tension)
  - angle (in degrees)
- Number of units per string
- Type of insulator (drawing)
- Spacing
- Creepage distance of unit

- *For substations*
- Type of insulator
  - post insulator (solid core)
  - pedestal insulator
  - bushing
  - hollow insulator
- Profile and spacing of shed (give details)
- Total creepage distance

- Indicate any modification in the initial insulation

A6. Schedule of incidents

- Date and time
- Situation of the tower (for line) and place of apparatus in substation
- Critical meteorological conditions at the moment of incidents:
  - relative humidity
  - rain
  - drizzle
  - fog
  - temperature
  - storm
  - wind (direction, speed)
  - time between last rainfall and incident
  - other
- Type of incident:
  - flashover
  - heavy corrosion of metal parts
  - punctured dielectric
  - visible damage to dielectric
  - erosion or tracking
- For a string of insulators, place of damaged units in the string
- Comments of the incident indicating any special circumstances.

APPENDIX B

GREASING AND WASHING

In exceptional cases, pollution problems cannot be solved economically by a good choice of the insulator. For instance, in areas having very severe contamination or low annual rainfall, insulator maintenance may be required. This can also occur when the environment of an already built substation (or line) changes due to new polluting industries.

Maintenance normally takes one or more of the following forms:

- periodic hand wiping on de-energized installation or dry cleaning either energized or de-energized;
- periodic coating with grease compounds;
- periodic washing, either energized or de-energized.

a) Greasing

Grease compounds used for coating insulators are mainly silicone products or hydrocarbons. The thickness of the applied layer of grease depends on the type of grease and on the degree of pollution; generally, for the silicone based compounds it is about 1 mm and for hydrocarbon compounds can reach some millimetres.

This type of application requires regular maintenance for removing the grease and recoating and is expensive. It should be pointed out that the greased insulators lose most of their properties of self-cleaning through the rain or through the wind and that under certain conditions of heavy pollution the grease can damage the ceramic or the glass.

The frequency of cleaning and regreasing ranges from some months to some years, depending upon the degree of contamination and the weather conditions. An optimization of these operations shall be reached by a check of the conditions of the grease, taking into account the accumulation rate of the pollution content in the grease and the ageing of the grease itself.

b) Washing

There are two main methods for the washing of insulators to remove pollution:

- by fixed sprays;
- by using a manually controlled portable jet.

The frequency of washing should be such as to avoid significant accumulation of pollution. Thus the objective is to keep the insulators in as clean a condition as possible.

Insulator washing with fixed, automatic sprays is an effective and reliable method of combating pollution, particularly when the deposit rate is high. This technique has high capital cost and low running cost.

Portable jet washing equipment operates under the direct control of suitably trained persons and can be used at more than one site. It has low capital cost and high running cost. Some safety precautions are necessary.

Both systems require:

a) a stored supply of water of adequate capacity and suitable low conductivity. Town mains water may be suitable for washing in some cases;

b) special nozzles to ensure that the wash water breaks into droplets;

c) precautions to reduce the risk of water being blown onto unwashed insulators by strong winds.

Where the pollution deposit rate is high, a pollution detector is desirable to initiate fixed washing or to call for a manual wash.

The effectiveness of washing is dependent on the design of the insulators, particularly the shape and spacing of sheds. In general, insulators of good pollution performance will wash well, particularly if the shed profile has good aerodynamic qualities.

Note. — For lightning arresters with internal gaps, special care should be taken to avoid flashover or explosion during washing.

ANNEXE C

RELATION ENTRE NIVEAUX DE POLLUTION ET ESSAIS SOUS POLLUTION ARTIFICIELLE

Ces relations entre niveaux de pollution et essais sous pollution artificielle sur certains isolateurs à capot et tige et à fût long sont données seulement à titre d'exemples et ne peuvent être prises en compte pour des essais de type sur les isolateurs de ligne. Ces valeurs ne peuvent en aucun cas être interprétées comme des exigences de tenue pour les isolateurs de postes et pour les enveloppes isolantes.

Le tableau III donne, pour chaque niveau de pollution, la gamme des valeurs qui ont été obtenues lors de certains essais de pollution artificielle effectués conformément aux procédés d'essai décrits dans la Publication 507 de la CEI (1975).

Note. – Ces procédés d'essai sont en cours de modification dans la révision actuelle de la Publication 507 de la CEI, surtout ceux des méthodes par couche solide. Cela pourra faire aboutir à des valeurs différentes de celles qui sont indiquées.

TABLEAU III

Ligne de fuite spécifique (voir colonne 2, tableau II) (mm/kV)	Essais de pollution artificielle Valeurs de sévérité tenues sous tension phase-terre		
	Méthode du brouillard salin (kg/m³)	Méthode de la couche solide	
		D. D. S. *) (mg/cm²)	Conductivité de la couche (µS)
16	5 à 14	0,03 à 0,06	15 à 20
20	14 à 40	0,10 à 0,20	24 à 35
25	40 à 112	0,30 à 0,60	36
31	>160	–	–

*) D. D. S. = Densité du dépôt de sel.

APPENDIX C

RELATION BETWEEN POLLUTION LEVELS AND ARTIFICIAL POLLUTION TESTS

These relations between pollution levels and artificial pollution tests on particular cap and pin and long-rod insulators are given only as examples, and cannot be used for type tests on line insulators. Neither should the given withstand severity be interpreted as a specification for post insulators and hollow insulators.

Table III gives for each pollution level the range of values which were obtained in some artificial pollution tests performed according to the test procedures described in IEC Publication 507 (1975).

Note. — The test procedures are being modified in the current revision of IEC Publication 507, especially those of the solid-layer methods. This may lead to values different from those given.

TABLE III

Specific creepage distance (see column 2, Table II) (mm/kV)	Artificial pollution tests Severity withstand values at the phase-to-earth voltage		
	Salt fog method (kg/m³)	Solid-layer methods	
		S. D. D.*) (mg/cm²)	Layer conductivity (μS)
16	5 to 14	0.03 to 0.06	15 to 20
20	14 to 40	0.10 to 0.20	24 to 35
25	40 to 112	0.30 to 0.60	36
31	>160	—	—

*) S. D. D. = Salt Deposit Density.

APPENDIX D

PARAMETERS CHARACTERIZING THE INSULATOR PROFILE

These parameters are related to insulators installed in a vertical position. For other positions, see Sub-clause 5.2.

D1. Minimum distance *c* between sheds

c is the minimum distance between adjacent sheds of the same diameter, measured by drawing a perpendicular from the lowest point of the outer rib of the upper shed to the shed below of the same diameter (Figure D1, page 36).

This distance is important in rainfall conditions to avoid bridging between two successive sheds. According to present knowledge, a value of *c* in the order of 30 mm or more fulfils this requirement.

For insulators having an overall length less than or equal to 550 mm, or for insulators with small shed overhang *p* (see Clause D2) ($p \leqslant 40$ mm) a value of *c* in the order of 20 mm is acceptable.

Notes 1. — *c* is not applicable to pedestal-type post and pin-type insulators.

2. — For insulators with alternate sheds, see Clause D4.

D2. Ratio *s/p* between spacing and shed overhang

The ratio *s/p* describes the limitation on providing arbitrarily too high a leakage distance by either overdimensioning the shed overhang *p* or by unjustifiably increasing the number of sheds. The ratio is important for self-cleaning properties of insulators.

s/p should be equal to or greater than 0.8. Field experience shows that this value can be reduced to 0.65 in the case of plain sheds (without ribs).

s is the vertical distance between two similar points of successive sheds (spacing).

p is the maximum shed overhang (i.e. *p* in Figures D3a and D3d, pages 37 and 38, p_1 in Figure D3b, page 37 and p_2 in Figure D3c, page 38).

D3. Ratio l_d/d between creepage distance and clearance

The ratio l_d/d describes the use of the creepage distance in order to avoid local short-circuiting and should be lower than 5. This ratio should be checked for the " worst case " on any section, for example, of the underside of an anti-fog insulator profile.

d is the straight air distance measured between two points situated on the insulating part or between any point located on the insulating part and the other on a metal part.

l_d is the part of the creepage path measured between the above two points.

D4. Alternating sheds (see Figure D3b)

The difference ($p_1 - p_2$) between two consecutive shed overhangs is important in rain conditions to avoid bridging between them.

p_1 is the shed overhang of the larger shed;

p_2 is the shed overhang of the smaller shed.

This difference ($p_1 - p_2$) should be in general greater than or equal to 15 mm.

D5. Inclination of sheds

The inclination of sheds is important for the self-cleaning properties. For the top of the shed, the minimum inclination of the shed (α) should be greater than 5° (see Figure D2, page 36).

No minimum angle is specified for the bottom part of the shed. However, if this bottom part is without ribs, a minimum inclination of 2° is advisable.

D6. Parameters characterizing the entire insulator

The insulators, as far as their performance under pollution is concerned, can be designed in different manners. When the pollution severity increases, a solution to satisfy the specific creepage concept is obviously to increase the length of the insulator while keeping the same shed profile.

Note. — When clean string insulator units are added to or replaced in a polluted insulator string, the complete string shall be cleaned before the line is re-energized.

However, this solution cannot be applied or may not be economical when the pollution severity is too high. Therefore it is possible to design insulators having different profiles suitable for the specified pollution severity.

The different parameters given above characterize local parts of a profile, but it is still necessary to characterize the entire insulator by the creepage factor (C.F.) and by the profile factor (P.F.). These two factors depend on the pollution severity.

C.F. has a theoretical and scientific meaning, while P.F. is an empirical quantity derived from experience. C.F. can be used to characterize the profile of all types of insulators, whereas P.F. is not applicable to cap and pin insulators (see Figure D3c, page 38) and pedestal post insulators (see Figure D3e, page 39).

D6.1 *Creepage factor C.F.*

The creepage factor, C.F., is equal to $\frac{l_t}{S_t}$

where:

l_t is the total creepage distance of an insulator, and

S_t is the arcing distance, which is the shortest distance in air, outside the insulator, not considering arcing horns, between the metallic parts to which the voltage is normally applied

It is advisable to keep:

C.F. $\leq$ 3.50 for pollution levels I and II,

C.F. $\leq$ 4 for pollution levels III and IV.

Note. — If an insulator has a profile with a C.F. higher than the limit value recommended, the insulator profile may be used if experience in operation, or a laboratory test reproducing operation conditions, permits the assumption of good performance.

D6.2 *Facteur de profil P.F.*

Le P.F. est défini comme étant le rapport entre la ligne de fuite simplifiée et la ligne de fuite réelle d'un isolateur, mesurée entre les deux points qui définissent le pas *s*.

La ligne de fuite simplifiée est la somme de :

$2p + s$ pour les isolateurs des figures D3a et D3d, pages 37 et 38,

$2p_1 + 2p_2 + s$ pour les isolateurs de la figure D3b, page 37,

p, p_1, p_2 et s ayant les définitions déjà données et indiquées sur les figures D3.

P.F. est alors égal à :

$$\frac{2p + s}{l}$$ pour les isolateurs des figures D3a et D3d

$$\frac{2p_1 + 2p_2 + s}{l}$$ pour les isolateurs de la figure D3b

l étant la longueur de la partie de fuite mesurée entre les deux points qui définissent *s*.

Il est conseillé de garder :

P.F. supérieur à 0,8 pour les niveaux de pollution I et II,

P.F. supérieur à 0,7 pour les niveaux de pollution III et IV.

Note. — Si un isolateur a un P.F. inférieur à la valeur recommandée, ce profil d'isolateur peut être utilisé à condition que l'expérience en exploitation, ou un essai en laboratoire reproduisant les conditions d'exploitation, ait permis d'en présumer le bon comportement.

Remarque. — La partie protégée du profil (longueur de fuite protégée) ne doit pas, en principe, être spécifiée comme paramètre caractérisant le profil d'ailette.

En effet, aucune règle générale ne peut être quantifiée parce que la proportion dans laquelle un profil d'ailette est « ouvert » ou « protégé » dépend principalement :
- des conditions de contamination des différents sites,
- de la condition prédominante d'autonettoyage,
- de la position de l'isolateur (angle d'inclinaison).

Par exemple, pour des isolateurs utilisés en position verticale dans une région exposée à des tempêtes salées et à des pluies fréquentes et intenses, les profils « protégés » (profils comportant soit des nervures soit des ailettes simples à forte inclinaison) se sont avérés efficaces.

Par contre, pour les isolateurs utilisés dans une région où les pluies ou les polluants atmosphériques sont rares ou de faible intensité, les profils « ouverts » (ou aérodynamiques) semblent montrer de bonnes performances. Dans de tels cas, la ligne de fuite des isolateurs ayant des ondulations protégées peut être rendue inutile car elle peut être remplie par les dépôts polluants.

D6.2 *Profile factor P.F.*

The P.F. is defined as the ratio of the simplified leakage distance to the actual insulating creepage distance measured between the two points which define the spacing s.

The simplified leakage distance is the sum of:

$2p + s$ for insulators in Figures D3a and D3d, pages 37 and 38,

$2p_1 + 2p_2 + s$ for insulators in Figure D3b, page 37,

p, p_1, p_2 and s having the definitions given above and shown in Figures D3.

Thus, P.F. is equal to:

$$\frac{2p + s}{l} \text{ for insulators in Figures D3a and D3d}$$

$$\frac{2p_1 + 2p_2 + s}{l} \text{ for insulators in Figure D3b}$$

l being the creepage distance of the insulated leakage path measured between the two points which define s.

It is advisable to keep:

P.F. above 0.8 for pollution levels I and II,

P.F. above 0.7 for pollution levels III and IV.

Note. — If an insulator has a profile with a P.F. lower than the limit value recommended, the insulator profile may be used if, experience in operation, or a laboratory test reproducing operation conditions, permits assumption of good performance.

General note. — The protected part of the profile (protected creepage distance) should not be specified as a parameter characterizing a shed profile.

In effect, no general rules can be quantified because the degree to which a shed profile is " open " or " protected " depends mainly on:

- the different site conditions of contamination,
- the prevailing self-cleaning conditions,
- the position of the insulator (angle of inclination).

For example, for insulators used in vertical position in an area exposed to salt storms and frequent and intensive rain, " protected " profiles (either profiles with underribs or plain sheds of steep inclination) have proved to be useful.

On the other hand, for insulators used in an area with rare or low intensity rain or airborne contaminants, " open " (or aerodynamic) profiles seem to show good performance. In such cases, the creepage distance of underribs can be put out of action by being filled with contaminants.

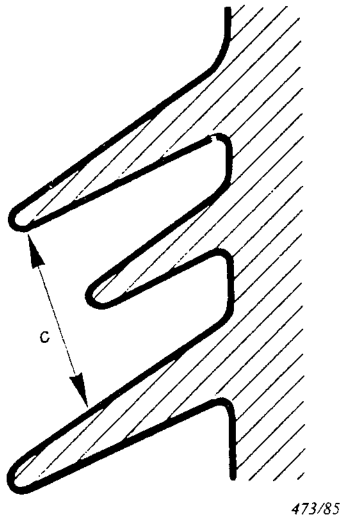

FIG. D1. – Distance minimale c entre deux ailettes.
Minimum distance c between sheds.

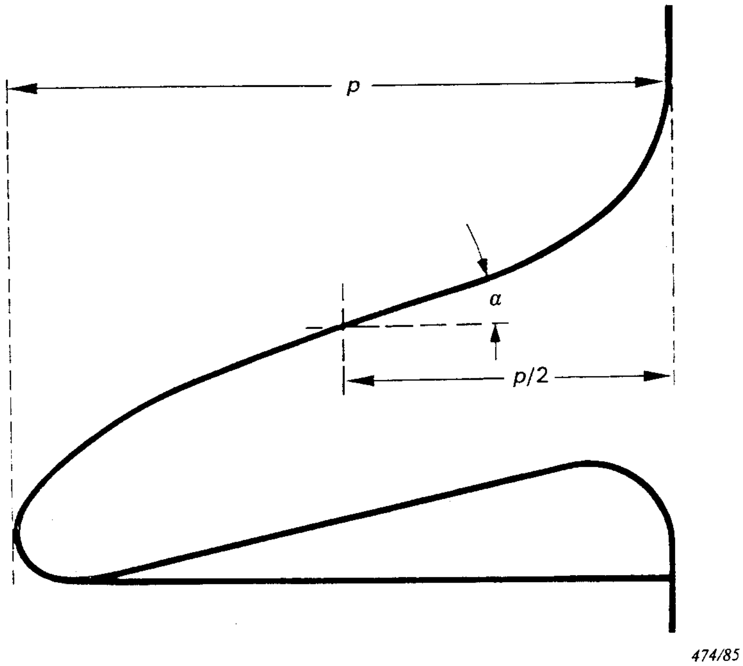

FIG. D2. – Inclinaison des ailettes.
Inclination of sheds.

Ces profils ne sont donnés qu'à titre indicatif.

The profiles are only indicative.

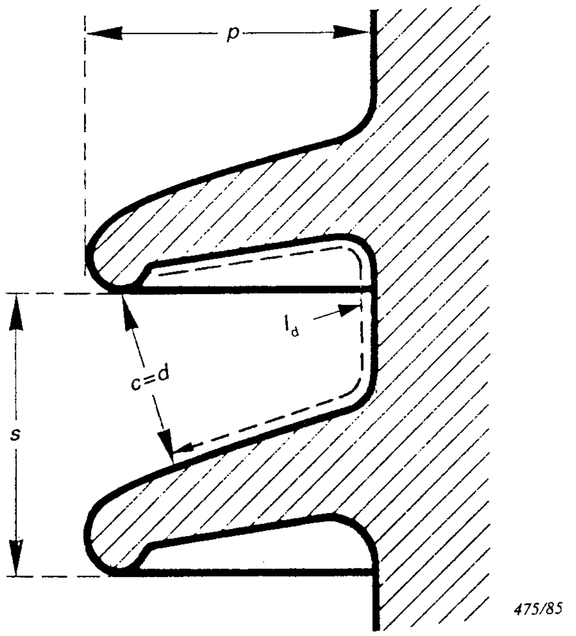

FIG. D3a. — Ailettes normales.
Normal sheds.

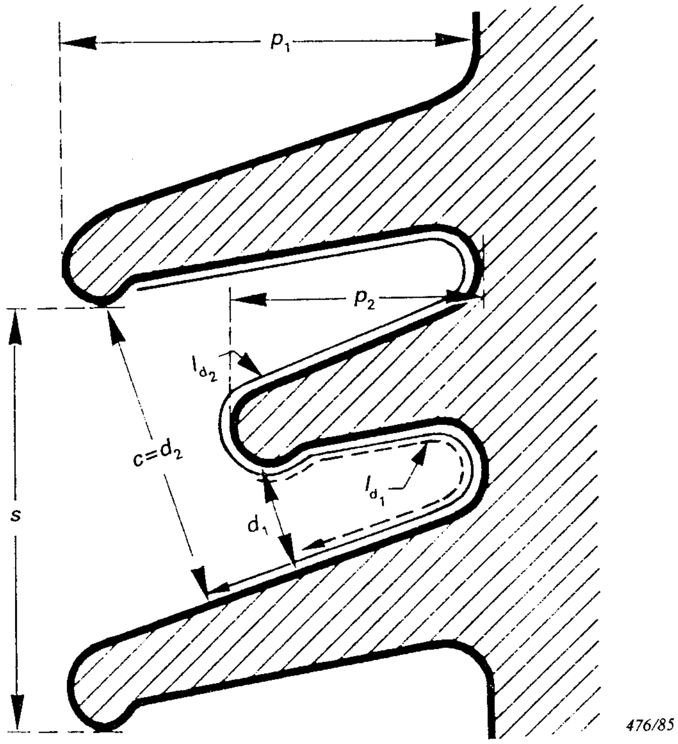

FIG. D3b. — Ailettes alternées.
Alternating sheds.

Ces profils ne sont donnés qu'à titre indicatif.

The profiles are only indicative.

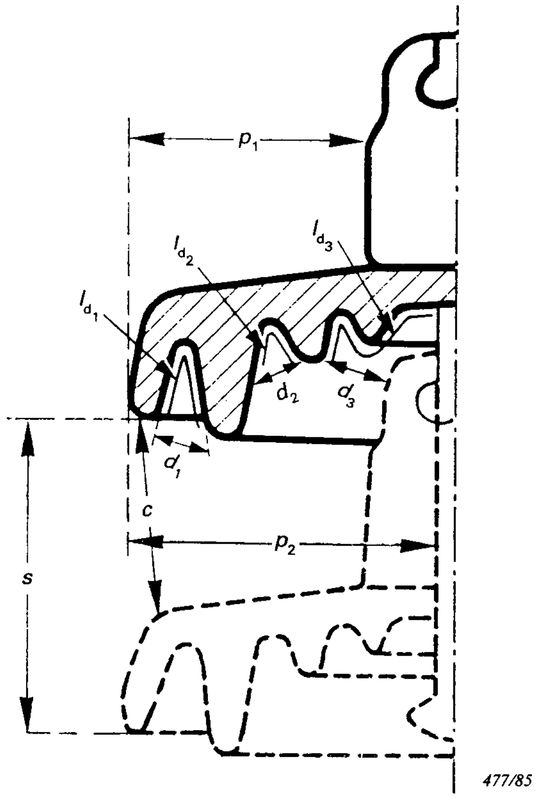

FIG. D3c. — Isolateur à capot et tige.
Cap and pin insulator.

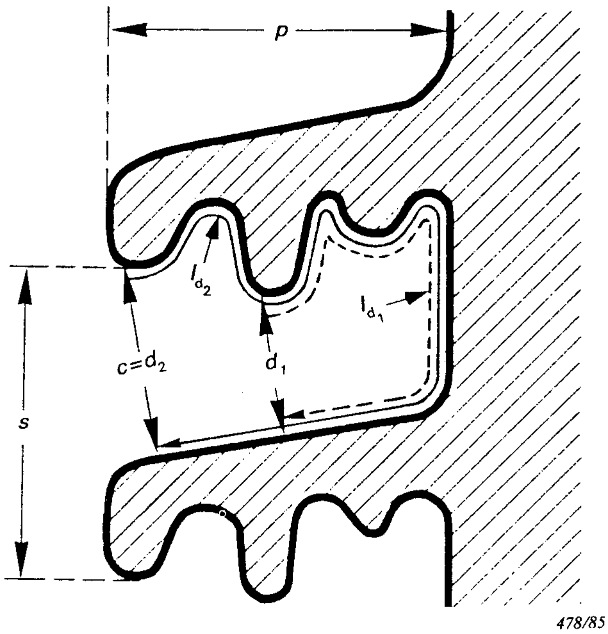

FIG. D3d. — Ailettes à ondulations.
Underrib sheds.

Ces profils ne sont donnés qu'à titre indicatif.

The profiles are only indicative.

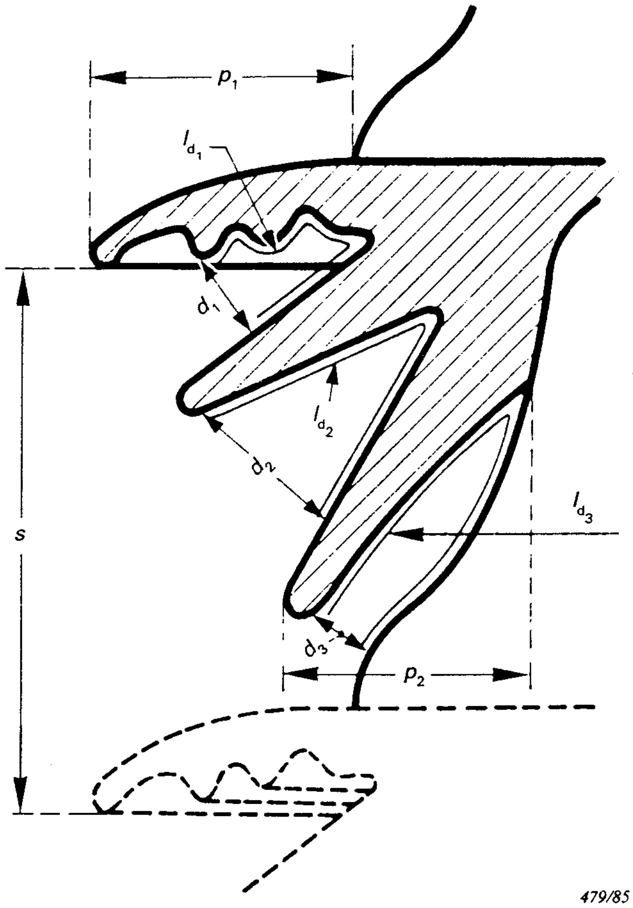

FIG. D3e. — Support isolant à capot et embase.
Pedestal type post insulator.

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