Introduction

This Guideline is mainly intended to be used in procurement but can also be used for maintenance of overhead transmission lines.

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.
## Revision

<table>
<thead>
<tr>
<th>Notes</th>
<th>Change notes</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>This Guideline is a translation of Swedish version TR05-13 revision 2 and replaces TR5:113 EARTHING from 14 September, 2000.</td>
<td>2012-10-05</td>
</tr>
<tr>
<td>2</td>
<td>SS-EN 50522 replaced by TR01-13 in references. Table in clause 13.5.3.12 is changed according to Telestörningsnämndens meddelande Nr 21. Links to clauses in 13.6.2 and 13.6.3 is corrected. Figure 6 is revised.</td>
<td>2015-11-01</td>
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13.1 References

Note that standards, regulations, guidelines etc., referred to in this guideline are constantly changing and may be discontinued, revised or superseded. It is for the contractor to promptly denounce such changes. Following list comprise of documents referred to in this guideline but also documents that can be of interest.

- **SFS 2009:22** Starkströmsförordning
- **ELSÄK-FS 2008:1** Elsäkerhetsverkets föreskrifter och allmänna råd om hur elektriska starkströmsanläggningar ska vara utförda
- **SvK-TR01-01** Stamnätsanläggningar (in Swedish)
- **SvK-TR01-13** Stamnätsstationer Jordning
- **SvK-TR05-04E** Overhead transmission lines, Conductors
- **SvK-TR08-04** Dokumentationsinnehåll och teknisk data för ledningar (in Swedish)
- **SvK-TR10-01** Svenska kraftnäts kompletterande elsäkerhetsanvisning (in Swedish)
- **SvK-TR10-05** Elektriska och icke elektriska anläggningar invid Svenska kraftnäts anläggningar (in Swedish)
- **SS-EN 50341-1** Overhead electrical lines exceeding AC 45 kV
- **SS-EN 61936-1** Power installations exceeding 1 kV a.c. – Part 1: Common rules
- **SS 436 21 10** Installations for grounding switchgear with nominal voltage above 1 kV
- **EBR K25** Jordningskonstruktioner distributionsnät och nätstationer 0,4-24 kV
- **EBR U301E** Underhåll ledningar 0,4 - 420 kV - Jordning
13.2 Scope

These rules apply to earthing of overhead lines and give a general indication of how functional and protective earthing must be carried out in solidly earthed neutral AC system overhead transmission lines for HVAC with towers made of electrically conductive and non-conductive materials. These guidelines can also be used for HVDC overhead transmission lines.

13.3 Definitions

13.3.1 Earthing
Electrically conductive connection between the construction part and the surrounding soil. Most earthing combines the two purposes as functional earthing and protective earthing. For example a line with a continuous shield wire the earthing is a single coherent system with these two properties.

13.3.2 Functional earthing
Earthing to divert lightning currents and 50-periodic fault currents so safe tripping is obtained.

13.3.3 Protective earthing
Earthing a point or points in a system or in an installation or in equipment, for purposes of electrical safety for protection against electric shock from step and touch voltage.

13.3.4 Earth conductor
Conductor forming a part of the fixed installation for earthing purposes.
13.3.5 Earth electrode
Conductor located in the earth designed to give an electrically conductive connection with the surrounding soil layers. The conductor can consist of rod, wire, sheet-metal or equivalent.

13.3.6 Shallow earth electrode
Earth electrode consisting of a continuous counterpoise, radial earth electrode or otherwise to the surface parallel located earth conductors down to a depth of about 1 m. Continuous counterpoise is in principle a shallow earth electrode but is not comprised in this guideline when shallow earth electrode is mentioned.

13.3.7 Deep earth electrode
Earth electrode consisting of vertically placed earth electrode buried or driven down in the soil at a greater depth than 1 m.

13.3.8 Radial earth electrode
Horizontally radially placed earth conductors in the soil.

13.3.9 Counterpoise
Conductor or combination of conductors buried in the ground and electrically connecting the footings of the supports of the towers.

13.3.10 Continuous counterpoise
Conductor buried in the ground electrically connecting the footings of the supports of the towers along an overhead line.

13.3.11 Local earth electrode
Earth electrode comprising deep earth electrode, radial earth electrode or a combination thereof.

13.3.12 Protective bonding conductor
Conductor provided for protective-equipotential-bonding.

13.3.13 Potential grading earth electrode
Protective earthing consisting of a protective bonding conductor in the soil around structure and/or stay anchors.

13.3.14 Earthing conductor
Conductor between an earth electrode and an earth terminal or, if such terminal is missing, between an earth electrode and a construction part that shall be earthed.
13.3.15 Down conductor
Conductor for connection of insulator string attachments, crossarm and shield wire to a fixed earth terminal on the tower.

13.3.16 Shield wire
Conductor, horizontally located in an overhead line, usually located above the phase conductors. The shield wire is part of the earthing system, but could be connected to the substation earth via a spark gap.

13.3.17 Continuous shield wire
Shield wire located along the entire length of overhead lines.

13.3.18 Insulated shield wire
Shield wire electrically separated from the tower with insulators.

13.4 Description

13.4.1 General
An installation being a part of a solidly earthed neutral system shall be designed so an earth fault instantaneous and automatically is switched off and that elevated ground potentials caused by the earth fault is levelled out, so that necessary security is obtained for person and property. This is achieved by functional and protective earthing. See ELSÄK-FS 2008:1 and changing regulation ELSÄK-FS 2010:1.

Earthing of a line is determined both by the individual towers earthing and the connection via continuous counterpoise and shield wire. A tower placed on rock can be allowed not to have an earthing conductor if the electrical connection to the shield wire is guaranteed. This connection is then used for protective earthing and to some extent functional earthing from nearby tower. Normally shall, for individual towers, the earth resistance be below $100 \, \Omega$.

13.4.2 Functional earthing
Functional earthing shall be accomplished with shallow earth electrode or deep earth electrode, with regard to the circumstances regarding terrain, obstacles, etc.

13.4.3 Protective earthing
Protective earthing shall be carried out at towers and stay anchors where people usually travel or stay, so that no unallowable step and touch voltages arise.
Protective earthing shall, if earth electrode for functional earthing is not enough, be carried out by a potential grading earth electrode (see clause 0) surrounding the exposed conductive part and connected to this.

Protective earthing shall be connected directly to exposed-conductive-part and not via spark-gap.

In some places (beaches, playgrounds, sports fields, parking lots and the like), additional actions may be necessary like touch protection according to clause 13.4.4.

13.4.4 Touch protection

Touch protection of Svenska kraftnäts towers can be made if the protective earthing cannot be made with enough safety. Svenska kraftnät shall approve proposed solution.

Touch protection is carried out by placing insulation on the exposed conductive parts, which are accessible to touch from the ground. Protective earthing can also be completely avoided by selecting the supports and cabinets in plastic. But Svenska kraftnät does not use support in plastic.

*Note*

*Touch protection is normally carried out in places as described in clause 13.4.3.*

*Example of a touch protection is a plastic covering of pole.*

13.4.5 Galvanic corrosion

Measures shall be taken to prevent corrosion of the buried steel components which are electrically connected to earth conductor of copper or copper-clad steel.

Metallic contact between copper and other metals beneath the ground surface is not allowed. All these connections must be made above the ground surface.

When earth electrode or earthing conductor of copper or copper-clad steel is used, the conductors shall be connected to the tower or stay via a spark-gap (see Figure 10 and Figure 11). In exceptional circumstances, stay insulator, can be used but they should be avoided in new designs.

Normal practice is to connect the shield wires via spark-gaps to the substation in order not to connect the substation copper earth system to the line towers. These spark-gaps have an ignition voltage of about 20 kV. In this respect, greater stress on counterpoise occurs in the first spans at earth faults. See furthermore Figure 6 – Figure 9.

If earth electrodes and earth conductors is made of steel or if the whole line consist of tower or stay where NO details have direct contact with the soil (e.g. towers on concrete foundations without stays) the spark-gaps can be omitted both for connection to
counterpoise and shield wires to the substations even if earth electrodes is made of copper or copper-clad steel wires.

Protective earthing, is normally carried out with galvanized steel wire, is never connected via spark-gap.

### 13.5 Requirements

#### 13.5.1 Material

**13.5.1.1 Earthing conductor and shallow earth electrode**

Earthing conductors for location in the soil shall be of copper, copper-clad steel or galvanized steel. For the copper-clad steel wire its conductivity is given relative to pure copper in accordance with “International Annealed Copper Standard”, IACS. Normally, copper-clad steel wire and strand shall be annealed and with a conductivity of 40 % IACS. The copper layer on the copper-clad steel shall be at least 0.25 mm thick in accordance with SS 436 21 10 and shall be attached to the steel in such a manner as to resist the arising stresses without separating from the steel.

The dimensions shall not be less than:

<table>
<thead>
<tr>
<th>Material</th>
<th>Minimal Dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper wire</td>
<td>35 mm²</td>
</tr>
<tr>
<td>Copper-clad steel wire</td>
<td>35 mm²</td>
</tr>
<tr>
<td>Steel wire</td>
<td>50 mm²</td>
</tr>
<tr>
<td>Copper plate</td>
<td>1 mm × 0.5 m²</td>
</tr>
</tbody>
</table>

**13.5.1.2 Deep earth electrode**

Deep earth electrode shall consist of tube, plates, rod or angle bar and rod made of copper, copper-clad steel (normal design) or alternatively hot-dip galvanized steel. Normally, copper-clad steel shall have a conductivity of 40% IACS. The copper layer on the steel shall be at least 0.25 mm thick in accordance with SS 436 21 10 and be attached to the steel in such a manner as to resist the arising stresses without separating from the steel.
Material Minimal Dimension
---
Steel tube ⌀ 49 mm
Copper-clad steel rod ⌀ 16 mm
Steel angle section 60 × 60 × 6 mm²
Copper plate 1 mm × 0,5 m²

13.5.1.3 Potential grading earth electrode
Hot-dip galvanised 50 mm² soft steel wires with three strands shall be used. Exceptions may be made for certain towers with concrete foundations (see clause 13.5.3.8).

13.5.2 Electrical requirements
The maximum earth fault current is calculated from the lines fault current. Depending on the lines design and its induction, different parts of the current will pass the shield wire and the counterpoise respectively. Examples of the current distribution are given in EBR U602.5 and Telestörningsnämndens meddelande Nr 20. For a new line, the voltage inducing current is normally approximately 40% of the earth fault current.

13.5.2.1 Shield wire
Normally as Shield wire FeAl conductors shall be dimensioned so that the maximum current according to TR05-04 is not exceeded taking into consideration the reduction for the induction above.

13.5.2.2 Counterpoise
Earth conductor and down conductor shall be so dimensioned, that the maximum earth fault current does not produce a higher current density in the conductor than listed in the table below. Normally shall the conductors be dimensioned for 1 s but at high fault currents an agreement can be made with Svenska kraftnät in a reduction to 0,5 s.

<table>
<thead>
<tr>
<th>Material</th>
<th>Max allowed current density at 1 s [A/mm²]</th>
<th>Max allowed current density at 0,5 s [A/mm²]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel</td>
<td>65</td>
<td>90</td>
</tr>
<tr>
<td>Copper</td>
<td>200</td>
<td>275</td>
</tr>
<tr>
<td>Copper-clad steel</td>
<td>130</td>
<td>180</td>
</tr>
</tbody>
</table>

* at 40% IACS

13.5.2.3 Repair of continuous counterpoise and down conductors
Repair of the continuous counterpoise and down conductor the area shall be selected from the following table, depending on the maximum current and type of material.
The table shows maximum current at 1 s duration.

<table>
<thead>
<tr>
<th>Copper-clad steel</th>
<th>Copper</th>
<th>Steel</th>
</tr>
</thead>
<tbody>
<tr>
<td>IACS = 40%</td>
<td>mm²</td>
<td>kA</td>
</tr>
<tr>
<td>35</td>
<td>7.0</td>
<td>6.5</td>
</tr>
<tr>
<td>50</td>
<td>10.0</td>
<td>9.8</td>
</tr>
<tr>
<td>70</td>
<td>14.0</td>
<td>13.0</td>
</tr>
<tr>
<td>95</td>
<td>19.0</td>
<td>19.5</td>
</tr>
<tr>
<td>120</td>
<td>24.0</td>
<td>----</td>
</tr>
<tr>
<td>150</td>
<td>30.0</td>
<td>----</td>
</tr>
</tbody>
</table>

13.5.2.4 Functional earthing
Earth electrode shall be located in such a way that the earth electrode resistance is not significantly affected by variations in humidity of the surrounding soil, ground frost, or corrosion.

At tower sites with difficult earthing conditions such as rock, etc. local earth can, after agreement, be omitted if the shield wire has good electrical contact via the earth clamp to the tower. In these cases, the towers of the surrounding spans have to have approved earth electrodes.

13.5.2.5 Protective earthing
Protective earthing (potential grading ring) shall be designed so that the step and touch voltage does not exceed 600 V, at an earth fault, when a current passing 3 000 Ω to earth (see ELSÄK-FS 2008:1).

Where the potential equalizing above is inadequate, touch protection can be required.

13.5.2.6 Touch protection
Touch protection must be made of age-resistant and non-conductive plastic. Touch protection shall be of a material that is not attacked by animals or destroyed by frost and low temperature and is stable against UV light.

13.5.3 Performance
Performance of the following electrical installations is considered to be heavy currant installations and must be performed under the supervision of electrical contractor with authorization from Swedish National Electrical Safety Board.

13.5.3.1 Earthing of different tower designs
Down conductor and counterpoise shall normally be dimensioned for the lines earth fault current (see clause 13.5.2). If more than one down conductor is used normally each down conductor shall be dimensioned for the short-time current (see table in clause 13.5.2.2).
Steel towers
Functional earthing shall be made as continuous counterpoise.

Concrete towers
Beam gantry, insulator mounts, and reinforcement must be connected to the tower earth electrode down conductor in the tower. Normally one down conductor per pole is used.

Wooden towers
Earthing of wooden towers is made when requirements in SS-EN 50341 regarding the wooden isolation length is not met. Beam gantry, insulator mounts, and reinforcement must be connected to the tower earth electrode with down conductor. Normally one down conductor per pole is used.

HVDC lines
For HVDC line with steel towers local earth electrodes can be used instead of continuous counterpoise. HVDC line is equipped, at new building, with a separate metallic return conductor that is not to be used for earthing of towers.

13.5.3.2 Continuous counterpoise
The earth conductor shall be buried in the ground between the boundaries formed by the outer phase conductors and be continuous along the line. The earth conductor shall be connected to the tower and all the stays at the towers it passes. For the excavation depth see clause 13.5.3.6.

In the case of obstacles (rock, roads, railways etc.) which prevent the counterpoise being buried between the boundaries of the outer phase conductors, the counterpoise is to be arranged as follows:

> If the extent of the obstacle beyond the boundaries of the outer phase conductors is small, the counterpoise is to be routed around it.

> If the obstacle extends to a significant distance perpendicular to the line, the continuous counterpoise is to be discontinued in the span. See Figure 1. This is not valid for connection to a substation.

If a section with a continuous counterpoise is terminated before a tower area with local earth electrode or if the continuous counterpoise is discontinued for obstacles, the continuous counterpoise shall be extended to at least half the span from the last tower area with a continuous counterpoise. If that is not possible continuous counterpoise shall be terminated with a deep earth electrode. Only one break of the continuous counterpoise per span is allowed.

For a connection to a substation no break is allowed on the continuous counterpoise within 1 km from the substation.
13.5.3.3  Radial earth electrode
The earth conductor shall be placed horizontally and radially out from the object to be earthed. The number of rays should be maximized to eight (8) pieces. The length of the rays shall be adapted to the soil conductivity. See Figure 2 and for the excavation depth see clause 13.5.3.6

The number and the length of the earth conductors included in the earth electrode shall be so that the expected earth resistance is below $100 \, \Omega$ according to clause 13.4.1.

If necessary, a combination of radial and deep earth electrodes can be used in order to obtain a sufficiently low earth resistance.

13.5.3.4  Deep earth electrode
Earth conductor (rods) in accordance with 13.5.1.2 shall be driven vertically into the ground and connected to the tower with horizontal conductors.

If so required, to obtain a sufficiently low earth resistance, several earth conductors shall be installed, separated by a distance not less than the excavation depth, adjacent to each other.

The vertical earth conductors shall be located within a distance of 25 m from the nearest part of the object to be earthed. See Figure 3.

The number and the length of the vertical conductors shall be so that the expected earth resistance is below $100 \, \Omega$ according to clause 13.4.1.

If necessary, a combination of radial and deep earth electrodes can be used in order to obtain a sufficiently low earth resistance.

13.5.3.5  Potential grading earth electrode
Potential grading earth electrode shall be located horizontally around stays and associated tower. For material selection, see 13.5.1.3, and for location, see Figure 4.

Potential grading earth electrode are available as two types:

> A simple variant positioned as a single loop, 1 lap and 1 m from the post/bar around all the stays and tower legs. This design generally applies to poles in urban areas and where tower are placed on concrete foundations.

> Potential grading earth electrode placed in a spiral as in Figure 4. This design applies in places where people usually travel or stay.

Potential grading earth electrode shall be connected directly (without spark-gaps) to tower and/or stay.
At towers placed on rock where protective earthing cannot be arranged for the exposed tower parts shall, which are accessible to touch, be touch-protected.

13.5.3.6 **Excavation depth**
Earth conductor, for both continuous counterpoise and radial earth electrode, shall be located at a minimum depth of 60 cm. However, in meadowland and arable land a minimum depth of 80 cm shall be used.

In the presence of rock at a depth less than the above, earth conductor may be located on the rock. However, only in exceptional cases may the earth conductor be laid on surface rock. If the earth conductor is to be laid on surface rock it shall be placed in a protecting pipe and bolted to the rock. As protecting pipe a pipe of SDR class PE 80 shall be used.

Earth conductor for Potential grading earth electrode shall be located at a depth of 20 – 30 cm.

13.5.3.7 **Touch protection**
Insulation shall be applied to those parts which are accessible within 3 m from the ground. See Figure 5.

13.5.3.8 **Connection of earthing conductors to support and stays**
Earthing conductor shall be placed in a loop below the ground surface to prevent conductor breakage occurring and also to prevent the conductor from coming loose from clamps on the tower or stays. See Figure 10 and Figure 11.

Earthing conductors of copper or copper-clad steel shall, both below and above the ground surface, be insulated with protecting pipe or plastic tube without interruption to a point at least 0,5 m outside tower legs, foundations, anchor bolt, Potential grading earth electrode or other steel details. As protecting pipe a pipe of SDR class PE 80 shall be used. The plastic tube shall be black and of a material that is not attacked by animals or destroyed by frost and low temperature and is stable against UV light. An example of an approved hose is E0762012.

Earthing conductor of copper-clad steel shall be marked with a sign E0668255. The sign is placed on the earthing conductor at the connecting to tower/stay.

**Support in the ground**
Support with steel base and/or stay in the ground.

Connection of steel wire is made directly to the support. Connection copper conductors or copper-clad steel wires are made via spark gap. Spark-gap shall be placed at least 1,5 m respectively 1,0 m above ground level. See Figure 10 and Figure 11.
Support on concrete foundation
Supports where all the legs and stay rods is connected to a concrete base at least 0,3 m above ground.

Connection can be made directly (without spark-gaps) if the whole line comprise of these type of towers even if copper or copper-clad steel wires are used. In this case the Potential grading earth electrode can be replaced with copper conductor or copper-clad steel conductor.

If there are towers along the line with support in the ground, the connection shall be made with spark-gap if copper or copper-clad steel wires are used. See Figure 10 and Figure 11.

Stays in the ground
For support with steel parts and stay placed in the soil, connections are made according to the following options:

- Stay insulator mounted on the chosen stay (at new building, stay insulators should be avoided according to section 13.4.5).
- Steel wires are connected directly to the stay. Connection is made via spark-gap for copper wire or copper-clad steel wire. The spark-gap shall be at placed least 1,0 m above ground level. See Figure 11

13.5.3.9 Connection to down conductor
Connection to down conductor for wood and concrete towers is made according to Figure 10.

13.5.3.10 Connection and jointing underneath the ground surface
Earth conductor is connected to earth electrode and jointing of earth electrodes shall be performed in such a way that a lasting good contact is obtained and that corrosion of the connection is prevented. This can be made with crimpling (double C-sleeves type Elpress) or welding.

13.5.3.11 Connection of shield wire

Connection of shield wire
Shield wire is connected to the tower as support, suspended or tension wire. In tension towers is the shield wire connected to an earthing terminal in the tower.

Connection of insulated shield wire
Insulated shield wire is to be connected to spark-gap in the tower with an earthing terminal. Spark-gaps are made according to Figure 12.
13.5.3.12 Crossings

General
Minimum distance between earth electrodes and structures described below are considered to be indicative only. The measurement of step and touch voltages shall be carried out to ensure functionality.

Distances
To prevent possible damage to, in the buried ground pipes and cables, from lightning strokes or earth faults on nearby high voltage overhead lines the distances should be kept between the buried pipes and cables and the overhead lines in the ground buried metallic components (bars, rods, earth electrodes, continuous counterpoise).

Earthed detail associated with high voltage overhead lines with solidly earthed neutral system (see also Telestörningsnämndens meddelande Nr 21):

<table>
<thead>
<tr>
<th>Installation</th>
<th>Minimum distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buried telecommunications line</td>
<td>20 or 50 m or 2 m</td>
</tr>
<tr>
<td>Buried cable or overhead line</td>
<td>20 or 50 m or 2 m</td>
</tr>
<tr>
<td>Earth electrode for low voltage and bar parallel earth continuity conductor &gt;1 kV</td>
<td>20 or 50 m or 2 m</td>
</tr>
<tr>
<td>Metal tube for water-, drainage- or gas pipes</td>
<td>20 or 50 m or 2 m</td>
</tr>
<tr>
<td>Telephone office</td>
<td>50 m or 100 m or 2 m</td>
</tr>
<tr>
<td>Trace wires along optical fibres</td>
<td>20 or 50 m or 2 m</td>
</tr>
</tbody>
</table>

1) Outside urban areas. Definition "Urban area" acc. SCB’s website: "A place with up to 200 properties where the distance between them is no more than 200 meters".
2) Short distance between a construction for a solidly earthed neutral system and other longer buried metallic pipes can influence the cathode protection for the pipe through voltage energizing. This impact may require greater distances.
3) Possible action if the above distance cannot be maintained without any construction is moved, is that any of the constructions buried in the ground is equipped with extra external insulation, for example by placing in waterproof plastic tubing so long that insulation distance is achieved.
4) Insulation of earthing conductor and location of earth electrode is made so that the electrical distance in the table is kept.
5) Must be insulated or removed within these distances.

Regarding the vertical distance counterpoise is to be located at least 0.5 m under/over crossing installation/part of installation listed to the left in the table above.

If the earthing conductor of copper or copper-clad steel are crossing other in the ground placed conductors of steel, the conductor shall be isolated to a point at least 1.5 m beyond such conductors.
13.5.3.13 Connection between overhead line and substation
Connection of to the earthing grid of substation to terminal tower of:

1. steel, for line with shield wire and continuous counterpoise of copper is made according to Figure 6.

2. steel, for line with shield wire and continuous counterpoise of steel is made according to Figure 7.

3. steel, for line with insulated shield wire and continuous counterpoise of copper is made according to Figure 8. These figures shall be seen as an example and in this design, the entire earthing situation have to be studied.

4. wood, for line with shield wire and continuous counterpoise of copper is made according to Figure 9.

Earthing conductor from the station and the transmission line must have separate connections on the transmission line end support.

13.6 Check

13.6.1 General
Swedish National Electrical Safety Board (Elsäkerhetsverket) requires for the processing of the operating permit an account of ground conditions including a specification of measured earth resistance and be informed that necessary safety precautions has been taken at disturbed sites.

Measurements are to be performed according to one of the following two methods; heavy current method and light current method. All towers (with earth electrodes taken care of) individual and resultant earth resistance shall be measured and documented in accordance with SvK-TR08-04.

13.6.2 Heavy current method
The check is to determine that the requirements of section 13.4.1 are met. Earthing resistance measurement is performed in accordance with and ERB U301E and EBR U602.5.

At new plants the heavy current method of station earthing, and for important parts along lines. At periodic measurements heavy current method is normally only used for station earthing. Other tower locations are measured with light current method.
13.6.3 Light current method
The check is to determine that the requirements of section 13.4.1, 13.5.3.3 and 13.5.3.4 are met. Earthing resistance measurement is performed in accordance with and ERB U301E and EBR U602.5.

On lines with continuous shield wire and with the earth electrode connected without spark-gap the resulting earthing resistance is measured.

On lines with continuous shield wire and with the earth electrode connected via spark-gap the earthing resistance of individual earth electrode is measured. To measure the resulting earth resistance, the spark-gap shall be short-circuited during the measurement.

On lines with insulated shield wire or parts of lines without shield wires earth resistance for individual earth electrode is measured.

At measurements a written protocol shall be used in accordance with EBR U301E. Appropriate protocol sheet is provided at request from Svenska kraftnät.

13.6.4 Measurement of step and touch voltage
The check is intended to determine that the step and touch voltages fulfil the requirements of section 13.5.2.5 for the protective earthing of towers.

The heavy current method according to section 13.6.2 shall be used and the control is normally made for new construction only. In older lines visual inspection of accesses and connections continuity with earth clamp method is made.

13.6.5 Functional check of spark-gap and stay insulator
For newly built or rebuilt line a functional check is made with potential measurement with reference electrode of copper/copper sulphate to the first five towers outside the switchyard.

Recurrent checks of spark-gap regarding welding, especially after thunderstorms and nearby earth faults. Checking the spark-gap is made by Svenska kraftnät.

13.7 Delivery

Before handing over, the earthings shall be approved by the orderer. For approval, the contractor shall demonstrate that the earthing meets the requirements in the guidelines.
The contractor shall provide documentation, in accordance with Svenska kraftnät's guidelines TR08-04, for approval.

Approval of the documentation does not release the contractor from responsibility that the earthing fulfils the requirements in the guidelines.
13.8 Figures

13.8.1 Figure 1
13.8.2 Figure 2

13.8.3 Figure 3
13.8.4 Figure 4

13.8.5 Figure 5
13.8.6 Figure 6

Förklaringar

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Diagram 6.1, 6.2, 6.3, 6.4
13.8.7  Figure 7
13.8.8 Figure 8
13.8.9 Figure 9

### Förklaringar

- Staket
- Isolator
- Ömstgap

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**Andstolpe**

**Toptuna** / OPGW till andstolpe

**Topplina** / OPGW till andstolpe

**ople** i träd, direkt förbind av toppina, genomgående marklinja av koppar

**Ställverk**

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**Andstolpe**

**Topplina** / OPGW till andstolpe

**ople** i träd, direkt förbind av toppina, genomgående marklinja av koppar

**Ställverk**

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**ople** i träd, direkt förbind av toppina, genomgående marklinja av koppar

**Ställverk**

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13.8.10 Figure 10
13.8.11 Figure 11
13.8.12 Figure 12