Deep earthing

Elpress system for deep earthing

Advantages

The Elpress deep earthing system has a number of advantages:

- the main earthing wire does not have to be jointed
- the tips and leading rods accept 16 - 95 mm² wire
- can be used for several wire types such as soft or hard copper, galvanised or stainless steel
- when Cu wire is used, the rods act as sacrificial anodes and protects the wire against corrosion
- there is a full control over wire travel during drive down
- earthing resistance can be monitored during drive down
- few parts make earthing easy and reliable
- low total system weight
- very attractive total cost picture

Radio Base Station is an application for Elpress deep earthing system.

Principal design

The Elpress deep earthing concept is a system without extra connection points. The earthing electrode is a copper wire which is pulled down by means of 0.8 m steel tubes ("rods").

A hardened steel tip locks the Cu wire into the leading rod. For each extension rod the wire is pulled a further 0.8 m down alongside the rods. See picture.

As the earthing resistance may be continously monitored at the other end of the wire, the driving down is interrupted when a satisfactory low resistance is reached. The top extension rod is pulled up and re used.

The driving down is normally made by power hammers with a suitable driving stud or with a sledge hammer and the driving cap FS61 or FS62C.

Driving stud FS62C.

Life expectancy

The Elpress deep earthing system consists of steel tubes and copper wire. The steel tubes, besides their pull-down function, also act as sacrificial anodes with a relatively high corrosion current to the Cu cathode.

This metal combination has a stabilising and neutralising effect on the close by soil. If a lead coated cable exists in the ground a few meters away from the earthing, the corrosion current is approx. 40 % lower than would have been the case without steel tubes. In other words, the lead coating will have life expectancy of almost double.

Experiments have shown that after a few months the corrosion current decreases to practically zero. The explanation is that a specific surface layer, the polarisation layer, is created close to the electrode. The current is reduced and therfore also the corrosion. How great this effect will be is related to among other things the soil properties. An AC load will theoretically reduce the corrosion and in that case the expected life will often be longer.

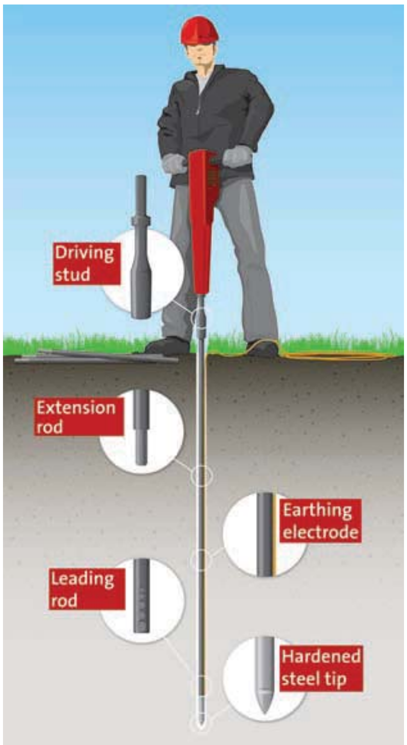
System design and function

The Elpress System consists of five parts:

- hardened steel tip
- leading rod
- extension rods
- driving studs or sleeves
- earthing wire (supplied by whole salers)

Simple function

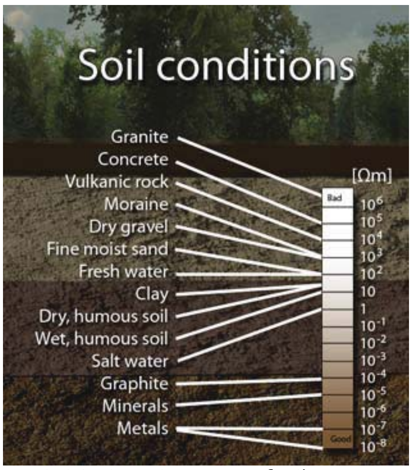
- the earthing wire is inserted into and held by the steel tip
- the extension rods have guiding pins to enter into the previous tube end to form a stable extension of the system
- by monitoring the earthing resistance, the driving down may be interrupted at best point



Practical advice

1. Plan the earthing. What soil properties prevail?
   Normal or soft soils - FS-rods are enough
   Hard and stony soils - FSHD-rods are recommended
   Are parallel earth takes of interest?
2. Try to establish the soil resistivity. From this and the maximum earthing resistance, the depth can be estimated.
3. Start the drive down by locking the wire into the steel tip with the leading rod. A 16 mm² wire should be folded before the tip is pushed on. In soft soils the drive down may be made with a sledge hammer but in somewhat harder soils a power hammer is preferred. Note that the driving tip in the power hammer must not rotate during driving.
4. Safeguard that the rods and the wire move with same speed. If not, the following is imminent:
   - more rods than wire is needed. The rods may have turned off into a more horizontal track and the wire is taking a short cut
   - the rods travel down but the wire has stopped. The wire has come lose and may be pulled up or the rods have started folding. Stop driving down.
   - rod and wire stop. The rod has hit a stone or rock. If not moving after 10 sec, stop and change place.

   If another earthing has to be made, move away 1.5 times the depth of the nearest earthing.
5. Monitor continously the resistance during drive down. Parallel earthings may be made. Connect together with Elpress C-sleeves or through connectors.



Resistivity in various types of soil.


Measuring of earthing resistance.


The earthing wire locks in the hardened steel tip with the leading rod.


The driving down has started.

Deep earthing system components

FS11

FS11

Steel tip with hardened top.

Particulars:

- special steel material
- accepts different types of earthing wires
- to be used with FS21 leading rod

Area	Cat. no.	Weight	Pcs/pack	Length
16-70 mm^2	FS11	0.90 kg/pack	5	135 mm

FS12

FS12

Steel tip with hardened top.

Particulars:

- special steel material
- accepts different types of earthing wires
- to be used with FS21 leading rod

Area	Cat. no.	Weight	Pcs/pack	Length
70-95 mm^2	FS12	1.3 kg/pack	5	135 mm

FS21

FS21

Leading rod, with a knurled recess for effective locking of the earth conductor. Used for normal and soft soils.

∅	Cat. no.	Weight	Pcs/pack	Length
17 mm	FS21	3.3 kg/pack	5	800 mm

FS31

FS31

Extension rod with locating pin fitting into the preceeding tube. For normal and soft soils.

Particulars:

- steel tube, diameter 17 mm
- to be used with FS21 leading rod

∅	Cat. no.	Weight	Pcs/pack	Length
17 mm	FS31	3.9 kg/pack	5	870 mm (incl guiding pin)

FSHD11

FSHD11

Heavy duty special steel tip with hardened top, used for hard and stony soils.

Particulars:

- to be used with FSHD23 leading rod

Area	Cat. no.	Weight	Pcs/pack	Length
25-70 (95) mm^2	FSHD11	1.3 kg/pack	5	153 mm

FSHD23

FSHD23

Heavy duty leading rod with a knurled recess for effective locking of the earthing wire. For hard and stony soils. To be used with the FSHD11 tip.

∅	Cat. no.	Weight	Pcs/pack	Length
21 mm	FSHD23	5.5 kg/pack	5	800 mm

FSHD31

FSHD31

Heavy duty extension rod, with guiding pin that fits into the preceding tube. For hard and stony soils.

∅	Cat. no.	Weight	Pcs/pack	Length
21 mm	FSHD31	6.2 kg/pack	5	870 mm (incl guiding pin)

FS41 withdrawal handle

FS41

Withdrawal handle to pull up the top extension rod for re-use. Fits FS and FSHD type rods.

Particulars:

- easy to use, with rubber handle grip
- for FS Ø17 and FSHD Ø21 rods

Dimensions hole	Cat. no.	Weight	Pcs/pack	Length x Width
∅ 18,5 mm and ∅ 22,5 mm	FS41	0.42 kg	1	230 x 60 mm

FS62C

FS62C

Driving sleeve used when driving the rods down with a sledge hammer. Must be used to prevent rod end damage.

Particulars:

- specially designed for FS21 and FS31 rods

Cat. no.	Weight	Pcs/pack	Length x Width
FS62C	1.0 kg	1	110 x 45 mm

FS61

FS61

Driving cap used when driving the FS21 and FS31 rods down with a sledge hammer. Used as an alternative to FS62C to prevent rod end damage.

Cat. no.	Weight	Pcs/pack	Length x Width
FS61	0.15 kg	1	58 x 22 mm

FSHD62C

FSHD62C

Driving sleeve used when driving the FSHD type rods down with a sledge hammer. Must be used to prevent rod end damage.

Particulars:

- specially designed for FSHD23 and FSHD31 rods

Cat. no.	Weight	Pcs/pack	Length x Width
FSHD62C	1.0 kg/pack	1	110 x 45 mm

Power hammer driving studs for Elpress deep earthing system

- specially designed for use with Ø17 mm FS type rods. Studs for use with FSHD rods, contact Elpress
- must be used to protect the rod ends from damage and distorsion when power hammers are used
- marked with the catalogue number

Power Hammer		Driving tip			kg/1		
Manufacturer	Type	Cat.no.	Shaft ∅ mm	Flange length mm	Total length mm	kg/1	Note
Atlas Copco	BBD 12 TS	FS 71 C	19	108	305	1,8	1
Atlas Copco	BBD 12 T-01	FS 72 C	22	108	305	1,9	1
Atlas Copco	Cobra 148/248	FS 72 C	22	108	305	1,9	1
Atlas Copco	Cobra BBM 47	FS 71 C	19	108	305	1,8	1
Atlas Copco	Pico 20	FS 72 C	22	108	305	1,9	1
Atlas Copco	RH 571 5L/5LS	FS 72 C	22	108	305	1,9	1
Atlas Copco	RH 658 5L/5LS	FS 72 C	22	108	305	1,9	1
Atlas Copco	TEX 11-DCS	FS 74 C	22	82	280	1,8	1
Atlas Copco	TEX-11-DKS	FS 74 C	22	82	280	1,8	1
Atlas Copco	TEX 23E	FS 73 C	25	108	305	2,0	1
Atlas Copco	TEX 25E	FS 73 C	25	108	305	2,0	1
Atlas Copco	TEX 31/31s	FS 77 C	32	160	380	2,5	1
Atlas Copco	TEX 41/41s	FS 77 C	32	160	380	2,5	1
Berema	Pionjär 120/130	FS 72 C	22	108	305	1,9	1
Bosch	USH 10	FS 82 C	19	-	272	1,5	1
Bosch	USH27	FS 83 C	29	-	310	2,2	1
HILTI	TE 52	FS 81 C	18	-	265	1,4	1
HILTI	TE72	FS 81 C	18	-	265	1,4	1
HILTI	TE 92	FS 81 C	18	-	265	1,4	1
HILTI	TE 905/TE805	FS 88 C	22	-	288	1,7	
Hunter		FS 73 C	25	108	305	2,0	1
Kango	950	FS 84 C	19	64	289	1,5	1
Stanley	BR 37	FS 74 C	22	82	280	1,8	1
Stanley	BR 45	FS 74 C	22	82	280	1,8	1
Stanley	BR 67 UK	FS 77 C	32	160	380	2,5	1
Stanley	BR 87 UK	FS 77 C	32	160	380	2,5	1
Stanley	DR 19	FS 74 C	22	82	280	1,8	1
Wacker	BHB 14	FS 71 C	19	108	305	1,8	1
Wacker	BHB 25	FS 72 C	22	108	305	1,9	1
Wacker	BHF 25	FS 85 C	27	80	302	2,1	1
Wacker	BHF 30S	FS 85 C	27	80	302	2,1	1
HILTI/Bosch	SDSMax Syst.	FS 81 D	18	-	215	1,4	

Note

1. Also available in a HD-version (ex FSHD71C), for FSHD rode with outer diameter 21 mm.

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General deep earthing information

Earthing

An earth electrode is a conductor placed in the soil with the purpose to discharge electrical current from a connected facility.
A customer that buys power expects good earthing. This, is in view of the fact that use of electricity with bad earthing includes a high risk. All suppliers of power must have approved earth electrodes at their facilities. It means that flash-over voltages, which can appear for different reasons, are led into the soil so they do not cause any damages and/or injuries. Earthing serves as, among other things, person protection, property protection, Electro Magnetic Pulses protection, lightning protection and similar.
Approved earthing should include:
(1) low electrical resistance, (2) ability to conduct stable voltage, even at weather changes and (3) long life expectancy, ie high resistance against corrosion.

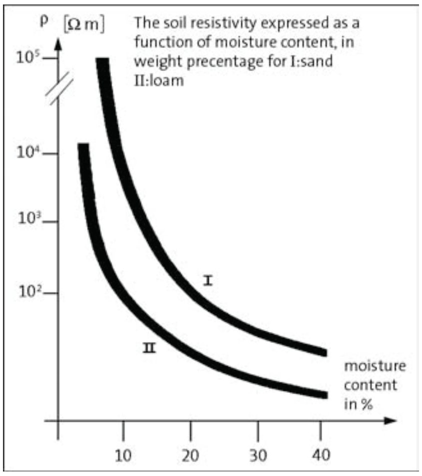
Soil conditions or external conditions

The soil's importance as conductor of electricity is large. This is proven by the fact that the technical specifications and demands, which apply to earthing, will confirm the advantages deep earthing has, both technically and economically, in comparison to surface buried conductors. Conductivity in the soil is made possible through an electrolytic process known as ion conduction. Homogenous particles, such as sand and gravel, are generally non-conductive.

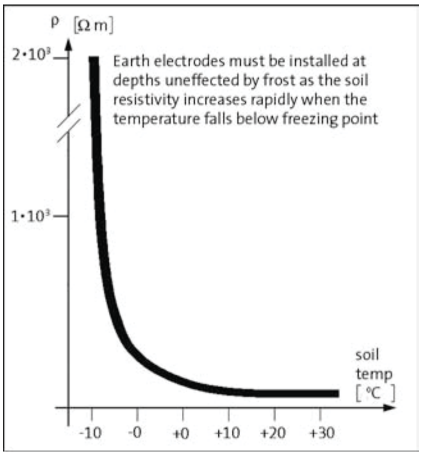
The conductive ability of the soil is therefore dependant of the proportion of saline water that is bound through capillary forces and osmotic pressure in the pores laying between the sand and the hygroscopic humous particles. The water in the lower soil layers generally has a higher percentage of salt than the water in the upper soil layers.
Also the moisture content influences the conductive ability of the soil.

The higher moisture content (%) in the soil, the better conductive ability it has. Normally, the moisture content of the soil varies between 5 - 40 %. At variations to under 14 - 18 %, the conductive abilities become considerably lower. Frost also decreases the conductivity in the soil. It is of great importance to consider all these facts when planning an earth electrode or earthing system.

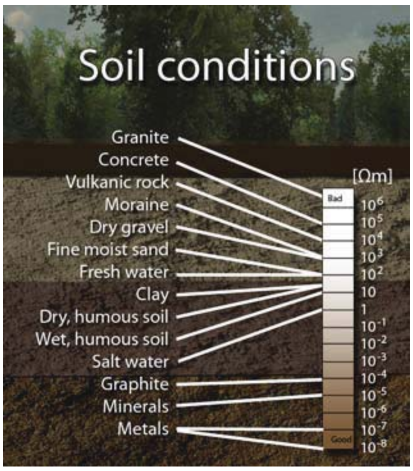
Weather conditions such as ice, snow, sun, rainfall and wind, greatly influence the upper soil layers (0 - 1,5 m in depth) and therefore the upper layers show the largest variations. The most effective earthing will be achieved when the earth electrode is placed deep enough not to be influenced by changes of the moisture content and temperature in the soil.



Soil resistivity as a function of the moisture content.



Soil resistivity as a function of the temperature.



Resistivity in various types of soil.

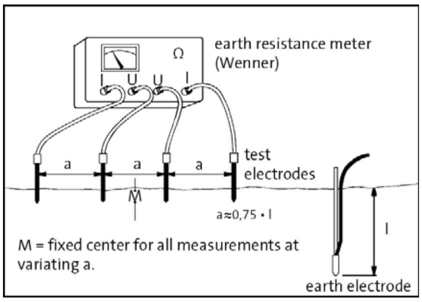
Resistivity

You declare the quality of the soil´s electrical characteristics with help from its resistivity, which is measured in Ωm (previously in Ωcm, 1 Ωm = 100 Ωcm). Therefore, soil with low resistivity (10 - 100 Ωm) has good conductivity. In each case of different type of soil, the resistivity should be measured and the operation is preferably carried out at different times of the year and under seasonal weather conditions. When carrying out resistivity readings today, almost all are exclusively voltage compensated bridges (measuring method from Wenner) with 4 external termination pints, of which 2 are for current electrodes and 2 for voltage electrodes. The termination points are connected to 4 vertical metal rods which are driven into the soil in a straight line wiht equidistant spacing **"a"** to a depth of about 0,3 - 0,5 m. (See picture).

On instruments giving a direct reading in ohms, R, the resistivity of the soil can be calculated with the following formula:

$$\rho = 2 \times a \times R \ \Omega m$$

In non stratified soil the resistivity is independant of the distanc 'a'. By increasing the distance 'a' the test current will penetrate deeper into the soil layers and thus the measured resistivity will decrease or increase depending on the true resistivity exisiting in the soil layer at the depth of l. At approximate calculation of the resistance on a depth of l, the soil resistivity must be measured with a probe distance of a x 0,75 x l.



Measurement of earthing resistivity.

Measuring of earthing resistance.

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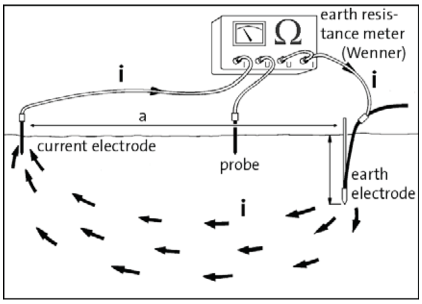
Earthing resistance

Due to the high resistivity of the earth (10^9 x resistivity$_{metal}$)a voltage gradient is built up around the earth electrode in the soil, which decreases with the distance from the electrode. On a particular distance this field gradient can be neglected (distant earth).

The resistance to earth of an electrode is usually measured with the same type of instrument that was used when measuring the resistivity of the soil. At this mesurement only one voltage probe and one current electrode is used. The location of probes and electrodes vary between various measuring methods. Out of the two methods to follow, one is very accurate when speaking of measurement techniques whereas the other is a more practical and not so sofisticated.



Measurement of earthing resistance - Method 1.

Method 1

(According to the Swedish lightning protection standard SS 487 0110)
This method has a measure deviation of ± 2 %.
General instructions:

- The external current electrode and the probe should be driven in a straight line with the earth electrode, as the picture shows.

- If the soil layers are stratified the measurements should be repeated with the external test probes being driven at alternative distances. The highest of the two values should be used.

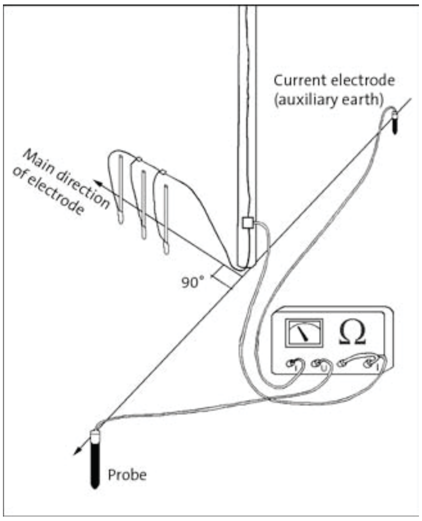
- The reliability of the measurement depends on the location of the external current electrode and the probe. Note: The distances in the table below normally give acceptable accuracy of the measurement.

earth electrode - probe = 0,5a - 0,6a

earth electrode - current elektrod = a

$a \geq 40$ m if $l \leq 4$ m

$a \geq 10 \times l$ if $l > 4$ m



Measurement of earthing resistance - Method 2.

Method 2

This method has a measure deviation of more than 2 % in general. It is, however, easier to carry out in practice compared to method 1.
An abridged report of this method will be as follows:

- Probes and electrodes to be located according to the figure, 90 degrees from the main direction of the earthing.
- The location of probe/electrode is the same be it measuring of an individual earthing or an earthing system which means at least 80 m from the earthing.
- Measurement of an earthing system is made by open earthing clamp.
- Measurement of resultant contact resistance of several earthing systems is made by a closed clamp and with the pilot wire connected to the top of the earthing clamp.

With assistance from the conductive ability and the max resistance, that are required according to directives, you can estimate the length of wire required from the formula:

$$l = \rho / R$$

l = length in meters

ρ = earthing resistivity in Ωm

R = earthing resistance in Ω

In our discussion about the advantages deep earth electrodes have compared to surface buried electrodes, we can mention that for the same conductor lengths, the resistance for a horizontal buried electrode is twice as high as for a deep earth electrode, ie:

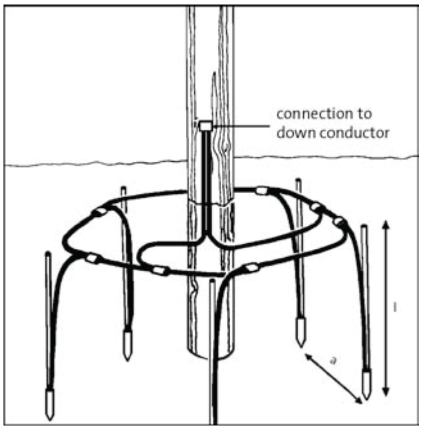
$$R_0 = 2 \times \rho / l$$

Parallel connection of several earth electrodes is often necessary, for practical reasons, to achieve a satisfactory low value of the earthing resistance. In order to limit the mutual influence between the individual earth electrodes, the electrodes shall be installed at distances of a of 1,5 times the depth of l. The resulting earthing resistance is:

$$R_{res} = k \times R_m$$

where R_m is the mean value of the earthing resistances of the individual electrodes. The reduction factor k is obtained from the following table.

No. of parallel earth electrodes	k for a = 1,5l
2	0,60
3	0,40
5	0,25
10	0,13



Parallel connection.

From an economical point of view, it can be mentioned that the diameter of the electrode has low influence when calculating the resistance when deep earthing is used. This means that when Elpress deep earthing system with a copper electrode is used, the cost will be lower than when using for example conventional systems. Practically, when it comes to the wire diameter it depends on what currents you dimension the system for and what rules and demands that apply.

Corrosion

The life expectancy of an earth electrode depends on its resistance against corrosion. The assumption for all types of corrosion is an electrolyte which makes it possible to transport metal ions from the anode to the cathode. At the anode the metal atoms in the electrolyte will dissolve and create free positive ions - oxidation - and at the cathode these ions will become neutralized and scale on the metal surface - reduction. At **galvanic corrosion**, which is caused by contact between

two metals, the speed of corrosion is proportional to the galvanic voltage between the metals.
An un-noble metal has higher electronegative potential than a noble metal and is therefore the anode in a corrosion process.
There is also a clear connection between the speed of corrosion and the earthing resisitvity. The speed of corrosion depends on the composition of the soil. Influencing factors are the soil's pH-value, temperature, amount of oxide, amount of water and resistivity. These factors influence the corrosion current, Ic, which is directly proportional to the speed of corrosion. Ic can be decided by direct measuring with an Ammeter or calculated according to the formula below if the contact resistance, Rc, between the two electrodes are known:

$$I_c = U_g / R_c$$

U_g = the galvanic voltage
R_c can in some cases be measured with the same type of resistance instrument that is used when measuring an earth electrode's resistance.
The speed of corrosion is often expressed in µm/year where 1 µm is 1/1000 of 1 mm and denotes the thickness of the corroded outer metal layer during one year.
The table below shows some practical direction values at various soil resistivities.

Resistivity	Corrosion
ρ < 1 Ωm	100 µm/year
ρ = 1-10 Ωm	100-30 µm/year
ρ = 10 -100 Ωm	30-4 µm/year
ρ > 100 Ωm	neglectable