KINGDOM OF CAMBODIA
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ELECTRICITE DU CAMBODGE

ANNEX of TECHNICAL POLICY

EDC-TP-002-TDS
Technical Data Sheets
EARTHINGS for MV and LV Distribution Networks

August 2019

Version 1.0

ELECTRICITE DU CAMBODGE

Version	Date	Annex of Technical Policy	Authorized by : (name and signature)
1.0	August, 2019	Technical Data Sheet Earthing for MV and LV Distribution Networks	Dr. PRAING CHULASA

Version	Drafted/reviewed by	Verified by	Approved by	Date
Draft1	AD			
Draft 2 Draft 3	EDC/AD EDC/AD			August 2018 December 2018
Final	EDC/AD			August 2019

Content

TDS N°23 : Measurement of Soil Resistivity

TDS N°24.1 : Measure of Earthing Resistances

TDS N°24.2 : Process for Measuring Earthing Resistances and Coupling

TDS N°25 : Safety

TDS N°26 : Specific Connectors for Earthing

EDC-TP-002 Technical data sheets	**Ohmic Value of Earthing and Periodicity of Controls HV/MV and MV/MV Substations**	**TDS N°1.1** February 2019

1. HV/MV Substations

HV/MV Substations	Maximal value	Checking of value
Mass earthing of the whole substation	1.0 Ω	Every year

2. MV/MV Substations (Step-up and Step-down Transformers)

MV/MV Substations	Maximal value	Checking of value
Mass earthing of the whole substation	10.0 Ω	Every 5 years

EDC-TP-002 Technical data sheets	**Ohmic Value of Earthing and Periodicity of Controls MV/LV Indoor Substations, PTT, RMU Cabinet, and OPS**	**TDS N°1.2** February 2019

Legend:

LBE = Loop at the Bottom of Excavation, **EB** = Equipotential Belt

Notes: 1. The values in the tables of this sheet are maximum values;
2. Substation does not have an equipotential belt when integrated to building.

Area	**Type of earthing**	**Earthing value** (22kV phase/earth fault current limited to 800 Amperes)
1/ Urban and peri-urban areas: with MV masses earthing and LV neutral earthing are interconnected.		
Before interconnection	LBE + EB (Masses)	Not applicable in full urban area with full MV underground network
		10.0 Ω in peri-urban area
	Global value of LV neutral earthing	5.0 Ω or less
After interconnection	Global earthing (Mass + LV neutral)	1.0 Ω or less
2/ Peri-urban areas and rural areas: with separated MV masses earthing and LV neutral earthing.		
	MV masses earthing	10.0 Ω with LBE and EB
	Global LV neutral earthing	5.0 Ω or less

Periodicity of controls: every 5 years at least

Types of checking carried out:

• Urban and peri-urban areas with full MV underground network: Verification of links (continuity, connections);

• Peri-urban with interconnection of the earthing connections: measurement of the value of the earth connection of the interconnected system, if this type of measurement is physically possible taking into account the environment of the structure, and verification of the links (continuity, connections);

• Peri-urban or rural areas with separation of the earthings (MV masses and LV neutral): measurement of earthing value of the MV masses, the global earthing of the LV neutral and the coupling coefficient of the first grounding of the LV neutral with grounding of MV masses.

EDC-TP-002 Technical data sheets	**Ohmic Value of Earthing and Periodicity of Controls Other MV Equipment**	**TDS N°1.3** February 2019

Equipment Mass	Max Ohmic value (Ω)	Periodicity of control
Metallic Pole	100.0	NA
Load Break Switch	10.0	5 years
Recloser	10.0	5 years
AVR	10.0	5 years
Pole Mounted Substation	10.0	5 years

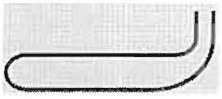
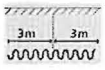
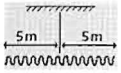
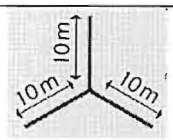
EDC-TP-002 Technical data sheets	**Separated MV Mass and LV Neutral Earthings Distance between Earthings to be Respected**	**TDS N°2** February 2019

When the earthing of the MV masses and LV neutral are not connected together, the distances to be respected between those earthings are given in the table below.

Minimal distance between MV mass earthing and any LV neutral earthing	
Soil resistivity ρ	Minimum distance (with 22kV MV neutral impedance limiting the fault current to about 800A)
ρ < 300 Ω.m	25 m
300 Ω.m ≤ ρ < 500 Ω.m	50 m
500 Ω.m ≤ ρ < 1000 Ω.m	75 m
ρ ≥ 1000 Ω.m	To be studied case by case

EDC-TP-002 Technical data sheets	**Forms of Earthings**	**TDS N°3** February 2019

Flow of fault currents

Soil resistivity	Loop at bottom of excavation		Rod	Net or grid	Folded conductors (serpentine)			Multidirectional
								
	2 m perimeter	10 m perimeter	3 m	2m x 0.4m 0.8 m deep	10 m in trench 3m	2x10m in 2 trenches 3m	2x15m in 2 trenches 5m	3 rectilinear branches of 10 m + 1 central injection point (from 3 to 5m
50 Ω.m	30 Ω	8 Ω	17 Ω	12 Ω	12 Ω	7 Ω	5 Ω	3 Ω
100 Ω.m	60 Ω	17 Ω	34 Ω	25 Ω	25 Ω	14 Ω	10 Ω	6 Ω
200 Ω.m	120 Ω	34 Ω	66 Ω	50 Ω	50 Ω	28 Ω	20 Ω	12 Ω
300 Ω.m		50 Ω	100 Ω	75 Ω	75 Ω	42 Ω	30 Ω	18 Ω
400 Ω.m		66 Ω	133 Ω	100 Ω	100 Ω	56 Ω	40 Ω	24 Ω
500 Ω.m				125 Ω	125 Ω	70 Ω	50 Ω	30 Ω
750 Ω.m						105 Ω	75 Ω	45 Ω
1000 Ω.m							100 Ω	60 Ω

Expected grounding values based on soil resistivity and shape

Efficient only at power frequency current (50 Hz)

Efficient at 50 Hz and high frequency currents (Surge)

Flow of impulse fault currents (atmospheric, surge ...)

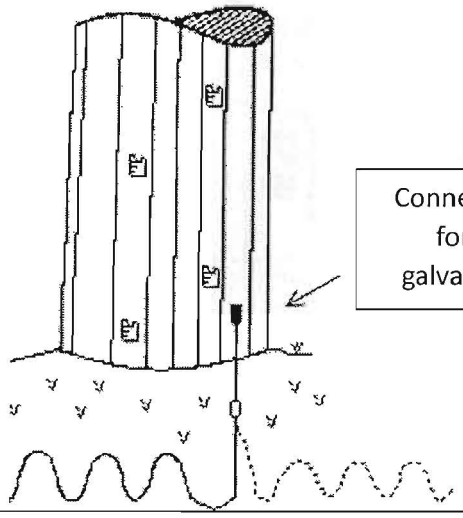
The shape of the grounding is preponderant in its ability to flow surge currents; in the current state of knowledge, an earthing formed by a crow's foot on the surface (3 straight strands, associated or not with nets, 5.0 m to 10.0 m maximum) associated with a central injection point (rod of 3.0 m to 5.0 m) allows the flow in good conditions of the atmospheric currents.

A multi-directional surface earth should first be investigated and then, if necessary, lengthened conductors or nets to obtain the necessary ohmic value.

This is the mass earthing form to be used in case of surge arresters

EDC-TP-002 Technical data sheets	**Earthings Connection of** **MV Metallic Tubular Pole or Steel Tower**	**TDS N°4** February 2019

1/ Tubular metallic pole

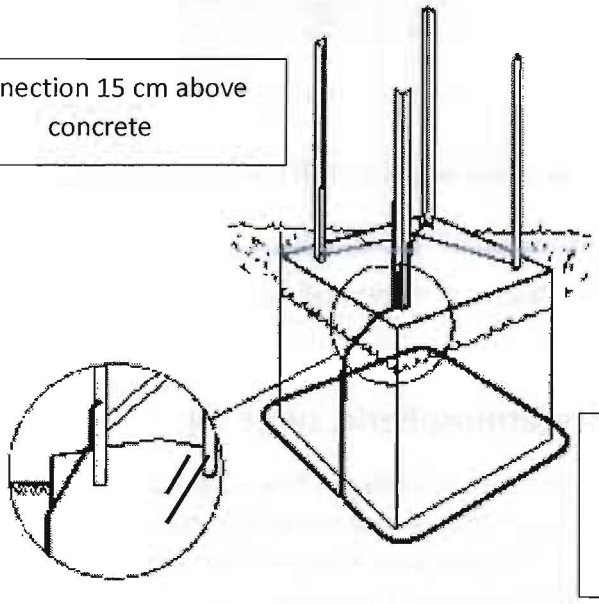


Connection with compressed forged lug and hot dip galvanised or stainless-steel

R ≤ 100 Ω

Serpentine with 50 mm² hot dip galvanised mild steel conductor

2/ Steel tower



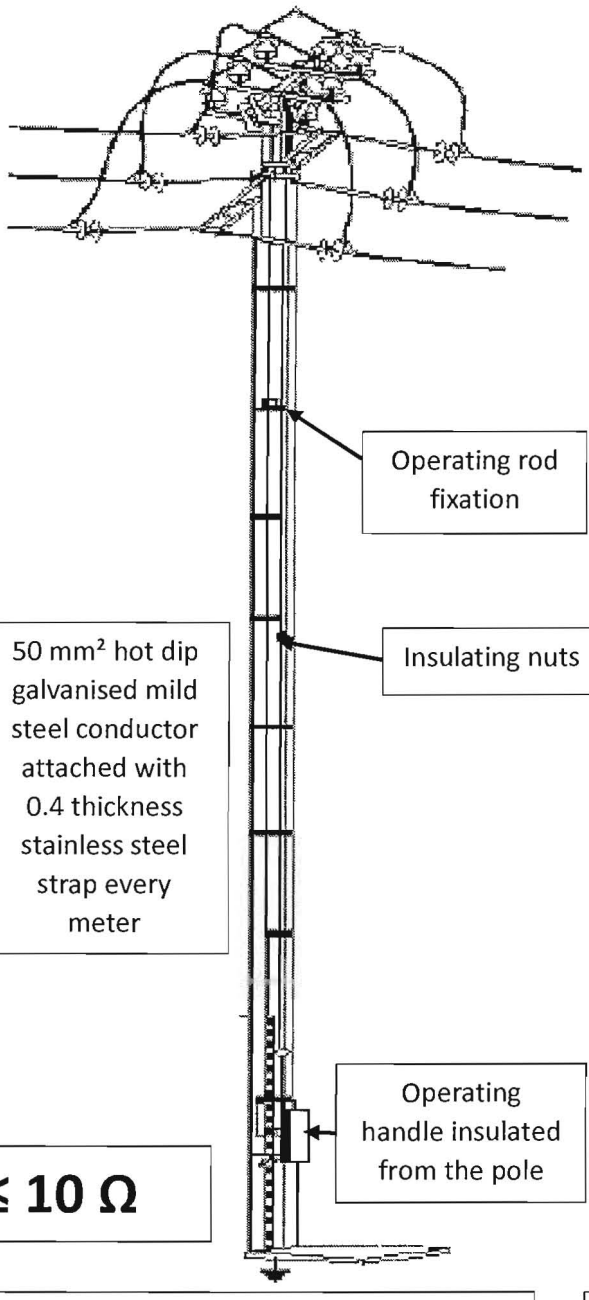
Connection 15 cm above concrete

R ≤ 100 Ω

50 mm² hot dip galvanised mild steel conductor at bottom of excavation outside the concrete

Conductor free inside a plastic pipe.

EDC-TP-002 Technical data sheets	**Earthings Connection of** **Manually Operated Pole Mounted Load Break Switch**	**TDS N°5** February 2019



Load break switch frame (forged compressed lug)

Conductor cross arm (forged compressed lug + C connector)

Operating rod fixation

Operating rod fixing (forged compressed lug + C connector)

Insulating nuts

50 mm² hot dip galvanised mild steel conductor attached with 0.4 thickness stainless steel strap every meter

Operating handle insulated from the pole

Operating lever fixing (forged compressed lug + C connector)

R ≤ 10 Ω

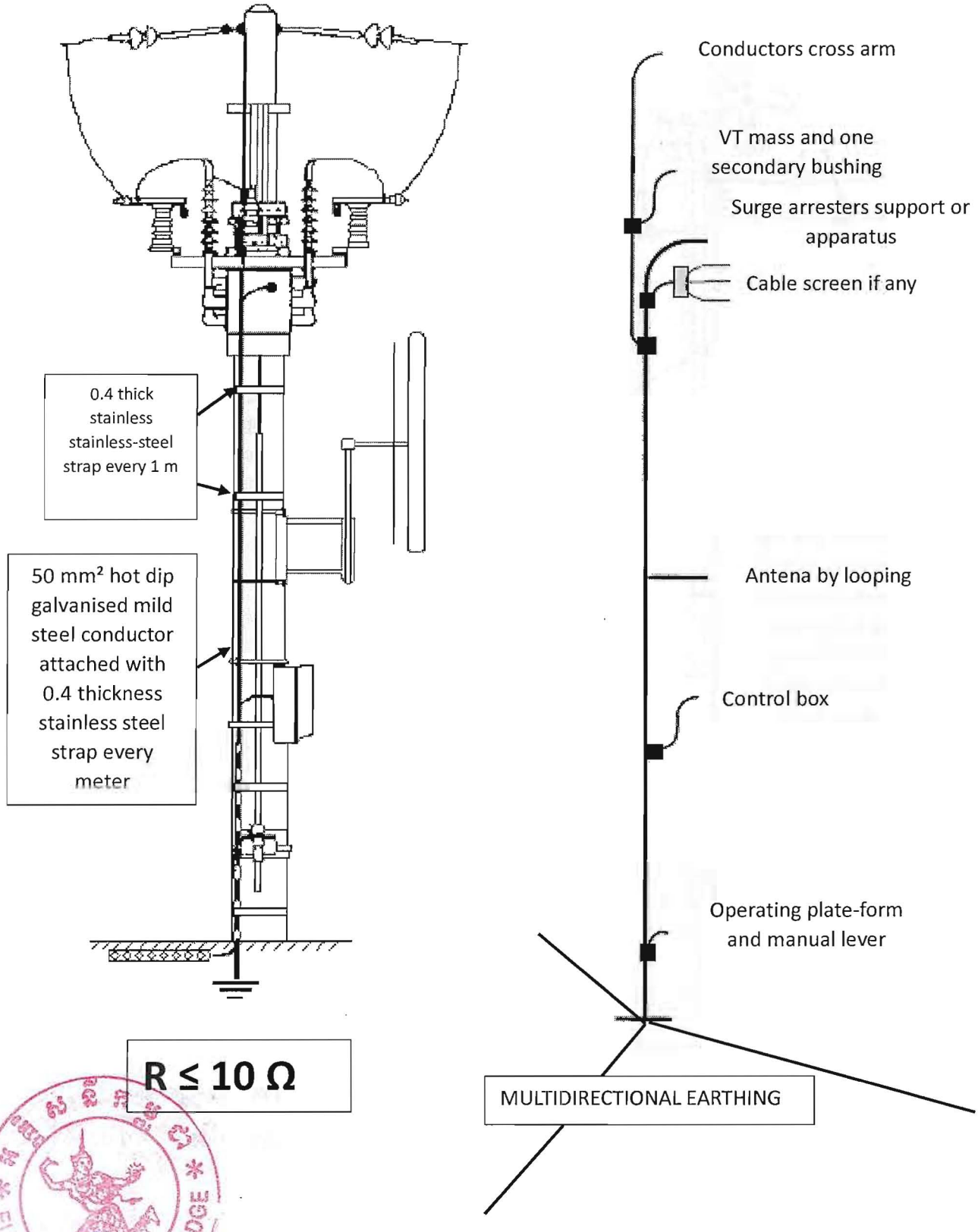
Operating platform steel reinforcement not connected to earthing. In case of not insulated handle it is mandatory to connect it to the earthing

Multi-directionnal earthing.

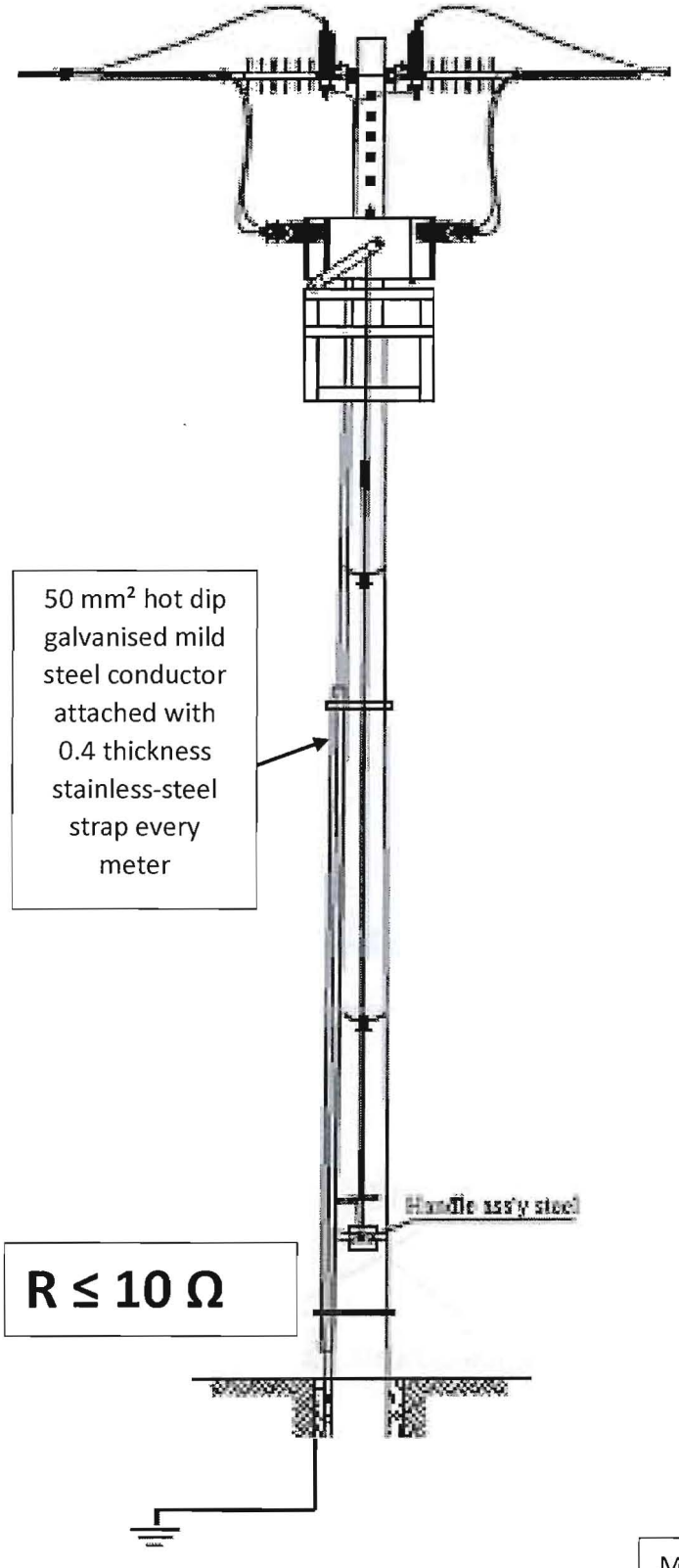
ρ ≤ 200 Ω.m : 3 x 5 m + injection rod 3 m

ρ > 200 Ω.m : 3 x 10 m + injection rod 5 m

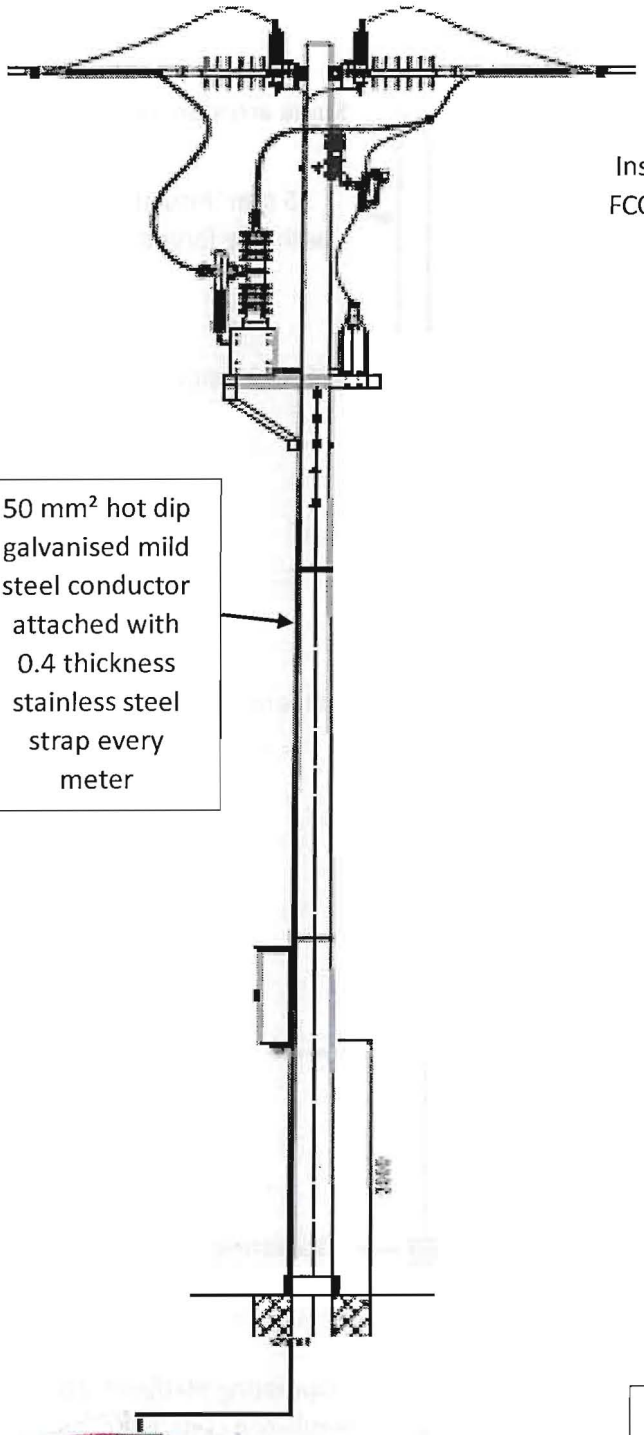
EDC-TP-002 Technical data sheets	**Earthings Connection of** **Remote Controlled Pole Mounted Load Break Switch and Recloser with Surge Arresters Fixed onto the Apparatus**	**TDS N°6** February 2019



EDC-TP-002 Technical data sheets	**Earthings Connection of** **Pole Mounted Load Break Switch with Surge Arresters on Cross Arm**	**TDS N°7** February 2019



EDC-TP-002 Technical data sheets	**Earthings Connection of** **Pole Mounted Auto Recloser**	**TDS N°8** February 2019



50 mm² hot dip galvanised mild steel conductor attached with 0.4 thickness stainless steel strap every meter

Surge arresters cross arm

Insulator and FCO cross arm

35 mm² insulated copper with one forged lug on both ends

Recloser + VT mass and 1 VT secondary bushing and support

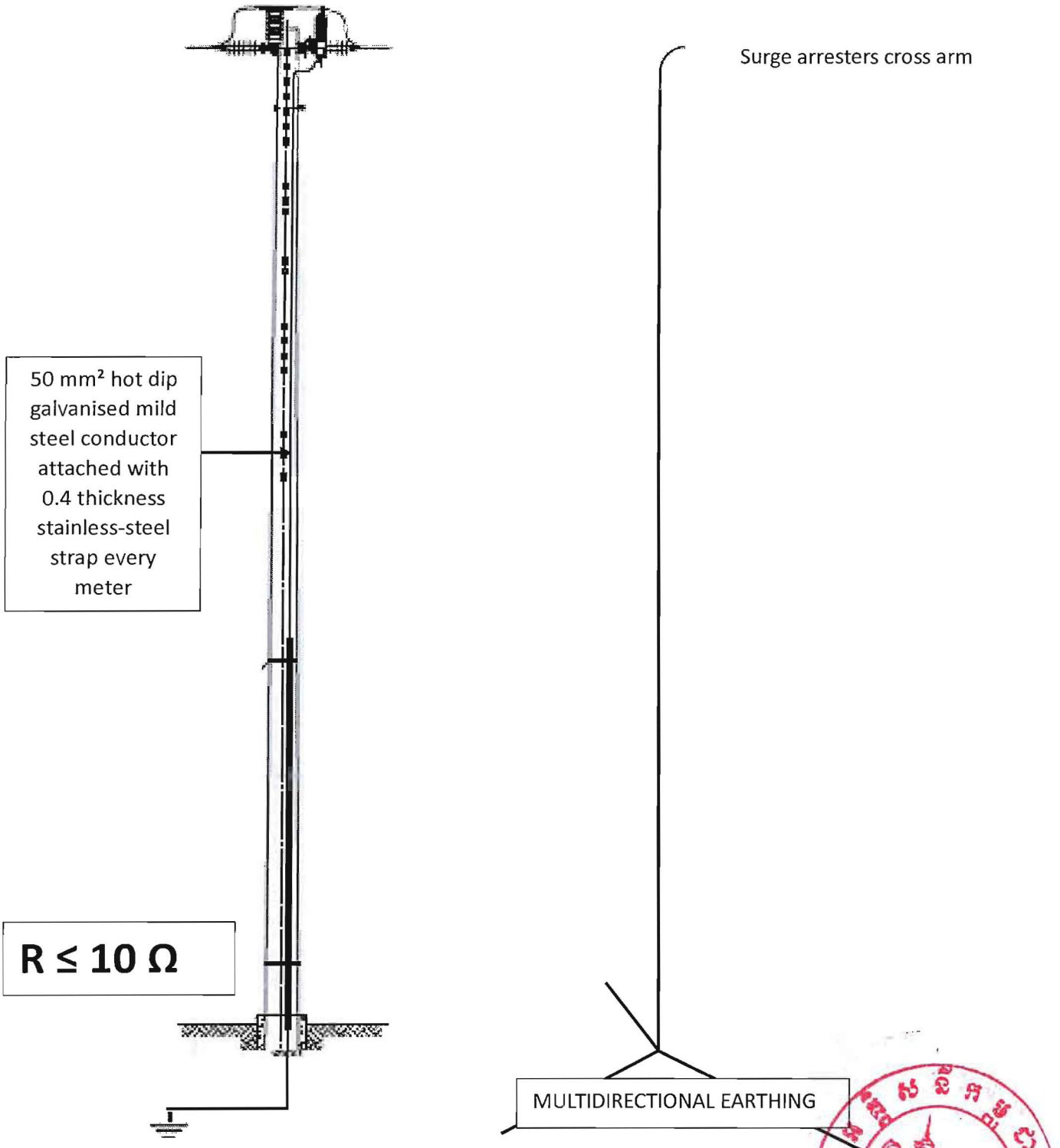
Control box

Operating platform steel reinforced concrete or small equipotential belt in case of non-insulated control box

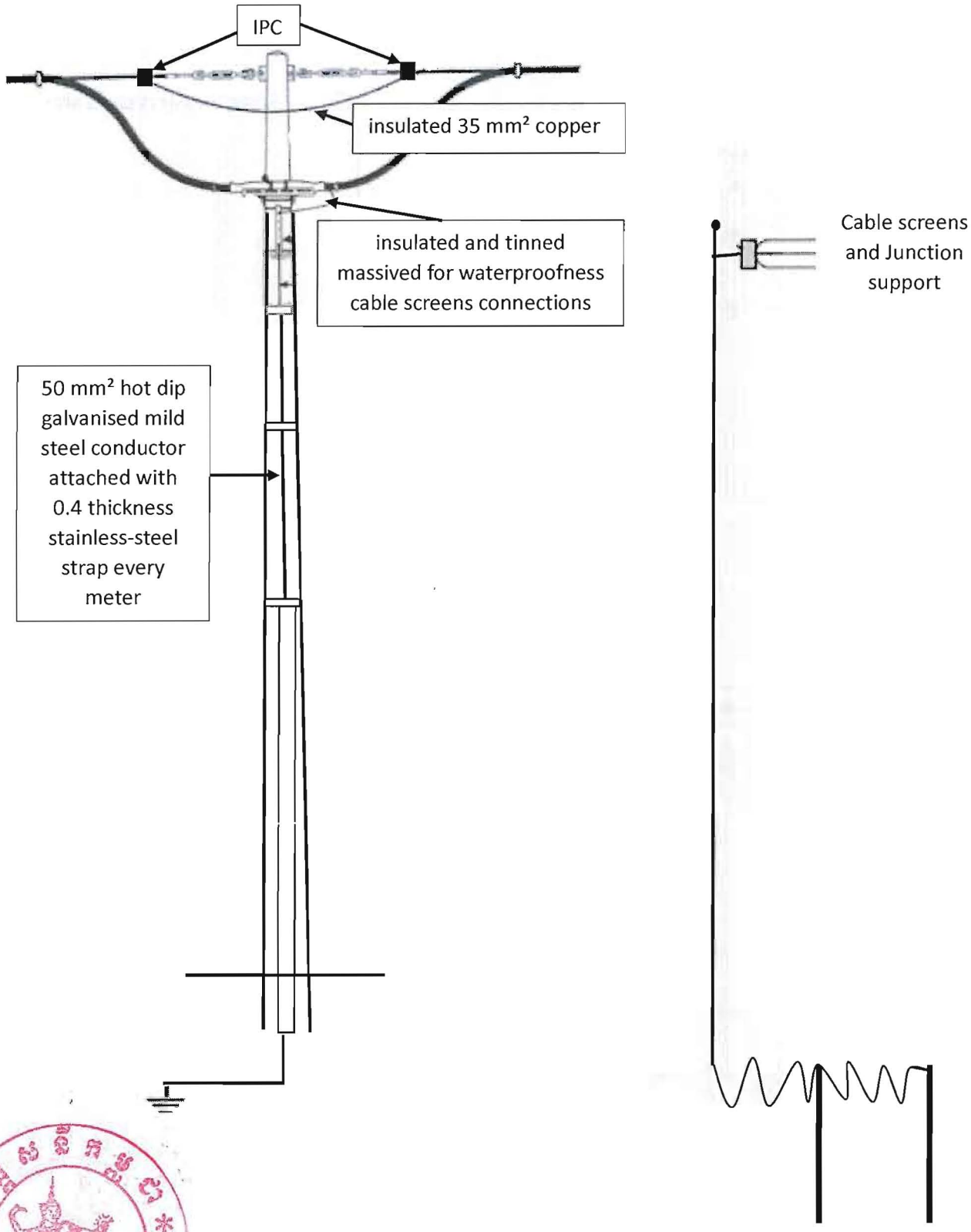
MULTIDIRECTIONAL EARTHING

R ≤ 10 Ω

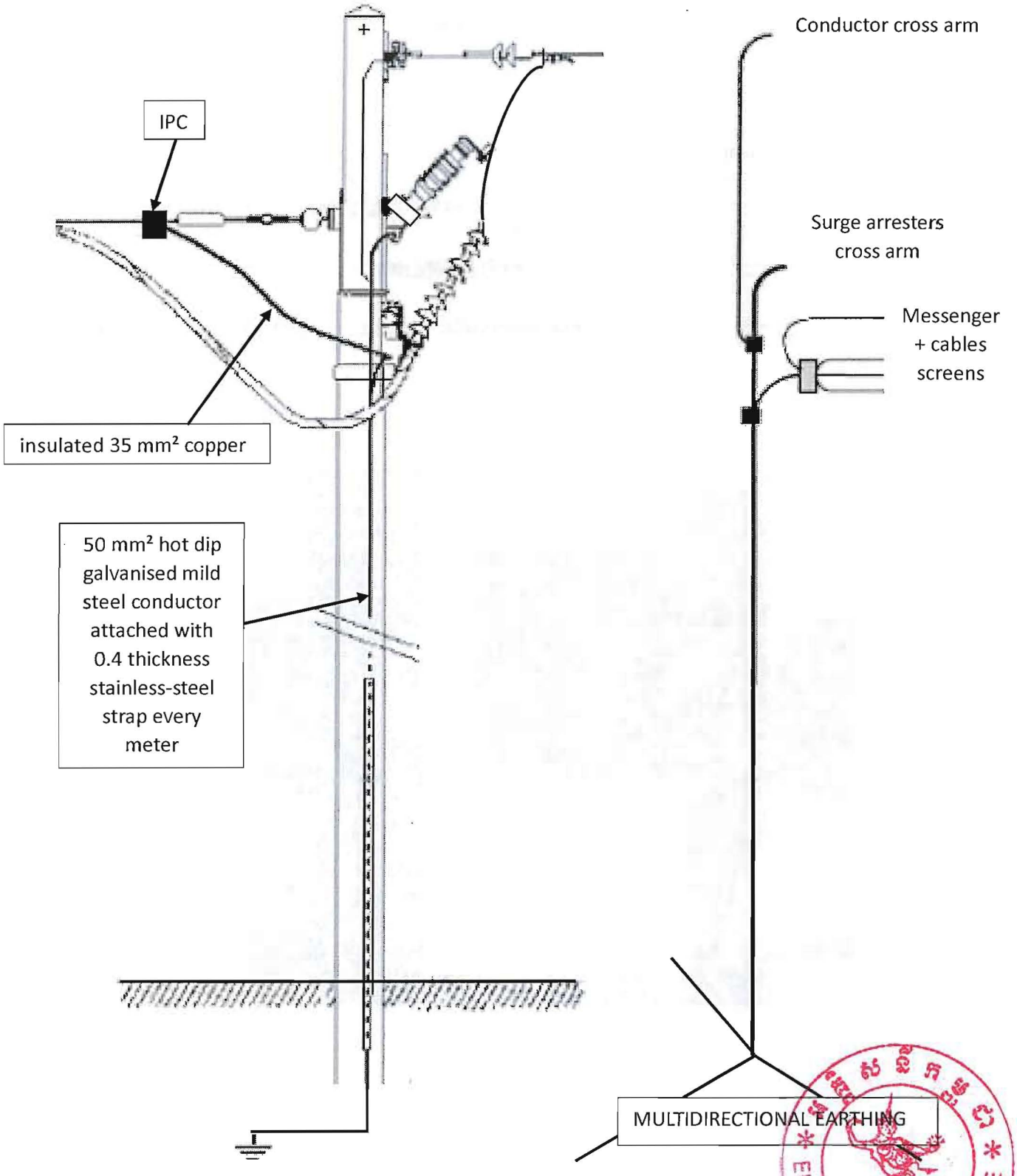
EDC-TP-002 Technical data sheets	**Earthings Connection of** **Surge Arresters on Pole and Cross Arm Only**	**TDS N°9** February 2019



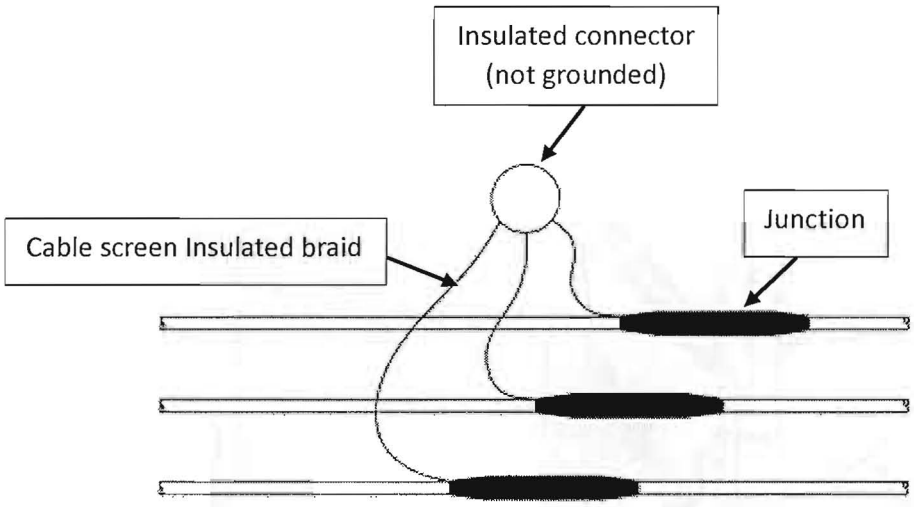
EDC-TP-002 Technical data sheets	**Earthings Connection of** **MV ABC Overhead Network – Junctions**	**TDS N°10.1** February 2019



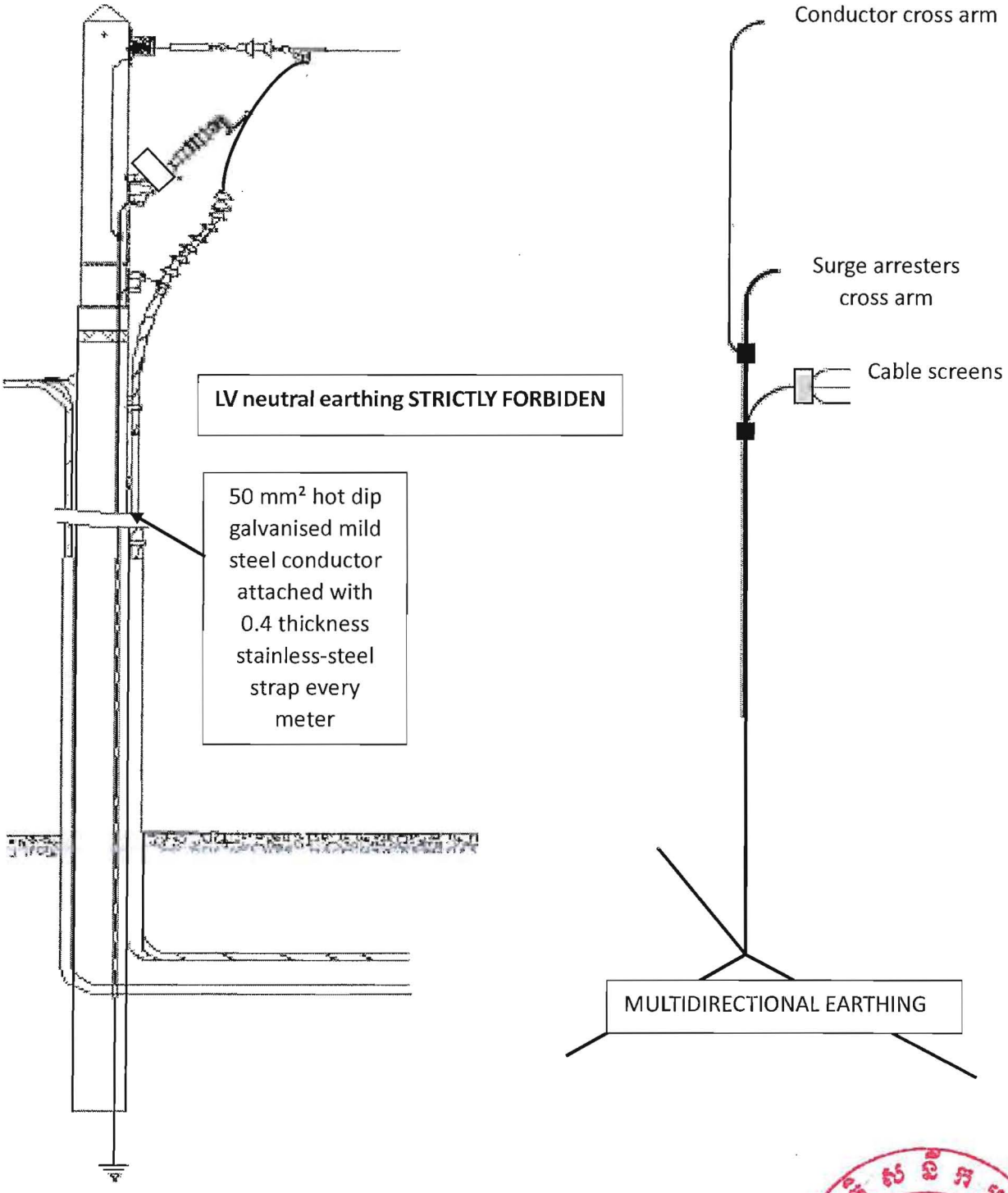
EDC-TP-002 Technical data sheets	**Earthings Connection of** **MV ABC Overhead Network – at the Ends**	**TDS N°10.2** February 2019



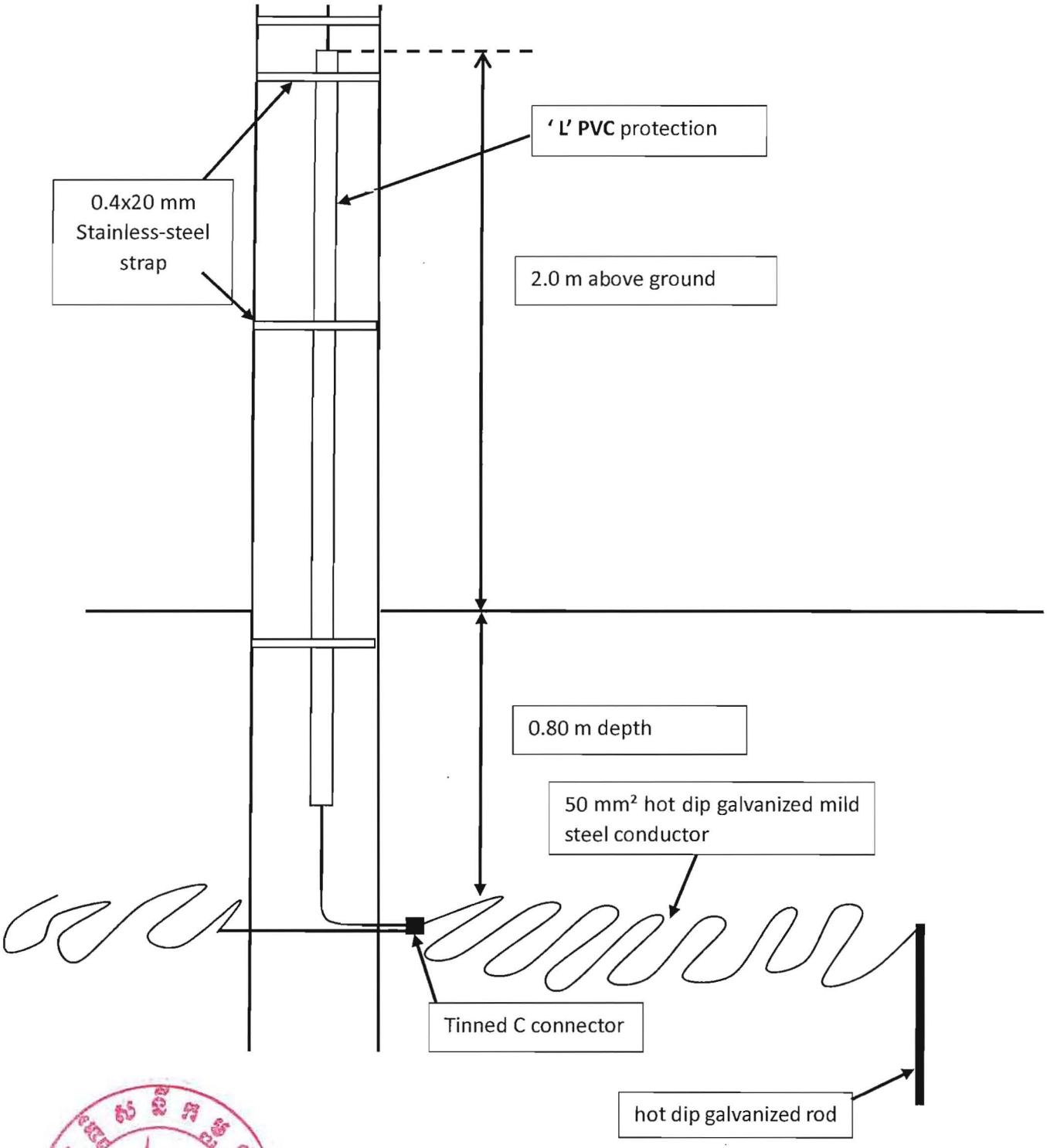
EDC-TP-002 Technical data sheets	**Earthings Connection of** **MV Underground Network**	**TDS N°11** February 2019



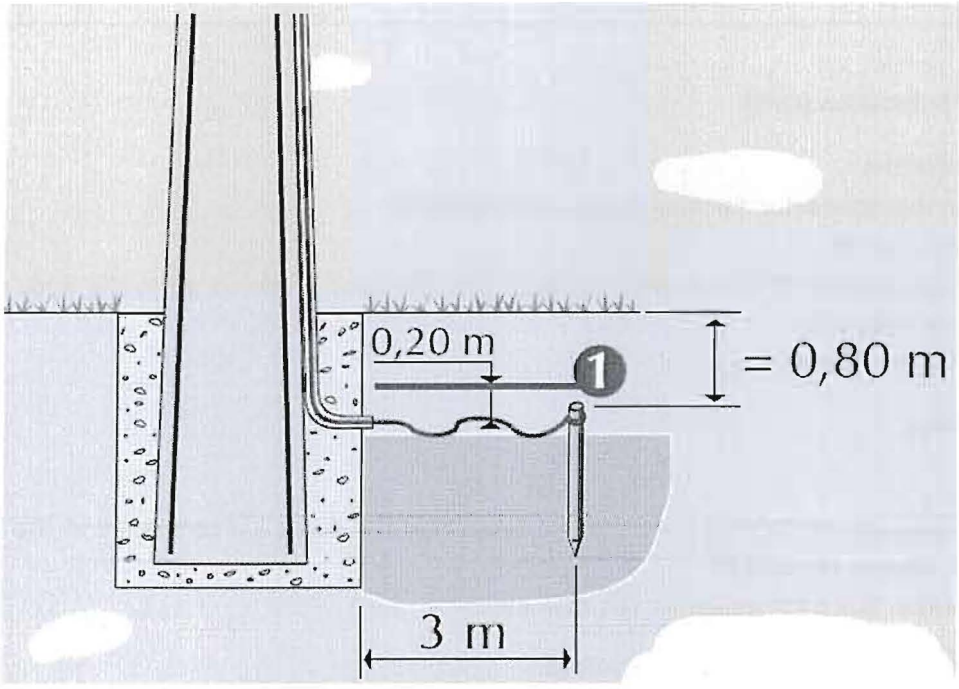
EDC-TP-002 Technical data sheets	**Earthings Connection of** **MV Overhead/Underground Interface**	**TDS N°12** February 2019



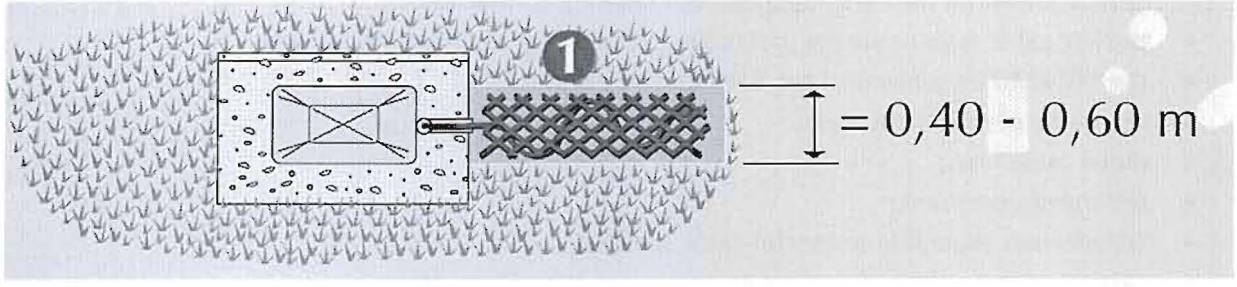
EDC-TP-002 Technical data sheets	**Pole Earthings Installation**	**TDS N°13** February 2019



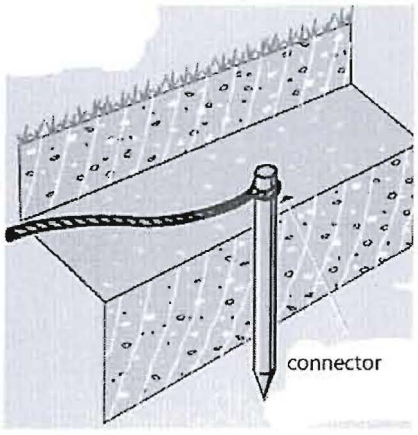
EDC-TP-002 Technical data sheets	**Pole Earthings Installation**	**TDS N°13** February 2019

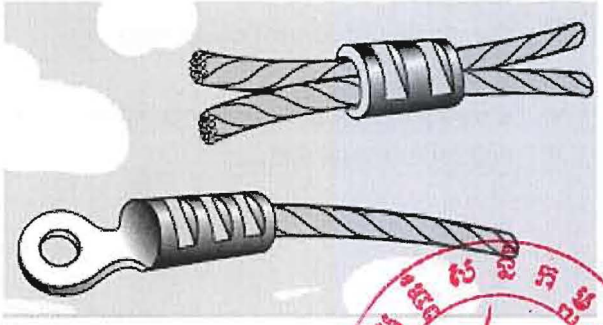


View from top



1 Red Plastic warning net





EDC-TP-002 Technical data sheets	**Masses Earthings for** **OPS, RMU Cabinet, Prefabricated and Indoor Substation,** **Equipment to be Connected to the Equipotential Bonding Conductor**	**TDS N°14** February 2019

1/ One Pilar Substation (OPS)

- Transformer
- Separable connector earthing braids (cable screen)
- Frame of LVDB
- Metallic body of OPS (care shall be taken that the door is connected to the body with extra flexible conductor)
- Any other metallic mass

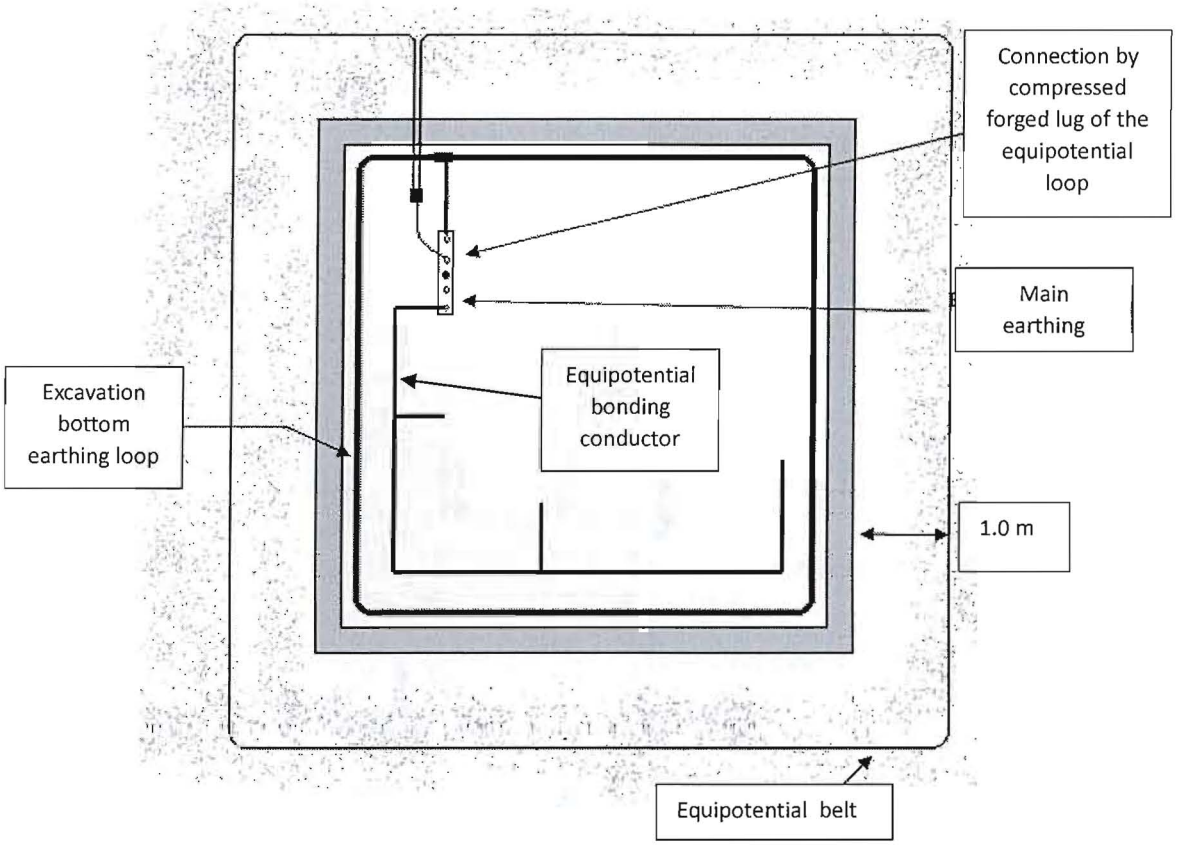
2/ RMU Cabinet

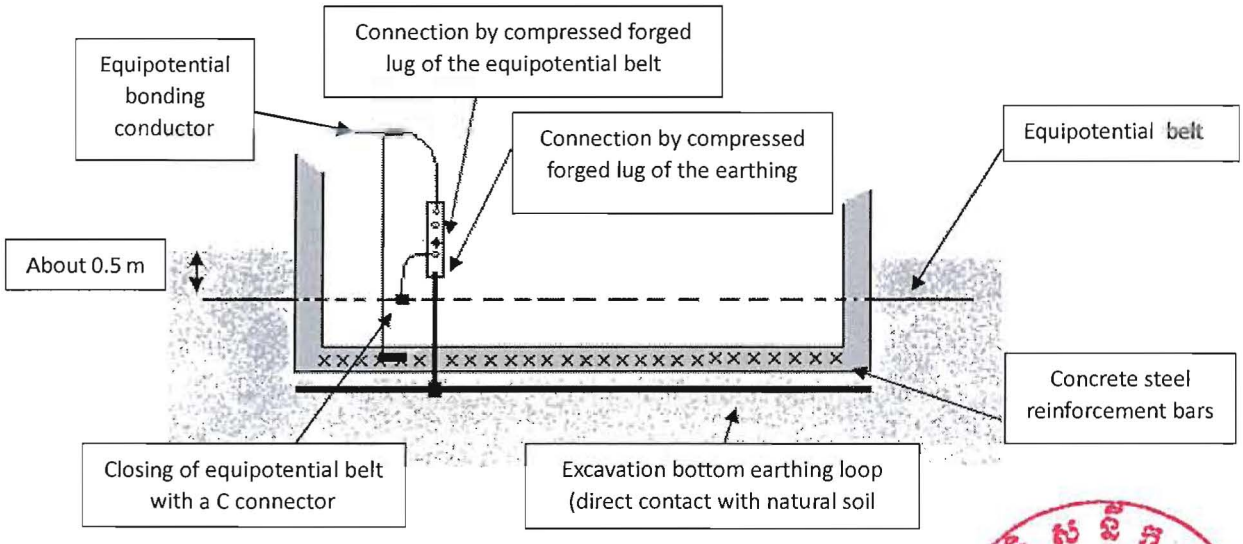
- RMU
- Metallic body of Cabinet (care shall be taken that the doors are connected to the body with extra flexible conductor)
- Any other electrical equipment as RTU, etc....

3/ Prefabricated (PTT) and indoor substations

- Steel reinforcement of the concrete by a connection connecting one of the bars of the reinforcement to the main equipotential bonding conductor
- the MV cable screens via the protective conductor of the MV switchboard;
- the MV RMU via a terminal provided for this purpose;
- the frame of LV switchboards;
- metal cable trays;
- the transformer tank;
- Transformer separable connector cable screens;
- earth terminals of measurement transformers, capacitors, etc. ;
- protective metal screens and panels;
- the cell fences, the control panel of the devices and the various fittings in the open type substations
- the doors;
- the masses of control equipment
- RTU if any,
- envelop of metallic prefabricated substation
- any other metal masses.

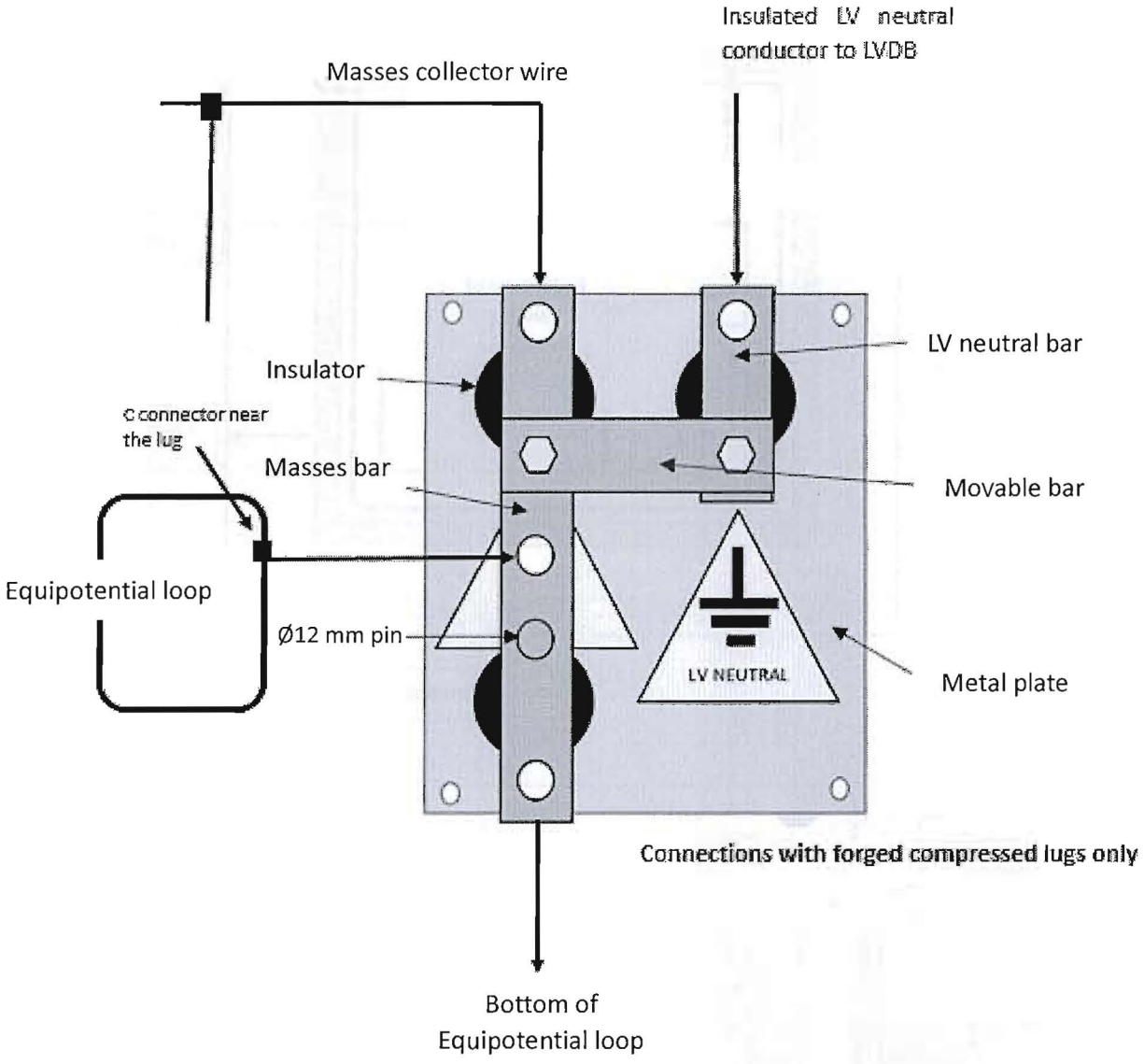
EDC-TP-002 Technical data sheets	**Masses Earthings for** **Prefabricated or Built Substation, OPS and RMU Cabinet** **Earthing Circuit**	**TDS N°15** February 2019





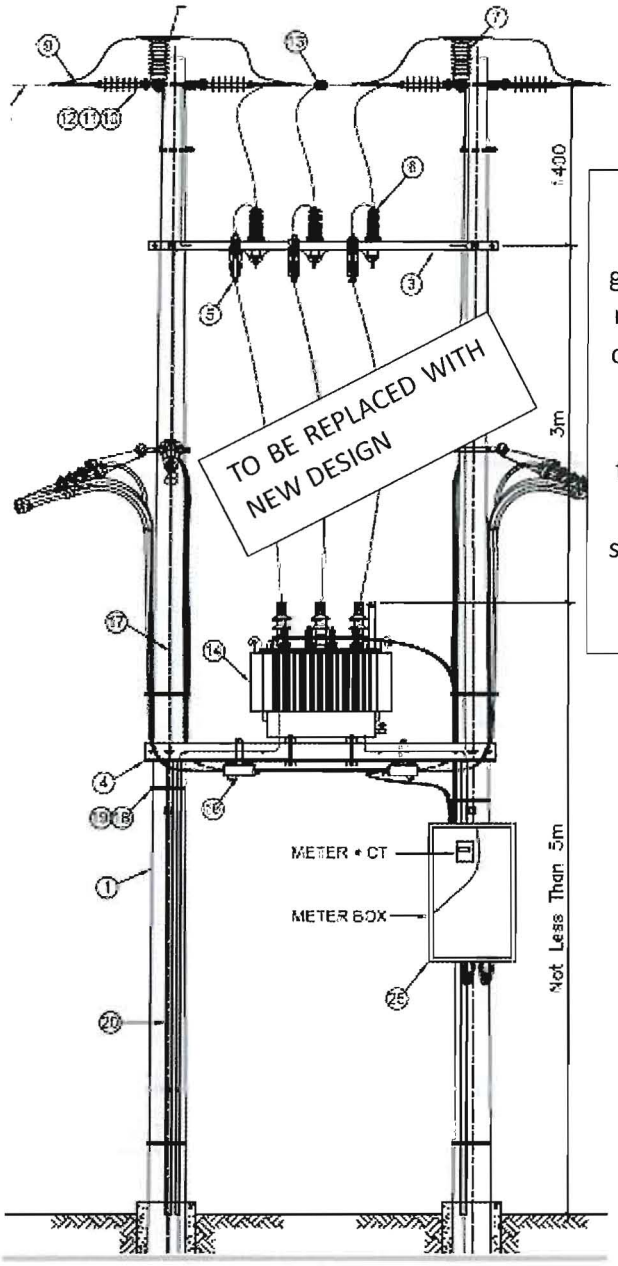
Additional grounding may be required to obtain the required ohmic value; it will then be crimped downstream of the main earth terminal.

EDC-TP-002 Technical data sheets	**Masses Earthings for** **Prefabricated or Built Substation, OPS and RMU Cabinet** **- Main Earthing Board**	**TDS N°16** February 2019



Main earthing board: Made of 20 mm x 3 mm copper bar, hole diameters = 10.5 mm, central pin dimensions: L = 40 mm, Φ = 12 mm and fixed against the wall with a distance of about 25 mm.

EDC-TP-002 Technical data sheets	**Earthings Connection of** **Pole Mounted Substation**	**TDS N°17** February 2019



50 mm² hot dip galvanised mild steel conductor attached with 0.4 thickness stainless steel strap every meter

Conductors cross arm

Surge arresters cross arm

35 mm² insulated copper with one forged lug on both ends forged lugs

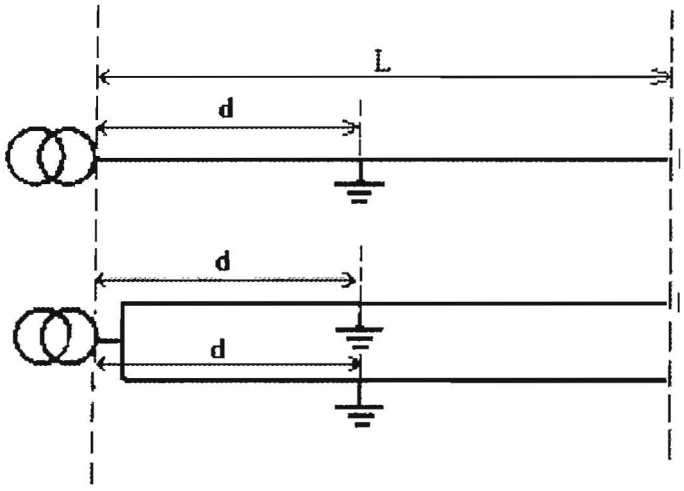
Transformer tank

LVDB Frame and support

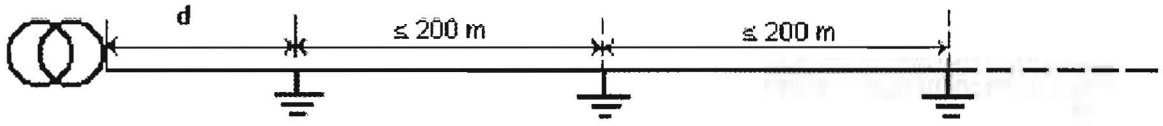
MULTIDIRECTIONAL EARTHING

EDC-TP-002 Technical data sheets	**LV Neutral Earthings on ABC Network**	**TDS N°18** February 2019

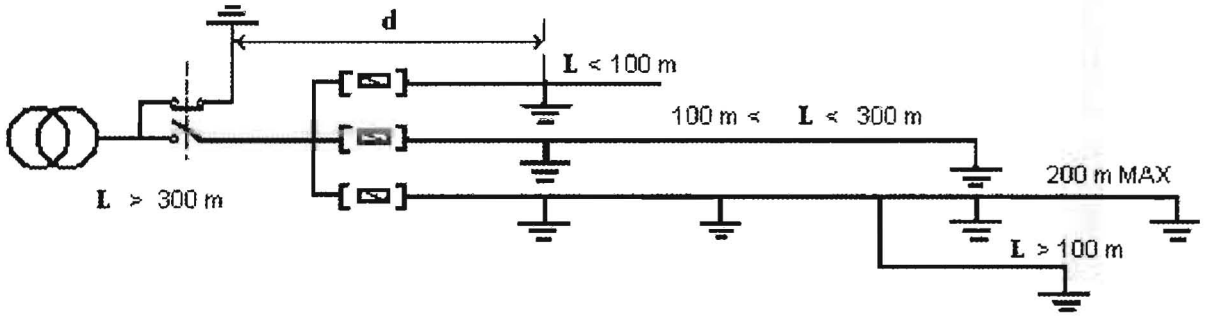
1/ Feeder length L ≤ 100 m



2/ **Feeder length L > 100 m**



3/ Case of several feeders

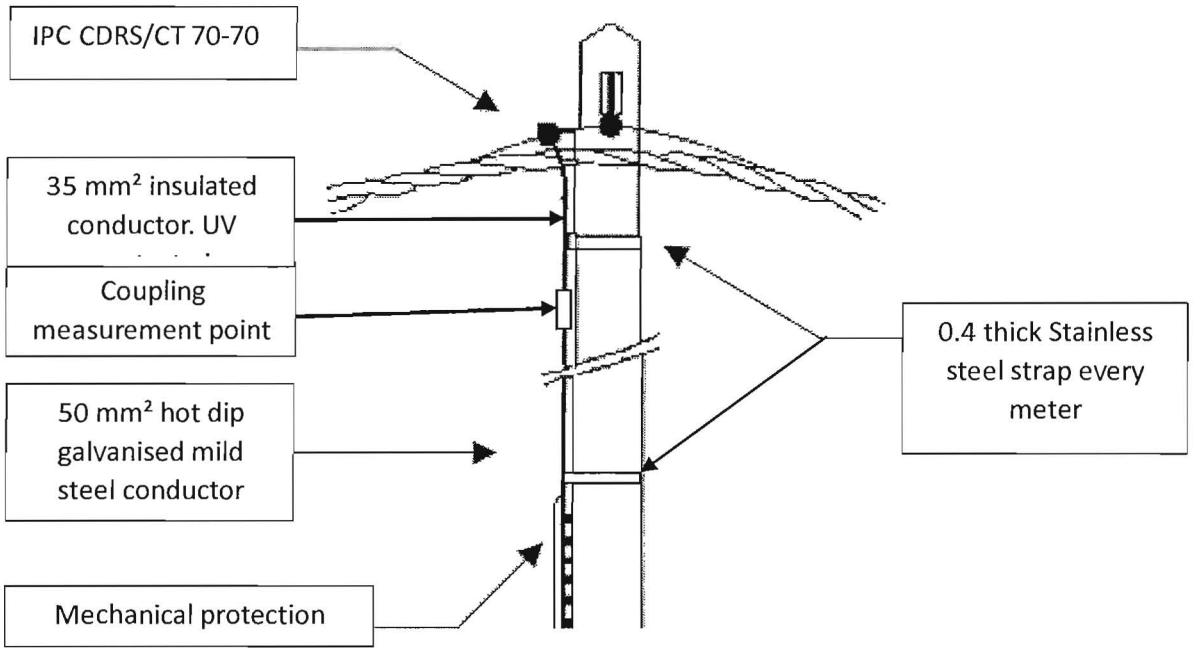


4/ Distribution of LV neutral eartings:

- In addition to a point in the network as soon as the length of the line exceeds 100 meters;
- The number of earthing is equal to or greater than one every 200 meters of feeder network length;
- One LV neutral earthing is near each major branch or group of individual branches.

The distance d is specified in technical data sheet N°2.

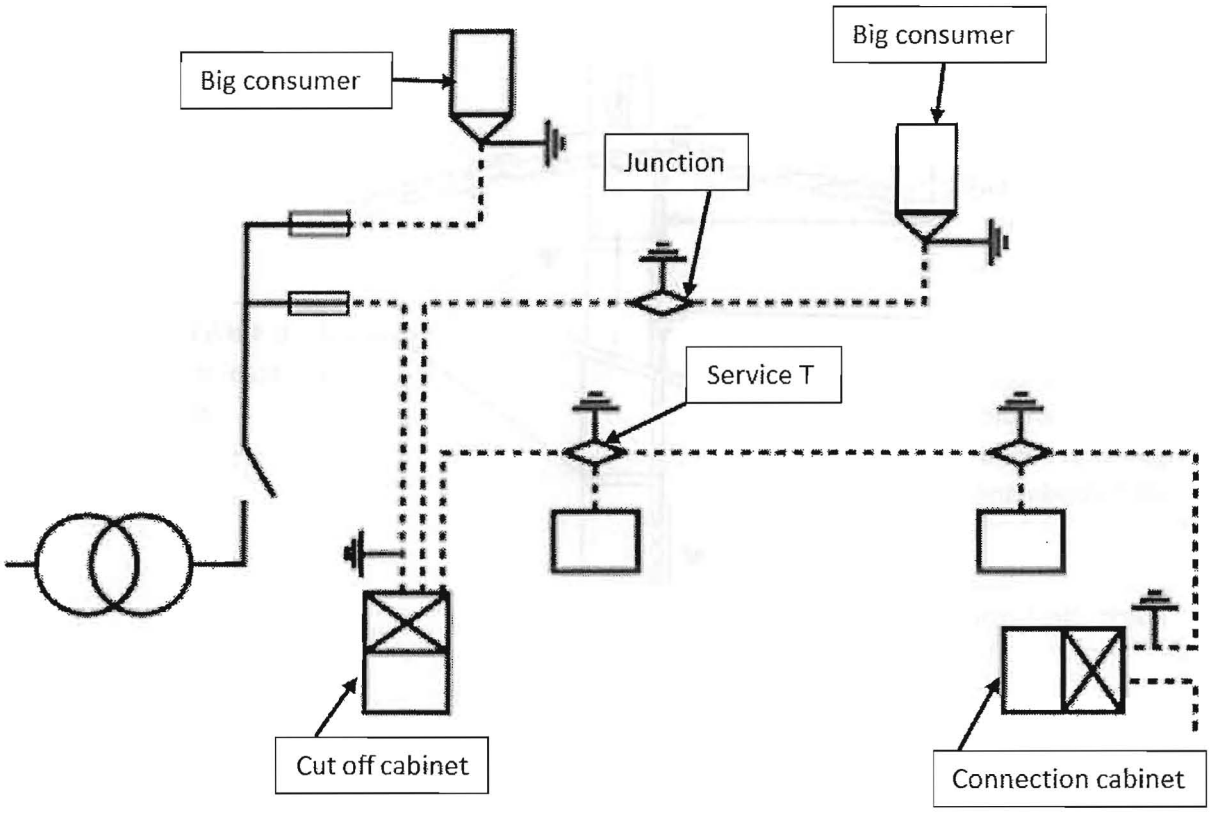
EDC-TP-002 Technical data sheets	**LV Neutral Earthing Connection on ABC Network**	**TDS N°19** February 2019



The coupling measurement point is located about 1 meter below the ABC. It is constituted of 2 compressed tin copper forged lugs and one stainless steel bolt (see TDS below)

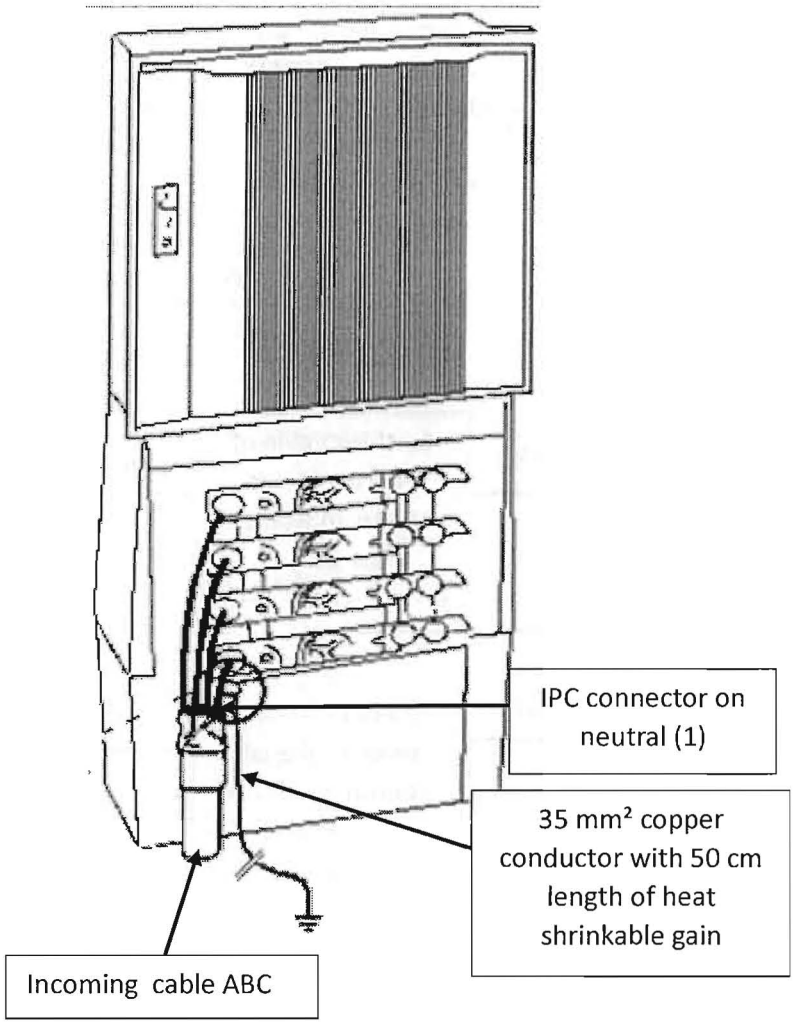
The 35 mm² copper insulated UV protected conductor is mandatorily attached to the ABC before entering in the IPC and the outersheath is removed. Piercing is done through the insulation.

EDC-TP-002 Technical data sheets	**LV Neutral Earthing Connection on Underground Network**	**TDS N°20** February 2019

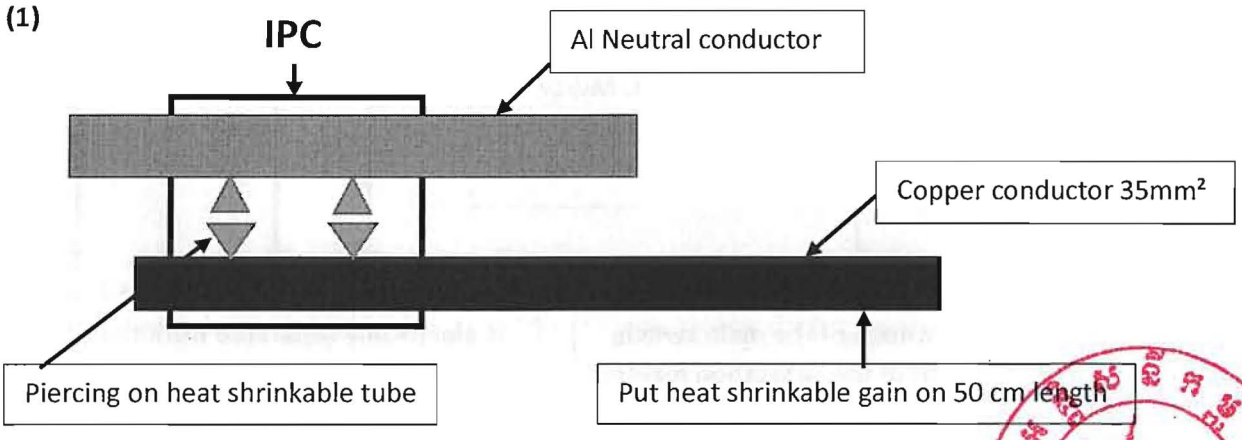


Single Line Diagram for LV Neutral Earthing Connection on Underground Networks

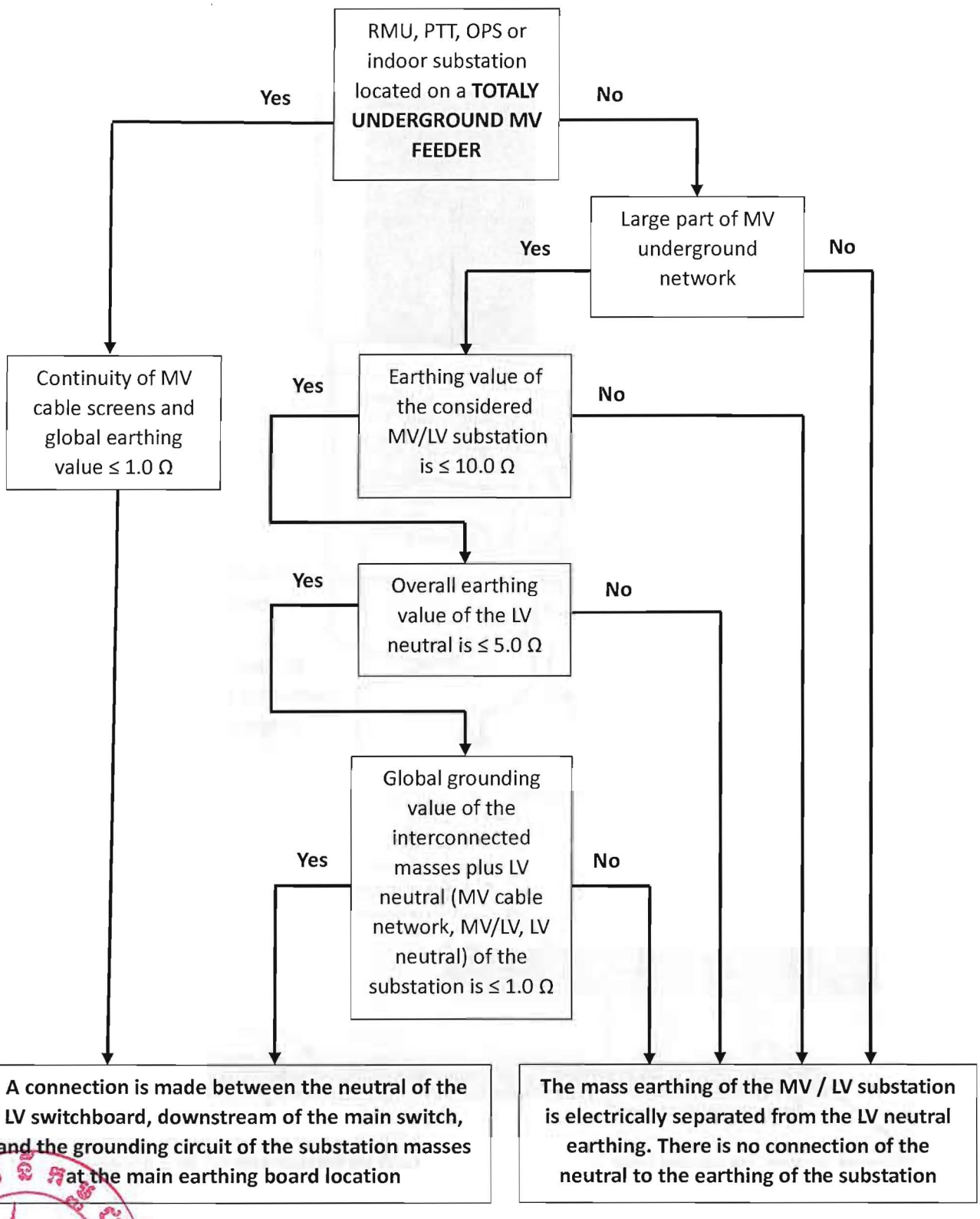
EDC-TP-002 Technical data sheets	**LV Neutral Earthing Connection inside LV Underground Network Connection Cabinets**	**TDS N°21** February 2019



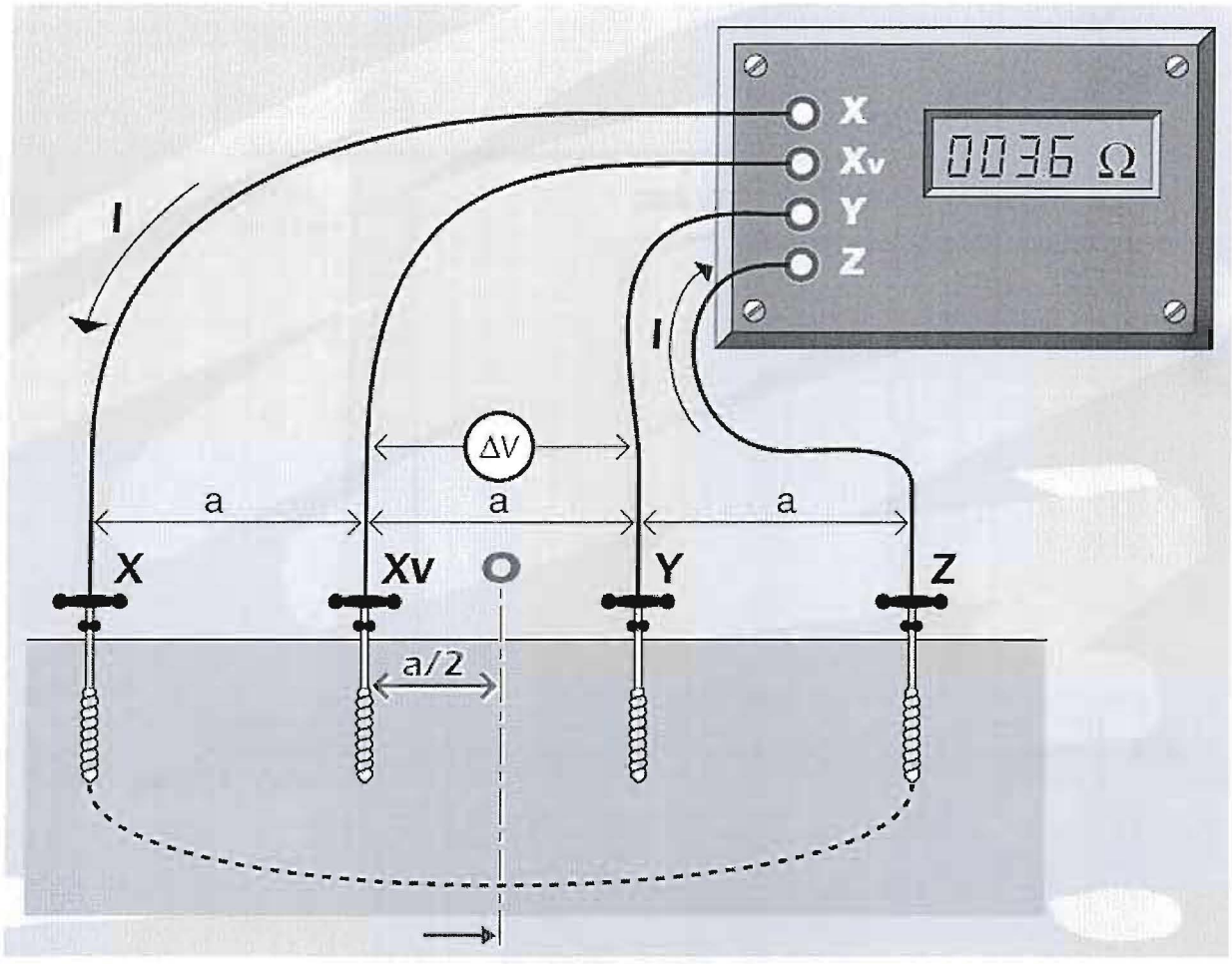
(1)



EDC-TP-002 Technical data sheets	**Condition of Connection of LV Neutral to Mass Earthing MV/LV Indoor Substations, PTT, RMU Cabinet, and OPS**	**TDS N°22** February 2019



EDC-TP-002 Technical data sheets	**Measurement of Soil Resistivity**	**TDS N°23** February 2019



Point "O" : Location of future earthing

Note: The four rods MUST be in straight line

a : 4 m

ρ: Soil resistivity in Ωm

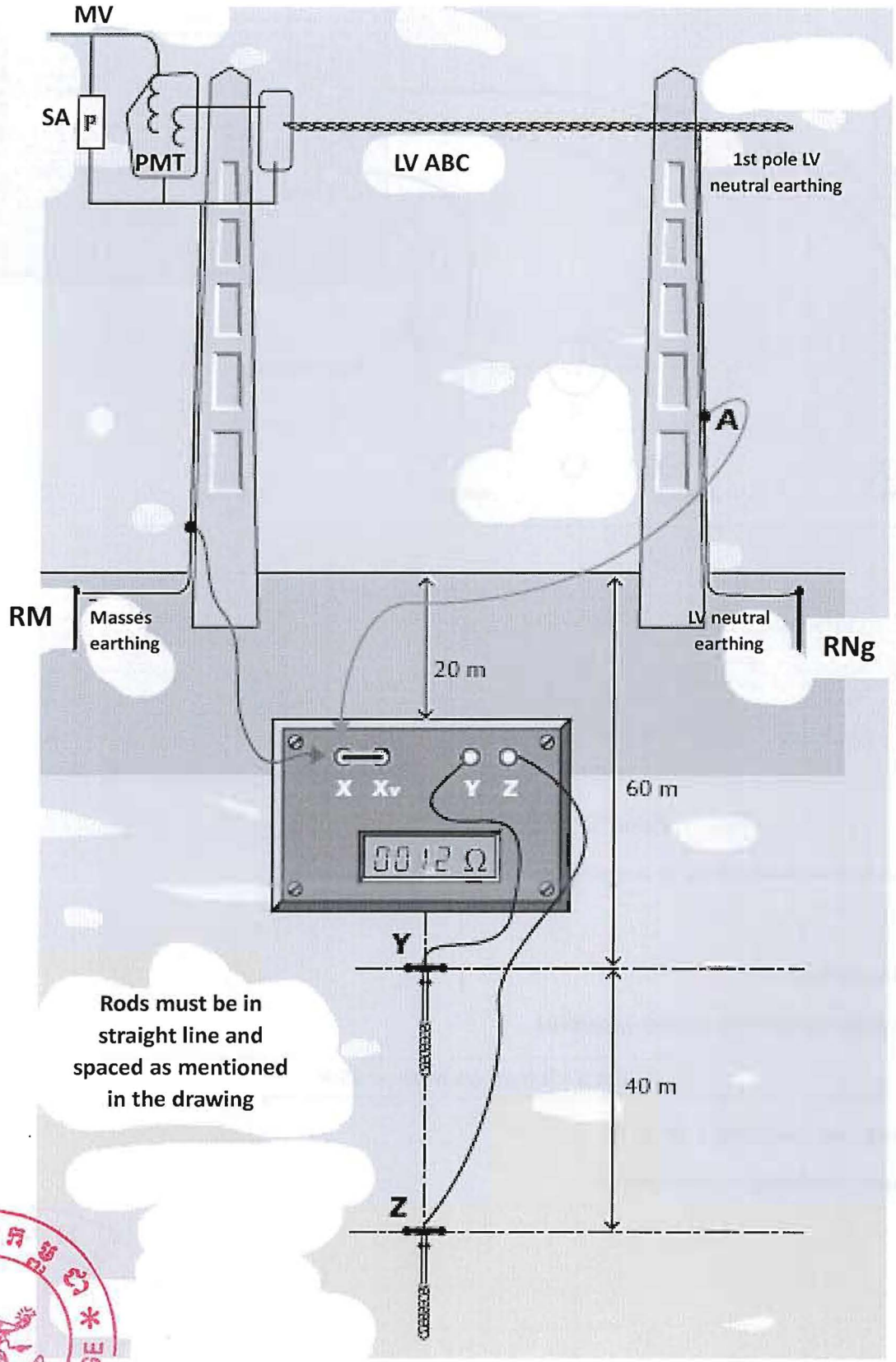
R: Value measured on the testing apparatus

For a = 4.0 m, we have ρ= 25.R

The general formulae is: $\rho = 2\pi . a . R$

a : may vary for deeper measurement.

EDC-TP-002 Technical data sheets	**Measure of Earthing Resistances on 2 and 3 phases PMT**	**TDS N°24.1** February 2019



EDC-TP-002 Technical data sheets	**Process for Measuring Earthing Resistances and Coupling**	**TDS N°24.2** February 2019

1/ Measure the RM resistance with the red cord (see drawing 24.a). Note: This method applies to any measure of single earthing.

2/ Measure the resistance of the **global earthing** of the LV neutral RNg with the blue (see drawing 24.a).

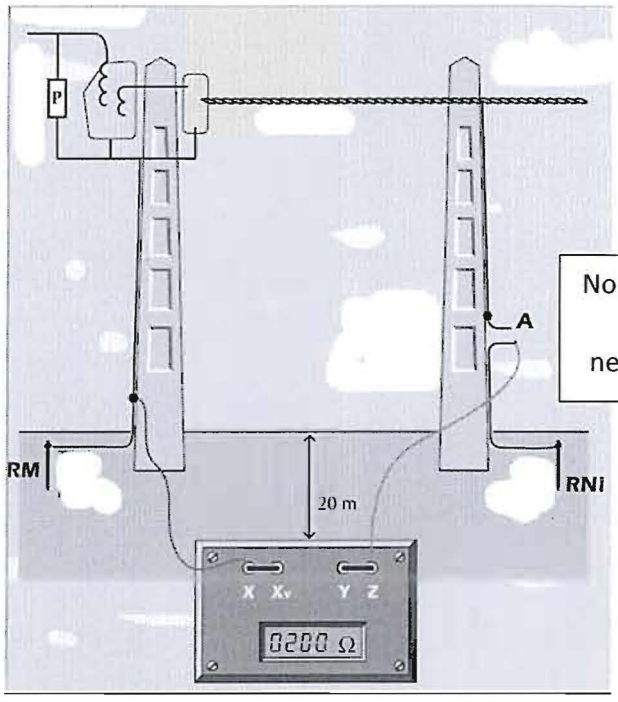
3/ Determine the coefficient of coupling:

3.1/ If there is only one neutral earthing, do not disconnect because RNg = RNi and go to step 3.4

3.2/ if there are several neutral earthings on the network, disconnect the point A and measure the resistance of the individual LV neutral earthing RNi (blue cord in place with A disconnected)

3.3/ Check that RNi> RNg.

3.4/ Proceed to RNM measurement according to the following drawing.



No disconnection if only one neutral earthing

3.5/ Check that: RM + RNi ≥ RNM.

3.6/ Calculate the coupling resistance **Rc**

$$\mathbf{Rc} = \frac{RM + RNi - RMN}{2}$$

3.7/ Calculate the coefficient of coupling C

C = RC/RM

Make sure that C < 0.15

4/ Restore the link at point A.

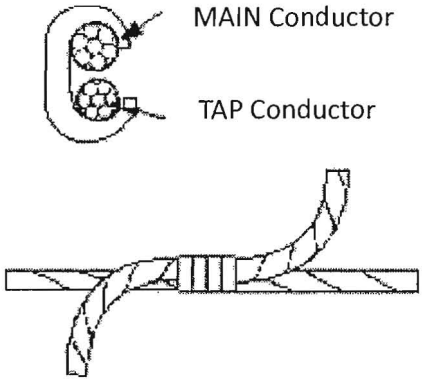
EDC-TP-002 Technical data sheets	**Safety**	**TDS N°25** February 2019

- **It is forbidden to intervene during thunderstorms on the earthing circuit of a structure in service.**
- **The operator must wear its individual protection equipment as well as LV insulating gloves and be located on the insulating mat.**
- **The absence of voltage between two earthing must be permanently checked**
- **In case the work requires the opening of the earthing circuit of a structure in service, the continuity of the grounding of each circuit element to be separated must be ensured: either by placing a shunt maintained throughout the intervention, either by connecting the part to be separated from the earth ground to an existing or created auxiliary earth ground.**

EDC-TP-002 Technical data sheets	**Specific Connectors for Earthing**	**TDS N°26** February 2019

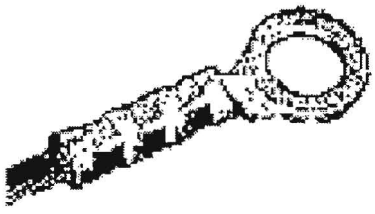
1/ Tin copper C connector: For earthing tap connection that can be buried in the ground

For connection of copper or galvanized mild steel earthing conductors



2/ Tin copper forged lug: For mass connection that cannot be buried in the ground

For connection of copper earthing conductors. Associated with heat shrinkable tube for hot dip galvanized earthing conductor



3/ LV neutral coupling measuring point: For mass connection that cannot be buried in the ground