Deep earthing

Deep earthing system

Benefits

Elpress systems for deep earthing have many advantages:

- The ground line has no joints – no risk of contact failure.
- Tip and leading rod are manufactured for a large area range; 16 - 95 mm².
- Can be used for different types of line e.g. soft or hard copper, galvanized or stainless steel.
- When copper line is used, the extension rods act as sacrificial anodes and provide good protection against corrosion.
- Full control over the line and tip is maintained and it is possible to continuously measure the earthing resistance.
- Thanks to the few components of the system, driving is both uncomplicated and reliable.
- The system has a low overall weight compared to other systems.
- The overall cost of a complete earth connection will be lower than that made in a conventional manner.
- Rod length 800 mm for best ergonomics.

Radio base station is an application for Elpress deep earthing systems.

Theory

Elpress' approach is an earthing system without joints. The electrode consists of a copper line that is driven down by a system consisting of 0.8 m long steel rods. A hardened steel tip paves the way for the ground line that is inserted into the steel tip and clamped by the leading rod. For every 0.8 m length of driven line and rod, an extension rod is pushed into the preceding rod. Because the earthing resistance can be continually measured at the other end of the line, one can stop driving when a suitable value is reached and the last extension rod is then withdrawn.
Driving takes place with the aid of a power hammer with an adapted driving sleeve or a sledge hammer and impact sleeve FS62C.

Impact sleeve FS62C

Service life

Elpress deep-earthing system consists of steel rods and a copper line. The steel rods act as sacrificial anodes with relatively high corrosion current against the copper electrode (cathode).
This combination of metal both stabilises and equalises its surroundings. If a lead sheathed cable is located in the soil a few metres from the earth connection, the corrosion current from the lead anode to the Fe+Cu earth connection is 40% less than the value of an earth connection without FE rods. In other words, the lead sheath has a theoretical service life of almost double.
Experiments have shown that after a few months, the corrosion current drops to virtually zero. The explanation is that a special layer – the polarization layer – is formed next to the electrode. The current is thereby reduced and thus also the corrosion. The amount of the reduction depends on the properties of the soil. An AC load should theoretically counteract the corrosion. This means that the practical service life is often longer than the theoretical.

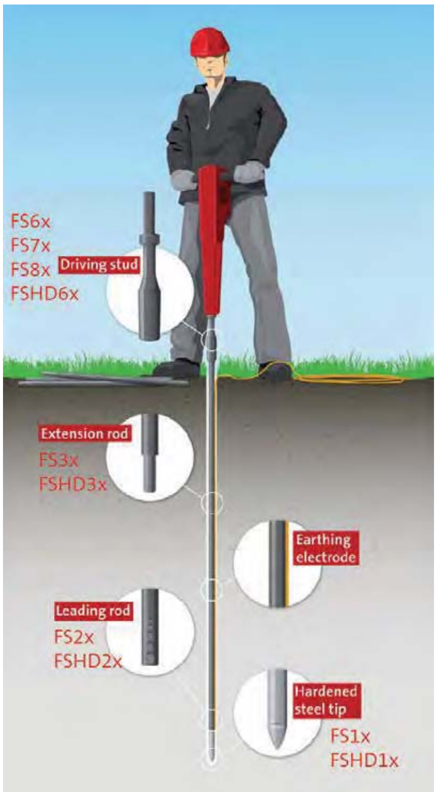
Structure and operation of the system

Elpress systems consist of the following 5 parts:

- hardened steel tip
- leading rod
- extension rod
- driving sleeve/impact sleeve
- earth line (not supplied by Elpress)

This feature is simple

- the earth line is inserted into the hardened steel tip and clamped by the leading rod.
- the extension rods are fitted with a guide pin, which during work is pushed into the preceding rod.
- earthing resistance can be measured continuously. When the appropriate value is reached, driving is interrupted and the last extension tube is withdrawn (and can therefore be reused).

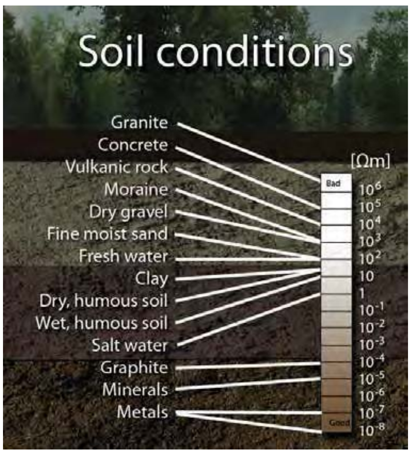


Practical advice:

1. Plan the earth connection.
What are the soil conditions?
Normal and loose soil - steel pipe Ø 17 mm is sufficient.
Hard and rocky soil- steel rod Ø 21 mm (type HD) should be used. Is a parallel earth connection possible?
2. Determine the soil resistivity. Based on that and the maximum earthing resistance it can be estimated how much line is needed.
3. Start the driving by locking the line into the hardened tip with the leading rod. 16 mm² line should be folded double before the tip is attached. In loose soil, a sledgehammer and impact stud is sufficient. In heavier soil/at greater depth, a power hammer should be used. NOTE: Do not rotate the driving sleeve during the work.
4. Make sure that the line maintains the same speed down into the soil as the rod. If it does not, there are the following possibilities:
- more rods than line required; the rod may have been bent and then runs parallel to the surface of the soil and the line does not follow the pipe through the ground.
- the rod continues and the line stops; the line has come loose and can be pulled up or the tip has folded.
- both stop; stone or rock has been found. If the stone does not shatter after about 10 seconds, you must start over.

In the event of interrupted driving, start again at a distance at least 1.5 times the line length already driven down.

5. Preferably measure the earthing resistance continuously while driving down the earth line. Arrange a parallel earth connection if necessary. Splicing and branching of the earth line is contact crimped by means of Elpress through connectors or branching sleeves and tools.



1. Resistivity in different soil conditions.

2. Measurement of ground resistance.

3. The earth line is locked to the hardened steel tip with the leading rod.

Driving starts.

Deep earthing system FS

Elpress deep-earthing system FS consists of 3 parts. Tip (FS1x), leading rod (FS2x) and extension rod (FS3x).

FS1x

Tip, with hardened steel furthest out. Fits FS21 and allows the use of different types of earth line.

mm²	Name	Net weight (kg)	Length	Pcs/pack
16-70	FS11	0,176	135	5
70-95	FS12	0,176	135	5

FS21

Steel leading rod, equipped with a grooved notch to lock the earth line effective-ly. For loose and normal soil conditions.

ø	Name	Net weight (kg)	Length	Pcs/pack
17	FS21	0,644	800	5

FS31

Steel extension rod, HD, equipped with a guide pin that fits inside the preceding rod. For loose and normal soil conditions.

ø	Name	Net weight (kg)	Length	Note	Pcs/pack
17	FS31	0,804	870	Length incl. driving cap	5

Deep earthing system FSHD

Elpress deep-earthing system with thicker rods for tougher soil conditions FSHD (HD: ”Heavy Duty”) consists of 3 parts. Tip (FSHD1x), leading rod (FSHD2x) and extension rod (FSHD3x).

FSHD11

Hardened steel tip intended for hard and rocky ground. Used in conjunction with leading rod FSHD23.

mm²	Name	Net weight (kg)	Length	Pcs/pack
25-70 (95)	FSHD11	0,254	153	5

FSHD23

Steel leading rod, equipped with a grooved notch to secure the earth line effectively. Designed for hard and rocky ground.

ø	Name	Net weight (kg)	Length	Pcs/pack
21	FSHD23	1,088	800	5

FSHD31

Steel extension rod, HD, equipped with a guide pin that fits inside the preceding rod. Robust rod intended for hard and rocky ground.

ø	Name	Net weight (kg)	Length	Note	Pcs/pack
21	FSHD31	1,224	870	Length incl. driving cap	5

Accessories for Elpress deep-earthing systems

Withdrawal handle FS

Pull handle with grip-friendly design that facilitates withdrawal and allows reuse of the last extension rod FS3x/FSHD3x.

ø	Name	Net weight (kg)	Length mm	Width	Pcs/pack
18,5/22,5	FS41	0,403	230	60	1

Impact sleeve FS

Impact sleeve used when driving using a sledgehammer, or similar, to prevent deformation of the rod end. Specially designed for use with FS21 or FS31 rods.

Name	Net weight (kg)	Length mm	Width	Pcs/pack
FS62C	1,018	110	45	1

Impact stud FS

Impact stud used when driving using a sledgehammer, and similar, to prevent deformation of the rod end.

Name	Net weight (kg)	Length mm	Width	Pcs/pack
FS61	0,081	58	22	1

Impact sleeve FSHD

Impact sleeve used when driving using a sledgehammer, or similar, to prevent deformation of the rod end. Specially designed for use with FSHD23/FSHD31 rods.

Name	Net weight (kg)	Length mm	Width	Pcs/pack
FSHD62C	0,93	110	45	1

Driving sleeves for FS and FSHD deep-earthing systems

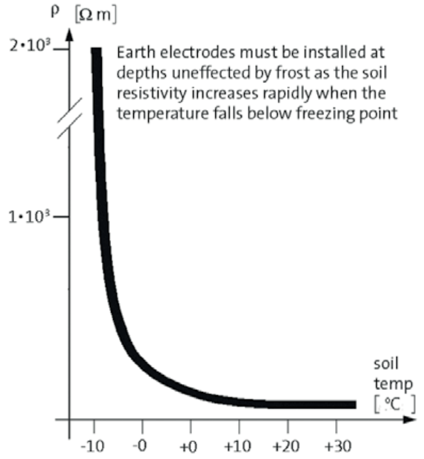
- specially designed for use with the FS21 and FS31 rods
- protects the end of the rod from deformation when driving with a power hammer
- for FS-type rods with an external diameter of 17 mm
- marked with the catalogue number

Name	Tool	Shaft ø	Flange length	Total length	Pcs/ pack	Note
FS71C	BBD 12 TS, BHB 14	19	108	305	1	HD version also available for rods with 21 mm outer diameter
FS72C	BBD 12 T-01, Cobra 148/248, Pico 20, RH 571 5L/5LS, RH 658 5L/5LS, BHB 25	22	108	305	1	HD version also available for rods with 21 mm outer diameter
FS73C	TEX 23E, TEX 25E	25	108	305	1	HD version also available for rods with 21 mm outer diameter
FS81C	TE 52, TE 72, TE 92	18		265	1	HD version also available for rods with 21 mm outer diameter
FS83C	USH27	29		310	1	HD version also available for rods with 21 mm outer diameter
FS85C	BHF 25, BHF 30S	27	80	302	1	HD version also available for rods with 21 mm outer diameter
FS88C	TE905/TE805	22		288	1	
FS81D	SDSMax Syst.	18		215	1	
FS74C	TEX 11-DCS, TEX-11-DKS, BR 37, BR 45, DR 19	22	82	280	1	HD version also available for rods with 21 mm outer diameter
FS77C	TEX 31/31s, TEX41/41s, BR 67 UK BR 87 UK	32	160	380	1	HD version also available for rods with 21 mm outer diameter

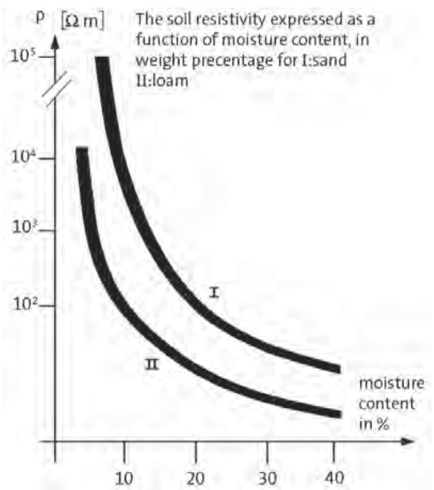
System structure and function - deep earthing

Earthing

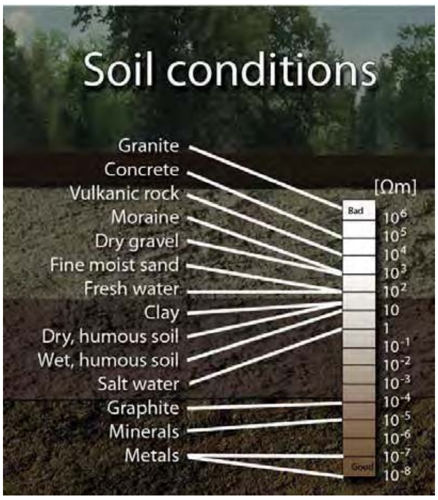
An earth connection is a conductor placed in the soil, with the aim of diverting electrical current from an installation connected to the earth connection and into the surrounding soil.
A customer who buys power takes earthing for granted. This is despite the fact that the use of power without, or with poor, earthing incurs great risks.
All power suppliers must have approved earth connections at their installations. This means that voltage surges that can occur for various reasons are led into the ground so that they do not cause damage. Earthing thus functions as, among other things, personal protection, property protection, signal transfer protection, lightning protection and the like.
An approved earthing should have: (1) low electrical resistance, (2) ability to conduct voltage stably (despite weather changes) and (3) long service life, i.e. good resistance to corrosion.
Soil conditions or external conditions?
The importance of the soil as a conductor of electric current is great. The technical specifications and requirements for earthing demonstrate the advantages of deep-earth connections, both as a technical and economic solution, in relation to surface-earth connections.
Current conduction occurs in the soil through electrolytic processes, known as ionic conduction. Solid particles such as gravel are not usually conductive.
The electrical conductivity of the soil therefore mainly depends on the proportion of saline water bound by capillary forces and osmotic pressure in the pores between grains of sand and in hygroscopic humus particles (e.g.clay).
The water in deeper lying ground layers usually has a higher salinity than the water in the surface layer. The higher the moisture content of the soil, the better the conductivity. Soil humidity normally varies between 5-40%. At variations below 14-18%, conductivity deteriorates significantly.
Cold (frost) significantly impairs the ground's conductivity. It is of great importance that all this is taken into account for earth connections or earth connection systems.
Weather conditions - cold, heat, rain and wind - mainly affect the upper layer of the soil (0 - 1.5 m), which therefore exhibits the most powerful variations. The most efficient earthing is thus reached when the electrode is placed deep enough so as not to be affected by changes in soil humidity and temperature.



Soil resistance in relation to temperature.



Soil resistance in relation to humidity.



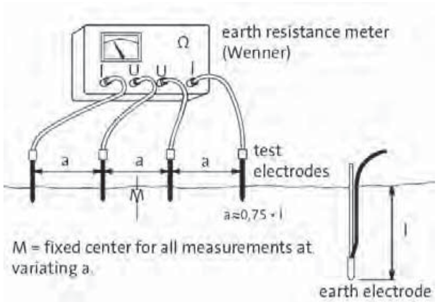
Resistivity in different soil conditions.

Resistivity

The electrical properties of the soil are quality declared by means of its resistivity, which is measured in Ωm (former unit Ωcm, 1 Ωm =100 Ωcm). Soil with good electrical conductivity thus has low resistivity: 10 - 100 Ωm.
For each case of different soil type, soil resistance must be measured and preferably during several seasons and in different weather conditions. In measurement today almost exclusively voltage compensated electronic resistance bridges are used (measurement method according to Wenner) with 4 connection contacts, 2 of which are for current electrodes and 2 for voltage probes.
The connectors are connected to 4 vertical metal tips that are driven down in a row about 0.3-0.5 m deep a metre apart. (See image)
If the instrument reading is R, the resistivity of the soil is calculated according to the following equation:

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

In unlayered soil, resistivity is independent of the electrode distance a.
By increasing distance a, the current penetrates deeper into the ground and the measured resistivity can fall or increase depending on the resistivity of the ground layer at 1 metre's depth. When calculating approximate earthing resistance of the earth connection when the depth is l, the resistivity of the soil must be measured with electrode distance a ≈ 0.75 x l.



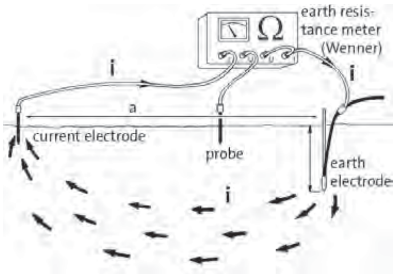
Measurement of ground resistance.


Measuring earthing resistance of the earth connection

Earthing resistance

Due to the high resistance of the soil (109 x resistivity metal) at current bleed in the soil a strong electrical field is formed in the earth connection, which diminishes in strength with distance from the earth connection. At a certain distance, this field can be neglected (removed earth).

The earthing resistance of the earth connection is usually measured with the same type of instrument used to measure the resistance of the soil. However, this measurement requires only one voltage probe and a current electrode (auxiliary earth connection). The location of probes and electrodes varies between different measurement methods. The two methods that follow are a method of accurate technical measurement and a more practical, simplified method.



Measuring earthing resistance of the earth connection - Method 1

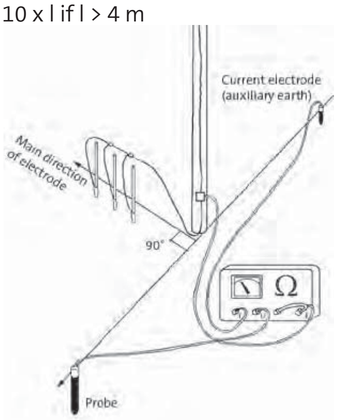
Method 1

(acc. to the lightning protection standard SS 4870110). This method has a measurement error of +/ - 2%.

The summary gives this method:

- The probe and auxiliary electrode are placed in a straight line from the earth connection to be measured as illustrated.
- If the ground is layered, measurement should be carried out in two directions. The largest value is used.
- The reliability of the measurement result depends on the location of the probe/ auxiliary electrode. Note the distance table below. These provide normally acceptable measurement accuracy.

earth connection - probe = 0.5a-0.6a
earth connection - electrode = a
a ≥ 40 m if l ≤ 4 m
a ≥ 10 x l if l > 4 m



Measuring earthing resistance of the earth connection - Method 2.

Method 2

(acc. to EBR-standard U2:80)

This method normally has a measurement error of more than 2%, but practically is easier to perform than Method 1.

The summary gives this method:

- Probes and electrodes are placed as illustrated, 90° from the main direction of the earth connection.
- The position of the probe/electrode is equal when measuring both an individual earth connection as earth connection system, i.e. at least 80 m from the earth connection.
- Measurement of an earth connection is carried out with an open earth conductor clamp.
- Measurement of the resulting transition resistance on multiple earth connection systems is carried out with the clamp closed and with the measuring line connected on the top of the earth conductor clamp.

With the help of the conductivity and the maximum earthing resistance, which is required by, among other things, the high current regulations, it is possible to estimate how much line may be needed according to the formula:

$$l = p / R$$

l = length in metres
p = soil resistance in ohmmeter
R = earthing resistance in ohms.

In the discussion of the advantage of deep-earth connections compared to surface-earth connections, it should be mentioned here that the earthing resistance of a horizontal surface-earth connection is twice that of a similar line length in a deep- earth connection, i.e.

$$R0 = 2 \times p / l$$

Parallel connection

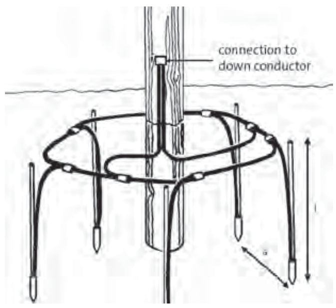
Parallel connection of several earth sockets is often necessary for practical reasons to achieve a sufficiently low value of earthing resistance during earthing. In order to limit reciprocal connection between individual earth connections, deep-earth connections shall be installed a distance apart of 1.5 times the depth of the earth connection l.

Resulting earthing resistance:

$$Res = k \times Rm$$

where Rm is the mean of the resistance value of the earth connection and k a reduction factor, the value of which is obtained from the following table.

No. of parallel earth connections	k for a = 1.5l
2	0.60
3	0.40
5	0.25
10	0.13



Parallel connection.

From economic aspects it can be pointed out that the diameter of the earth connection has a negligible role when calculating the earthing resistance in deep earthing. This means that when using Elpress deep-earthing systems with copper line, the cost will be lower than when using, for example, conventional systems. What is important in practice in terms of the cable diameter is what currents the system is dimensioned for and what rules and requirements apply.

Examples of applicable requirements: the lightning protection standard states Cu-line min 25 mm², EBR prescribes min. Cu-line 35 mm² for earth connections in overhead line networks and min. 50 mm² for earth connections in ground cable networks.

Corrosion

The service life of an earth connection depends on its resistance to corrosion (rust). The prerequisite for all types of corrosion is an electrolyte fluid that allows the transport of positive metal ions from anode to cathode. At the anode, metal atoms are dissolved in the electrolyte, forming free positive ions - oxidation- and at the cathode these ions are neutralized and deposited on the metal surface - reduction.

In **galvanic corrosion** caused by contact between two metals, the corrosion rate is proportional to the galvanic tension between the metals. A base metal has higher negative potential than a nobler metal and therefore forms the anode in a corrosion process.

There is also a clear correlation between the corrosion rate and ground resistance. The rate of corrosion depends on the composition of the soil. Influencing factors are the pH of the soil, temperature, oxygen content, moisture content and resistivity. These factors affect the corrosion current Ik, which is directly proportional to the rate of corrosion. Ik can be determined by direct measurement with an Ammeter or calculated, if the transition resistance Rö between the two electrodes is known, according to formula:

$$Ik = Ug / Rö$$

Ug = galvanic voltage

In some cases, Rö can be measured with a resistance bridge of the same type used to measure the earthing resistance of an earth connection. The rate of corrosion is often expressed in µm/year where 1 µm represents 1/1000 of 1 mm and denotes the thickness of the corroded away outer metal layer for 1 year. The table below indicates some practical values as guide values for different soil resistivity.

Resistivity	Corrosion
p < 1 Ωm	100 µm/year
p < 1-10 Ωm	100-30 µm/year
p < 10-100 Ωm	30-4 µm/year
p > 100 Om	negligible

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