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ELECTRICITE DU CAMBODGE

TECHNICAL POLICY

EDC-TP-004

MV UCG/ABC and Under River Network Construction

October 2021

ELECTRICITE DU CAMBODGE

Version	Date	Technical Specification Name	Authorized by : (name and signature)
1.0	May, 2022	MV UGC/ABC and Under River Network Construction	Dr. PRAING CHULASA

Version	Drafted/reviewed by	Verified by	Approved by	Date
Draft1	AD			
Draft 2 Draft 3	AD AD/EDC			July 2021 August 2021
Draft 4	AD/EDC			October 2021

Content

MV UGC/ABC and Under River Network Construction

1 Generalities

1.1 Field of Application

This document is applicable to the establishment of all underground, ABC and under river electrical Distribution networks of the medium voltage level (22kV and 35 kV).

1.2 Maximum length of one cable section

The maximum length of a cable section is strictly limited to 3 Km with exception of under river cable.

In case a cable section is more than 3 km the following will be installed:

- **One RMU inside a RMU cabinet (One switch function) or one MV/LV substation with RMU in case of UGC**
- **One pole mounted load break switch fitted with separable connectors instead of bushings or one span of bare conductors in case of MV ABC**
- **Other suitable technical solution could be applied**

In all cases, the screens of the cables shall be mandatorily connected to the earth on BOTH ENDS of the cable.

1.2.1 Definitions

- MV equipment

A set of apparatus or devices for the protection or operation of Network elements.

- Switchgear

Device consisting of an operating member for opening or closing Transformers or MV network.

- Compact RMU

Set of switching and / or protective devices integrated in a metal envelope Unique, not dismountable and not extensible or extensible.

Example: Set 2S + P = 2 unit "switch" + 1 unit "Transformer protection ".

- MV feeder

All of the network components (frames and branches), HV / LV substations and Equipment constituting the network element supplied from a single MV source (Circuit Breaker of a source station or of a distribution station).

- Emergence

Apparatus for the transition between underground cable and Overhead lines or sectioning of an underground cable.

- Feeder frame or backbone

MV main line, loopable, from a source, generally of large section ensuring the transit of energy to the connection points of the leads or loads point.

- Derivation or secondary line

Secondary MV feeder element, from a feeder skeleton, ensuring the transit of the energy to the Connection points for MV / LV stations or MV / LV substation clusters.

- Normal Operating Scheme

Diagram showing the set of feeders supplied in undisturbed and normal operation mode. Each outlet being fed by a single source, the cut-off devices which ensure possibly the connection between feeders, are in the "open" position.

- Network structure

Arrangement of feeders and sources of energy constituting the distribution network.

- Structure of the network

Simplified representation of the network structure.

- Master plan or target scheme

Preliminary representation of the evolution stages of the network towards its target structure.

- Substation

The electrical equipment and the enclosed space or enclosure that protects it from climate conditions. Function is the conversion, transformation of electrical energy and / or the link between several circuits.

A substation is a room or access point reserved for electricians.

- MV Source

Electrical substation providing HV / MV transformation and feed MV public distribution network.

- MV Distribution Station

Electrical station for distributing energy on distribution line outlets MV from a MV source station or a MV production source.

- MV / LV substation

Electric substation for MV / LV conversion and low voltage feed

- UGC/OHL interface

Elements which ensure the transition between the aerial part and the underground part of a network.

2 MV underground cable (UGC) network construction

2.1 Terms and Conditions

2.1.1 Studies

2.1.1.1 Preliminary Draft

2.1.1.1.1 Preliminaries

In the case of works whose precise definition of technical characteristics is decisive for the success of the project and its integration into the network structures, it is recommended that a preliminary draft be the subject of a broad consultation between all stakeholders, namely, the representatives of the contracting authority, the operation and the networks operation representatives.

At this stage, coordination is organized in accordance with the general principles of Prevention, Health and Safety processes.

2.1.1.1.2 Description

The preliminary draft includes:

- a brief description of the work concerned (total length, type of cable, section, ...) and Its insertion into the structure of the network under the master plan,
- a definition of the route taken by the structure,
- a brief description of the nature of the lands crossed,
- a description of the interfaces between the existing network and the structure to be constructed (emergencies, MV / LV substations ...)
- an administrative approach: type of land traversed (private or public, under road or under pavement, ...), specific files (Crossings of railways, classified sites, etc.), dispatch of applications for Information...
- a file for subsequent intervention

2.1.1.2 Implementation Study

The implementation study begins with a consultation between the contractor and the representatives of Operation and management of the networks. This consultation then extends to any partner which could provide information on the points to be studied.

The outcome of the study is to achieve the following:

2.1.1.3 Points to be considered

A. Drawing on plan

It is in principle, established at the scale 1 / 200th or 1 / 500th; however, different scales may exceptionally (given local constraints) be used when they are better appropriate to the site.

Examples:

• 1 / 1000th in the field when the 1 / 200th or 1 / 500th does not allow to specify points fixed markers,

• 1 / 50th in the case of a layout plan for the location of substations, switching cabinets or singular points.

B. Recognition of the subsoil

This element is important in order to limit possible hazards at the time of installation and makes it possible to carry out fast and discreet work.

In addition, recognition of the subsoil is mandatory for particular works such as mechanized cable laying work or cable installation without trench.

It has two aspects:

- determining the nature of the subsoil,
- the search for clutter in the soil.

It may be the result of the implementation of one or more of the following means:

- the exploitation of the cartographies of the other occupants of the subsoil,
- previous knowledge of the land, information gathered from local residents, construction companies, other concessionaires or road managers,
- exploitation of existing geophysical maps,
- scientific measurements (electrical method, radio-magneto-telluric, geological radar...)
- subsoil surveys.

All this means that it is not possible to obtain a perfect and absolute knowledge of the subsoil but this give good indications for a smooth running of the works.

C. The singular points

Particular attention is paid to singular points likely to create difficult conditions (Other networks, various obstacles, etc.), to impede network exploitation, to impact the safety of the interveners or third parties, to hamper the smooth running of the site particularly in its programming, to reduce the final quality of the structure and to generate disadvantages to the existing networks in the right-of-way.

Particular attention is paid to:

- Materials and their implementation: equipment, emergencies, Aero-underground interfaces, MV / LV substations, cabinets, ...
- obstacles: crossing of bridge, railway, river, road, presence of Street lights and public lighting circuits, ...
- technical requirements: crossing with other energy distribution networks, electricity, street lighting, gas distribution, water distribution, telecommunication, drainage or other existing connections, ...

D. Representations in quoted sections

The cuts of the various trenches to be made indicate the position of the cable or cables with respect to the other works on the one hand and fixed landmarks (bollards, walls, pillars, curbs ...)on the other hand.

The distances between works must comply with the Cambodia technical requirements.

The cable installation depths are fixed at the time of the study in compliance with the Cambodia technical standards and possible road regulations.

Other imperatives (such as drainage or cropping) may need different cable installation depths.

E. Backfilling conditions

The backfill materials and the methods of compaction of the trenches are defined according to the Instructions of the road manager concerned, in compliance with the Cambodia and EDC standards.

As far as possible, backfilling shall be done with raw earth, sieved or even crushed if necessary.

> *Note: Electric cables are designed to be installed directly in the soil. However, this earth must possess mechanical, chemical and thermal properties which make it possible to guarantee the durability and lifespan of the cables. These properties are defined in the specification of the installation zone. If this is not the case, other filling material as sand must be laid in protection as sand.*

F. How to implement accessories

The staller of the terminations, junctions and T joints shall be determined and the interventions of the various interveners programmed as soon as the case is studied.

It should be noted that for a continuous mechanized installation, the preparation of the ends of the cable can be carried out by the manufacturer.

This indication is necessary at this stage in order to respect the delivery time of the equipment.

G. Health and safety coordination

The procedures for coordinating interventions are under contracting authority responsibility. The contracting authority is given a key role in preventing the health and safety of installation staff.

Integration of safety into the design of the structure to ensure better working conditions both during construction and maintenance is of the utmost importance.

H. Site preparation

It includes, in particular, conditions for access to the site and road traffic, and the coordination of the interveners (see previous paragraph), as well as all the provisions (Cleanliness of the site, removal of cuttings and various waste, etc.) to facilitate the works in the best conditions of safety and quality.

The following are clearly defined at the beginning of the work:

- the specific conditions for the construction of the site in terms of the date of execution, Traffic, beaconing, barrier and signalling,
- preparation of unwinding and making of connection accessories:

In case of long cable length, it is necessary to provide special means.

In the case of continuous mechanized laying, the length of the cables, direction of installation (in the case of cable ends prepared at the factory) must take into account points particular routes.

2.1.2 Works of Excavation

The following procedures apply to sites under open excavation but also to excavations carried out at points of entry and exit on a section made in underground drilling

2.1.2.1 Demolition of Soil Coatings

The coating is demolished with caution and following a clean cut with a disc cutter if it is asphalt, bitumen, cement.

It is also removed with all necessary care when it comes to pavers, pavements, bricks, tiles and, in general, separate elements.

These materials intended for reuse must be left in such a condition that they can be recovered when the coating is repaired.

In addition, the displaced materials are stored in such a way as to impede as little as possible the circulation and, if necessary, to follow the instructions of the road managers.

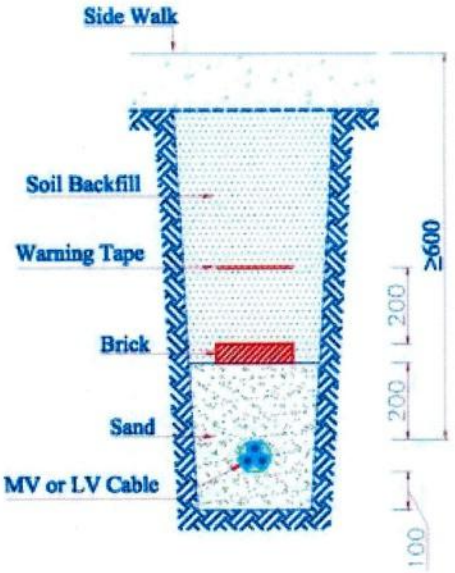
In the case the trench is made in a cultivated area, care is taken to remove the layer of topsoil which is returned to the surface during the backfilling of the trench.

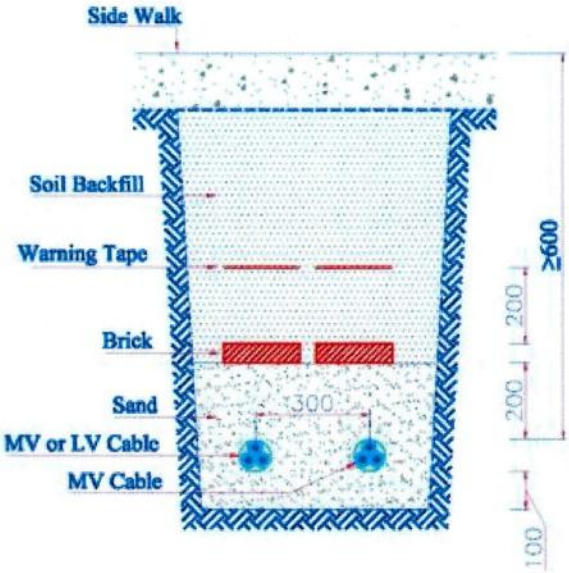
2.1.2.2 Execution of Trenches

2.1.2.2.1 Depth

In the absence of local regulations, the depths must comply with the EDC standard as follow:

A/ Under side walk with open trench (handmade or excavator):


Side Walk
Soil Backfill
Warning Tape
Brick
Sand
MV or LV Cable
≥600
200
200
100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Soil Backfill
Warning Tape
Brick
Sand
MV or LV Cable
MV Cable
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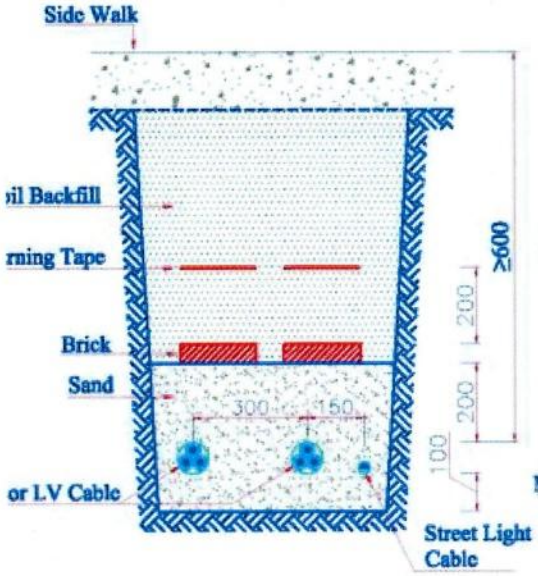
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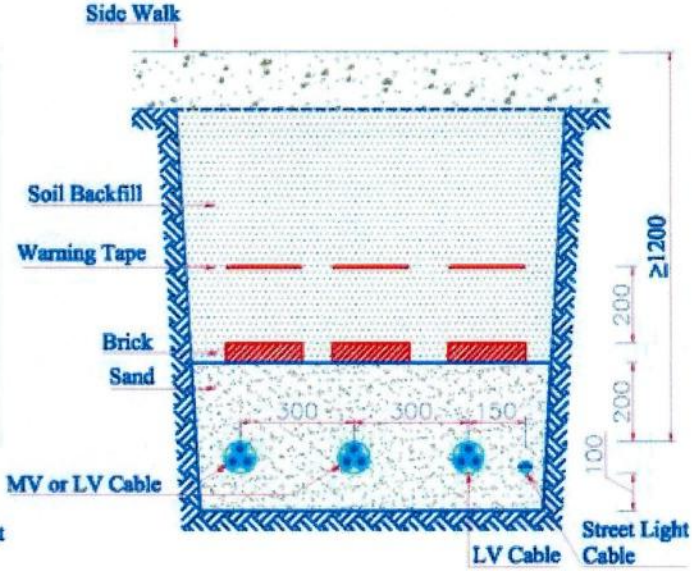
or LV Cable
300
150
≥600
200
200
100
Street Light
Cable


Side Walk
Soil Backfill
Warning Tape
Brick
Sand
MV or LV Cable
300
300
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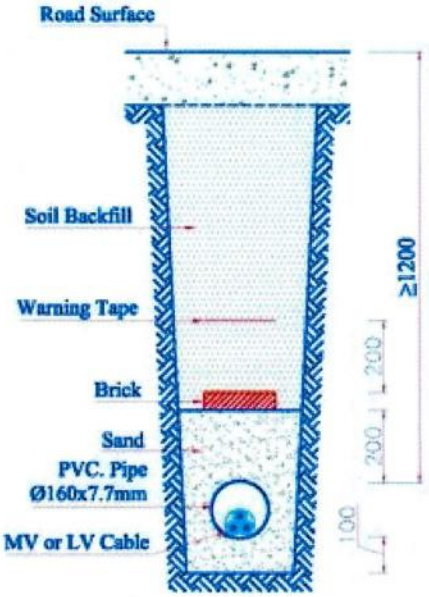
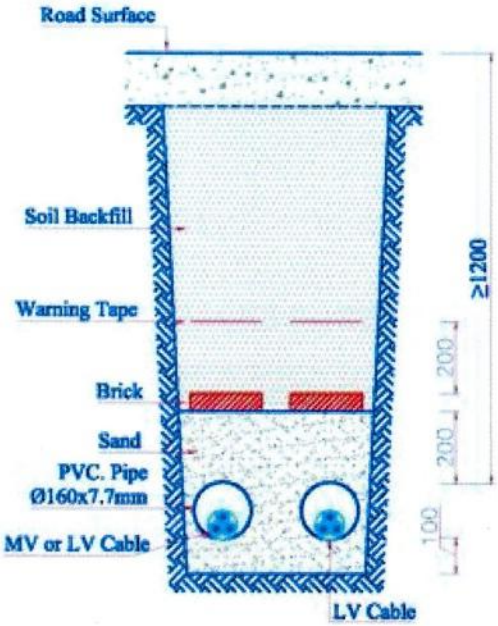
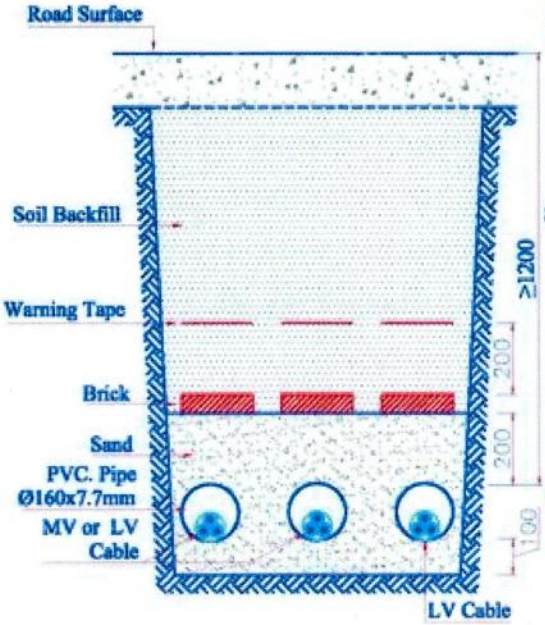
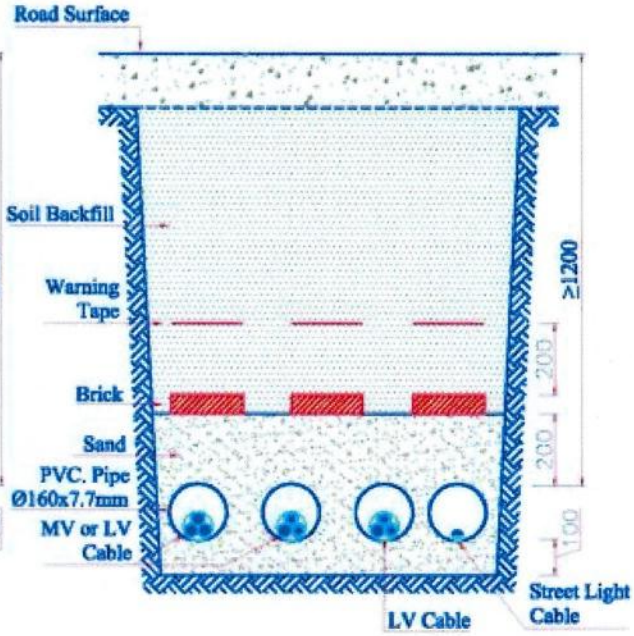
200
200
100
LV Cable
Street Light
Cable

B/ Under road or road crossing (handmade or excavator):

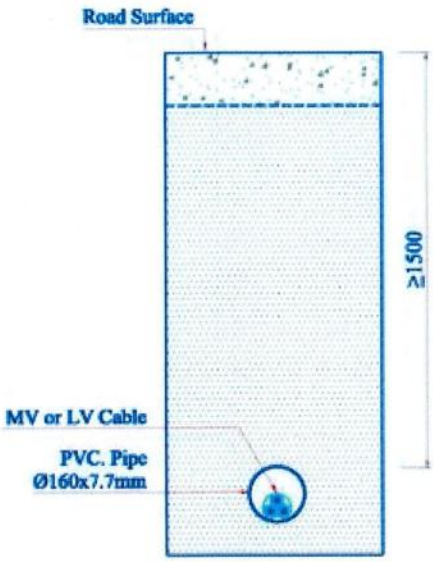


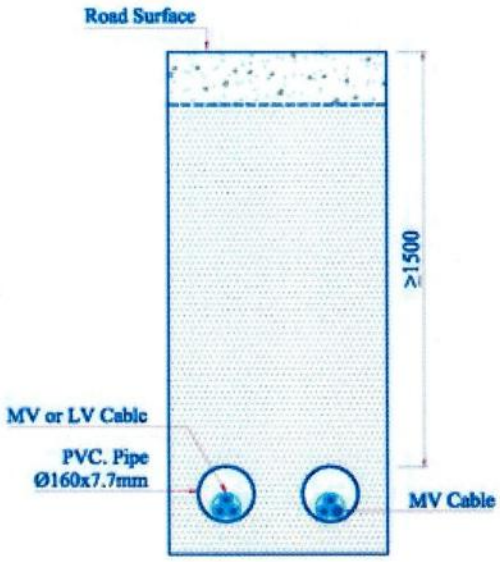


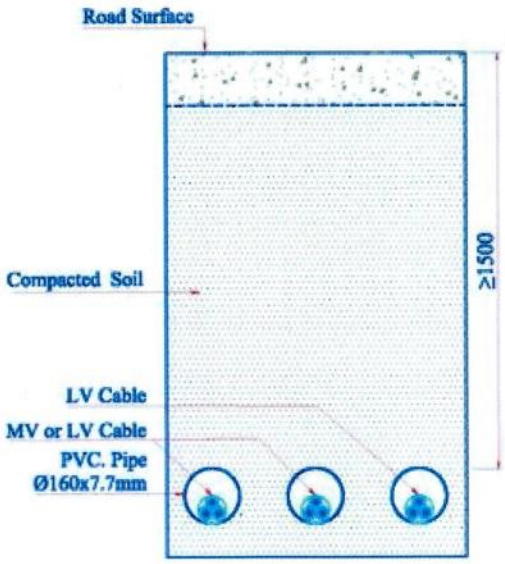


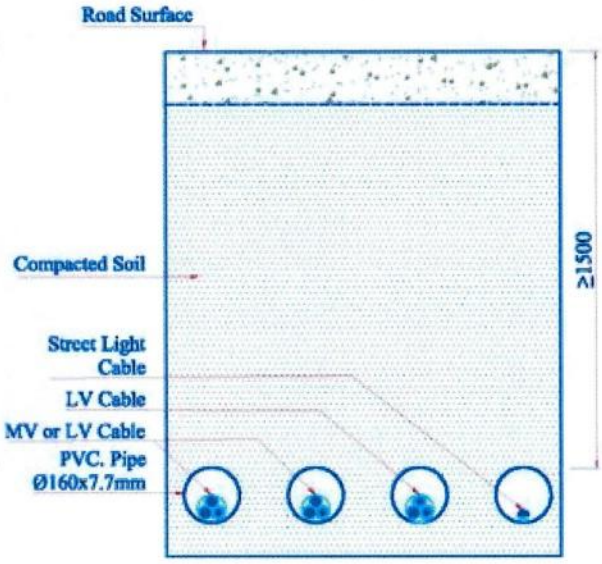


C/ Pipe jacking for road or railway crossing









In cultivation areas it may exceed 1.30 m depending on the particulars and it shall not be less than 1.20 m deep.

In the event a derogation is granted where local conditions do not allow for the intended depths to be respected, special arrangements are made to ensure the safety of third parties and sufficient mechanical protection to protect the cable from compressions due to surface forces and degradations due to the most frequent tools (pick, pile, ...).

This protection can be achieved by using steel sheet (> 4 mm) placed at 0.10 m above the cable, steel pipes, concrete cement pipes, synthetic pipes embedded in Concrete, multi-tube ducts ...

2.1.2.2.2 Width

The width should be as small as possible. It depends on the number and arrangement of the cables and other network.

The distance between two MV underground cables or between one MV cable and one LV cable is 0.30 m.

Following table shows the estimated trench width that need to be excavated when the MV cables are laid near the LV cables.

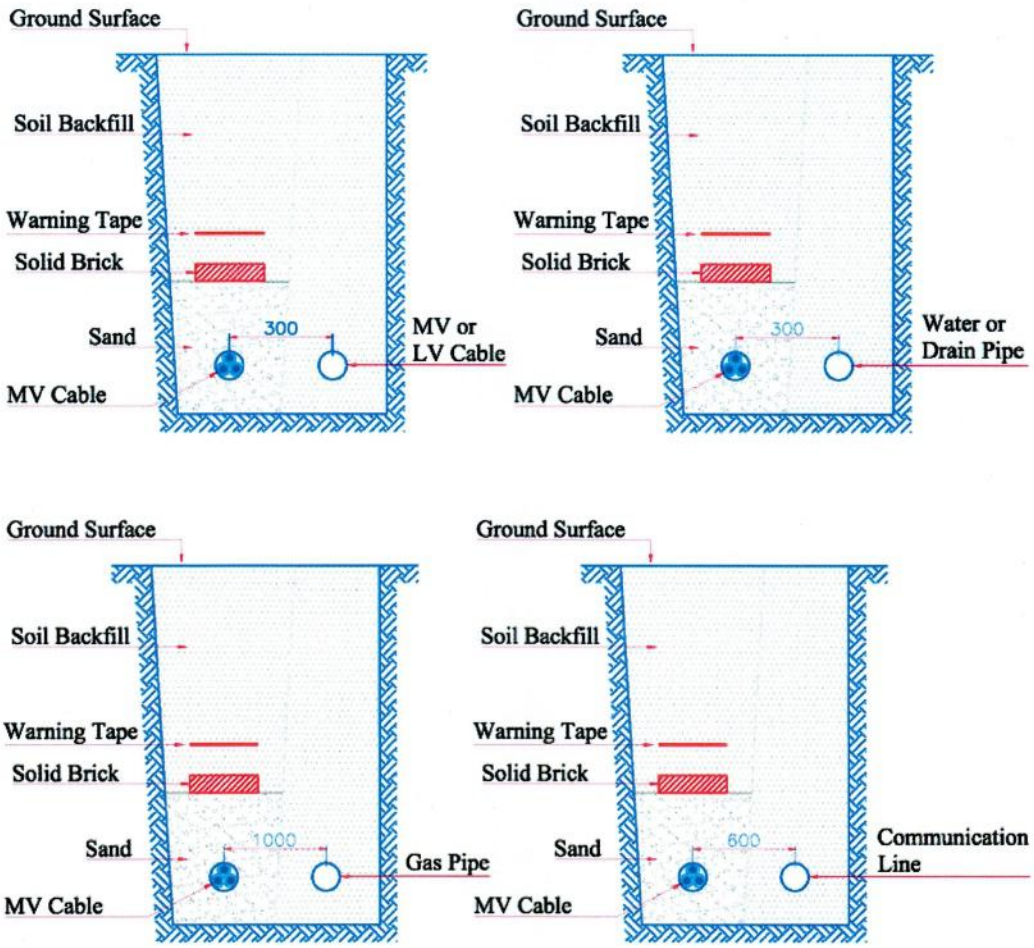
Table 1: Estimated Trench Width Related to the Number of Cables Laid

Estimated Trench Width Related to the Number of Cables Laid								
		Number of LV Cables*						
		0	1	2	3	4	5	6
Number of MV Cables	0		0.30m	0.50m	0.70m	0.90m	1.10m	1.30m
	1	0.30m	0.6m	0.8m	1.00m	1.20m	1.40m	1.60m
	2	0.60m	0.90m	1.10m	1.30m	1.50m	1.70m	1.90m
	3	0.90m	1.20m	1.40m	1.60m	1.80m	2.00m	2.20m

2.1.2.2.3 Distance/clearance with other networks

Distance from the MV underground cable to the underground pipes or the communication line are shown in the following table.

	Communication Line	Gas Pipe	Water Pipe	Drainage Pipe
MV Line	0.6 m	1.0 m	0.3 m	0.3 m



2.1.2.2.4 Clearance between Multiple Underground lines

The minimum clearance between a new underground line and other electrical lines shall be as shown in the following table:

New line	Other electrical lines (m)		
	Low voltage	Medium voltage	High voltage
Low voltage	0.15	0.3	0.3
Medium voltage	0.3	0.3	0.3
High voltage	0.3	0.3	0.3

2.1.2.2.5 Trench

In principle, the side walls of the excavations must be vertical.

When the trench has a depth of over 1.30 m and a width equal to or less than two-thirds of the depth, the vertical sides of the trench should be shielded, strutted or shored; in the other cases, they are adapted to the nature and condition of the land, weather conditions and topography of places to prevent landslides .

2.1.2.2.6 Use of Mechanical Equipment

The use of mechanical equipment for the execution of excavations is authorized.

However, their use must be stopped as soon as it presents dangers to persons and works of any kind existing nearby; In particular, in the case of excavation within 1m of an electric cable.

2.1.2.2.7 Water Flow

The drainage of public and private waterways must always be ensured.

2.1.2.2.8 Vehicle and Pedestrian Traffic

When carrying out work along public and private roads, all necessary precautions shall be taken to ensure adequate passage for vehicles and pedestrians. In particular, access to buildings, shops, garages and electric power distribution works must be maintained.

As soon as the site presents a danger for pedestrians, it must be surrounded by stable barriers or palisades; this is particularly the case in urban areas where it is advisable to think of blind pedestrians.

If necessary, the site is equipped with night-time signage.

2.1.2.3 Trench Filling and Surface Repair

2.1.2.3.1 Sand or fine earth

A layer of 10 cm of sand or fine earth shall be applied in the bottom of the trench and when the cable is installed, this one shall be covered by another layer of 20 cm of sand or fine earth. (See drawings).

2.1.2.3.2 Warning device

A plain bricks layer shall be jointly installed 20 cm above the cable (directly laid on the sand layer), then after backfilling and compaction of a first soil layer, a warning device (red plastic net) must be installed 0.20m above the bricks and above each power cable, even if it is below another cable of a different voltage level already warned (See drawings).

2.1.2.3.3 Replacement/repair of soil coatings

The repairs are carried out in agreement with the road or pavement management authority.

2.1.2.4 Network Cartography

Any installation or modification of an underground structure shall be mapped over immediately after work.

Maps/plan are normally drawn at 1 / 200th or 1 / 500th scale and conform to EDC's mapping system.

Generally, a single street plan shall cover all works; the particulars necessary for their identification must be reported.

2.2 MV Underground Networks

2.2.1 Implementation of Equipment

2.2.1.1 Cables and Accessories

2.2.1.1.1 General conditions for installation of MV cables

RULES

1- INSTALLATION TEMPERATURE

The temperature measured on the cable sheath must be between 0 ° and 40 ° C

RECOMMENDATION

In case of high outside temperature, it is advisable to ensure cable storage before installation on site in the shade.

If the PVC sheath and / or the screen of one core on the drum is found to be wrinkling, a contradictory statement will be made with the manufacturer.

The corresponding cable section must not be installed.

2- TRACTION EFFORTS on cables

It is important, during the whole operation, to limit the tensile stress to the value set by the manufacturer.

The forces should generally not exceed 3 daN / mm².

Max tensile force	
70 mm²	*755 daN*
150 mm²	*1350 daN*
240 mm²	*2160 daN*

A dynamometer, if possible with a torque limiter, is used to check it.

3- RADIUS OF CURVATURE

The changes in direction are determined in such a way that the radius of curvature of the cable after laying is not less than 10 times its external diameter.

Depending on the method and the machine used for laying the cable, two types of unwinding can be distinguished:

- unwinding with traction

when the cable is pulled by hand or by means of winches, the drum is then fixed,

In this drawing phase, the radius of curvature of the cable shall not be less than 20 times its outside diameter.

- unrolling without traction

when the cable is laid at the bottom of the trench by hand or by means of a mechanized laying machine, the reel moves at the same time as the machine.

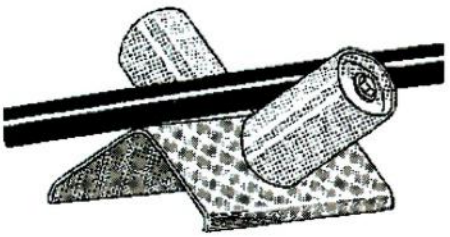
The radius of curvature authorized during operation must not be less than 1 meter at any point of the cable

The radius of curvature of the installed cable must therefore comply with the following values:

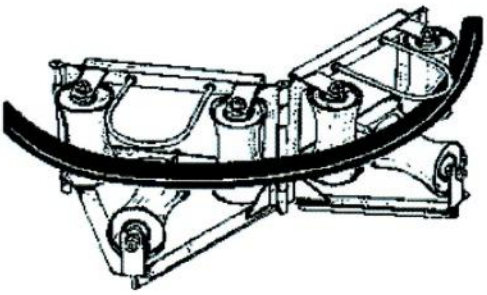
Section (mm²)	*3x70*	*3X150*	*3X240*
Min Radius (cm)	*65*	*80*	*90*

The radius of curvature of the cable during the cable installation must therefore comply with the following values:

Section (mm²)	*3x95*	*3X150*	*3X240*
Min Radius (cm)	*140*	*160*	*180*



Care should be taken to install additional rollers (alignment or angle) on the cable routing, possibly on the machine and in the box in the case of mechanized installation.



4- MAXIMUM NUMBER OF INVERTED FOLDINGS (S)

The number of folds at a minimum of 90 ° of the allowed radius of curvature is limited to two.

5- OUTER SHEATH

The integrity of the outer sheath is essential to the reliability of the cable.

Any incident must be reported to the prime contractor who will inform the contracting authority.

If a notch is located on the sheath and affects less than half the thickness of the sheath and no deformation or crushing of the cable is found, repair is carried out by laying a sheath.

In all other cases, the faulty part is eliminated and a repair is carried out by installing a junction or a shoulder strap.

In the case of unwinding on the ground, the cable must be protected whenever there is a risk of vehicle crossing (entry of properties, agricultural holdings, etc.)

INSTALLATION OF PIPES

The use of pendulous pipes avoids a new opening of the trench on the same course in close times.

Care is then taken to mention their positioning on the map.

Plastic pipes (PVC or HDPE) are generally used.

Nevertheless, in road crossing subjected to considerable crushing forces and where it is not possible to respect the usual cable depths, metal

The inside diameter of the pipe shall be appropriate to the apparent diameter of the cable (about 2 time the apparent diameter of the cable)

pipes or plastic pipes in concrete with 50 cm of concrete above the pipes can be used.

END CAPS

The end caps provide sealing at the cable ends and must be kept intact.

In the event of a cap fault, it is imperative to check the absence of water penetration into the core (by turning over the cable it will be possible to see if water flows or not).

If a water penetration is observed, the cable is cut to a sufficient length (of the order of one half turn of the drum) and the covers are individually reconstructed phase by phase as well as the preparation of the ends if necessary.

Under no circumstances should the ends of the cable strike the ground (risk of bursting the cover).

CABLE MARKER

In the case where it is impossible to find immutable landmarks in the immediate vicinity of a structure for reporting and mapping, systematic locating of underground cables by cable markers at ground level is mandatory.

In other cases, in the case of works by definition invisible, and in particular when they are established in low-density areas, demarcation constitutes an interesting complement by meeting two expectations:

• informing third parties about the presence of an underground electrical cable (safety during work in the vicinity)

• help to identify and identify the structure in addition to the support mapping.

Given the diversity of geographical and physical environments, the nature, number and location of the markers shall be determined by the network operator in agreement with the developer at the time of the study.

We choose the type of terminal (shape, dimensions and in particular height, material,

Depending on the case, the cable markers are positioned vertically above the cable (where possible) or are offset (the horizontal distances are indicated on a plate fitted to the marker to identify the cable)

In all cases, a text drawing attention to the voltage level of the structure may be inscribed on a plate attached to the marker.

It may also include a number for mapping, monitoring and maintenance of these materials.

According to necessities, markers are used to simply mark singular points

• *change of direction,*

• *change of road side,*

• *crossing an obstacle (crossroads, bridge ...),*

• *crossing private property,*

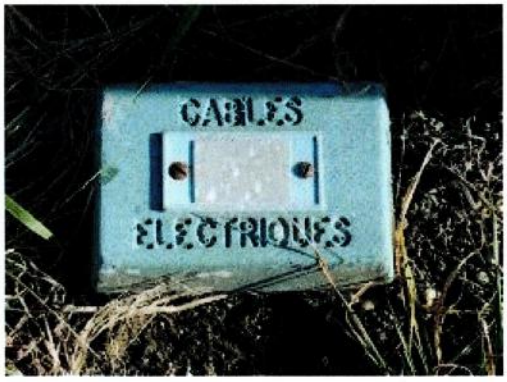
• *presence of accessories on cable (Te, junction, ...).*

or, in the case of large linear paths, to visualize and mark the sections one terminal every x meters.

It is appropriate in all cases where the demarcation exists to provide for its maintenance.

fixing system ...) depending on the constraints and risks of deterioration or even destruction (agricultural machines, road maintenance machines) and according to the goals to be achieved.

The colour of the cable markers is red for electric power networks.



CABLE INSTALLATION AREA

The MV underground cable is designed to be buried in the ground if there is sufficient fine earth.

The material of the installation area must comply with the specification of the cable laying area.

Reuse of excavated material will always be preferred. Either without treatment or after screening and sieving or after recycling (grinding, crushing and screening).

If the material is not adapted the cable will be installed in a 20cm layer of sand

- **Traditional installation**

It is ensured that the means used in unwinding exert a traction sufficiently continuous and progressive.

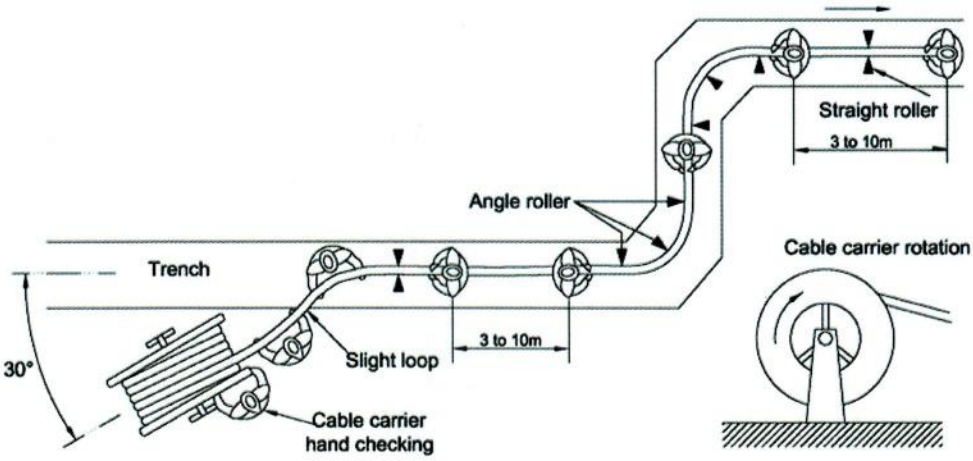
Drum trailer

If the pulling of the cable uses a mechanical means, the device for coupling the cable to the traction system is made:

• or by means of a welding head, in the case where it is necessary the conductors are used for the transmission of loads (long cables length)

• or by means of a sock (adapted to the apparent diameter of the twist in other cases (short cables).

Care is taken, then, after drawing, to cut by a length of approximately 1.5 m the end of the cable on which the sock has been fixed.



In case there is no perpendicular obstacles in the trenches (pipes, cables, etc..) and if there is a road all along the trench, cables can be installed in the trench when unwinding from the unwinding trailer device that progress slowly on the road. The cable must be installed in the trench directly from the drum trailer without dragging the soil.

- **Mechanized installation**

Mechanized installation means:

- opening of excavation,
- Simultaneous installation of the cable,
- the warning device,
- connection equipment, (possibly)
- backfilling of the excavation.

in a single operation.

Two types of machines are used for the mechanical laying of cables:

- wheel trencher,
- chain trencher,

The general provisions set out below apply, and particular attention will be paid to the following points:

The recommended minimum cross-section of the caisson or trough shall be 160 mm x 160 mm for a cable with a cross-section of 240 mm².

A choice of 10 mm protection around the cable envelope and accessories (maximum diameter + 20 mm) is well adapted for mechanical protection of cables.

At the time of the junctions pass through the installation box, it is checked with the eye that the cable mechanical stress or excessive vibrations which could damage the cable and accessories (the

The choice of the laying machine is the responsibility of the contractor and must be agreed by EDC.

use of a vibrating coulter plow rigidly connected to the installation box is to be avoided)

A shrink wrap allows the connected phases to be held in trefoil and facilitates their passage through the laying machine.

The guiding and supporting elements must allow the cables to respect the minimum radius of curvature imposed and avoid any jamming and friction on the rough or aggressive parts

- **Trenchless installation (jacking)**

Crossing the main roads with heavy traffic, open cut excavation is not allowed. In this case pipe jacking machine is used to drill and pull PVC or HDPE pipes across under the roads. The pipe shall have enough mechanical strength to withstand the pressure from heavy vehicles driving on the roads. In case the strength of the pipe cannot be clarified, the depth of the pipe laid shall be at least 1.2 m from the road surface. The underground cable is pulled through these pipes.

The trenchless method involves several techniques:

- unguided,
- remotely guided,
- guided live, ...

We will only discuss here the so-called "directional drilling" principle:

This involves the drilling of a pilot hole between two excavations (about 100 to 150 m apart in the current state of the art) using a hydraulic unit pushing a drill string equipped with a hydraulic unit, a high-pressure injection head with water and bentonite.

This pilot hole is subsequently enlarged to the desired diameter (by about 50 to 200 mm) by successive passages of conical reamers of suitable size. The last operation consisting in carrying out the installation of the pipe always using the drill string, in which the

The pipe for the electric cable is mandatory in order to constitute the protection and the cable locating (warning) because of the impossibility of installing the warning net in this case..

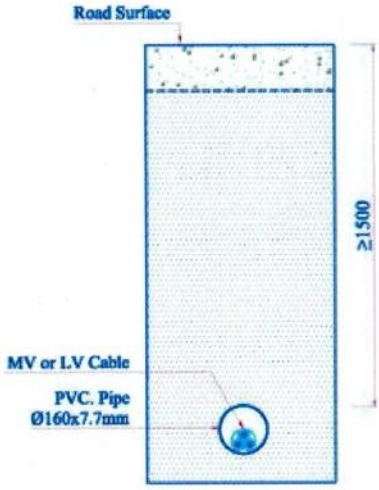
This pipe must be of red colour and made of HDPE.

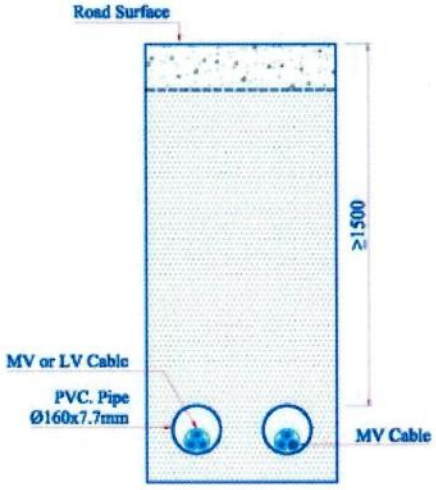
pulling of the cable is carried out subsequently by a winch equipped with a torque limiting device.

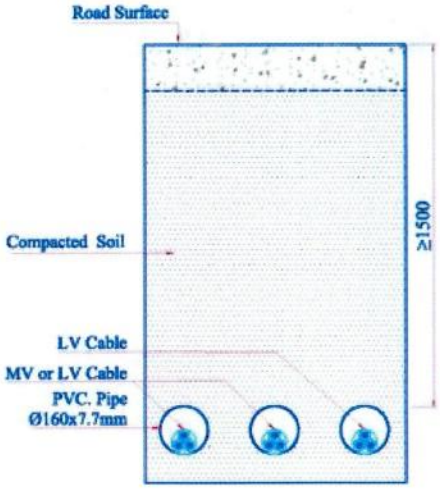
This technique allows the laying of a cable avoiding a certain number of disadvantages encountered during traditional installation with opening of trench.

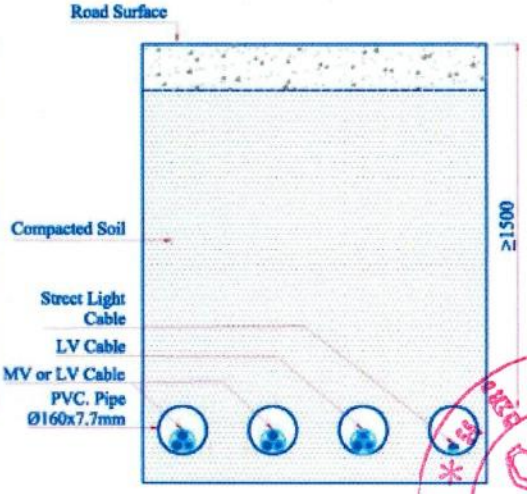
Nevertheless, the limits linked to the size and the nature of the subsoil should lead to its use with discretion, after recognition and a preliminary study of the subsoil confirming or not its feasibility.

In any case, this type of cable installation requires a very complete and very detailed preparation that is the unavoidable condition of success.









- **Implementation of termination, junction and branch accessories**

Termination, junction and branch accessories must be in accordance with the technical specifications of EDC and must be carried out by trained personnel.

For work sites where the cable junctions are made simultaneously with the laying of the cable,

it is imperative to:

- *slow down the speed of the laying machine and be ready to stop immediately,*
- *have staff to guide the junctions through a visual check of the good passage of the accessories in the box,*
- *in defining the programming of the work site and in order to optimize it, it is mandatory to foresee staff and troubleshooting equipment immediately available in order to mitigate any cable incidents and to limit work site interruption.*

EMERGENCES

Establishment, preparation of excavation and installation of civil engineering

The study defines a site with multiple considerations:

- electrical,
- operating,
- site integration,
- implementation.

In particular, the earthing circuits are designed to allow the flow the current of faults from all sources (lightning strikes, 50 Hz defects, electrostatic charges) into the ground,

The grounding is carried out at the bottom of the excavation during the execution of the foundations by a conductor of bare copper with a cross-section of at least 35 mm² forming a loop arranged on the outside perimeter of the civil engineering.

In addition, the safety of persons and animals must be ensured by a limitation of the pitch and contact tension in and around the premises.

The study points out, in particular, the following points:

- *Optimal framing of the network, distribution of loads, losses, ...*
- *Easy and immediate access for operations including difficulties: flooding, radio reception quality in case of remote control by this way, ease of maintenance ...,*
- *concealment in the surrounding landscape, ...*
- *immediate or delayed connection of cables, construction of earth circuits, ...*

In some cases, it may be necessary to make an operating sidewalk if it is not provided by the manufacturer and possibly a sidewalk of cleanliness (to be defined locally).

The finished floor level is established to ensure access and opening / closing of doors without difficulty.

All recommendations recommended by the manufacturer regarding the transport and handling of the equipment are strictly observed to avoid any

For this purpose, a second circuit consisting of a bare copper conductor with a minimum cross-sectional area of 35 mm², placed 50 cm around the envelope at a depth of approximately 20 to 30 cm, produces an equipotential belt connected to the circuit in the bottom of the excavation.

risk of embrittlement of the envelope and possible stresses on the equipment.

Electrical connection

The fitting of the accessories and the connection of the cables are made according to the technical specifications in force.

The installation of a pipes at penetration into the masonry civil engineering will ensure the mechanical protection of the cables over time.

The radius of curvature of the cables must be respected and the insulation of the cables must not be injured when cables are installed

As far as possible, the geographical position of the electrical equipment shall correspond to cable sections in order to avoid crossings, which are always a risk of confusion in operation, and their consequences

3 MV aerial bundled cables (ABC) installation

3.1 Studies

Similar studies that above mentioned in chapter 1.2.1 are to be carried out. It will necessary to take care about path and buildings (existing and future) as well of foreseen roads.

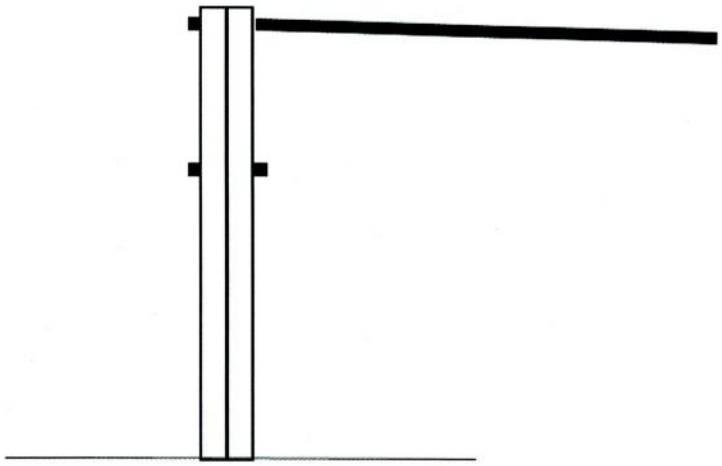
Nevertheless, with exception of soil checking, the study will include all topic as:

- Preliminary draft
- Implementation study
- Drawing on map

Concerning the drawing of map, the scale shall be larger than mentioned: as example 1/5000.

Additionally, a full mechanical study and line profile shall be established as requested by Annex 1 of EDC-DTS-TP003 policy.

It is mentioned that in order to avoid the multiplication of guys because the ABC is heavy and because of its strength, **it is strongly suggested to use twin poles** in urban or sub-urban area in order to get strong supports without large soil occupation.



With twinned poles of 9kN, the effort of the pole assembly become 18kN

3.2 Unwinding of ABC

3.2.1 Installation temperature

Similarly to UGC, The temperature measured on the cable sheath must be between 0 ° and 40 ° C.

In case of high outside temperature, it is advisable to ensure cable storage before installation on site in the shade.

If the PVC sheath and / or the screen of one core on the drum is found to be wrinkling, a contradictory statement will be made with the manufacturer.

The corresponding cable section must not be installed.

3.2.2 Mechanical tension.

The mechanical tension in case of installation using a winch is limited by the mechanical tension of the ABC steel messenger.

In any case, mechanical traction on the MV ABC shall be done using traction on the messenger only.

During cable installation using a winch, the mechanical traction shall not exceed 20 KN.

3.2.3 Cable radius curvature

The maximum cable curvature during cable installation shall not be less than 20 times the apparent diameter of the ABC.

3.2.4 Unwinding machine/trailer

The cable drum shall be mandatorily installed on a specific equipment for unwinding as a drum trailer.

This one shall be installed:

- At one end of the line in case of installation under mechanical tension using small steel cable and winch.
- On a slowly moving drum trailer on the road if the cable is installed on the ground before to be installed on pulley on the pole top. In that case, it is necessary that the cable do not drag the soil. If necessary rollers identical to UGC installing shall be used.

3.2.5 End caps, Water

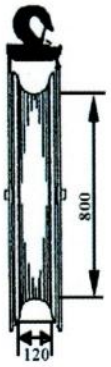
The requirements mentioned above for UGC shall be strictly applied

3.2.6 Tools, mechanical accessories

It is very strongly requested to use adequate accessories and tooling. Any botch up or bad tooling will not be accepted.

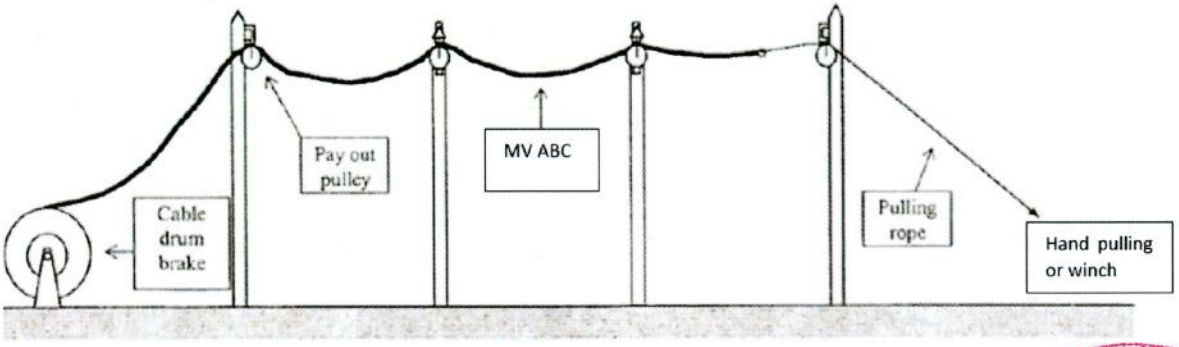
3.2.6.1 Pulley

In order to respect the radius of curvature of the ABC, so in order to avoid internal cable problem mainly for the metallic screens, the minimal diameter of the pulley shall be 800 mm with and internal larger of 120 mm that allow unwinding of 3x1x240mm² ABC.



The use of double pulley is accepted as fully equivalent.

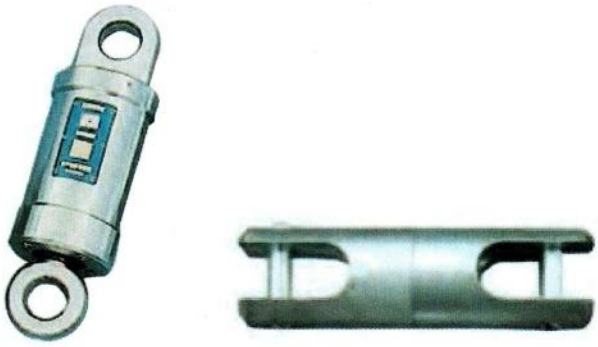
The internal larger of the pulleys shall not be less of 120 mm.



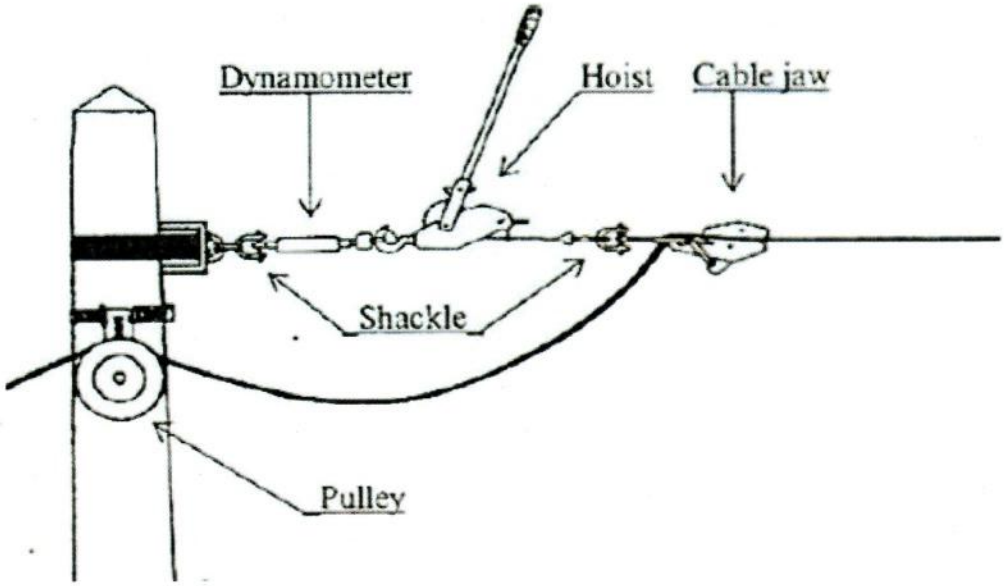
3.2.6.2 ABC stretching and adjusting

Considering the strong traction to be applied to the ABC for stretching and final adjustment, strong pullers will be used with strong come along clamp.

They will be mandatorily associated with a dynamometer and a swivel in order to check the tension of the ABC.



The ABC adjustment shall be carried out from the top of the pole.



The final stretching from the ground is strictly forbidden because it can produce too strong efforts on the pulley on the top of the pole that could break and create an accident.

4 Under river cable installation

Under river cables are necessary when a river bridge is not accessible not too far.

This kind of cable is specifically design to operate permanently under water. Numerous care must be taken in order to avoid any cable damage during installation.

It is of the upmost importance that the cable manufacturer being involved in the cable installation. The cable installation team must be experienced in this kind of work.

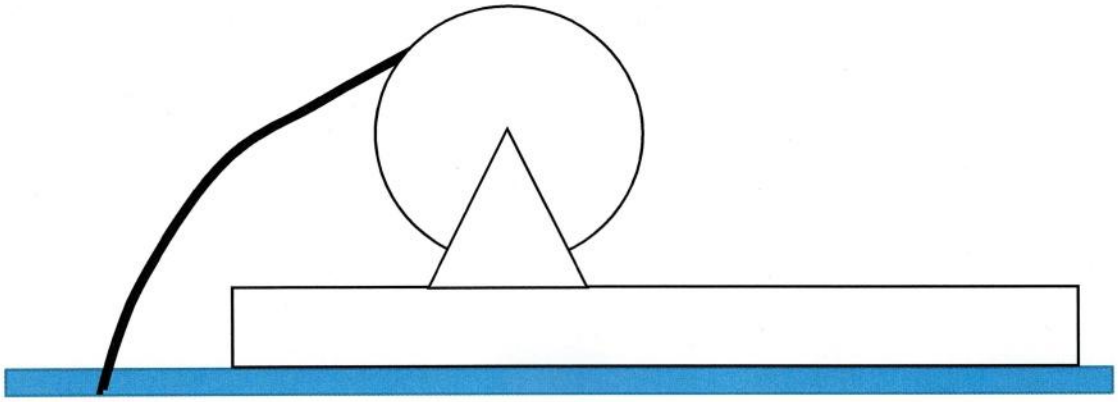
4.1 Main Rules

- A deep study must be carried out before selection of the river crossing location. Flow speed of water during all seasons, checking if there is big metallic parts (cars as example) of big stones inside the river that can damage the cable at installation or during its lifespan (divers will be employed for checking), etc.
- The under river cable must see its energising side protected by a circuit breaker (recloser without reclosing cycle) or at least by a sectionalizer. This equipment shall be installed on the pole before the pole where the under river cable is connected to the OHL in order to facilitate dead work or cable checking.
- Both ends of the cable must be easily disconnected in case of problem.
- The best solution in order to ease any cable checking is to install RMU cabinet on both side of the cable. Nevertheless this solution is not feasible in floodable area that is often the case near a river. So, under river cables can be connected on poles using outdoor terminations on top of poles.
- On the river bank and about 3 meters under water (low water lever), the cable must be buried. In that places the cable must be protected from river bank erosion.
- No traction shall be exerted on under river cable during installation.
- All protections shall be taken in order to avoid penetration of water inside the cable.
- All cable data as radius of curvature, etc. shall be asked to the cable manufacturer and strictly respected during installation.

4.2 Cable unwinding

Before installing the cable, it is necessary to check if there is big metallic parts (cars as example) of big stones inside the river that can damage the cable at installation or during its lifespan. For doing this, divers will be employed for checking.

The cable drum unwinding system shall be mandatorily installed on a boat (as a ferry) or a floating river barge able to support all involved weigh and forces applied during cable installation.



The cable shall be unwinding from the boat or barge starting from one river bank where this cable is installed firstly inside the already prepared trench taking care of the necessary cable length for installation and connection. This part of cable must be installed by hand with the help of cable rollers.

The cable is then unwind in the same time, the boat progress slowly.

No traction shall be applied on the cable during unwinding so the drum is mandatorily rotated and the cable guided by hand. Cable rollers will be used if necessary.

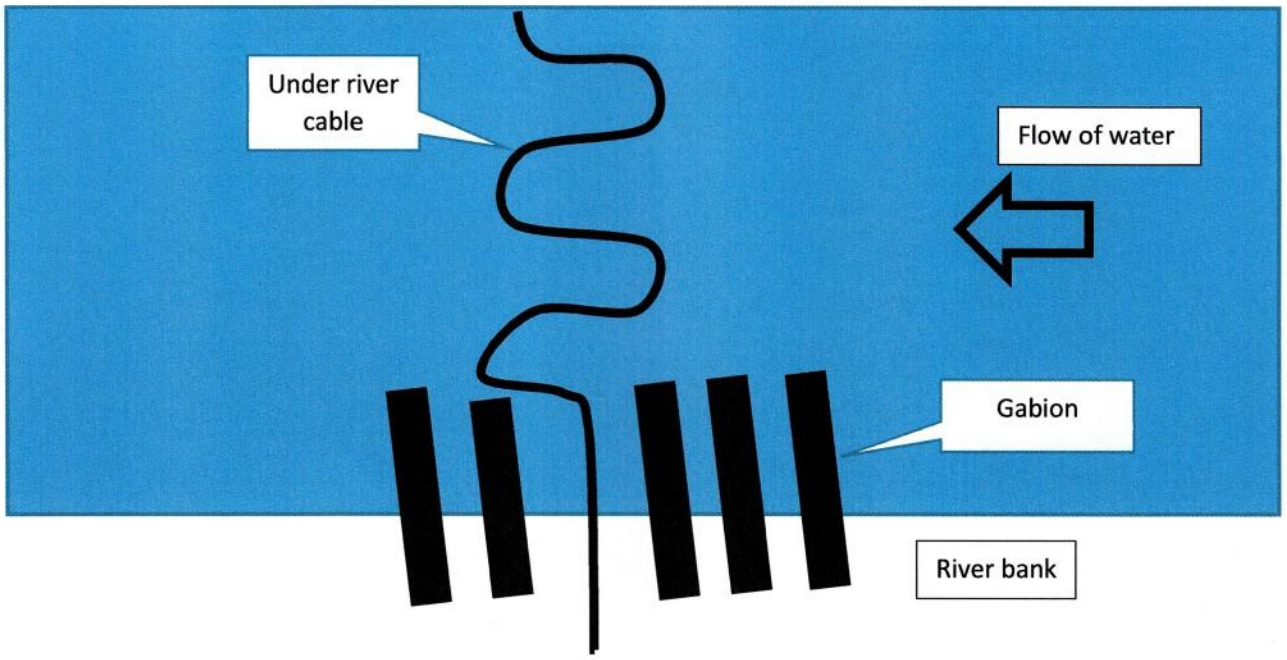
The cable in mandatorily installed by making S all along the river crossing.

Divers must check the cable installation inside the bottom of the river. The cable must be installed flat on the soil ALL along the river crossing. Any loop on the soil or in the water are not tolerated.

4.3 River bank erosion's protection

It is absolutely necessary to protect the river bank against erosion due to high level and high speed water in order to protect the cable.

The best solution consists in installing gabion wall (wall of stones inside galvanized steel net) that decrease the water speed on the both sides of the cable as follow:



The use of concrete wall is not recommended because it do not allow water to pass through as gabion can do. So water speed could push too much on concrete wall that will fall down.

5 Public Distribution MV/LV Substations

This chapter deals with the construction and electrical equipment of public MV / LV substations connected to underground MV networks. We will find successively described the general characteristics of the various types of constraints to study related to the environment and the exploitation, the criteria that preside over their choice.

Pole mounted substations and simplified base stations are excluded because designed to be connected either to overhead structures or to overhead branches or grapes of MV networks.

5.1 General

The MV / LV substation is planned in size and layout to allow installation and the operation of the devices which have been previously defined as a function of the loads to be supplied in the future, their situation with regard to the structure of the MV network and the need or not to provide the remote control of the operating units.

Moreover, their location is determined in such a way as to ease their access and the rapidity of the interventions.

MV / LV substations are technical rooms "reserved for electricians". Civil engineering must take into account the fire protection constraints and, as the case may be, the regulations on high-rise buildings or premises for which the public has access.

Apart from the base stations, they consist of:

- an MV Switchboard;

- regulatory posters
- fault detectors;
- one or more transformers;
- one or more LV distribution board;
- the equipment required for interior lighting and a low-voltage socket outlet without ground pin,
- public lighting equipment in the majority of cases;
- and generally:
- the specific hardware required for remote control, automation and remote signalling;
- a remote reading hub in case of smart meters.

The substation must allow the installation of a transformer with a power of 1 000 kVA, if not possible it is recommended to solve on case by case basis.

In some cases, it is possible to install several transformers with a maximum unit power of 1,000 kVA, each transformer is protected by a fuse switch which is part of the MV RMU.

The MV / LV substations can be:

- prefabricated;
- masonry
- inside building
- one pillar type

They must be approved by EDC and Cambodian authorities.

5.1.1 Prefabricated Substation with Indoor Operated

This station, of reduced dimensions, allows:

- quick and installation;
- to have products guaranteeing a high level of performance;
- ensure the quality control of manufacturing;
- standardization;
- an aesthetic of industrial quality.

Several types of substations exist according to the size and equipment needs (from 6 m^2 to 12m^2)

The maximum height above ground of these substations is about 2.60 m, except for specific installations (roofing or exterior cladding).

5.1.2 Kiosk Substations

This substation is prefabricated, semi-buried or above ground level design, its main characteristics are

- floor area of about 6 m2;
- maximum height 2.5 m above ground level;
- operations from outside the station;
- Industrial quality aesthetics.

The operation carried out from outside make it sometime difficult to exploit in bad weather conditions especially in sites with heavy rain or subjected to strong winds.

5.1.3 Masonry in elevation or inside building substations

These types of substations are carried out to meet specific constraints in terms of:

- installation of equipment (number and size of the "switch" or "circuit breaker", ...);
- Integration into the environment (form of available land, particular architecture, integration with other buildings, sound insulation, etc.); which cannot be met by the use of a prefabricated substation.

5.1.3.1 Masonry in elevation

It is a building type substation. Tailor-made civil engineering can solve any problems related to non-standard equipment configurations, multiple transformers, connection of more than two MV cables, large number of LV cables, integration in the site, etc.

5.1.3.2 Inside building

The installation of a substation in a specific room of a building with the same equipment criteria as for the masonry substation allows for better integration in the site but must be planned as soon as the building is designed (access, insulation acoustic, etc.).

5.1.4 Provisional Backup Supply Possibility

The target of reducing power cuts during work or incidents leads to constructive arrangements being made on the majority of the substations so that LV backup supply by a generator is possible.

For this purpose, an outlet with "cable glands" of sufficient diameter (about 120 mm) must be provided during construction or manufacture to allow the passage of a LV multipolar cable of 240 mm² and its possible connection. This passage is provided on the main facade so that a temporary LV connection can be made or the station can be supplied by generator. Envelope protection levels must be maintained when the cable is in place.

This arrangement is to be implemented on prefabricated units, substations in traditional masonry or in buildings.

5.2 Studies

The study of the design and construction of a MV / LV substation must take into account the specific constraints related to its environment, its mode of operation and specific climatic conditions.

The land on which the substation will be constructed will be the subject of a purchase or a supply agreement or a lease. The area of the land will take into account the foreseeable future developments.

Account will be taken of the constraints related to the specifications of the concession throughout the study.

5.2.1 Location

The location of a substation is determined primarily by considerations of an electrical nature (reinforcement of the LV network, appearance of important new loads, etc.).

The nature of the structure also requires that its site meet certain conditions necessary for its operation.

The manufacturer of a prefabricated substation will be informed of the installation conditions (slope for example), it will specify the permissible constraints or technical provisions to ensure the durability of the structure.

The location must be chosen so that the Distributor's agents can access the substation without delay and at any time to carry out the operations necessary for the operation of the network.

As a rule, staff must have direct access from a public road, or possibly from a private road if it is permanently accessible.

5.2.1.1 Hardware access facilities

The access routes to the substation must be as direct as possible to allow the supply of transformers weighing up to 2 tons by truck.

To allow easy handling of the equipment, the door must always be left free.

5.2.1.2 Access to MV and LV network

The location of the substation must permit the installation of all existing and future underground cables required for its operation from the public thoroughfare.

The passage of cables in private land must be the subject of a special agreement by an agreement regulated by notarial deed or by an administrative act.

5.2.1.3 The location of the station must protect it from flooding and infiltration

If the only location is located in a flood zone, special provisions (elevation, watertight casing) will be used.

5.2.1.4 Soundproofing

A transformer station can be a source of noises sometimes disturbing to the neighbourhood.

In order to minimize the inconvenience to local residents and to avoid further onerous and uncertain operations in terms of their effectiveness, the noise level likely to be perceived in the near vicinity should be evaluated at the design stage.

The following limits must be respected:

- outdoor substations 35 dB (A) at night in front of the nearest dwellings (2 m from the facades);
- substations in buildings 30 dB (A) at night inside the main rooms (bedroom, living room).

5.2.1.5 Integration to the site

The public becomes very sensitive to the quality of the living environment and in particular to the appearance of buildings.

Precautions must be taken to visually inscribe the structures into the environment.

5.2.1.6 Other subjects

The location of the substation, even in a building, must allow for the realization of an effective natural ventilation, opening into the open air either directly or, if necessary, through ducts. A minimum distance of 20 cm between ventilation grilles and external walls or obstacles shall be allowed. In polluted or marine areas, avoid aeration of the winds in front of the prevailing winds.

In all case, the use of a compact MV RMU (extensible or not) will be preferred.

5.2.2 Interior Arrangements

When considering a MV / LV substation, the following general principles are taken into account:

- keep the transformer away from the access door to ensure the safety of personnel to facilitate access to the appliances to be operated or in case of fire;
- preferably place the MV and LV boards perpendicular to the access face (which is most often that of the cable entry) and as close as possible to the latter in order to reduce the length of the gutters and MV and LV cables within the premises.
- find the position of the transformer so that its positioning does not lead to a rotation of the apparatus on itself; in positions with an oil pit, this rotation would be possible only by unnecessarily increasing the surface of the room;
- ensure, where available, that the corridor or operating area enabling personnel to access the various equipment has a minimum width of 80 cm in taking into account the maximum clearance of the operating handles;
- provide space for the installation of various measuring, control, remote control and other equipment;
- in case of damage or increase of power, it must be possible to extract the transformer easily;
- a space of 10 cm between the walls of the station and the transformer is provided to facilitate the circulation of air along the cooling fins, in no case may it be less than 5 cm;
- have a location such that it accepts, in view of the above recommendation, a 1 000 kVA transformer;
- install the transformer LV terminals, which are not insulated, on the wall side of the substation for safety reasons;
- make the nameplate of the transformer visible, once it is in place;
- place the LVDB as close as possible to the transformer to achieve the shortest possible LV connection;
- make it easy to control the LV switch;
- realize the earthing circuits of the masses in accordance with EDC-TP-EDC-TP-002- EARTHING for MV and LV distribution networks;
- ensure the coordination of LV fuses of the LVDB and the RMU MV fuses;
- ensure proper heat dissipation and avoid condensation (correct position and size of the ventilations, possible heating of the MV cells while respecting the 10 kV - 50 Hz and 20 kV insulation between LV circuit);
- to install an equipotential belt, in the case of prefabricated or kiosk substations with a metal envelope in order to avoid, in the event of an incident, high potential increases between the envelope and the ground around the substation. This belt should be placed approximately 50 cm from the envelope and at a depth of 20 cm, it should be made of bare copper with a minimum cross-section of 35 mm² and connected to the earth circuit of the masses (refer to EDC-TP-EDC-TP-002- EARTHING for MV and LV distribution networks)

5.3 Construction and Installation

5.3.1 Prefabricated Station Indoor Operation

Prefabricated substations with indoor operation of 6 m2 to 10m² are described below

5.3.1.1 Implementation

The implementation, does not require extensive civil engineering preparatory work.

The installation can take place in less than half a day (excavation ready, connections excluded).

The interventions on site are limited:

- the preparatory work:
  - carrying out earthworks or excavations, ensuring the stability of the soil;
  - Installation at the bottom of the excavation of a bare copper conductor of 35 mm2 minimum cross-section, forming a loop;
  - realization of a levelled form in compacted sand or lean concrete;
  - if the enclosure of the substation is metallic, connected to the ground conductor laid at the bottom of the excavation, an equipotential belt consisting of a 35 mm^2bare copper cable laid 50 cm from the envelope at a depth of about 20 to 30 cm under a pavement described below (refer to EDC-TP-EDC-TP-002- EARTHING for MV and LV distribution networks).
- the establishment of the prefabricated substation;
- Connections to external electrical lines.
- finishing work:
  - making a sidewalk of cleanliness around the envelope of the station, at least in front of its main facade;
  - Development of approaches and access;

Implementation must respect the integrity of the envelope and the equipment to maintain compliance with the required degree of protection.

Note: The transport, delivery and unloading operations are under responsibility of the EDC or the contractor. In the case of subsequent movements, it shall be necessary to call upon the latter and to entrust him with the responsibility for this operation.

5.3.1.2 Masses and dimensions

Its masses and dimensions make this type of post a unit transportable by road generally without recourse to an exceptional convoy. Suitable devices are provided for handling the station by crane.

The dimensions of the envelope are:

- Roof height relative to ground level ≤ 260 cm;
- depth of the buried part of the workstation ≤ 70 cm.

5.3.1.3 Characteristics of the envelope

The envelope comprises an elevation portion and a buried portion (tank), the whole constituting a single transport unit.

Both parts can be manufactured using different materials. These must be incombustible and protected from water penetration. The envelope may thus be made either of traditional or composite concretes or of metal provided that it fulfils the following conditions:

- The shape, dimensions and colour of the envelope ensure a good integration into the environment.
- the exterior facades have reliefs (bosses or plaster for example), in order to avoid the posting of posters,
- the interior floor must be at least 10 cm above the level of the exterior floor, if it is concreted, and have a slight slope of at least 1 cm / m towards the access door;

- the free ceiling height is at least 210 cm;
- the envelopes must resist, by nature or by protection, the attacks of atmospheric elements and the aggressiveness of the soil;
- obtaining a decennial guarantee;
- the cooling must be carried out satisfactorily.

The upper and lower ventilations are generally located on opposite walls of the room and the difference in level between them is as large as possible.

The upper part of the envelope, or roof, is calculated for an overload of 250 daN / m2, has a perfect seal and a slope allowing the drainage of rainwater. The materials used for the floors must be incombustible (M0 or M1), rot-resistant, water-repellent, capable of withstanding a load of 250 daN / m^2 under the transformer.

The doors open to the outside in such a way as to avoid any obstacle or grip, and they are provided with a stop device which keeps them against the wall of the station in the open position. They are equipped with a lock of the model used by the Distributor and hastily that can receive a lock with a handle 10 mm in diameter. The gates contain the standard posters. Closed doors have a sufficient

prevent water penetration and allow for the installation of a compressible joint in the event sound insulation is required.

The vessel has drainage ports to prevent corrosion of the casing; as a result, it is prohibited to use non-biodegradable liquid dielectrics for the transformer.

5.3.1.4 Electrical equipment

In all cases, the electrical equipment must be fixed in such a way that it can withstand without harm the vibrations of external origins originating from the transport or the environment on the site; it must also exhibit a good resistance to the efforts required by the operators

5.3.1.4.1 6 m^2 prefabricated substation

This station is fed with a 3 functions RMU.

Each type of substation is approved with a particular type of MV board because the volume and layout of this switchboard are of great importance for the cooling of the transformer, the operating maneuvers and the behaviour of the equipment in case of internal fault .

They must be able to house:

- two "switch-arrivals" (S) and one "protection-transformer" (P) by switch and fuses, consisting of a so-called "compact" unit 2S + P;
- a transformer with a maximum power of 1,000 kVA;
- LV switchgear comprising a switchboard with 8 monoblock feeders (or 4 feeders for transformers up to 400 kVA);
- a lighting circuit with low-voltage plug;
- a grounding circuit;
- Optionally one or more fault detectors.

5.3.1.4.2 8 m^2 prefabricated substation

This station is fed with an RMU.

As for the 6 m² substation and for the same reasons, each type of post is approved with a particular type of MV switchboard.

The equipment differs from that of 6m² by:

- the possibility of installing several "switch-arrivals" (I) and a "transformer protection" (P) by switch and fuses, constituted by a unit called "modular" , 3I + P, 2I + 2P ...); the possible presence of the remote control or of the automatism associated with one or more operating members;

5.3.1.4.3 10 m² prefabricated substation

This station is fed with an RMU. As for the 6 and 8 m² prefabricated substation and for the same reasons, each type of substation is approved with a particular type of RMU.

The equipment differs from that of the 8 m² by the possibility of installing in the MV RMU a Circuit Breaker (D.R.R.).

5.3.2 Small prefabricated substation

Reduced-congestion public MV / LV substations for underground networks is mainly the Compact Urban Post (PTT) and the One pillar substation (OPS).

They are designed for transformer powers which can be changed for PTT up to 1,000 kVA and 630 kVA for OPS.

5.3.2.1 Implementation

5.3.2.1.1 PTT (about 6m² and more)

The installation must not require extensive preparatory work only basement with trench made of masonry and bricks. It also involves the **imperative construction of an operating pavement in front of**

Considering the envelope is metallic, in addition to the earthing circuit, it is necessary to install an equipotential belt, in order to avoid, in the event of an incident, high potential increases between the envelope and the ground around the substation. This belt should be placed approximately 50 cm from the envelope and at a depth of 20 cm, it should be made of bare copper with a minimum cross-section of 35 mm² and connected to the earth circuit of the masses. (Refer to EDC-TP-EDC-TP-002- EARTHING for MV and LV distribution networks)

5.3.2.1.2 OPS

The station can be entirely prefabricated and consists of one large pillar that is necessary to fix on a concrete foundation.

The transformer is fixed on the top of this pillar and the LVDB installed inside the metallic pillar.

The foundation of concrete shall be large and deep enough for supporting prefabricated elements assembled on site.

As for the other metallic envelops, in addition to the earthing circuit, it is necessary to install an equipotential belt around the OPS, in order to avoid, in the event of an incident, high potential increases between the envelope and the ground around the substation. This belt should be placed approximately 50 cm from the envelope and at a depth of 20 cm, it should be made of bare copper with a minimum cross-section of 35 mm² and connected to the earth circuit of the masses. (Refer to EDC-TP-EDC-TP-002- EARTHING for MV and LV distribution networks)

The OPS support one transformer and house the 4 LV feeders LVDB.

5.3.2.2 Operating conditions

5.3.2.2.1 PTT

Current operations:

- Operation on the MV RMU;
- Operation on the LVDB;
- disconnection of 24 kV separable connectors;
- change of voltage tap on the transformer;
- change of MV or LV fuses;
- laying of the paving stone (etc.), must be easy to carry out.

Access must be obtained without the use of special tools.

In the LV compartment, sufficient clearance shall be provided for measurements at the ammeter clamp on the LV feeders and on the incoming cables from the transformer.

An operating pavement of at least 70 cm wide is provided in front of the MV RMU and the LVDB in order to carry out the normal operations from outside the station in safe conditions.

This sidewalk is designed in such a way that it allows rainwater to flow out of the station. It is recommended to extend it all around the station by a clean pavement, in order to avoid the subsequent closure of the air intakes located in the lower part of the envelope.

5.3.2.2.2 OPS

This type of station is designed to be maintenance-free.

The position must be designed in such a way that the current operations: disconnection of the separable connectors, change of plug on the transformer are carried out from outdoor. All operation of the LVDB as well as measurements on the LV monoblocks can be carried out immediately after opening the doors of the pillar.

5.3.2.3 Electrical Equipment

5.3.2.3.1 PTT

This station is fed with a compact RMU.

Each type of PTT is approved with a particular type of MV RMU board because the layout of this RMU is of great importance for the cooling of the transformer, the routine operation and the behaviour of the equipment in case of internal fault.

They must be able to house:

- two "switch-arrivals" (S) and one "protection-transformer" (P) by switch and fuses, consisting of a so-called "compact" unit 2S + P that can be extended to 4 functions;
- a transformer with a maximum power of 1,000 kVA;
- LV switchgear comprising a switchboard with 8 monoblock feeders (or 4 feeders for transformers up to 400 kVA);
- a lighting circuit with low-voltage plug;
- a grounding circuit;
- One remote control terminal box

- one or more fault detectors.

Note: Given the environmental and dimensional constraints, the use of compact MV RMU is imperative as per requirement of EDC-DTS-MV003: 22 kV Ring Main Units.

5.3.2.3.2 OPS

This type of substation can support 100 to 630 kVA transformers.

It is powered by simple line from a RMU located inside a RMU cabinet located not too far, using an underground connection made of synthetic insulated cable.

The assembly is integrated in a metal envelope which support a 100 to 630 kVA transformer, connected by a set of separable connectors. The protecting fuses are located in the RMU.

This pillar house a 4 feeder LVDB

5.3.3 Substation in or against building

5.3.3.1 Location selection

The choice of location is made according to the criteria described in chapter 5.2.1.

5.3.3.2 Civil Engineering

5.3.3.2.1 Masonry bunker elevation

The elevated station, isolated or fastened to another building, is the most satisfactory solution for the operation of the structure; it must preferably be located at the side of a road.

Two type of masonry substation can be found:

- Isolated
- Against or in a building

5.3.3.2.2 Position of in Buildings substation

The national constructive provisions must be strictly respected.

The civil engineering of this post must take into account the fire protection constraints required by the national and/or EDC provisions.

In case the substation is located against or inside a building (offices, flats, etc..) the following provisions must be respected:

- The transformer must be of dry type
- The walls and internal building doors (if any) must withstand more than 2 hours fire inside the substation.
- Automatic switch-off by fire detection.
- Automatic flame arrester

In building substations pose problems of access to personnel and equipment, sometimes of ventilation of the room and always present a risk of acoustic nuisance for the occupants. It is recommended to try to obtain premises in the following preferential order:

- ground floor room, with direct access;
- local basement accessible by external courtyard.

5.3.3.3 Electrical Equipment

Electrical appliances and accessories must comply with current and approved standards.

The construction of the electrical equipment of the masonry stations requires certain rules to be followed

• Accessibility of equipment

The arrangement of the apparatus shall allow:

- the connection of the MV and LV cables respecting the radius of curvature of the cables (10 times the outside diameter of the cable);
- locking and laying of earthing and short-circuiting devices on the LV parts;
- cable testing on the MV and LV side;
- disconnection of MV separable connectors;
- the change of the MV fuses;
- Adjustment of the transformer MV voltage.

The layout of the equipment must also allow the installation of access passages for the day-to-day operations. These passages have a minimum width of 80 cm, taking into account the maximum clearance of the operating handles; these provisions apply only to the LV and MV switchboards.

• Wiring diagram

These substations are generally equipped with:

- a number of "arrival-switch" (S) and a "fuse-switch" (P) protective transformer, constituted either of a non-evolutive unit called "compact" or "modular" (2S + P, 3S + P , 4S + P, 2S + 2P ....);
- one or more transformers of a power to be chosen from the standardized range;
- LV switchgear comprising one or more 8-trip boards (or one 4-trip boards up to 400 kVA);
- a lighting circuit and low voltage connector;
- a protection and earthing circuit;
- one or more fault detectors;
- a remote control unit or an automation associated with the operating devices;
- a set of regulatory posters.

The room must be able to receive a 1800 A LVDB for each transformer installed

Depending on the foreseeable evolution of the installed power, a 800 A or 1200 A LVDB may be installed in the first stage.

5.3.3.3.1 MV Cables

The connection to the MV network will be made by single-pole cables with synthetic insulation of section 95, 150 or 240 mm2, homogeneous with cables of the existing or future network.

Connection of the cables to the network cells will be carried out by 630 A 24kV separable connectors of C interface

5.3.3.3.2 MV connection between the protection cell and the transformer

The connection is made of single-pole cables with synthetic insulation of section 70 mm2 of aluminum.

In the case of powering a satellite station, the connection may be made in single-pole cables with a cross-section of 95 mm2 or 70 mm2, but must include, in addition to the phase conductors, an earth conductor which will ensure the interconnection of the substation and the satellite station.

When replacing the transformer, the connection can be maintained above ground by a suitable device.

5.3.3.3.3 MV connection to the transformer

It is made using 24 kV separable connectors of the 250 A model (interface A).

In the event that the **dry** transformer room is separated from the MV equipment, the transformer part must have grounding and short-circuiting pads, in all other cases, these pads must be avoided.

5.3.3.3.4 MV / LV Transformer

The transformer is of **dry** type, equipped with MV bushings for 24 kV separable connectors and LV outputs per barrier from 250 kVA.

It must comply with national and/or EDC standards.

The power of the transformer will be chosen in the standard EDC range.

5.3.3.3.5 LV links

The transformer must be connected to the LVDB in unipolar aluminum core cables insulated with cross-linked polyethylene.

The links to be used are as follows:

Connection in 240 mm2 of cross-section:

- 2 cables per phase for a transformer up to 400 kVA;
- 3 cables per phase for a transformer of 630 kVA
- 4 cables per phase for a 1,000 kVA transformer.

Connection in 630 mm2 cross-section:

- 1 cable per phase for a 630 kVA transformer;
- 2 cables per phase for a 1,000 kVA transformer.

The number of cables for the neutral conductor can be reduced by half.

The cables will be connected on the transformer side on the one hand and the LV board on the other side by means of copper-aluminum lugs.

The connection from the transformer to the LV panel shall be provided in order to support the installation of the different transformer types envisaged in the future. It must also absorb the vibrations of the transformer, for this reason the cables must not be placed together.

This connection must not cause mechanical stress on the LV switchgear.

5.3.3.3.6 LV equipment

The LV switchgear is made up of reduced panel elements and comprises, according to the power to be served:

•A 800 A LVDB with 4 feeder monoblocks for a transformer up to 400 kVA

• A 1200 A LVDB with 8 feeder monoblocks for transformers up to 630 kVA;

• A TR 1 800 A LVDB with 8 feeder monoblocks for transformers up to 1 000 kVA;

In all cases in the final stage, the space must be reserved for a 1 800 A LVDB.

Depending on the layout of the equipment in the station additional screens may be necessary to ensure the safety of the personnel (at the back of the panel for example): they must be made of insulating materials.

5.3.3.3.7 LV Feeders

The LV outgoing cables will be connected to the monoblock by copper aluminum lugs;

it is not necessary to provide another fixing of the LV cables on the frame of the LVDB. The conductors must be expanded in order to make measurements with an ampmeter clamp in good conditions.

The connection to the LV network shall be made of multi-core cables with a cross section of less than or equal to 240 mm2 with synthetic insulation conforming to the EDC-DTS-LV006-LV Underground Cable and Connecting Accessories standard.

Note: The first monobloc feeder installation on the LV panel must be carried out from right to left. Indeed, this operation is generally carried out with no voltage and the risks are thus limited during the subsequent installation of new LV sends under voltage.

5.3.3.3.8 Other LV electrical installations

The isolation voltage of the substation's low voltage equipment with respect to ground must be at least 10 kV at the industrial frequency for one minute and 20 kV in standardized lightning strike (1.2 / 50 µs); The LVDB corresponds by specification to this requirement; precautions (insulating supports, distances) must be taken during assembly so that the prescribed resistance is respected for the entire installation consisting of the equipment, the connections and the pipes.

The lighting of the station is controlled by a preferably end-of-travel switch actuated by the opening of the door of the station; this illumination includes an electrical protection located in the LVDB. Its connection upstream of the LV main switch is made by means of insulated copper cables of 2 x 2.5 mm^2 cross-section.

A power outlet (2P) without a 16 A-230 V grounding pin can be inserted into the substation and powered from the lighting circuit.

The stations connected to an arterial network must be capable of being equipped with a device for detecting and signalling MV defects, visible from the outside and from an approved model.

5.3.3.4 Grounding

Please refer to EDC-TP-EDC-TP-002- EARTHING for MV and LV distribution networks for more information.

5.3.3.4.1 Ground earth circuit

The earth circuit consists of a bare copper conductor with a minimum cross section of 35 mm2.

The masses of the devices are individually connected to the main earth conductor via copper conductors of 35 mm2 minimum cross-section.

There is no sectioning bar in the earth ground circuit.

At the earthing point, the circuit has a copper terminal of 12 mm diameter and 40 mm long to allow the measurement of earth resistance and the connection of a removable device ground and short-circuited.

5.3.3.4.2 Elements to be connected to earth ground circuit

- screens of MV cables;
- possibly, the earth conductor of the MV cables if any;
- the MV RMU from one of the terminals provided for this purpose;
- the transformer tank;
- the frame of the LVDB;
- metal cable trays;
- the framework of the raft;
- Possibly earth terminals of measuring transformers, capacitors, etc.

Note: - an equipotential belt is required for metal prefabricated substation, OPS and PTT; this implies that the metallic access doors and the ventilation grilles are systematically connected to the earth ground circuit.

5.3.3.4.3 LV Neutral Grounding

It is necessary to refer to EDC-TP-EDC-TP-002- EARTHING for MV and LV distribution networks for substation and neutral earthing connection first.

Generaly, as summary of EDC-TP-EDC-TP-002- EARTHING for MV and LV distribution networks if the mass earthing of the substation is:

* at most equal to 1 ohm: the neutral is connected to the earth circuit of the substation masses. The earthing of the neutral will be in this case on the neutral link of the LVDB neutral bar which is located downstream of the LVDB;

* greater than 1 ohm: the earthing of the neutral is separated electrically from that of the substation masses; it is carried out on each LV feeder outside the substation and at a distance dependent on the resistivity of the ground and at least 8 m from the grounding of the masses.

The earthing board defined by EDC-TP-EDC-TP-002- EARTHING for MV and LV distribution networks shall be used for this purpose.

5.3.3.4.4 Earthing of the masses

- Prefabricated substation, base, masonry in elevation or in earth: at the bottom of excavation and before any possible work of concreting, put a conductor in bare copper of minimum section 35 mm2;

- Post in building: the ground circuit of the substation is connected to the loop at the bottom of the building by a copper cable with a minimum section of 35 mm2.

Note: Copper must not be in direct contact with the concrete, protection will be ensured for example:

- by a heat-shrinkable sleeve when the copper conductor passes through the concrete slab,
- by a layer of materials (earth, sand) when the copper conductor is located under the concrete slab.

5.3.3.4.5 Protective and earthing circuits for substation / MV voltage substation

Refer to EDC-TP-EDC-TP-002- EARTHING for MV and LV distribution networks and its annex.

The point of measurement of the earth:

- is placed as close as possible to the LVDB while remaining easily accessible;
- has a dielectric strength of 10 kV - 50 Hz - 1 min - and 20 kV shock;
- has a plain terminal of copper or brass with a diameter of 12 mm and a length of 40 mm;
- allow the connection with 30 mm2 copper with the earth connection device.

5.4 Criteria for choosing the location of a substation

For reasons of safety and ease of operation, in particular in the event of a breakdown, priority is given, where possible, to a type of workstation allowing the operations to be protected from the elements.

The creation of a new MV / LV substation for public distribution results from:

- the arrival of a significant new load due to the creation of a business area, a subdivision or a particular customer (surface growth);
- or of the normal evolution of the existing loads causing a constraint on the network whose solving can only be brought by the implantation of a new transformation point (depth increase).

The choice of the type of post and its method of connection is subject to the study of a certain number of criteria; however, certain configurations remain imposed by circumstances.

5.4.1 Scalability of the load

The load level of the new customer (s) to be connected and / or the existing load threshold to be reset determines the power of the transformer to be provided.
This one element already makes it possible to situate the type of position to be considered:
- PTT (1),
- 6, 8 or 10m² prefabricated or built station (2).

(1) The PTT solution is to be retained only if the other criteria allow it (network structure, respect of the maximum number of tangent boxes admissible, possibility of replenishment). It generally corresponds to a zone of low density and not evolutionary.
(2) In dense areas, solutions in buildings may prove to be indispensable. Masonry is considered to be exceptional because of their relative complexity.

5.4.2 Scalability of the area to be served

In addition, an average annual rate of change in loads will be taken into account in the area concerned in order to ensure that the solution is sustained for a sufficient period (to be determined by a technical and economic calculation) as well as any planned development programs, in particular for areas of activity and subdivisions.
Knowledge of the master plans of the MV networks is an indispensable help in this respect.
This information may lead to the provision, for example, of civil engineering meeting the final need, which will be equipped in the first instance in a simplified manner (provision for a subsequent passage in an artery cut, for example)

5.4.3 Customer sensitivity to power outages

The level of sensitivity of customers to cuts determines the positioning and the connection method of the substation on the network (bypass, framing section) as well as the type of station and the emergence materials to be associated with it.

5.4.4 Nature of the proximity network

The geographical location of the future substation in relation to the existing MV network, on which the connection is envisaged, also determines the positioning and the connection mode on the network (bypass, RMU) and, consequently, the type of connection.
If the work is located in a dense area where the existing substations are connected in an arterial cut, this method of connection will be preferred in order to maintain overall consistency of the operation and the level of recharge quality.
If you are in a less dense area where the "power" criterion does not require a major civil engineering, the connection in arterial cut-off is not necessary (unless specific constraint of quality caused by too long distance between two points of cut of the artery for example). A branch connection will then be chosen, providing, depending on the quality criteria and the structural scheme, the associated installation on the framework of a manual or remotely controlled shut-off device making it possible to respect the re-supply constraints of customers of the entire feeder concerned.

5.4.5 Need for remote control or automation equipment

The structure of the network and the optimization of the operation, in order to achieve the quality thresholds desired by the customers, lead to the installation of a number of remote-controlled cut-off devices, in particular in sectioning of the feeder backbone.
This necessity can lead to (in addition to the specific equipment without transformation function arranged elsewhere on the frame) the opportunity of a civil engineering post to install a remote controlled shut-off device or a circuit breaker.
This requires the use of civil engineering enabling the installation of the corresponding equipment (MV equipment and control).