# Contact line: Design. Insulators

# 1 Purpose and scope

Insulators are used where two installation components must be electrically separated, while at the same time being mechanically linked. Thus, both mechanical and electrical requirements must be stipulated for insulators.

Overhead contact line systems include insulators connected to contact wires, messenger wires, cantilevers, feeders, bridging feeders, reinforcing feeders and return wires, segmentation, switches and anchoring wires.

# 2 General requirements

If insulators are damaged and the insulation effect is lost, they must retain their mechanical strength.

Construction lengths should be standardised; one or two default values are acceptable.

Requirements must be stipulated regarding the diameter of insulators, depending on where the insulators are to be installed.

Cap and pin insulators must be made of composite materials and must satisfy the following design requirements:

- insulator pins must be interchangeable
- standardised requirements for dimensions, fastening devices, threads, etc.
- requirements for the cradle in which the wire is to sit

It must be specified where the insulator is to be used.

To provide optimum protection from consequential damage resulting from vandalism, the most vandal-proof material should be selected.

The insulator must be supplied in its packaging. This must not be removed before the entire overhead contact line system has been completed and the construction site has been tidied and cleaned.

# 3 Mechanical requirements

## 3.1 Insulators in contact wires and messenger wires

Insulators in contact wires and messenger wires must be designed to withstand the following mechanical stresses:

|-

!Overhead contact line system!!width="100pt"|Tensile forces in contact wires and messenger wires
kN!!width="100pt"|4 x load
kN!!width="100pt"|1.6 x the wire's breaking stress for contact wire
kN!!width="100pt"|1.6 x the wire's breaking stress for messenger wire
kN |-

|System 35||



||

28.8
||
56.0
||
31.7
|-
|System 20 A||
10
||
40.0
||
56.0
||
44,7
|-
|System 20 B||
10
||
40.0
||
56.0
||
44.7
|-
|System 1||
13
||
52.0
||
56.0
||
44.7
|-
|System 25||
15
||
60.0
||
67.2
||
61.8
|-
|System 25 tunnel||
15
||
60.0
||
67.2

||

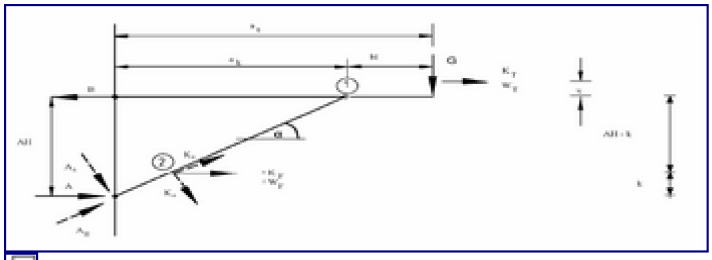
61.8

|}

Insulators in contact wires and messenger wires are subject to tensile forces. Thus, tensile testing must be conducted on insulators in accordance with the norms specified in Tabell 10.

## 3.2 Cantilever insulators

Cantilever insulators must be designed to withstand the following mechanical stresses (refer to Figur 1 and Tabell 3 and Tabell 4):



Figur 1: Forces and loads on cantilevers

Tabell 3: Minimum mechanical requirements for insulators in cantilevers under tension

| **Overhead contact line system** | **Tensile/compressive forces in insulators in cantilevers under tension** | | **4 x load** | |
|---|---|---|---|---|
| | **B (N)** | **$A_{II}$ (N)** | **B (N)** | **$A_{II}$ (N)** |
| System 35 | 5306 | 4253 | 21224 | 17012 |
| System 20 A | 6024 | 4993 | 24096 | 19972 |
| System 20 B | 6015 | 4780 | 24060 | 19120 |
| System 20 $C_1$ | 7789 | 5325 | 31156 | 21300 |
| System 25 | 6339 | 5014 | 25356 | 20056 |
| System 25 tunnel | 7903 | 4475 | 31612 | 17900 |

caption>Minimum mechanical requirements for insulators in cantilevers under compression</caption>

| **Overhead contact line system** | **Tensile/compressive forces in insulators in cantilevers under compression** | | **4 x load** | |
|---|---|---|---|---|
| | **B (N)** | **$A_{II}$ (N)** | **B (N)** | **$A_{II}$ (N)** |
| System 35 | 2831 / -2102 | 4463 | 11324 / -8408 | 17852 |
| System 20 A | 3594 / -3385 | 5420 | 14373 / -13540 | 21680 |
| System 20 B | 3516 / -2868 | 5402 | 14064 / -11472 | 21608 |
| System 20 $C_1$ | 2011 / -5164 | 5485 | 8004 / -20656 | 21940 |
| System 25 | 2660 / -4570 | 5073 | 10640 / -18280 | 20292 |
| System 25 tunnel | 1228 / -4848 | 5318 | 4912 / -19392 | 21272 |

Insulators in cantilevers are subject to tensile/compressive and bending forces. Thus, tensile testing must be conducted on insulators in accordance with the norms specified in Tabell 10.

### 3.3 Insulators in return wires, feeders, bridging feeders and reinforcing feeders

Tabell 5: Minimum mechanical requirements for insulators in return wires, feeders, bridging feeders and reinforcing feeders

| Loads | Maximum forces | 3 x loads |
|---|---|---|
| | kN | |
| Vertical forces | 2.81 | 8.43 |
| Horizontal lateral forces | 1.11 | 3.33 |

in accordance with [FEA-F], maximum cable tension is calculated equivalent to 40% of the wire's breaking load. The requirements for the insulator's electro-mechanical breaking stress is four times 40% of the wire's breaking load of 4 x 0.4 equivalent to 1.6 times the wire's breaking load.

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36.29

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58.06

Tabell 6: Minimum mechanical requirements for wires<

| Line | Breaking load kN | 1.6 x breaking load kN |
|---|---|---|

### 3.4 Anchoring wire insulators

Tabell 7: Minimum mechanical requirements for anchoring wire insulators<

| Overhead contact line system | Tensile forces on contact wires and messenger wires kN | Tensile forces on anchoring wires kN | 3 x the load |
|---|---|---|---|
| System 35 | 2 x 7.2 | 20.4 | 60.6 |
| System 20 | 10.0 | 14.1 | 42.3 |
| System 20 C | 13,0 | 18.4 | 55.2 |
| System 25 | 15.0 | 21.2 | 63.3 |

Anchoring wire insulators are subject to tensile forces. Thus, tensile testing must be conducted on insulators in accordance with the norms specified in Tabell 10.

# 4 Electrotechnical requirements

## 4.1 General

The insulation level of insulators must be in accordance with Felles elektro/Prosjektering og bygging/Isolasjonskoordinering og overspenningsbeskyttelse.

## 4.2 Creep current path

The requirements are based on EN 50124-1. IEC 60815 must also be taken into account for areas without rain. The requirements for the minimum creep current path may be found in Tabell 8.

|-

!Pollution/environmental conditions!!width="200pt"|Minimum nominal creep current path
Normal voltage
Phase - earth
[mm/Kv]!!width="150pt"|Minimum creep current path
17.25 kV
Normal voltage
Phase - earth
[mm] |-

|width="200pt"|Normal environment without
any particular pollution, a good distance
from the sea (10-20 km).
Insulators are exposed to rain
(natural cleaning)||
40
||
690

|-

|Areas with high
levels of pollution(pollutive
industries, built-up areas
or areas close to the sea/exposed
to wind from the sea (salt water)).
Insulators are exposed to rain
(natural cleaning)||
48
||
828

|-

|Areas with high levels
of pollution.
Insulators are not exposed to
rain (natural cleaning)||
52
||
897

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At existing route obstacles (bridges, tunnels, etc.) where insulators are not exposed to rain (natural cleaning), Head Office may grant exemption from the requirements regarding the minimum creep current path down to 690 mm if insulators are adequately washed/cleaned.

## 4.3 Insulation coordination - insulator requirements

In order to avoid weak points occurring in the overhead contact line system in respect of disruptive strength, all insulators should possess the same disruptive strength, as referred to in the section on holding voltage above.

Refer also to Chapter 12.

# 5 Documentation requirements

## 5.1 General

All insulators supplied require type test certificates. The type tests to be performed on insulators are specified in Tabell 10

Documentation should also be attached regarding the routine tests and spot tests that have been performed. For larger deliveries it is natural for the customer to participate in the routine tests and spot tests. As well as test documentation, suppliers should submit documentation of their quality assurance system.

## 5.2 Glass and porcelain insulators

Tabell 10: List of tests that must be performed on various categories of insulator

| **Insulator type** | **Support insulator(1** | | | | **Line insulator(2** | | | |
|---|---|---|---|---|---|---|---|---|
| **IEC-publ.** | | | **168** | | | **383 and 305** | | |
| **Nature of test** | **T** | **S** | **R** | **Note** | **T** | **S** | **R** | **Note** |
| 1.2/50 impulse holding voltage | X | | | | X | | | |
| 50 Hz 1 min. holding voltage | X | | | | X | | | |
| 50 Hz voltage test | | | X | (3 | | | X | (3 |
| 50 Hz disruptive discharge test | | X | | (3 | | X | X | (3 |
| Radio frequency interference | | | | | | X | X | |
| Mechanical bending stress | X | X | X | | X | X | X | (5 |
| Monitoring of bending | X | | | (4 | | | | |
| Mechanical torque test | X | X | | (4 | | | | |
| Mechanical tensile test | X | X | X | (4 | X | X | X | (6 |
| Internal compression test | | | | | | | | |
| Ultrasonic test | | | X | | | | X | |
| Visual inspection | | X | X | | | X | X | |
| Dimension control | | X | | | | X | | |
| Temperature change test | | X | | | | X | | |
| Temperature shock test | | | | | | X | | (7 |
| Porosity test | | X | | | | X | | (8 |
| Zinc test control | | X | | | | X | | |
| Pollution properties | | | | | | | | |

- ) T: type test, S: spot test, R: routine test

1) Cap and pin insulators
2) Support insulators and rod insulators
3) Only with different bowl insulators: Where the disruptive discharge path is less than one-half of the strike distance
4) Only upon further agreement
5) T & S only for cap and pin insulators and line or support insulators. R only for line or support insulators
6) Only glass insulators and rod insulators
7) Only glass insulators
8) Only porcelain insulators

## 5.3 Composite insulators

Composite insulators must be silicon based (silicon percentage must be specified)

For composite insulators, [IEC 1109] applies. This norm specifies type tests, routine tests and spot tests, as in equivalent norms for glass or porcelain insulators. Design tests have also been defined.

The purpose of design tests is to verify that the design, choice of material, material composition and production are satisfactory. When design tests are performed on a number of composite insulators, the results will be accepted for other insulators in the same class. A class has the following common characteristics:

- identical core material (supporting element), identical cover material and production and installation process.
- identical armature material, identical design and fittings.
- identical or thicker layer of cover material above the supporting element in relation to the insulators tested in accordance with the design tests.
- identical or greater diameter on the mechanical supporting element in relation to the insulators tested in accordance with the design tests.

During the design test, the properties of the respective class of insulator are tested with regard to

- mechanical tensile load
- varying mechanical tensile load
- mechanical properties in relation to temperature
- electrotechnical properties
- water diffusion properties