Earthing Introduction

How to apply earthing equipment

An effective earthing system is a fundamental requirement of any modern structure or system for operational and/or safety reasons. Without such a system, the safety of a structure, the equipment contained within it and its occupants is compromised.

Earthing systems typically fall into (but are not limited to) one of the following categories:

- Power generation, transmission and distribution
- Lightning protection
- Control of undesirable static electricity
- Telecommunications.

The following schematic illustrates the key elements of an effective earthing system.

Conductors and Earth rods

As with lightning protection, the first choice faced by the designer of an earthing system is the type of conductor to be used. The correct choice of conductor is extremely important, whether it be a simple below ground electrode or a complex computer room signal reference grid.

Conductors

Furse offer three types of conductor: Flat tape, Solid circular and Stranded cable.

A range of conductor materials are available. Above ground, copper, aluminium and steel may be used. Below ground, copper is the most common choice due to its high resistance to corrosion.

It is important that earthing conductors should be correctly sized for their application, as they may be required to carry a considerable current for several seconds.

Earth rods and plates

In addition to the conductors outlined above, earth rods and plates or any combination thereof can be used to achieve an effective earth depending on the site conditions.

Earth rods take advantage of lower resistivity soils at greater depths than normal excavation will allow.

Earth plates are used to attain an effective earth in shallow soils with underlying rocks or in locations with large amounts of buried services. They can also provide protection at potentially dangerous places e.g. HV switching positions.

Connectors and terminations

An effective earthing system relies on joints and connections to have good electrical conductivity with high mechanical strength. Poorly chosen or badly installed joints and connectors can compromise the safe operation of an earthing system.

Furse offer a range of connectors and termination methods to suit a wide range of applications.

FurseWELD exothermic welding

A simple, self-contained method of forming high quality electrical connections which requires no external power or heat source. Connections are made using the high temperature reaction of powdered copper oxide and aluminium.

FurseWELD connections allow conductors to carry higher currents than other types of connections. They will never loosen, are highly conductive and have excellent corrosion resistance.

Compression connectors

For applications where exothermic welding is not appropriate for creating permanent connections, compression connectors may be used.

Compression connectors produce very robust joints which can be buried in the ground or in concrete.

Mechanical clamps

Where permanent connections are not appropriate, mechanical clamps offer the ideal solution. These are typically used on smaller scale installations where periodic disconnection for testing is required.

All Furse mechanical clamps are manufactured from high copper content alloy. They have high mechanical strength, excellent corrosion resistance and conductivity.

Earth inspection pits

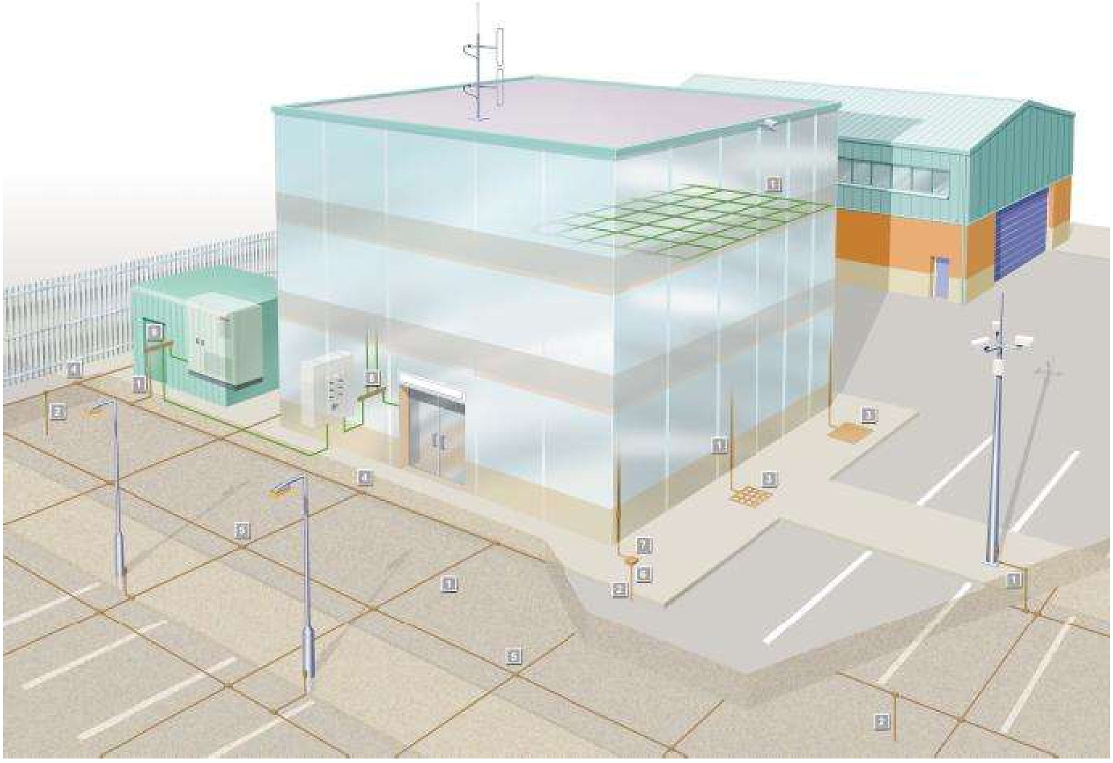
Regular inspection and testing of the earthing system is essential. Inspection pits allow easy access to earth electrodes and conductors to facilitate this procedure.

Earth bars

Earth bars are an efficient and convenient way of providing a common earth point. Integral disconnecting links mean the earth bars can be isolated for testing purposes.

Soil conditioning agents

Soil conditioning agents are to be used in areas where required resistivity levels are difficult to achieve. When used as a backfill for earth electrodes, soil conditioning agents effectively act to increase the electrodes surface area thus lowering its resistance to earth.



Product selector

(1) Conductors
(2) Earth rods
(3) Earth plates
(4) FurseWELD exothermic welding
(5) Compression connectors
(6) Mechanical clamps
(7) Earth inspection pits
(8) Earth bars

This illustration is designed to demonstrate the main aspects and individual components of an earthing system. It is not intended to represent an actual scheme conforming to a particular code of practice. The drawing is not to scale.

Earthing

Earthing design considerations

A correctly designed and installed earthing system will safeguard both lives and equipment.

A good earth connection should have:

- Low electrical resistance to earth
- Good corrosion resistance
- Ability to carry the required current repeatedly
- A reliable life of at least 30 years

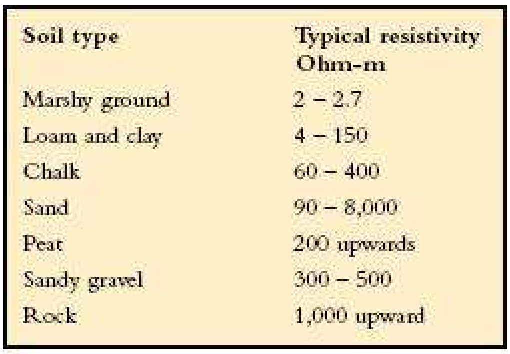
The crucial factors that determine the resistance to earth of an electrode are:

- Soil resistivity
- Electrode dimensions
- Area available

Soil resistivity

Physical composition

Different soil compositions give different average resistivities.



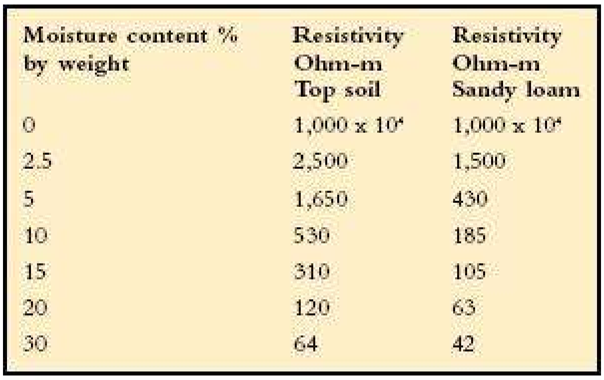
Soil type	Typical resistivity Ohm-m
Marshy ground	2 – 2.7
Loam and clay	4 – 150
Chalk	60 – 400
Sand	90 – 8,000
Peat	200 upwards
Sandy gravel	300 – 500
Rock	1,000 upward

Table 1 – Effect of soil type on resistivity

Moisture
Increased moisture content of the ground can rapidly decrease its resistivity.

It is especially important to consider moisture content in areas of high seasonal variation in rainfall.

Wherever possible the earth electrode should be installed deep enough to reach the “water table” or “permanent moisture level”.

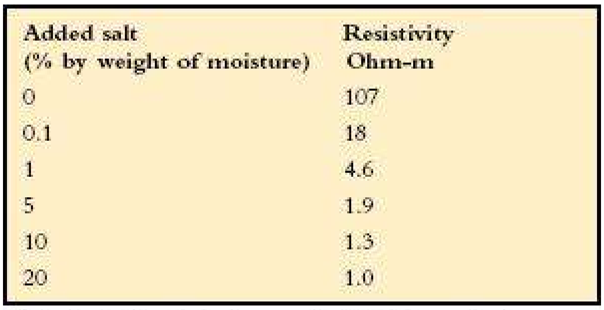


Moisture content % by weight	Resistivity Ohm-m Top soil	Resistivity Ohm-m Sandy loam
0	$1{,}000 \times 10^4$	$1{,}000 \times 10^4$
2.5	2,500	1,500
5	1,650	430
10	530	185
15	310	105
20	120	63
30	64	42

Table 2 – Effect of moisture on resistivity

Chemical composition
Certain minerals and salts can affect soil resistivity. Their levels can vary with time due to rainfall or flowing water.

Note that although the addition of salts can lower soil resistivity, they are not recommended due to corrosion and leaching.

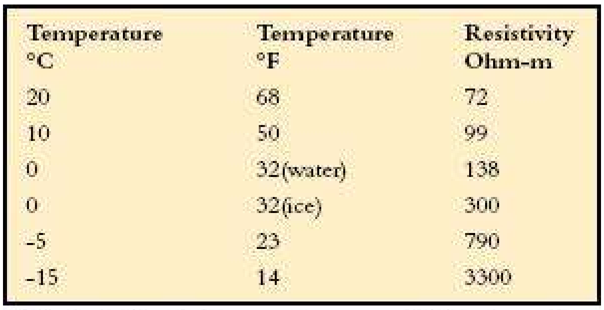


Added salt (% by weight of moisture)	Resistivity Ohm-m
0	107
0.1	18
1	4.6
5	1.9
10	1.3
20	1.0

Table 3 – Effect of salt on resistivity for sandy loam, 15.2% moisture

Temperature
When the ground becomes frozen, its resistivity rises dramatically. An earth that may be effective during temperate weather may become ineffective in winter.

Please note that, if your soil temperature decreases from +20°C to -5°C, the resistivity increases more than ten times.



Temperature °C	Temperature °F	Resistivity Ohm-m
20	68	72
10	50	99
0	32(water)	138
0	32(ice)	300
-5	23	790
-15	14	3300

Table 4 – Effect of temperature on resistivity for sandy loam, 15.2% moisture

Electrode dimensions

The most important dimension to consider when designing an earth electrode is its length. The greater the length of an electrode the lower the density of the current in soil in the immediate vicinity of that electrode.

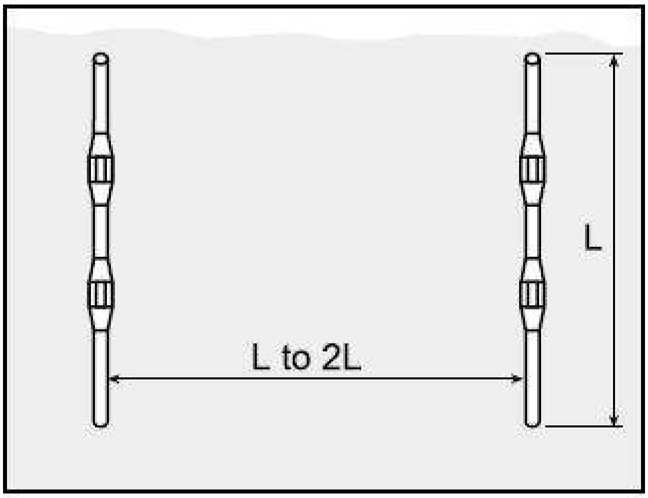
For this reason a rod or strip type electrode will have a much lower resistance to earth than a plate type electrode of the same surface area.

By reaching permanent moisture and frost free soil levels, low resistance should be achieved. Often these levels are some metres below the surface and the most economical way of reaching them is by extensible deep driven earth rod electrodes.

Furse recommend the use of deep driven earth rod electrodes wherever conditions allow.

Where rocks lie just below the surface and deep driving is not possible, parallel driven shorter rods, plates, mats or buried conductors, or a combination of these can be used. However, these should still be buried as deep as possible to avoid seasonal variations, damage from agricultural machinery etc.

Area available



Parallel rods

Often a single earth rod, strip or plate will not achieve the desired resistance alone. If a number of electrodes can be installed in parallel the combined resistance is then practically proportional to the reciprocal of the number employed. This is true so long as each electrode is situated outside the resistance area of any other. For rod electrodes this separation distance is considered to be equal to the driven depth. When an earth electrode must be composed of multiple parallel electrodes the area available for earthing becomes of major importance.

Earth electrode materials

Quality earth rods are commonly made from either solid copper, stainless steel or copperbonded steel.

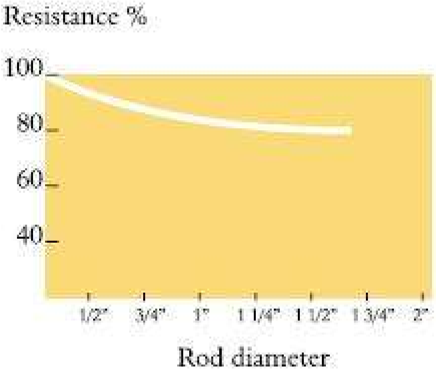
Furse can supply all three types, but the copperbonded steel cored rod is by far the most popular, due to its combination of strength, corrosion resistance, and comparatively low cost.

Solid copper and stainless steel rods offer a very high level of corrosion resistance at the expense of lower strength and higher cost.

Diameter of rod

One common misconception is that the diameter of the rod has a drastic effect on lowering earth resistance. This is not true! As the graph shows, you only lower the resistance value by 9.5 per cent by doubling the diameter of the rod (which means increasing the weight and the cost of the rod by approximately 400 per cent!)

Thus the rationale is: Use the most economical rod that soil conditions will allow you to drive. This is one of the ways to ensure that you don’t waste money on over-dimensioned rods.

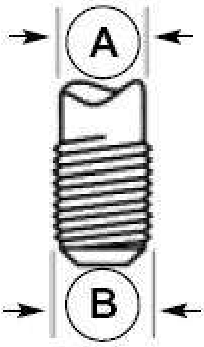


Effect of electrode diameter on resistance.

Thread and shank diameters

Confusion often arises between thread and shank diameters for threaded rods.

The thread rolling process, used by quality rod manufacturers, raises the surface of the rod so that thread diameter (B) is greater than shank diameter (A) (see drawing).



All threads are Unified National Coarse (UNC-2A).