5.0 Insulator Characteristics

An insulator’s total function is characterised by material and design. Primarily, the core is supplying distance between electrodes to prevent direct flashover, a combination of dielectric and mechanical support. Secondarily, the outside surface is supplying high enough resistance to prevent flashover derived from leakage currents when the insulator is covered with a contamination layer. This chapter concerns the outside surface in outdoor environment i.e. pollution performance. Choice of surface material, supplementary surface attributes, dimensions and design characterise the function. Restrictions include high demands on durability and limitations of manufacturing processes.

5.1 Materials

<table>
<thead>
<tr>
<th>Material</th>
<th>Purpose</th>
<th>Remarks</th>
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<tbody>
<tr>
<td>Traditional porcelain</td>
<td>All types of insulators with limited demand for strength and optimised design</td>
<td>Cristobalite porcelain has good strength but prone to internal tensions. IEC 60672: C110 Insulators are furnished with big metal parts to give the mechanical strength which results in very heavy structures</td>
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<tr>
<td>Glass</td>
<td>Cap &amp; pin and post insulators.</td>
<td>An uncomplicated method to make cap and pin discs</td>
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<tr>
<td>Contemporary porcelain</td>
<td>All types of insulators and is suitable to supply advanced functions.</td>
<td>High strength aluminous porcelain IEC 60672: C 120-C130. Redesign of traditional types gives improved insulator performance. Design is flexible due to strong and homogenous material in combination with CAD/CAM support. Modern production technologies can be used. A much lighter structure occupying less weight and space is the result</td>
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<tr>
<td>Porcelain with semiconducting glaze</td>
<td>Gives an even field distribution and a slight over temperature to the surface of an insulator.</td>
<td>The glaze contains crystals to give a controlled conductivity through the glaze This keeps the surface dry and prevents flash over also in bad environment</td>
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<tr>
<td>Porcelain with hydrophobic coating</td>
<td>Normally a RTV-type silicone rubber compound or silicone grease</td>
<td>Gives a water repellent surface to the porcelain in combination with lower thermal conductivity that minimises dew formation. In this way an unbroken water film on the insulator is avoided.</td>
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</table>
Non ceramic, Composites, Polymers. | Most used for long rod insulators. Hollow and post insulators are also available | The materials are not standardised. Consists of an insulating core, bearing the mechanical load and protected by a polymer housing. The load being transmitted to the core by metal fittings. Composite insulators give a lighter structure than porcelain. The housing and sheds can be of hydrophobic material.

| Non Ceramic housing material | To protect the glass fibre core and to give a good surface to protect against leakage current | Different housing materials have very different properties. EPDM and Silicones are mostly used. Filler materials and additives are used to provide different features as durability, hydrophobicity and resistance to fungus, pests and birds. Silicone normally keeps hydrophobicity differently in different atmospheres. EPDM loses hydrophobicity quickly and is badly hurt by flashovers.

| Hybrids | Porcelain core and polymer housing. Can be used for different types of insulators. | They are considered to be of great potential by combining the best features from different materials and technologies, but has not yet made any major impact. They are not common in service.

5.2 Design

Insulator design is dependent of production methods and the performance required for the insulator. Traditional porcelain insulators (TPI) as cap & pin types had a complicated wide undercut shed. This was necessary because big metal parts took a lot of space. Big undercut sheds were also dominant on early bushings made with the jollying technique where sheds were jointed together. Contemporary porcelain insulators (CPI) are turned in one piece and it is possible to make differently designed sheds on one product. A higher amount of small sheds is better from cost and performance point of view than a smaller number of big sheds. Post insulators, can be produced stronger and stiffer and electrically better as they have smaller diameters and shed design is more flexible. Non ceramic insulators (NCI) have a very limited range of design flexibility depending on tool demanding production.

Creepage distance and form factor

Creepage distance is the established method to calculate distance necessary to avoid flashover. However a better way is to determine the resistance for the entire surface of the insulator using the form factor or K-value, as described in IEC 507. With computer technique it is possible to work with this parameter as the optimum base for design of insulators. Apart from the form factor or creepage distance there are some limits for how to design sheds for better pollution performance. The most important parameters are as follows:
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.
This distance is important in rainfall conditions to avoid bridging between two successive sheds.
$c$ is not applicable to pedestal-type post and pin-type insulators.

![Diagram of shed arrangement]

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 selfcleaning properties of insulators.
$s$ is the vertical distance between two similar points of successive sheds (spacing)
$p$ is the maximum shed overhang

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. This ratio should be checked for the worst case on any section, for example, of the under side of an antifog 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.
Alternating sheds
The difference (p₁-p₂) between two consecutive shed overhangs is important in rain conditions to avoid bridging between them.

p₁ is the shed overhang of the longer shed.
p₂ is the shed overhang of the smaller shed.

Inclination of sheds
The inclination of sheds (α) is important for the selfcleaning properties

Creepage factor
The creepage factor C.F. is used to characterise the entire insulator. C. F = l/s where l is the total creepage distance and s is the arcing distance, which is the shortest distance in air, outside the insulator, not considering arcing horns, between metallic parts to which the voltage is normally applied

Position
All given factors are given for insulators in vertical position. Generally the change to inclined or horizontal position is improving the performance, but in certain cases a reduction may result due to for example the cascade effect of heavy rain or uneven wetting

Protected creepage distance
The protected part of the profile should not be specified as a parameter characterising a shed profile.
In effect no general rules can be quantified because the degree to which shed profile is “open” or “protected” depends mainly on:
• The different site conditions on contamination,
• The prevailing selfcleaning conditions
• The position of the insulator(angle or inclination).