Overhead transmission lines
Insulators

Introduction
These guidelines describe the requirements on insulators for insulator sets in accordance with TR 05-10E for overhead transmission lines with alternating current and cover design and inspection. The guidelines intend to guarantee satisfactory performance of insulators during the lifetime of the overhead line and shall be used at purchasing of insulators.

This English text is to be regarded as a translation of the Swedish guideline. The Swedish text and the interpretation thereof shall govern the contract and the legal relations between parties.
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<th>Change notes</th>
<th>Date</th>
</tr>
</thead>
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<td>New template.</td>
<td>09 / 07 / 2008</td>
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<td>New template. Clause 11.5.2.1 and 11.5.2.3 revised. Clause 11.9.2.5 revised. Rev. 11.9.2.7.</td>
<td>02 / 04 / 2012</td>
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<td>3</td>
<td>New template clause numbers changed. Clause 5.1.6 inserted. Clause 7.1 sample size revised.</td>
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1 References

Note that standards, regulations etc. which are referred to in these guidelines are subject to continuous change and can be withdrawn, revised or replaced. It is the obligation that the contractor immediately will inform the client of such changes.

C.I.S.P.R 16-2-1 Specification for radio disturbance and immunity measuring apparatus and methods - Part 2: Methods of measurement of disturbances and immunity

IEC/TR0 60797 Residual strength of string insulator units of glass or ceramic material for overhead lines after mechanical damage of the dielectric

SS-EN 10045-1 Metallic materials - Charpy impact test - Part 1: Test method

SS-EN 60305 Insulators for overhead lines with a nominal voltage above 1 kV - Ceramic or glass insulator units for a.c. systems - Characteristics of insulator units of the cap and pin type

SS-EN 60372 Locking devices for ball and socket couplings of string insulator units - Dimensions and tests

SS-EN 60383-1 Insulators for overhead lines with a nominal voltage above 1 000 V - Part 1: Ceramic or glass insulator units for a.c. systems - Definitions, test methods and acceptance criteria

SS-EN 60383-2 Insulators for overhead lines with a nominal voltage above 1 000 V - Part 2: Insulator strings and insulator sets for a.c. systems - Definitions, test methods and acceptance criteria

SS-EN 60437 Radio interference test on high-voltage insulators

SS-EN ISO 9001 Quality management systems - Requirements

SS IEC 60120 Dimensions of ball and socket couplings of string insulator units

SS-ISO 5455 Technical drawings - Scales

SvK TR 05-10 Technical guidelines – Insulator sets

SvK TR 08 Technical guidelines - Documentation
2 Scope

These guidelines describe the requirements on insulators for insulator sets in accordance with TR 05-10E for overhead transmission lines with alternating current and cover design and inspection.

The guidelines intend to guarantee satisfactory performance of insulators during the lifetime of the overhead line and shall be used at purchasing of insulators.

3 Definition

Technical terms and definitions used in these guidelines:

**Residual breaking load**

Breaking load of insulators with the shed of the insulating part cracked or completely broken off.

4 Description

4.1 Ball and socket type disc insulator

Individual insulators with the insulating part shaped as a dish made from porcelain or glass with sockets shaped as into a cap and a pin with an end ball made from metal. See SS-EN 60305.

5 Requirements

5.1 General

Insulators shall be able to withstand the mechanical stresses which can occur during transport, handling and installation at temperatures as low as −40 °C, in addition to the mechanical stresses which can occur during the lifetime of the overhead line at temperatures from −50 °C to +100 °C.
5.1.1 Material

5.1.2 Insulating part
Disc insulators shall have insulating parts made from toughened glass.

5.1.3 Couplings
Caps with sockets shall be made from malleable cast iron, spheroidal graphite iron or forged steel and be hot dip galvanised.

Pins with end balls shall be made from forged steel and be hot dip galvanised.

5.1.4 Cement
Cement for assembling shall be aluminous cement.

5.1.5 Locking devices
Locking devices shall be made from bronze, copper alloy with not more than 15 % zinc content or austenitic stainless steel.

5.1.6 Fog type disc insulator corrosion protection
Fog type disc insulator shall be equipped with a corrosion protection zinc sleeve.

5.2 Design

5.2.1 Measurement
Disc insulators with normal creepage distances shall have measurements in accordance with SS-EN 60305.

Disc insulators with extended creepage distances shall have measurements in accordance with Table 1.

5.2.2 Displacements
The maximum axial and radial displacement shall conform to SS-EN 60383-1.

5.2.3 Couplings
Balls and sockets shall conform to SS-IEC 60120. However size 16B shall not be used.

5.2.4 Locking devices
Locking devices shall conform to SS-EN 60372. However W-clips are not to be used.

5.2.5 Porosity
Porcelain porosity shall conform to the requirements of SS-EN 60383-1.

5.2.6 Zinc layer
The thickness of the zinc layer shall conform to the requirements of SS-EN 60383-1.
5.3 Mechanical requirements

5.3.1 Locking system
The locking system shall conform to the requirements of SS-EN 60372.

5.3.2 Electromechanical failing load
Insulators made from porcelain shall conform to the electromechanical failing load requirements of SS-EN 60305, see Table 2.

5.3.3 Mechanical failing load
Insulators made from toughened glass shall conform to the mechanical failing load requirements of SS-EN 60305, see Table 2.

5.3.4 Temperature cycling
Insulators made from porcelain shall conform to the temperature cycling requirements of SS-EN 60383-1.

5.3.5 Thermal shock
Insulators made from toughened glass shall conform to the requirements for thermal shock in accordance with SS-EN 60383-1.

5.3.6 Thermal-mechanical failing load
Insulators shall conform to the thermal-mechanical performance requirements of SS-EN 60383-1, see Table 2.

5.3.7 Residual failing load
Insulators shall conform to the residual failing load requirements of Table 2.

5.3.8 Impact properties
Insulator pins shall conform to the impact property requirements of Table 2.

5.3.9 Routine test load
Insulators shall conform to the routine test load requirements of Table 2.

5.4 Electrical requirements

5.4.1 Dry lightning impulse withstand voltage test
Insulators made from toughened glass or porcelain shall conform to the dry lightning impulse withstand voltage requirements of Table 2.

5.4.2 Wet power frequency withstand voltage test
Insulators made from toughened glass or porcelain shall conform to the wet power frequency withstand voltage requirements of Table 2.
5.4.3 Power frequency puncture voltage
Insulators made from toughened glass or porcelain shall conform to the power frequency puncture voltage requirements of Table 2.

5.4.4 Flash over at fast front over-voltages
Insulators shall conform to the flashover requirements with fast front over-voltages.

5.4.5 Radio interference
The radio interference level for insulators shall be determined at 20 kV respectively 24 kV 50 Hz alternating current (r.m.s. value) over 1 μV interference voltage and 500 kHz measuring frequency. The radio interference level shall comply with the requirements of acceptance level $C_{20} \geq 1.6$ at 20 kV respectively $C_{24} \geq 1.2$ at 24 kV.

6 Type test

6.1 General
Unless otherwise agreed type tests shall be performed in accordance with Clauses 6.2-6.17 on the number of samples as given in Tables 3.

The tests shall be performed in such a way that neither the method nor the equipment affects the result.

6.2 Dimensions
The number of insulators to be tested is given in Table 3.

The tests shall be performed on disc insulators according to SS-EN 60383-1.

6.3 Displacements
The number of insulators to be tested is given in Table 3.

For disc insulators the tests shall be performed in accordance with SS-EN 60383-1.

6.4 Locking system
The number of insulators to be tested is given in Table 3.

The tests shall be performed in accordance with SS-EN 60383-1.

6.5 Radio interference
The number of insulators to be tested is given in Table 3.
The test shall, on cap & pin insulators, be performed with 20 kV respectively 24 kV 50 Hz alternating current (r.m.s. value) over 1 µV interference voltage and 500 kHz measuring frequency at test in accordance with C.I.S.P.R 16-2-1 and SS-EN 60437.

From the individual interference levels X measured at the test shall the mean value $\bar{X}$ and the standard deviation $\sigma_{n-1}$ be calculated.

where

$X_{20} =$ mean value of the lot at 20 kV [dB]

$X_{24} =$ mean value of the lot at 24 kV [dB]

$\sigma_{20} =$ standard deviation of the lot at 20 kV [dB]

$\sigma_{24} =$ standard deviation of the lot at 24 kV [dB]

$C_{20} =$ acceptance level at 20 kV

$C_{24} =$ acceptance level at 24 kV

The insulators is considered to meet the requirements if: $X_{20} \leq 60 - 1.6\sigma_{20}$ and $X_{24} \leq 60 - 1.2\sigma_{24}$.

### 6.6 Temperature cycling

The number of insulators to be tested is given in Table 3.

The tests shall be performed in accordance with SS-EN 60383-1 for insulators made from porcelain.

### 6.7 Electromechanical failing load

The number of insulators to be tested is given in Table 3.

The tests shall be performed in accordance with SS-EN 60383-1 for disc insulators made from porcelain.

### 6.8 Mechanical failing load

The number of insulators to be tested is given in Table 3.

The tests shall be performed in accordance with SS-EN 60383-1 for disc insulators made from glass.

### 6.9 Porosity

The number of insulators to be tested is given in Table 3.
The tests shall be performed in accordance with SS-EN 60383-1 for insulators made from porcelain.

6.10 **Thickness of zinc coating**
The number of insulators to be tested is given in Table 3.

The tests shall be performed in accordance with SS-EN 60383-1.

6.11 **Dry lightning impulse withstand voltage test.**
The number of insulators to be tested is given in Table 3.

The tests shall be performed in accordance with SS-EN 60383-2 on an assembled insulator string consisting of 5 disc insulators or alternatively one composite insulator.

6.12 **Wet power frequency withstand voltage test**
The number of insulators to be tested is given in Table 3.

The tests shall be performed in accordance with SS-EN 60383-2 on an assembled insulator string consisting of 5 disc insulators or alternatively one composite insulator.

6.13 **Thermal shock**
The number of insulators to be tested is given in Table 3.

The tests shall be performed in accordance with SS-EN 60383-1 for disc insulators made from toughened glass.

6.14 **Power frequency puncture voltage**
The number of insulators to be tested is given in Table 3.

The tests shall be performed in accordance with SS-EN 60383-1 for disc insulators.

6.15 **Impact properties**
The number of insulators to be tested is given in Table 3.

The tests shall be performed in accordance with SS-EN 10045-1.

6.16 **Thermal-mechanical performance**
The number of insulators to be tested is given in Table 3.

The tests shall be performed in accordance with SS-EN 60383-1.

6.17 **Residual strength**
The number of insulators to be tested is given in Table 3.
The tests shall be performed in accordance with IEC/TR 60797 for disc insulators.

7 Sample test

7.1 General

Sample tests shall be carried out by the manufacturer on insulators selected at random from the lot to be supplied.

Test samples shall be supplied by the manufacturer free of charge to the client and shall not be included in the lot to be supplied.

The size of the test samples are indicated in table below.

<table>
<thead>
<tr>
<th>Lot size</th>
<th>Sample size</th>
</tr>
</thead>
<tbody>
<tr>
<td>$N \leq 300$</td>
<td>1-3 subject to agreement</td>
</tr>
<tr>
<td>$300 &lt; N \leq 2000$</td>
<td>4</td>
</tr>
<tr>
<td>$2000 &lt; N \leq 5000$</td>
<td>8</td>
</tr>
<tr>
<td>$5000 &lt; N \leq 10000$</td>
<td>12</td>
</tr>
</tbody>
</table>

The sample shall be subject to testing in accordance with Clauses 7.2-7.12 inclusive. Insulators which have been submitted to test shall be discarded.

The manufacturer shall inform the client when sample tests will be performed.

Records from the sample tests shall be filed by the manufacturer and be shown to the client on request. In the case where any component does not comply with the requirements, re-testing shall be performed as below.

If only one insulator, or part thereof, fails to comply with the sample test requirement, a new sample equal to twice the quantity originally submitted for that test shall be subject to re-testing. The re-testing shall comprise the test or tests in which failure occurred.

If two or more insulators, or parts thereof, fail to comply with any of the sample tests, or if any failure occurs during re-testing, the complete lot shall be considered not to comply with the requirements.

Provided that the cause of the failure can be clearly identified, the manufacturer may sort the lot to eliminate all the insulators with this defect. The sorted lot shall then be resubmitted for sample testing. The number then selected shall be three times the first quantity chosen for the test. The re-testing shall comprise the test or tests in which failure occurred in the original test.
If any insulator, or part there-of of the sorted lot, fails during this re-testing, the complete lot shall be considered as not complying with the requirements.

7.2 Dimensions
Number of insulators to be tested: E1 & E2.

The tests shall be performed in accordance with SS-EN 60383-1.

7.3 Displacements
Numbers of insulators to be tested: E1 & E2.

The tests shall be performed on disc insulators in accordance with SS-EN 60383-1.

7.4 Locking system
Numbers of insulators to be tested: E1 & E2.

The tests shall be performed in accordance with SS-EN 60383-1.

7.5 Temperature cycling
Numbers of insulators to be tested: E1 & E2.

The tests shall be performed in accordance with SS-EN 60383-1 for insulators made from porcelain.

7.6 Electromechanical failing load
Number of insulators to be tested: E1.

The tests shall be performed in accordance with SS-EN 60383-1 for disc insulators made from porcelain.

7.7 Mechanical failing load
Number of insulators to be tested: E1.

The tests shall be performed in accordance with SS-EN 60383-1 for disc insulators made from glass.

7.8 Thermal shock
Number of insulators to be tested: E2.

The tests shall be performed in accordance with SS-EN 60383-1 for disc insulators made from toughened glass.
7.9  Power frequency puncture voltage  
Number of insulators to be tested: E2.  
The tests shall be performed in accordance with SS-EN 60383-1 for disc insulators.

7.10  Porosity  
Number of insulators to be tested: E1.  
The tests shall be performed in accordance with SS-EN 60383-1 for insulators made from porcelain.

7.11  Thickness of zinc coating  
Number of insulators to be tested: E2.  
The tests shall be performed in accordance with SS-EN 60383-1.

7.12  Residual strength  
Number of insulators to be tested: E3.  
The tests shall be performed in accordance with IEC/TR 0 60797 for disc insulators.

8  Routine tests

8.1  Visual inspection  
All insulators shall be visually inspected.  
The visual inspection shall be performed in accordance with SS-EN 60383-1 for disc insulators.

8.2  Routine test load  
All insulators shall be tested.  
The tests shall be performed in accordance with SS-EN 60383-1 for disc insulators.

8.3  Electrical test  
All insulators shall be tested.  
The tests shall be performed in accordance with SS-EN 60383-1 for disc insulators made from porcelain.
9 Delivery

9.1 General
The client shall, according to these guidelines, approve the insulators before delivery. For approval the manufacturer shall demonstrate that the insulators conform to these guidelines.

The manufacturer shall provide documentation in accordance with Clauses 9.2.1 - 9.2.6 for approval.

The approval of drawings by the client does not release the manufacturer from his obligations regarding the insulators complying with these guidelines.

All documentation shall be written in Swedish or English.

9.2 Documentation
General requirements for documentation see SvK TR 08E.

9.2.1 Assembly drawing
The assembly drawing shall have a minimum of two views at an appropriate scale in accordance with SS-ISO 5455. On the drawing shall be given:

- Type and/or Catalogue number
- Principal dimensions
- Failing load
- Electrical data
- Creepage distance
- All marking
- Weight
- List of materials

9.2.2 List of material
Description of material in included parts.

9.2.3 Manufacturing process
Description of the manufacturing process
9.2.4  Quality system
Quality system in accordance with SS-EN ISO 9001.

9.2.5  Installation instructions
Installation instructions in Swedish or English with the required drawings.

9.2.6  Reports
Report in accordance with Clause 6 Type test report, 7 Sample test report and 8 Routine tests report.

9.3  Transport and storing
The insulators shall be packed up in that way that they will not be damaged or fouled at transport, construction and at storing.
### Table 1A  Fog type disc insulators, dimensions  
(Older type of insulator)

<table>
<thead>
<tr>
<th>Designation</th>
<th>U70fog</th>
<th>U120fog</th>
<th>U210fog</th>
<th>U300fog</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. nominal diameter of insulator disc</td>
<td>mm</td>
<td>255</td>
<td>255</td>
<td>320</td>
</tr>
<tr>
<td>Nominal coupling length</td>
<td>mm</td>
<td>146</td>
<td>146</td>
<td>170</td>
</tr>
<tr>
<td>Min. nominal creepage distance</td>
<td>mm</td>
<td>430</td>
<td>430</td>
<td>550</td>
</tr>
<tr>
<td>Max. pin/ball length</td>
<td>mm</td>
<td>30</td>
<td>30</td>
<td>35</td>
</tr>
<tr>
<td>Size of coupling IEC 60120</td>
<td>*</td>
<td>16A</td>
<td>16A</td>
<td>20</td>
</tr>
</tbody>
</table>

1) Maximum vertical distance from the lower edge of the ball to the lowest part of the insulator disc.

### Table 1B  Fog type disc insulators, dimensions

<table>
<thead>
<tr>
<th>Designation according to IEC 60305</th>
<th>U70BLP</th>
<th>U120BP</th>
<th>U210BP</th>
<th>U300BP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. nominal diameter of insulator disc</td>
<td>mm</td>
<td>280</td>
<td>280</td>
<td>330</td>
</tr>
<tr>
<td>Nominal coupling length</td>
<td>mm</td>
<td>146</td>
<td>146</td>
<td>170</td>
</tr>
<tr>
<td>Min. nominal creepage distance</td>
<td>mm</td>
<td>440</td>
<td>440</td>
<td>525</td>
</tr>
<tr>
<td>Max. pin/ball length</td>
<td>mm</td>
<td>30</td>
<td>30</td>
<td>35</td>
</tr>
<tr>
<td>Size of coupling IEC 60120</td>
<td>*</td>
<td>16A</td>
<td>16A</td>
<td>20</td>
</tr>
</tbody>
</table>

1) Maximum vertical distance from the lower edge of the ball to the lowest part of the insulator disc.
Table 2  Disc insulators, Electrical and Mechanical Requirements

<table>
<thead>
<tr>
<th>Designation according to IEC 60305</th>
<th>U70</th>
<th>U120</th>
<th>U210</th>
<th>U300</th>
<th>U70fog</th>
<th>U120fog</th>
<th>U210fog</th>
<th>U300fog</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electromechanical failing load</td>
<td>kN</td>
<td>70</td>
<td>120</td>
<td>210</td>
<td>300</td>
<td>70</td>
<td>120</td>
<td>210</td>
</tr>
<tr>
<td>Mechanical failing load</td>
<td>kN</td>
<td>70</td>
<td>120</td>
<td>210</td>
<td>300</td>
<td>70</td>
<td>120</td>
<td>210</td>
</tr>
<tr>
<td>Thermal-mechanical failing load</td>
<td>kN</td>
<td>70</td>
<td>120</td>
<td>210</td>
<td>300</td>
<td>70</td>
<td>120</td>
<td>210</td>
</tr>
<tr>
<td>Residual failing load</td>
<td>kN</td>
<td>45.5</td>
<td>78</td>
<td>136.5</td>
<td>195</td>
<td>45.5</td>
<td>78</td>
<td>136.5</td>
</tr>
<tr>
<td>Routine test load</td>
<td>kN</td>
<td>35</td>
<td>60</td>
<td>105</td>
<td>150</td>
<td>35</td>
<td>60</td>
<td>105</td>
</tr>
<tr>
<td>Dry impulse withstand voltage 1)</td>
<td>kV</td>
<td>400</td>
<td>400</td>
<td>455</td>
<td>500</td>
<td>400</td>
<td>400</td>
<td>480</td>
</tr>
<tr>
<td>Wet power frequency withstand voltage 1)</td>
<td>kV</td>
<td>170</td>
<td>170</td>
<td>195</td>
<td>215</td>
<td>170</td>
<td>170</td>
<td>205</td>
</tr>
<tr>
<td>Power frequency puncture voltage</td>
<td>kV</td>
<td>110</td>
<td>110</td>
<td>125</td>
<td>130</td>
<td>130</td>
<td>130</td>
<td>140</td>
</tr>
<tr>
<td>Impact properties at 0°C</td>
<td>J</td>
<td>27</td>
<td>27</td>
<td>27</td>
<td>27</td>
<td>27</td>
<td>27</td>
<td>27</td>
</tr>
</tbody>
</table>

1) To be tested on a short insulator string comprising 5 insulator units.
### Table 3  Disc insulators, Type test

<table>
<thead>
<tr>
<th>Type of test</th>
<th>Items to be tested</th>
<th>Porcelain Size</th>
<th>Porcelain Number</th>
<th>Glass Size</th>
<th>Glass Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Verification of dimensions</td>
<td></td>
<td>15</td>
<td></td>
<td>15</td>
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1) Refers to a short string consisting of 5 insulator units.

TEKNISK RIKTLINJE 2016-06-09 TR05-11E
11 Figures

Figure 1 Disc insulator