FOUNDATION AND EARTHING CONNECTION MANUAL

SOLAR TRACKER

Document background

Rev. No.	Date	Modifications
0	2009-01	First edition
1	2009-04	Second edition
2	2012-03	Third edition

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IMPORTANT

This manual is aimed at specialist installers and must be read carefully before the equipment is used. If you have no experience in handling and installing large equipment, please contact one of our experts.

Do not try to install, start up or perform maintenance work on this equipment if you are not prepared to do so and have not read and understood this manual. Should you have any doubts as to the installation or use of the equipment, please contact our technical department. DISREGARDING THESE INSTRUCTIONS MAY RENDER THE GUARANTEE NULL AND VOID.

1. Liabilities

The manufacturer is only liable for the parts included in the supply contract. Not following the instructions given in this manual releases the constructor from any liability.

Any modifications, alterations and use of inappropriate spare parts releases the constructor of any liability regarding the correct use and working order of the machine and the safety of personnel and objects.

The times and duration of work described in this manual are based on the average taken for various different installations. The times may vary depending on the skill of the operators, their equipment and the conditions of the workplace.

2. Safety precautions

Persons working or passing close to the worksite should respect the basic safety precautions concerning protection and prevention with metal materials and suspended loads.

2.1 Personal protective equipment

- Safety footwear
- Gloves for handling ferrous metals
- Hard hat.

2.2 Prevention

- Do not stand below suspended loads
- Galvanised surfaces may have uneven areas. Sand them down and always wear gloves for ferrous materials

- Check the fastenings on parts
- Use slings, cables and chains that are capable of withstanding the weights of the parts to be hoisted
- Situate the crane so that its elevating capacity is sufficient for the distance to its foundations

3. FOUNDATION ASSEMBLY

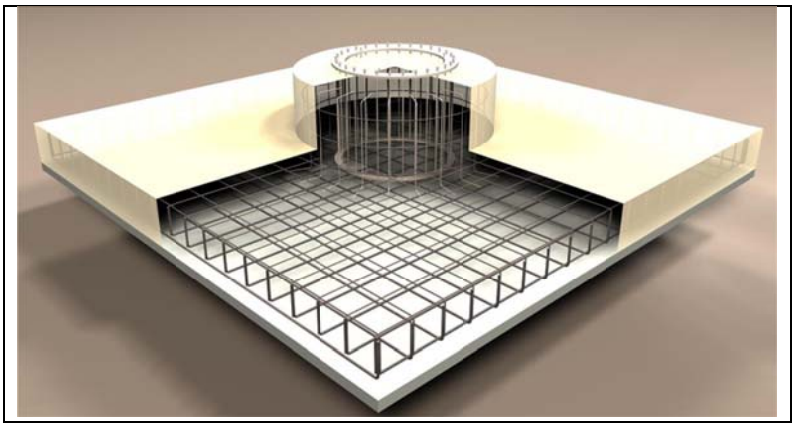
ADES recommends a geotechnical study be performed on each site to ensure the resistance of the ground with regards to foundation loads and the protective quality of the concrete in terms of site aggressiveness.

NOTE: The foundations must be built based on the plans that ADES provides after the geotechnical study commissioned by the customer and performed by an appropriate expert in the subject on the site of installation. Any error regarding distances or gradients will postpone assembly until said errors have been amended.

ADES supplies the following materials for each of the foundations to be built:

- 1 Anchoring flange
- 60 M16 DIN 934 ZN nuts
- 60 M16 DIN 934 PLASTIC nuts

NOTE: The threaded bars and rods are paid by the customer and must not exceed the maximum height and must be clean and 90º with respect to the ground.



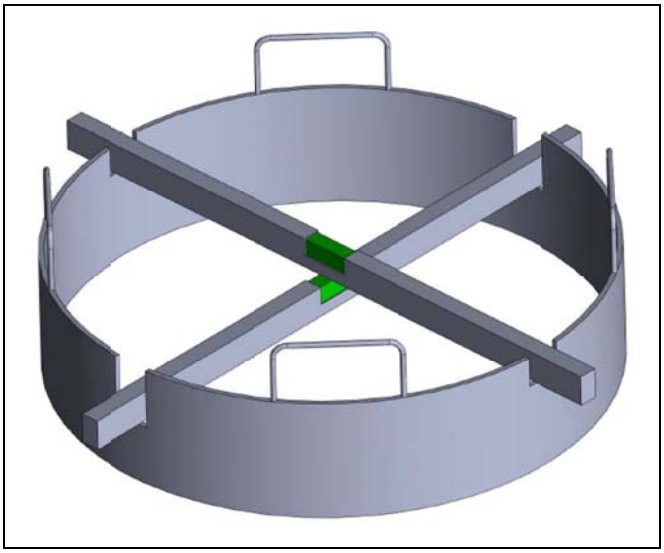
ADES reminds customers that as many tubes (see footing assembly plan) as required must be left ready on the top of footing and the earthing installation must be completed (see “Earthing Installation” document).

NOTE: The leveling mortar must be self-levelling, with a minimum compression strength of 35 N/mm2 for outdoor application.

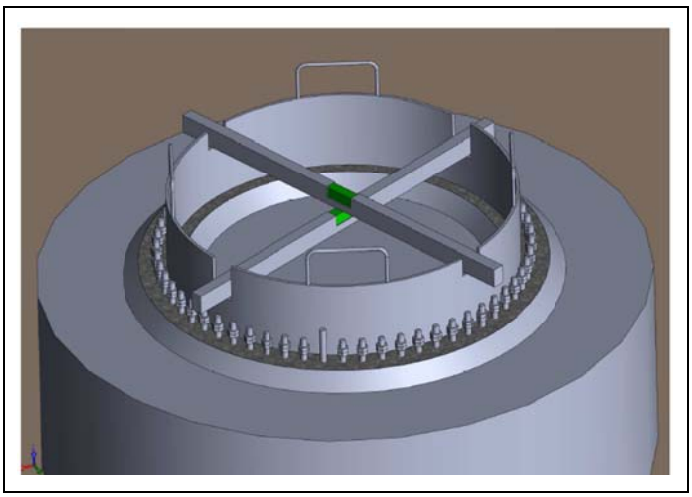
ADES provides to the customer a drawing of a leveling tool to get a perfect installation of the anchoring flange. It´s recommended its use.

The procedure of using is the following one:

1. The leveling mortar is poured at the top of the foundation.
2. Put two levels on the tool.



3. It places the tool on the flange.



4. With the help of the sight, it´s easy to get the possible gaps between the flange and the tool and correct them.

The plastic nut must be below the flange and the metal nut above the flange. The metal nuts will be used to secure the core and, therefore, must not be disposed of.

NOTE: The only form to make the flange installation is with the use of this tool.

NOTE: At the end of the work, mark the rod facing furthest north for easier orientation of the core when it is to be mounted. The core includes an "N" mark to indicate North.

3.1 Nuts and bolts plus equipment

- 60 M16 DIN 934 ZN nuts
- 60 M16 DIN 934 PLASTIC nuts
- 24 mm spanner
- Metal brush

4. Earthing installation

4.1 Necessity and obligatory nature of earthing

Due to the manufacturing specifications of the ADES Solar Tracker, it is necessary to protect the user from the difference in voltage that may occasionally arise amongst the metal parts with respect to the earth.

Likewise, by earthing the machine, we can ensure that its protective parts will work and eliminate or reduce the risks arising from possible faults in the electrical materials.

Therefore, it is considered compulsory to connect the ADES Solar Trackers to earth in the conditions established in the current document, without any exceptions whatsoever.

4.2 Field of application

The following document applies exclusively to ADES Solar Trackers, i.e. to its footing, column, arms, tracking-control panel, sensors and power feeds.

Nevertheless, given that the earth socket is located inside the solar tracker, other parts of the installation, such as inverters, may also be earthed in the same socket in the conditions specified in this document.

The customer will be responsible for installing the earth connections in compliance with current legislation with respect to transformation plants, power lines and channels and, in short, everything not included as part of the ADES Solar Tracker itself.

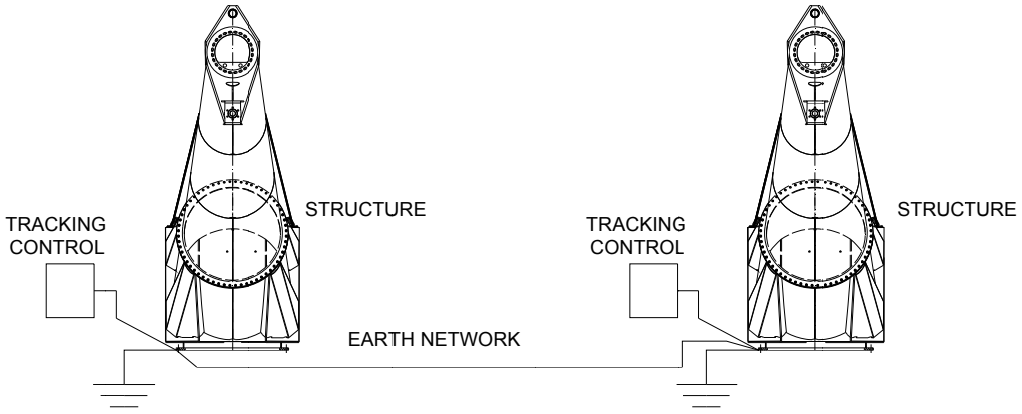
4.3 Standards and regulations

In the absence of any specific legislation and /or regulation concerning Solar Trackers, this document and, therefore, implementation of the earthing system shall be carried out in accordance with the following standards and guidelines:

- Low-voltage electrotechnical regulations
- ITC-BT-18 "Earthing Installations"
- ITC-BT-24 "Protection against direct and indirect contacts"
- Applicable UNE and IEC standards
- Earthing implementation systems in wind turbines (because of similarity)
- Acquired experience

4.4 Earth network

The earth network should be set up as shown in the following diagram:



The earth network will be divided into:

- External earthing connections: Physical connection of the earthing wires with the ground.
    - Individual connections for each solar tracker: earthing connection for each solar tracker
    - Accompanied by: link-up of all earthing connections for all the trackers in the solar farm. This will reduce the earth's resistance and improve performance if there is a short circuit.

- Internal earthing connections: Set up the electrical continuity of the elements that should be connected to earth at the base of the tracker: electrical panel, collectors, power pack, etc.

The main function of the tracker's external earthing connection is to obtain good resistance to earth in all the trackers.

For efficient protection, quite a low value for earth resistance needs to be achieved:

R < 10 ohms

4.5 Method of implementation for earthing ADES solar trackers

4.5.1- Earth electrodes

The earth electrodes should be installed by the customer when the foundations are laid for the footing for the tracker, under the terms and conditions set out below:

For earthing purposes, electrodes can be used consisting of:

- rods, tubes
- end plates, bare conductors
- plates

The copper conductors used as electrodes should conform to class 2 of UNE standard 21.022 with respect to their composition and electrical resistance.

The type and depth of burial of the earth connections should be such that their resistance will not go above the expected value due to any loss in moisture in the soil, presence of ice or other climatic effects. They should never be buried at a depth of less than 0.50 m.

The materials used, along with their construction, should not affect the mechanical and electrical resistance due to the effect of corrosion in such a way as to compromise the facility's design specifications.

The minimum dimensions for the earth electrodes are as follows:

Type of electrode		Minimum dimensions
Rods		*$\varnothing \geq 14.2$ mm (steel-copper 250 μ)* *$\varnothing \geq 20$ mm (galvanised steel 78 μ)*
Plates	Rectangular	*1m x 0.5m* *thickness $\geq$ 2 mm (copper); thickness $\geq$ 3 mm (galvanized steel 78 μ)*

	Square	*1 m x 1 m thickness ≥ 2 mm (copper); thickness ≥ 3 mm (galvanized steel 78 μ)*
Bare conductor		*35 mm² (copper)*

The minimum length of the rods is indicated in the regulations governing the standard that is applicable for such product.

4.5.1.1.-Earth resistance

The earth resistance value measured in any situation should always be equal to or less than 10 ohms.

The resistance of an electrode depends on its dimensions, shape and the resistivity of the soil where it is set up. The following formulae may be used for an initial idea of the number of electrodes required to achieve adequate resistance:

Electrode	**Soil resistance in Ohms**
Vertical buried plate	R = 0.8 ρ/P
Horizontal buried plate	R = 1.6 ρ/P
Vertical rod	R = ρ/P
Horizontally buried conductor	R = 2 ρ/L
P, soil resistivity (Ohm.m) P, plate perimeter (m) L, rod or conductor length (m)	

The following table can be helpful:

Nature of site	**Resistivity in Ohm.m**
Marshy ground	From a few units to 30
Slime	20 to 100
Humus	10 to 150
Damp peat	5 to 100
Plastic clay	50
Loam and compact clay	100 to 200
Jurassic Loam	30 to 40
Clayey sand	50 to 500

Silica sand	200 to 3.000
Lawn-covered stony ground	300 to 500
Bare stony ground	1.500 to 3.000
White limestone	100 to 300
Compact limestone	1.000 to 5.000
Cracked limestone	500 to 1.000
Slate	50 to 300
Mica and quartz rock	800
Granite and porcelain clay from alteration	1.500 to 10.000
Highly altered granite and porcelain clay	100 to 600

4.5.1.2.-Method of implementation

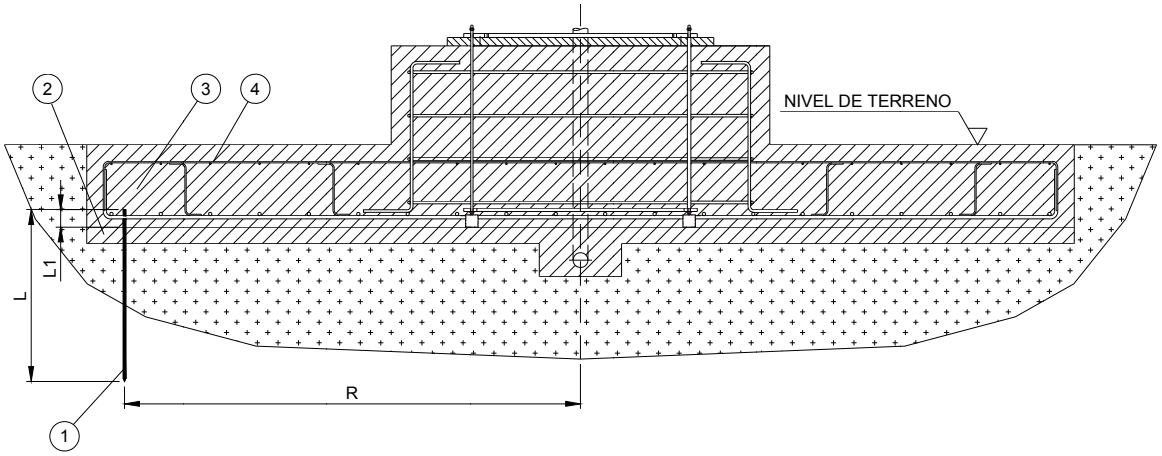
Once the land has been excavated to accommodate the footing for the tracker, the earth electrodes should then be placed in the soil. This will vary according to the type of electrode selected:

Vertical rod:

To make it easier to insert these in the ground, the earth rods should be assembled before adding blinding concrete, bearing in mind that the tops of the rods should protrude above the concrete so that the earth conductor can be connected.

When the rod is inserted, care should be taken to ensure that it is not in the way when the mesh reinforcement for the tracker's footing is fitted, the dimensions of which are provided by ADES.

If it is anticipated that this might happen, it can be avoided by adopting a different procedure: first the blinding concrete is poured in and then the mesh reinforcement is fitted. Then the blinding concrete is perforated with a drill of the same diameter as the earth rod and this is inserted in the hole that has been made by driving it into the ground.



1→ Earth rod
2→ Blinding concrete
3→ Footing concrete
4→ Mesh reinforcement

L→ Standardised rod length. The greater the length, the better the contact with earth and the lower the transition resistance

L1→ This should be sufficient to connect the earth conductor

R→ Radius in which the rods are located. The rods should be as close to the mesh reinforcement as possible without ever protruding.

Once the earth rod has been inserted in its final position, the transition resistance should be measured using the appropriate, standard equipment. The resistance should never be measured if the earth is damper than normal or in conditions that might distort the reading.

If the value obtained is less than 10 ohms, a single rod will be sufficient. On the other hand, if it is equal to or greater than 10 ohms, it will be necessary to have the number of rods required arranged parallel to one another until this value is reached. The minimum distance between the parallel rods should equal twice their length.

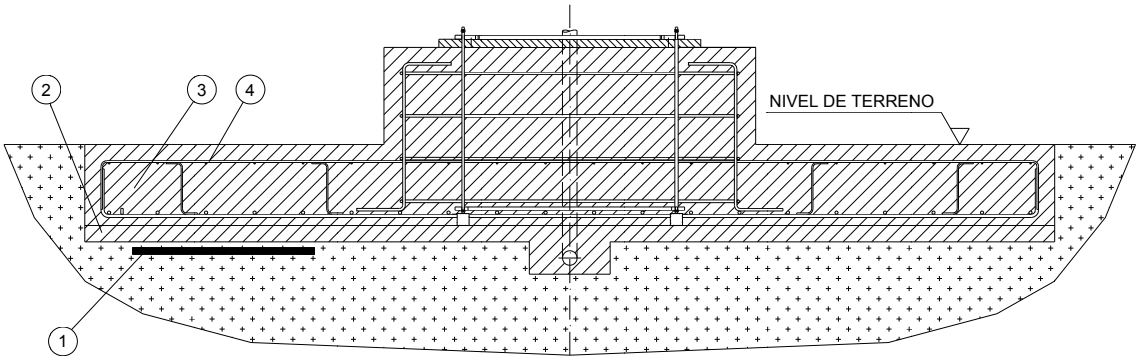
In the case where parallel rods need to be inserted, they should be joined together at the ends by means of a bare copper conductor measuring 35 mm^2.

The connection of the conductor to the rods will be considered to be electrically correct if connection clamps or aluminothermic or autogenous welding is used.

Buried plate:

Buried plates can be installed in a vertical or horizontal position. The former offers better contact with earth, although it is more expensive to install. The latter offers inferior contact with earth but its installation is more straightforward.

With either method adopted, it should be borne in mind that it will always be necessary to install the plate before the blinding concrete is added. At the same time, the earth conductor will have to be connected before pouring in the aforementioned concrete, as otherwise it will be impossible to connect up the plate later on.



1→ Earth plate
2→ Blinding concrete
3→ Footing concrete
4→ Mesh reinforcement

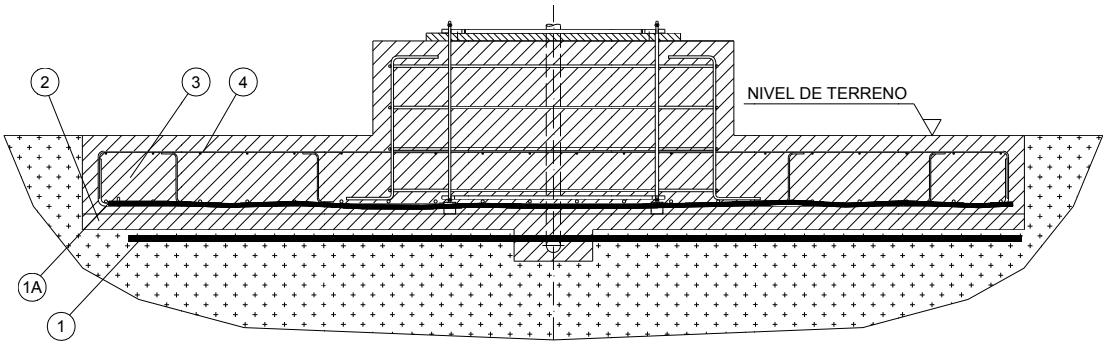
The procedure to follow is the same as that of the rods: install a sufficient number of electrodes to obtain a transition resistance that is less than 10 ohms, measured in the conditions mentioned above.

Horizontally buried conductor:

In this case the electrode will be a bare copper conductor measuring 35 mm^2, which could be extended as far as the column to act as the earth conductor.

This conductor can be installed in two ways, as long as the value measured for earth resistance is correct:

- By forming a loop below the layer of blinding concrete.
- By forming a loop following the structure of mesh reinforcement for the tracker's footing.



1→ Conductor below the footing
1A→ Conductor following the mesh structure
2→ Blinding concrete
3→ Footing concrete

4→ Mesh reinforcement

4.5.2.-Earth conductor

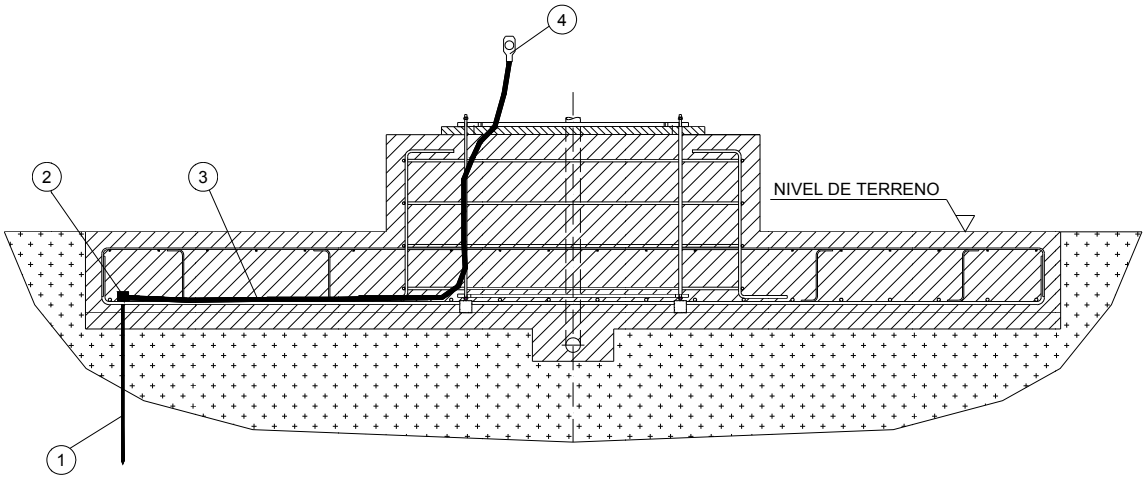
The installation of the earth conductor should be carried out by the client, at least in the part where it is buried with the tracker's footing, leaving enough space after the footing for ADES to be able to fit the relevant connections.

The earth conductor should consist of bare copper, with a minimum section of 35 mm^2. At the free end, it should have a terminal that has been approved for the section used, with a diameter of 16 to 18 mm which has been duly compacted.

The electrical connections of the earth conductor with the electrodes should be electrically correct. This is considered to be the case when done using suitable clamps, or aluminothermy or autogenously welding.

The route the earth conductor will follow can be seen in the diagram below. It should be borne in mind that the free end (opposite end to the electrode connection) should always protrude out of the interior of the cage formed by the bars, since it will always be connected on the inside of the column.

During installation, before cementing the footing of the tracker, it can be attached to the framework for the concrete by means of wires or clamps.



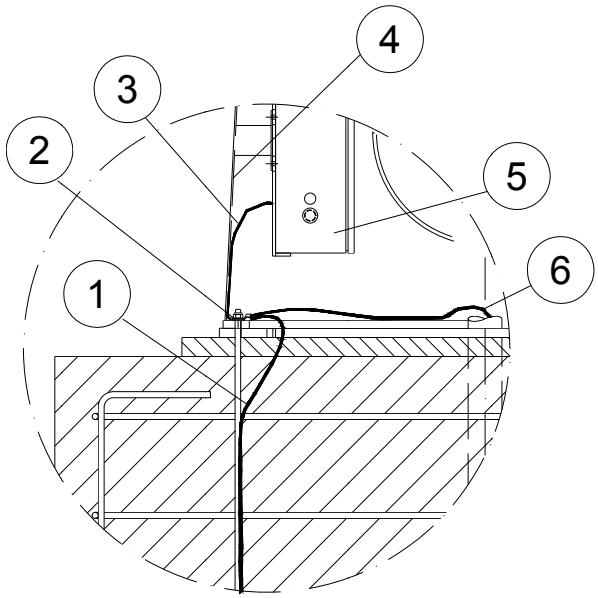
1→ Earth electrode
2→ Earth electrode-conductor connection
3→ Earth conductor
4→ Terminal for connection to earthing plate

4.5.3.-Earthing plate

In our case, the terminal for the earthing plate will consist of one of the bars at its threaded end. A nut will be used at this end to fix the end of the earth conductor in

place, using a terminal that is suitable in diameter and section, and compacted in the proper fashion.

This terminal should also be connected to the conductors making up the accompanying network and also the earth conductor on the terminal and protection panel (see section 5.5) and, occasionally, as will be explained below, the inverter, the power line for the trackers, etc.



1→ Earth conductor
2→ Earthing plate
3→ Cabinet -earth connection
4→ Tracker column
5→ Cabinet
6→ Accompanying network

4.5.4.- Accompanying network

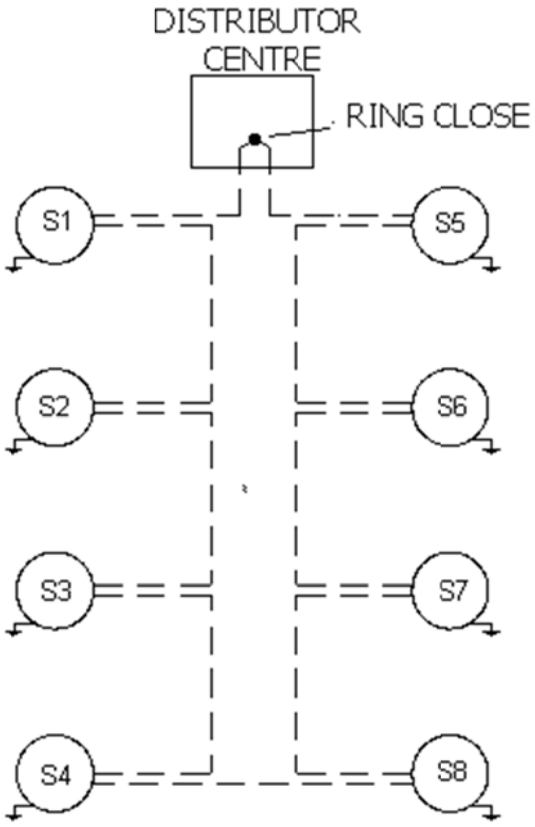
The accompanying network should be installed entirely by the customer under the terms and conditions listed below.

By means of the accompanying network, we can link up all the earth wires for the trackers on the entire solar farm. This will reduce the earth's resistance and improve performance if there is a short circuit.

This network should consist of copper conductors measuring 35 mm^2 made of insulated copper, with their path being determined by the characteristics of the channels and interconnections of the solar trackers on the farm. Thus, for laying this network, use can be made of channels or conduits that already exist for carrying other electricity cables such as production cables, etc. as long as they do not interfere with the working order of the former.

The best thing would be to install the interconnection network for the trackers in the following way:

As can be seen, when the accompanying network is installed through meter or distribution centres, it will be necessary to bring all the earth conductors forming part of it together in the centre. In this case, the earth formed by the network of trackers may be used as an earth for their supply system, keeping in mind the provisions set out in the Low-Voltage Electrotechnical Regulations at all times concerning the separation of low and medium or high voltage earth wires.



5. Liabilities

ADES shall not be held liable for the malfunction of solar trackers deriving from the faulty installation of the earth connections by the customer.

ADES reserves the right to modify this document unilaterally, giving customers sufficient notice so that they may carry out the earthing installation in accordance with the new conditions should these conditions be subject to any changes.