THE SOCIALIST REPUBLIC OF VIETNAM

MINISTRY OF INDUSTRY

TECHNICAL REGULATIONS
FOR RURAL ELECTRIFICATION/ELECTRIC NETWORK

QDKT.DNT - 2006

2006

MINISTRY OF INDUSTRY	**SOCIALIST REPUBLIC OF VIETNAM**
No.: 44/2006/QD-BCN	**Independence – Freedom – Happiness**

Hanoi, 8 December 2006

DECISION ON

Issuance of Technical Regulations on Rural Electrification/ Electric Networks

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THE MINISTER OF THE MINISTRY OF INDUSTRY

Based on the Decree No. 55/2003/ND-CP dated 28 May 2004 of the Government of Vietnam on the Functions, Tasks, Authorities, and Organisational Structure of the Ministry of Industry;

Based on the Electricity Law dated 3 December 2004;

Based on the Decree No. 105/2005/ND-CP dated 17 August 2005 of the Government of Vietnam on the Detailed Regulations and Guidelines for Implementation of some provisions of the Electricity Law;

According to the Proposal by the Director of the Department of Science and Technology,

DECIDES:

Clause 1: to issue the enclosed Technical Regulations for Rural Electrification coded QDKT.DNT-2006.

Clause 2: This decision goes in to effect 15 days after its publication in the Vietnamese Official Gazette and shall replace the Decision No. 57/2000/QD-BCN dated 25 September 2000 of the Ministry of Industry on the Issuance of the Technical Regulations on Rural Electricity Networks for Rural Electrification Projects. This new Technical Regulations shall be applied for designing and installing rural electrification projects nationwide.

Clause 3: Ministries, Ministerial-level Agencies, Government's Agencies, Provincial People Committees, Cities directly under the Central Government and related organisations and individuals shall bare responsibility of implementation of this Decision.

To:

- As referred in Clause 3
- People's Supreme Court of Vietnam
- People's Supreme Procuracy of Vietnam
- Department of Documentation Verification, Ministry of Justice
- Vietnamese Official Gazette
- Government's Website
- Filling in Administrative, Legislation, and Science and Technology Departments.

MINISTER

(signed and sealed)

Hoang Trung Hai

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Foreword

Rural electrification in Vietnam has increased significantly over the last years. Up to 31 December 2005, 64 provinces and cities all over the country has been connected to the national grid. 525 of the total 536 districts (97.95% of the total districts) have been connected (still one mainland district that is Muong Te District, Lai Chau Province and other 10 island districts have not been connected to the national grid but are electrified by diesel or off-grid mini hydro power). 8,619 of the total of 9,024 communes (95.3% of the total communes) have access to electricity. There is 90.4% of the rural households are supplied by the national grid.

According to the Master Plan on the Electricity Development of Vietnam for the period 2006-2015 (Master Plan VI), there will be 93.6% of the rural households electrified by 2010 and 96.5% by 2015. The investment capital needed for achieving these goals is more than 17,400 billion VND in which more than 10,200 billion VND will be needed for the period of 2006-2010 and nearly 7,200 billion VND will be needed for the period of 2010-2015.

However, there are still some technical and economic problems for the current rural electric networks such as:

- There are still many different voltages in rural electric distribution networks: 6-10-15-22-35 kV.
- The existing rural electric networks have been designed and installed according to different standards, creating difficulties for operation, maintenance, repairing and expansion.
- Investment costs according to these standards are rather high.

Therefore, the issuance of new Technical Regulations on Rural Electrification (QDKT.DNT) for uniform application nationwide was in urgent need. This new Technical Regulation is aiming at the following:

- Rural distribution networks (medium and low voltages and off-grid systems) will be rehabilitated and developed to meet with safety and reliability standards, meanwhile ensuring environmental protection, cost effectiveness and easy implementation.
- Ensuring the development of the electricity of Vietnam in the transition period that is able to harmonise the current rural electricity infrastructure with the trend of electrical technology development on the world.

This new Technical Regulation on Rural Electrification (QDKT.DNT-2006) under the Vietnam – Sweden Rural Energy Programme/ Area 2 - Technical Standards for Rural Electrification/ Electric Networks (2005-2006) is an output of the cooperation between the Ministry of Industry and Swedish International Development Agency (SIDA). It is sponsored by the Government of Sweden.

This new Technical Regulation QDKT.DNT-2006 has been compiled and revised according to comments from different agencies during several consultation workshops and finally approved by the Ministry of Industry on 8 December 2006 from Decision No. 44/2006/QD-BCN.

On this occasion, we would like to express our sincere thanks to SIDA and the Government of Sweden for their support during the compilation of this new Technical Regulation. We would like to thank the Carl Bro - Entec Consulting Consortium for their active cooperation during preparation of this document. We would like to thank the relevant agencies such as Vietnam Electricity (EVN), PECC1, PECC2, PECC3, PECC4, PC1, PC2, PC3 and the Provincial Power Companies on their valuable comments o the new Technical Regulations QDKT.DNT-2006.

Last but not least, we would like to express our sincere thanks to the Reference Committee for the Technical Regulations on the Rural Electric Networks and its members for their great contribution to the compilation of the new Technical Regulations QDKT.DNT-2006.

Ministry of Industry

Department of Science and Technology

PART I

TECHNICAL REGULATIONS FOR RURAL ELECTRIFICATION/ ELECTRIC NETWORK

CHAPTER I

GENERAL REGULATIONS

1-1. Scope of Application and Definitions

1-1.1. Technical Regulations of rural electricity network, abbreviated as QDKT.DNT/2006, is applied for planning, design, new construction, rehabilitation, upgrading and commissioning of electric projects of a nominal voltage up to 35kV in rural areas.

1-1.2. Rural area is the territory, which does not belong to territory inside cities, provincial centres and towns.

1-1.3. Areas of dense population are towns; commune centres; industrial premises, agricultural manufactories; piers; ports; train and bus stations; parks; schools; stadiums; bazaars and other crowded areas in villages.

1-1.4. Areas of sparse population are areas with scattered houses where people and vehicles often pass; plains; orchards or areas with temporary houses and architectural projects.

1-1.5. Areas difficult to access are those, which are very difficult to enter by foot.

1-1.6. Electric equipment is the equipment for transmission, transformation, distribution and consumption of electricity. The outdoor equipment is equipment, which is installed outside of buildings or protected by covering roof only.

1-1.7. Electric material comprises things, which often get in contact with electric current under normal operating conditions, such as conductor, cable, insulator...

1-1.8. Construction structure comprises pole, crossarm, beam, floor, stay, pole- and stay-foundation, transformer substation premises, building, fence...

1-1.9. Intermediary Transformer Substation is a substation, where the nominal secondary voltage of which is > 1kV.

1-1.10. Distribution Transformer Substation is a substation, where the nominal secondary voltage is: 380V/220V or 220V.

1-1.11. Medium voltage (MV) line is an aerial line or cable, where the nominal voltage is 1kV - 35kV.

1-1.12. Low voltage (LV) line is an aerial line or cable, where the nominal voltage is ≤ 1kV.

1-1.13. Several General Instructions

In this document, there are utilized some of the concepts and definitions with the meanings interpreted as follow:

1) The concepts:

- Nominal voltage system is an appropriate value for determining or identifying an electric system.

- Rated voltage is a value usually stipulated by manufacturer for operation condition of element, equipment or instrument in the respective electric system.

- Equipment with the high earth current is equipment, where the nominal voltage is higher than 1kV and the phase-earth short-circuit current is more than 500A.

- Equipment with the low earth current is equipment, where the nominal voltage is higher 1kV and the phase-earth short-circuit current is less than 500A.

2) The definitions:

- Not less is the minimum.
- Not more is the maximum.
- From... to...is to include the beginning number and the end number.

1-2. Application of Standards and Norms

In design and construction of rural electricity network, it is necessary to comply with the provisions stipulated in this Technical Standard and the other related Standards, Norms, Decrees as follows:

- Electricity Law No 28/2004/QH11, valid from 01/7/2005.

- Government Decree No 105/2005/ND-CP dated 17/8/2005 on detailed regulation and guideline for executing some articles of the Electricity Law.

- Government Decree No 106/2005/ND-CP dated 17/8/2005 on detail regulation and guideline for executing some articles of the Electricity Law on safe protection for MV and HV power grid.

- Electric Equipment Norms from 11TCN-18-2006 to 11TCN-21-2006.

- Decision No 07/2006/QD-BCN of MOI, dated 11/4 /2006 on the Regulation for technical standards and conditions of electricity usage as direct protection means.

- Decision No 1867/NL/KHKT of Ministry of Energy, dated 12/9/1994 on Technical Standards for 22kV network.

- Standard on Loading and Impacting Capacity-Design standard TCVN 2737-1995.

- Government Decree No 186/2004/ND-CP dated 05/11/2004 on management and protection for road transportation infrastructure.

- Regulations, standards relating to the design, construction and commissioning of electricity projects.

- Documents of electric equipment and materials manufactured by domestic industry in accordance with the technical standards of Vietnam or corresponding International technical standards applied in Vietnam.

- All of relevant Standards and Regulations, not mentioned in this document must be performed in accordance with the related Laws, Decrees, Introductions, Regulations, Norms, etc.

1-3. Rural Electricity Demand Forecast

1-3.1. In planning, project identification and rural power network design it is necessary to survey, define and forecast power demand in the proposed area for a period of 5-10 year later.

1-3.2. Power demand in rural area (Peak demand - P and Energy - E) includes household, public services (school, medical station, shop), small industry, handicraft, forestry and agriculture consumption.

1) Power demand of small industry, handicraft and forestry sectors, shall be specified on the basis of existing consumption and expected development of these sectors in the region.

2) Power demand of agriculture sector is defined on the basis of the agricultural development plan on the planed types of plants (garden land area and land areas for grain crops and industrial plants to be watered), on domestic animal (aquaculture and cattle breeding) and on the kind of irrigation relief in the locality of the proposed establishment.

3) Power demand of residential load and public lighting is forecasted on the basis of registered power consumption, on survey of living standard, and the power consuming appliances of the people and on the annual economic growth.

1-3.3. If, the surveyed data are not sufficient, it is possible to use some average power demand norms given below for carrying out planning and design of rural distribution network projects.

1-3.3.1. Demand forecast for household consumption in rural areas up to the year of 2010 and 2015:

No	Area	Demand by year 2010		Demand by year 2015	
		Energy kWh/household / year	Peak demand W/household	Energy kWh/household /year	Peak demand W/household
1	Town, District and commune Centre	1200	850	1600	1000
2	Delta, Midland	700	500	1000	650
3	Mountain	400	350	600	450

1-3.3.2. Demand for irrigation

- The average peak demand for irrigation:

  Delta region 80 ÷ 100W/ha

  Midland region 120 ÷ 150W/ha

  Mountain region 200 ÷ 230W/ha

- Annual utilisation time for irrigation:

  Rice crops 1200h/year

  Fruit trees 1000h/year

  Industrial plants 1500h/year

1-3.3.3. Demand for drainage

- The average peak demand for drainage: 350 ÷ 400W/ha
- Annual utilisation for maximum drainage: 700h/year ÷ 800h/year

1-3.3.4. Peak demand (P_{max}) for an area:

$$P_{max} = K_{KV} (K_{GD}.P_{GD} + K_{CN,TCN} . P_{CN,\ TCN} + K_{NN}.P_{NN})$$

Where:

Pmax Peak demand for an area

PGD Total peak demand of household and public services loads

PCN, TCN Total peak demand of small industry and handicraft loads

PNN Total peak demand of agriculture loads

KKV Simultaneous factor for all of kinds of loads in an area

KGD Simultaneous factor for household and public services loads

KCN, TCN Simultaneous factor for small industry and handcraft loads

KNN Simultaneous factor for agriculture loads

In the case there is no reliable basis for simultaneous factor selection, the peak load (Pmax) can be calculated by the following approximate formula:

$$Pmax = Kdt\ (PGD + PCN,\ TCN + PNN) = Kdt.\sum P,$$

Where, Kdt is the simultaneous factor for all loads in the area, which can be calculated as follows:

$K_{dt} = 0.6$ if $P_{GD} \le 0.5 \sum P$

$K_{dt} = 07$ if $P_{GD} = 0.7 \sum P$

$K_{dt} = 0.9$ if $P_{GD} = \sum P$

In other cases K_{dt} can be interpolated.

1-4. Requirement for Voltage Quality

For rural electricity network, in normal operating condition, deviation of voltage is permitted in an interval of ±5% from nominal value ($U_{DĐ}$) at the customer meter connection point or another point agreed between the customer and the utility. For the networks, which are not yet stable, the voltage deviation is permitted from -10% to +5%.

In the case of requirement for improving the voltage quality on MV lines, static capacitors may be installed.

1-5. Configuration of Distribution Network

Based on the characteristics of the electricity loads, the requirement and importance of supply and the economic conditions for network investments in rural area, the following types of distribution network schemes can be applied:

- Radial circuit configuration with sectioning of the MV network.

In case of supplying an area with high load density and many important customers, it could be favourable to use the meshed network with open circuits to improve reliability of the power supply.

- Radial circuit configuration only for LV network.

1-6. Distribution Voltage Level

1-6.1. MV Level

MV networks in rural areas must be designed and constructed with the perspective to ultimately achieve the standard system voltages of 22kV and 35kV.

1) 22kV networks for areas, where 22kV network exists today and areas with other voltages, which will be transferred to 22 kV.

2) 35kV network for mountainous areas with low load density and long line lengths and far from 110kV substation.

3) 6-10-15kV networks should not be developed any more. Only the existing ones shall be maintained.

1-6.2. LV Level.

LV level shall be selected as 380/220V for 3 phase and 230V for single phase and two-phase networks at primary side.

1-7. Distribution Network Configuration

1-7.1. 22kV Networks

1-7.1.1. Networks of other voltages to be converted to 22kV

1) Existing networks with the voltages of 6-10-15kV will ultimately be converted to 22kV networks with three-phase, three or four-wire main lines and branches with three-phase or three single-phase transformers for supplying electricity to the load centres, which require three-phase voltage. The networks supplying single-phase customers will be constructed mainly as single-phase and with two-wire branches with single-phase transformers.

2) When the operating voltage is still 6, 10 or 15 kV, the network will be operated with the existing network neutral connection (isolated or solidly grounded). In the future, these networks should be converted to the standard for 22 kV.

1-7.1.2. New constructed 22kV network

1) New 22kV networks will be constructed in form of three-phase and three-wire or four-wire lines with three-phase transformers or three single-phase transformers for three-phase customers. For single-phase customers, the network will be constructed mainly as single phase and with two-wire branches with single-phase transformers.

2) It is also permitted to exceptionally construct two-phase lines and transformers for household customers provided the requirement to satisfy unsymmetrical voltage condition in normal operation (not more than 5%) is met.

1-7.2. 35kV networks

1-7.2.1. Existing 35 kV networks, which are not likely to be converted to 22kV

1) For main lines, the three-phase three-wire form will be preserved.

2) For branches supplying small substations, it is permitted to construct for two-phase supply with two-wire lines and two-phase transformers, with a condition that the unsymmetrical level of voltage must not exceed 5%.

1-7.2.2. Existing 35kV networks, which will be converted to 22kV

1) Main lines supplying large and important customers must be designed for 22kV with three-phase and three or four wires for operation in the future with solid grounding.

2) For 35kV branches and 35kV substations supplying customers in areas, where it is planned to develop a 22kV network, design and construction must pay attention to the following issues:

+ Power lines will be constructed with three-phase and four-wire system with solidly grounded neutral conductor.

+ Transformers must have two primary windings, 35 and 22kV, in order to facilitate transfer of the network from 35kV to 22kV later on.

1-7.2.3. Newly constructed 35kV networks

1) For areas, where there is a source-substation(110/35kV) with isolated neutral on the 35kV side, the network will be constructed in form of three-phase with three-wire and

three-phase transformers 35/0.4kV.

2) In case of requirement, it is permitted to construct with 35 kV two-phase branches and two-phase transformers for supplying household customers with a total demand suitable to transformers capacity up to 50kVA. When utilizing the two-phase network, it is necessary to satisfy the condition on the permissible unsymmetrical voltage level of the network in normal operation (not exceeding 5%).

3) For areas, where there is a source-substation (110/35kV) with grounded neutral on the 35kV side, the network supplying large and important customers must be constructed in form of three-phase with three-wire or four-wire. Networks for supplying single-phase customers will be mainly single-phase with two-wire lines and single-phase transformers.

1-7.3. Low voltage networks

- Low voltage networks are to be constructed in form of three-phase with four-wire lines and single-phase with two-wire or three-wire for main lines and single-phase with two-wire for branches supplying single phase customers.

- Supplying household customers should be implemented mainly by single phase with two-wire branches. The three-phase with four-wire branches should be implemented in cases of supply for three-phase customers and load concentrated areas only.

1-8. Temperature and Wind Pressure

1-8.1. In designing overhead lines it is necessary to calculate the working capability of conductors, insulators and other equipment under normal operation, in accidental cases, during assembly and during atmospheric over-voltage conditions, with the following parameters and load combinations:

1) Under normal operation:

+ Maximal air temperature (T_{max}); wind pressure (q = 0)

+ Minimal air temperature (T_{min}); wind pressure (q = 0)

+ Average air temperature ($T_{tb} = 25^0C$); wind pressure (q = 0)

+ Average air temperature ($T_{tb} = 25^0C$); maximal wind pressure (q_{max})

2) In accidental cases:

+ Average air temperature ($T_{tb} = 25^0C$) and maximum wind pressure (q_{max})

+ It is permitted to reduce wind pressure by one step (20daN/m^2), but no less than 40daN/m^2

3) During assembly:

+ Air temperature $T = 10^0C$ and wind pressure q = 6.2daN/m^2

4) Under atmospheric over-voltage conditions:

+ Air temperature $T = 20^0C$ and wind pressure $q = 0.1q_{max}$, but no less than 6.25daN/m^2

For the low voltage pole types it is necessary to calculate only mechanical load in normal operation of conductor in the case with minimum temperature (T_{min}) and maximum wind pressure (q_{max}). In design, it is allowed to calculate only, the following principle load cases:

5) Load capacity by wind pressure in horizontal direction, perpendicular to line direction and pole body, for supporting poles.

6) Load capacity by wind pressure in horizontal direction, perpendicular to line direction, pole body and load capacity along the conductor in horizontal direction, created by unequal stretching tensions of conductor within short pole spans, for stay poles.

7) Load capacity in horizontal direction by combined stretching tension of conductor (directed along the snake axis) and load capacity in horizontal direction by pressure of wind to conductor and pole body, for angle poles.

8) Load capacity in horizontal direction, effected along the line by stretching tension to one side of conductor and by wind pressure, for the terminal poles.

1-8.2. The values of atmosphere temperature and wind pressure are taken in accordance with the climatic condition of each region including the highest standard wind pressure with the frequency of once every ten year and following to the regulations in Standard of Vietnam TCVN 2737-1995. For networks with voltage up to 35kV, using poles with height less than 12m, it is permitted to reduce the standard wind pressure value with 15%. In the case, that there are no available wind data, the maximum wind speed V_{max}= 30 m/s, can be used for calculation.

1-8.3. The calculating load capacity on pole top must be not exceeding the values stipulated in Standards for concrete poles and steel towers.

1-9. Calculation of Wind Pressure

1-9.1. Pressure of wind on the line is the combined pressure of wind, affecting the conductor, earth wire, pole and other construction components, installed on the line and substation in accordance with regulations in Standard of Vietnam TCVN 2737-1995.

1-9.2. Wind pressure affecting the conductor, earth wire and pole must be calculated, when selecting the pole structure. For equipment and components of small size, installed on the line, the wind pressure can be ignored.

1-9.3. Wind pressure calculation

1-9.3.1. Wind pressure on conductors:

Wind pressure on conductors is defined at the height of the centre of gravity of all conductors.

- Converted height is defined by the formula: $h_{qd} = h_{TB} - \frac{2}{3} f$

Where,

h_{TB}: is the average height, at which the conductor is tied to the insulator (m)

f: is maximum sagging of conductors within the calculated span under maximum temperature condition (m).

- Wind standard pressure, affecting the conductors and earth wire, is calculated by the formula:

$$P_d = a. C_x .K_l. q. F. \sin^2\varphi$$

Where,

q: is the maximum calculating wind pressure

K_1: is the conversion factor, considering the impact of span length on wind pressure, which is defined as:

1.20 if span is up to 50m

1.10 if span is 100m

1.05 if span is 150m

1,00 if span is 250m and above

a: is the factor, taking into account, the unevenness of wind pressure to each section of wire (conductor) within a span, which is defined as:

1,00 if wind pressure (Wp) is 27daN/m^2

0,85 if Wp is 40daN/m^2

0,77 if Wp is 50daN/m^2

0,73 if Wp is 60daN/m^2

0,71 if Wp is 70daN/m^2

0,70 if Wp is 76daN/m^2

intermediate values, are calculated by linear interpolation

C_x: is an aerodynamic factor considering the impact of the contact surface of a conductor, which is defined as

1,1 if wire (conductor) diameter is 20 mm and above

1,2 if wire diameter is less than 20 mm

F: is the wind affected section of the wire

φ: is the angle being formed between the direction of the wind and the power line route.

1-9.3.2. Wind pressure, affecting the pole

- Wind pressure, affecting the pole is defined by the formula:

$$P_c = q.K.F.C_x$$

Where, the values q and K are the same as for calculation of wind pressure affecting the conductor

F: is the square component of the wind affecting the pole

C_x: is an aerodynamic factor, depending on the kind of poles, like square, centrifugal and steel core of concrete poles and is taken from Table N^{o}6 of TCVN 2737 - 1995.

- Calculation of the pole structure must be done for the two cases with wind direction angles of 900 and 450.

1-10. Safety Distances and Protection Corridors

1-10.1. Safety distances:

1) For parallel lines and lines close to other lines, the horizontal distance between the

conductors of the two lines, which are most close to each other, must in a stationary situation not be less than distances given in each following table:

Voltage level (kV)	Up to 22	35	66-110	220	500
Distances (m)	4.0	4.0	6.0	6.0	8.0

For lines with different voltage levels the distances are specified by the higher voltage level.

2) For a line, parallel with asphalted road, the distance between outer conductor and the roadside must not be less than 2m and 3m, respectively for 22kV and 35kV lines.

3) The closest horizontal distance from outer surface of pole foundation to roadside (including perspective extension) must not be less than 0.5m.

4) It is allowed to erect overhead lines of voltage levels from 1kV to 35kV on common poles with 110–220kV lines under the condition that the distance on the poles between the conductors of the two voltages must not be less than 4m and 6m respectively, for common erection with 110kV and 220kV lines.

5) It is permitted to erect overhead lines of voltage levels up to 1kV on poles of lines with voltage level up to 35kV under following conditions:

+ Having an agreement from the owner of the high voltage line.

+ The high voltage line must be placed above and have a cross-section of at least 35 mm^2.

+ The distance on the poles between the conductors of the two voltages must not be less than 2.5 m if conductors placed horizontally and 1.5 m if conductors of low voltage line placed vertically.

6) For lines with two system voltages erected on the same pole the following requirements must be fulfilled:

+ The calculated conditions for the line of the lower voltage must be the same as for the line of the higher voltage.

+ Conductors of the lower voltage line are to be installed under the conductors of the higher voltage line.

+ In case that line post (or pin type) insulators are utilized for supporting conductors of the higher voltage line, it is recommended to place two insulators for each conductor on all poles.

1-10.2. Spacing between conductors on pole (Phase-phase Distance - D):

Conductors can be placed in horizontal, vertical or triangle configuration on line post or suspension insulators. The distances between them are defined by the following formula:

+ $D_{hor} = U/110 + 0{,}65\sqrt{f + \lambda}$ for horizontal configuration

+ $D_{ver} = U/110 + 0{,}42\sqrt{f}$ for vertical configuration

+ In triangle configuration:

The phase-phase distance with a small elevation difference between suspended points of phases ($\Delta h \le U/110$) is calculated by D_{hor}

The phase-phase distance with a large elevation difference between suspended points of phases (($\Delta h > U/110$) is calculated by D_{ver}

Where,

D is the distance between conductors (m)

U is the nominal voltage (kV)

Δh is the elevation difference between suspended points of phases

f is the maximum sag of conductor (m).

λ is the length of suspension insulator chain ($\lambda = 0$ if using line post insulators).

1-10.3. Minimum spacing between conductors on the same pole with two lines of the same system voltage is:

+ 2m and 1m for 22kV line, respectively with bare and insulated conductors

+ 2,5m and 3m for 35 kV line, respectively with line post and suspension insulators.

1-10.4. Minimum spacing between current carrying part and grounded parts on the pole of MV lines:

Calculating conditions for insulation distance selection	Minimum insulation distances (mm) on line poles, depending on the system voltage (kV)		
	up to 10	22	35
- By atmospheric over-voltage:			
+ Line post insulator	150	250	350
+ Suspension insulator	200	350	400
- By other over-voltage	100	150	300
- By maximum working voltage	70	70	100

1-10.5. Minimum spacing between phases on the pole of the line:

Calculating conditions	Minimum spacing (mm) between phases of the line, depending on the system voltage (kV)		
	up to 10	22	35
- By atmospheric over-voltage	200	450	500
- By other over-voltage	220	330	440
- By maximum working voltage	150	150	200

1-10.6. Minimum spacing for transformer substation:

Nominal system voltage (kV)	Minimum spacing phase-phase and phase-earth (mm)	
	Indoor	Outdoor
6	130	200
10	130	220
15	160	220
22	220	330
35 (max. working voltage 38.5kV)	320	400
35 (max. working voltage 40.5kV)	350	440

1-10.7. Minimum vertical distances from the conductor to the natural surface of ground and obstacles:

Conditions	Minimum distances (m)		
	Up to 0.4kV	22kV	35kV
- Natural surface of ground in densely populated areas	5.5	7.0	7.0
- Natural surface of ground in sparsely populated areas	5.0	5.5	5.5
- Natural surface of ground in areas difficult to reach	4.0	4.5	4.5
- Surface of asphalt road	6.0	7.0	7.0
- Surface of rails of railway	6.5	7.5	7.5
- Maximal water level of river, lake, channel...where vessels/boats are passing	Vertical clearance +1.5	Vertical clearance +1.5	Vertical clearance +1.5
- River alluvial plain and underwater area, where no vessels are passing	5.0	5.5	5.5
- Maximum water level of river, lake, channel, where vessels can not pass	2.0	2.5	2.5
- Line of lower system voltage in intersection area	-	2.0	3.0

- Communication line	1.25	3.0	3.0
- Surface of dyke, dam	6.0	6.0	6.0

1-10.8. If an over-head line has to be especially erected in areas related to political, economical, cultural, security, national defence or communication projects, it is necessary to satisfy the following requirements:

- Part of line, passing above obstacles must be strengthened by electrical and mechanical safety measures. It is not permitted to join conductors in these areas.

- Distance from the lowest point of conductors of 1kV-35kV lines in maximal sagging condition to natural surface of ground, must not be less than 11m.

- For crossing lines or lines going close to communication lines, radio or television antenna towers, tram rail, trolley-bus road, open pipes, suspended cables, explosive or inflammable substance stowage and airport bridges, the regulations for distances in Norm for Electricity Equipment 11TCN-19-2006 of Ministry of Industry are applied.

1-10.9. Safety protection corridor for overhead line

The safety protection corridor for an overhead line is the aerial space along the line and specified as the follows:

1) Length of the safety corridor for an overhead line is measured from the position, where the line is leaving the protection border of the transformer substation to the position, where the line is crossing the protection border of the next transformer substation

2) The safety corridor for an overhead line is the space along the line, limited by two vertical planes on both sides and parallel to the line direction, having a distance from the outer conductors to each side defined as:

+ 2m and 1m for 22kV lines with bare and insulated conductors, respectively.

+ 3m and 1.5m for 35kV lines with bare and insulated conductors respectively.

3) Height of the safety corridor for overhead lines up to 35kV is taken from bottom of the pole foundation to the highest point of the line plus 2m in vertical direction.

4) The distance from conductors of lines up to 35kV in a stationary situation to any point of trees inside the safety corridor must not be less than:

+ 1.5m for bare and 0.7m for insulated conductors of lines inside town areas

+ 2.0m for bare and 0.7m for insulated conductors of lines outside town areas

5) Distance from any component of overhead lines up to 35kV to any point of a tree, outside the safety corridor, must, when the tree falls, not be less than 0.7m.

1-10.10. Safety corridors for underground cables Safety corridors for underground cables are specified as follows:

1) The length of the safety corridors is the same as the length of the cable from the point of leaving the substation protection boundary to the entering point of the next substation protection boundary.

2) The width of the safety corridor of a cable line is limited by:

a) The outer planes of the cable ditch for the cables placed in ditch.

b) Two vertical parallel planes to both sides from the outer plane of the cable cover or the outer cable of the cable line for a cable directly placed underground or in water. The safety distances are stipulated as follows:

Cable placing mode	In a ditch	Underground		Underwater	
Safety distance on each side (m)		stable ground	unstable ground	where no crafts are passing	where crafts are passing
	0.5	1.0	1.5	20	100

3) The height is taken from the earth or the water surface to the outer plane of cable ditch for cable placed in a ditch, or equal to the depth lower than the lowest point of the cable cover for 1.5m for cable placed in water.

1-10.11. Safety corridors for transformer substations:

1) For pole mounted transformer substations (PMT) without a surrounding fence, the width of the safety corridor is limited by surrounding planes with a distance to the closest electricity carrying component of the PMT. That width is:

+ 2m for voltages up to 22kV

+ 3m for voltages up to 35kV

2) For transformer substations with a stable surrounding wall or a fence, the width of the safety corridor is measured up to the outer edge of the wall or fence.

3) The height of the safety corridor is measured from the deepest foundation bottom to the highest point of the substation plus a vertical safety distance of 2m for voltages up to 35kV.

1-11. Survey Requirements for Erection of Power Projects

A. For Overhead Line

1.11.1. Preliminary Survey

1-11.1.1. Topographical Survey

- Preliminary line route outlining:

  Outlining power line routes on maps in scale of 1/25,000 or larger.

  Defining the beginning and end points and the length of power lines with an accuracy of ≤ 1/300.

  Measuring steering angles with an accuracy of ± 30”.

- General line route surveying:

  General surveying from the beginning to the end point of line routes for suitable adjustments to the practical situation.

Adjusting the line route corridors and re-measuring the line lengths.

- Surveying the cross-section along the line sections, passing large rivers (if any), at a scale of 1/1000 crosswise and 1/1200 lengthwise.

- Surveying on maps in a scale of 1/1000, the topography along the line routes. When, passing large rivers (if any) surveying an area of 50 m x 50 m at coequal lines of 0.5m.

- Summary of survey results for the line route corridor concerning trees, forests, etc and power or communication lines, that are crossing and or adjacent to the route.

1-11.1.2. Geological Survey

- Collecting basic documents on classification of geological conditions along the line routes.

- Drilling holes, with a depth of 4 – 6 m each at every 4 km along the line routes.

- On every pole position of crossing spans over a large rivers (if any), drilling a hole with a depth of 6-10m.

- Taking a sample of water in holes with 2 specimens for lines, with a length of up to 10 km and 3-5 specimens for lines with a length for analyzing its chemical components and assessing its concrete corrosive or characteristics of more than 10km.

- Defining soil resistance along the line route.

- Defining the seismic situation in the area around the line route.

1-11.1.3. Hydro-Meteorological Survey

- Investigating flooding water levels (maximal and average levels) during flooding season in areas around the line route.

- Investigating maximal and average levels of the water surface at the spans of the lines crossing rivers. Recording the data of investigations.

- Investigating the meteorological characteristics, such as rainfall, risk of storms and lightning, temperature, etc...

1-11.2. Technical Survey

1-11.2.1. Topographical Survey

- Surveying the cross-section along the line routes, with an accuracy of 1/5000 breadth wise and 1/500 lengthwise.

- Measuring the length of the line with an accuracy of 1/300.

- Measuring the height of the space for every stay pole by the trigonometrically method with an accuracy of $\leq \pm$ 30,4D /n.

- On the terminal, angle and river crossing positions stakes must be placed with the size of 5cmx5cmx50cm of concrete with a steel core diameter of 6-8 mm. Before and after the stakes in around 10 m drive protection stakes of wood with a size of 4cmx4cmx30cm should be placed. Preliminarily drawing pole positions.

- Investigating, surveying, preparing statistical data of projects, houses, roads, forests, trees, lines and cables in around 20 m from the central line of power line routes. On the crossing spans over rivers, it is necessary to investigate the maximum vertical clearance for boats passing on the river.

- Surveying breadth wise sections with an accuracy of 1/500 with a width of 10-15 m on both sides of the central line, at line sections, perpendicular or crisscrossing with the inclination direction of the mountain or hill for an angle of inclination of more than 10^0.

- Surveying the topography on maps with a scale of 1/500 with coequal lines of 0.5 m at sections crossing a river or entering into a substation, and with connecting section for a width of 20 m on both sides from the central line of the line routes and at the length of 150 m from the water edge of river banks, and at 200 m from transformer substations.

1-11.2.2. Geological Survey

- Drilling holes, with a depth of 4-6 m, each in every 3 and 2 km for delta areas and mountain and midland area respectively.

- Drilling holes, with a depth of 6 – 10 m on every position of cross-supporting, braking stay poles on crossing spans over a large rivers (if any).

- Taking a sample of soil, and stones from the hole at different layers for testing. Taking one sample in original form of sticky soil and one sample for structural destroy of desultory soil.

- Taking a sample of water from the drilling holes in every 5 km, if there is subterranean water.

- Defining soil resistance along the line route.

- Defining seismic situation in areas around the line routes.

1-11.2.3. Hydro-Meteorological Survey

The same content as in 1-11.1.3.

B. Transformer Substation Survey

1-11.3. Preliminary Survey

1-11.3.1. Topographical Survey:

Surveying the topography on maps with a scale of 1/2000 and coequal lines of 1.0m for an area of 100 m x 100 m. For PMT the surveying area is 50 m x 50 m.

1-11.3.2. Geological Survey

- For every transformer substation site, drilling a hole with a depth of 5- 7 m.
- Taking samples of soil and stone from the drilling holes at different layers.
- Taking a sample of water from every 3 drilling holes, if there is the subterranean water, for analyzing its chemical components and assessing its concrete corrosive characteristics.
- Defining soil resistance of transformer substation sites.
- Defining seismic situation in the area around the transformer substation.

1-11.3.3. Hydro-Meteorological Survey

- Investigating the annual flooding in the areas around the transformer substation sites for maximum and average levels and flooding time duration.

- Investigating the meteorological characteristics like rainfall, risks of storms and lightning, temperature, etc. in the area of the transformer substation sites.

1-11.4. Technical Survey

1-11.4.1. Topographical Survey

Surveying the topography of transformer substation sites on maps with a scale of 1/200 with coequal lines of 0.5 m on an area of 50 m x 50 m.

1-11.4.2. Geological Survey

- For every transformer substation site, drilling a hole with a depth of 3-6m.
- Taking samples of soil and stone from the drilling holes at different layers. Taking one sample in original form of sticky soil and one sample for structural destroy of desultory soil.
- Investigating water source supply for construction and operation of transformer substations.
- Taking a sample of water from the drilling holes, if there is subterranean water, for analyzing its chemical components and assessing its concrete corrosive characteristics.
- Defining soil resistance of the transformer substation sites.
- Defining seismic situation in the area around the transformer substations.

1-11.4.3. Hydro-Meteorological Survey

The same content as in 1-11.3.3.

CHAPTER II

DISTRIBUTION SUBSTATIONS

2-1. Power Supply Scope, Selection of Capacity and Location

- The transformer capacity must be selected so that, it will satisfy the need of electricity consumption with adequate capacity and good quality in the area for 5 years, looking also at the long term planning for 10 years, and at the same time ensure, that the loading of the transformer would not be less than 30% and 60% in the first and the third operating year, respectively, in order to avoid long term under-loading of the transformer.

- The best location for transformer substations is close to the load centre at dry and safe sites. Beside this, also landscape and transportation aspects should be considered.

2-2. Substation Structure

2-2.1. For load centres of villages having a demand for 3-phase power supply with large supply area radius and a load □ 100kVA, install a pole mounted substation (PMT) with a thee-phase transformer or three single phase transformers placed on centrifugal-concrete poles (one or two poles, depending on the capacity of the transformer at the end stage of the planning period, so that a change of the initial transformer to one with double rated output will lead to a change of the substation structure).

2-2.2. For areas, where there are mainly household customers with demand up to 30kVA and 50kVA in mountain and delta/midland regions respectively, two-phase (for network with isolated neutral) or single phase (for network with grounded neutral) transformers placed on a concrete pole, could be used.

2-2.3. Two-phase transformers are allowed to be installed if needed. But, it is necessary to check unsymmetrical load condition, of the network, phase-earth or single-phase short circuit fault current in the network and to make an economical comparison of investment costs for MV, LV lines and transformer substation for the case of two-phase or three phase transformer to be installed.

2-2.4. In special cases, it can be necessary to erect a ground mounted substation with technical and safety requirements as stipulated in existing Norms.

2-3. Transformer Selection

2-3.1. Voltage and Vector group of Transformers:

1) The primary voltage of transformers is selected by the below stated principles:

- In areas, where at present and also in the future, the network voltage will be 22 or 35kV, the primary voltage of 22 or 35kV must be selected for the new transformer.

- In areas, where the ultimate network voltage will be 22kV, but at present the existing voltage is 35 or 15 or 6-10kV, the primary of the transformer must have dual voltages, the existing one and 22 kV. Voltage converting equipment shall be installed on the outside of the transformer.

2) The winding group of transformers is selected as:

Transformer	Nominal voltage (kV)[*]	Connection
Three-phase transformer on 35kV Network	35± 2 x 2.5%/ 0.4kV	Δ/Yo-11 or Y/Yo-12
Two-phase transformer on 35kV network	35± 2 x2.5%/ 2 x 0.23kV	I/2Io
Single phase transformer on 35kV Network	20.20± 2x 2.5%/ 2x 0.23kV	I/2Io
Three-phase transformer on 22kV Network	22 ± 2x2.5%/ 0.4kV	Δ/Yo-11 or Y/Yo-12
Two-phase transformer on 22kV Network	22 ± 2x2.5%/ 2 x 0.23kV	Io/2Io
Single phase transformer on 22kV network	12.7 ± 2 x 2.5%/ 2x 0.23kV	Io/2Io
Three-phase transformer on 15kV, possible to convert to 22kV network	15(22)±2x2.5%/ 0.4kV	Δ(Δ)/Yo-11(11) or Y(Y)/Yo-12(12)
Three-phase transformer on 10kV possible to convert to 22kV	10(22)±2x2.5%/ 0.4kV	Δ(Δ)/Yo-11 or Y(Y)/Yo-12
Three-phase transformer on 6kV possible to convert to 22kV	6(22) ± 2x2.5%/0.4kV	Δ(Δ)/Yo-11(11) or Y(Y)/Yo-12(12)
Three-phase transformer on 35kV possible to convert to 22kV	35(22)±2x2.5%/ 0.4kV	Y(Δ)/Yo-12(11) or Y(Y)/Yo-12(12)
Single phase transformer on 15kV possible to convert to 22kV	8.67 (12.7) ± 2x2.25%/ 2x 0.23kV	Io/(Io)/2Io
Two-phase transformer on 15kV possible to convert to 22kV	15(22) ± 2 x 2.5%/ 2x 0.23kV	I(I)/2Io

[*] *The primary voltage of transformers will be selected specifically for every substation in accordance with the rated voltage of the network connected to the substation*

2-3.2. Voltage step setting and conversion

All transformers shall have 5 voltage steps for 5%; 2.5%; 0%; -2.5%; -5%U_N (±2x2.5%U_N).

The primary voltage converting equipment must be installed on the outside of the transformer.

2-3.3. The capacity range of transformers, commonly utilised for rural power network

Rural distribution networks use mainly transformers (including single, two and three-phase) with a capacity of 50kVA, and a few of 100 or 250kVA. For single-phase transformers in particular, also the small sizes of 15kVA can be utilised.

The capacity range of transformers is proposed as below:

Three-phase: 30-50-75-100-160-200-250-400kVA

Two-phase: 15-25-37.5-50kVA

Single phase: 15-25-37.5-50-75kVA.

2-4 Lightning Protection and Grounding Solution for Substation

2-4.1. Lightning protection equipment:

1) It is not necessary to install direct lightning protection for transformer substations.

2) The number of suspension insulator bowls, installed at the entrance pole to a 35kV substation with lightning protection wire and on the terminal of a 35kV overhead line, must be increased with one bowl, compared with requirements for the 35kV line in case the lightning wire does not reach the substation.

3) Protection from atmospheric over-voltage, transmitted from overhead lines to substations is implemented by surge arrestors.

4) Surge arrestors are applied for substations with system voltage up to 35kV and for any size of capacity.

5) Surge arrestors are installed on the following positions:

+ At the out going point of a transformer with system voltage up to 35kV or at a point less than 5 m from the outgoing point along the line.

+ At the point of interconnection between overhead lines and underground cables

6) When selecting surge arrestor for transformer substations, it is necessary to consider the structure and voltage of the existing and expected distribution network in order to ensure suitable and economic selection.

7) Technical parameters of surge arrestor must be selected in accordance with TCVN 5717 and IEC-99.4, presented in Annex.

2-4.2. Grounding of transformer substations:

1) The neutral of transformers, arrestors, steel components and equipment must be connected to the grounding system of the substations.

2) Working, safety and arrestor grounding must be connected to a grounding rod set by separate wires.

3) Substation grounding system comprises connecting wires and grounding rod set, in which:

- The connecting wire must be round or flat steel wire, zinc plated (heat dipping), with a thickness of no less than 80µm or plated with copper, or a flexible copper wire.

- The minimum cross-section of grounding rods and wires are stipulated as follow:

Kind of material	Indoor	Outdoor	Under ground
Round steel for connecting wire, diameter (mm)	6	6	8
Round steel rod, diameter (mm)	16	16	16
Flat steel: - cross-section (mm^2) - minimum thickness (mm)	24 3	48 4	48 4
Angle steel, minimum thickness (mm)	3	4	4
Cooper wire, diameter (mm)	4	4	6
Aluminium wire, diameter (mm)	10	10	Prohibited

4) The connection between grounding wire and rod must be solidly welded. The connection of grounding wire to the cover of equipment with a steel structure, or between grounding wires, may be implemented by bolting or welding. The connection by wringing is prohibited.

5) The resulting value of the earth resistance within a substation with primary voltage up to 35kV must not be more than 10 ohm.

2- 5. Protection Equipment for Substation

2-5.1. For the MV side:

On the MV side, a fuse cut-out (FCO) or load break fuse cut-out (LBFCO) is to be utilised for the short circuit protection of a substation with primary voltage up to 35kV. Disconnection with sectioning function must be installed for the transformer. The nominal voltage of fuses and disconnectors is selected according to the ultimate voltage level of the network.

2-5.2. For the LV side:

1) On the LV side of substations, with meters for monitoring energy losses, common circuit breakers to be installed, while fuses are to be installed for the feeders.

2) For substations without meter installation, fuses are only to be installed for feeder protection.

3) The number of feeders from a substation should be decided in each case, considering the rating of the transformer and the geographical area to supply. However, the following general rules can apply:

- Substation > 100kVA, install 3-4 feeders
- Substation ≤ 100kVA, install 2-3 feeders.
- Substation ≤ 50kVA, install 1 feeder.

4) Fuses, breakers and meters (if any) can be placed in a LV Distribution cabinet installed on the substation pole.

2-6. Meters

2-6.1. Meters are installed only in substations, where monitoring of energy losses is wanted or where meters for debiting electricity are required.

2-6.2. Electric energy measurement by kWh meters is made either directly for currents up to 75 A or through current transformers (TI) for currents >75 A.

2-6.3. Voltage and current are measured with a portable V-A meter in the case it is necessary.

2-6.4. The current transformers and the kWh meter are placed in the LV Distribution cabinet with fuses and breaker (if any).

2-7. Substation Construction Solution

2-7.1. Distribution transformer substations in rural areas can be constructed of the following types:

- Pole mounted substations (PMT) where a three-phase, two-phase, single-phase transformer or three single phase transformers are mounted on one single pole or two poles of H configuration.

- Ground-mounted substations should be utilised only in special cases when the environment may so require.

2-7.2. Poles, cross arms and foundation structure for the above types of substations:

1) For PMT:

+ Poles for PMT are centrifugal concrete or pre-stressed centrifugal concrete pole.

+ Cross arms and beams are made of geometric steel, plated with zinc (heat dipping) of a thickness no less than 80μm.

+ Pole foundations are of concrete mass casting on the site or foundations with two barrage girders for good and stable ground area.

+ An operation platform can be placed on a PMT in often flooded areas.

2) For ground-mounted substations:

+ The transformer foundation can be cast on site by concrete or built by bricks with cement-sand mortar No 75, with a height of no less than 0.5m above the ground surface.

+ The LV 380/220V cabinet is placed outdoor as for PMT. When a LV 380/220V cabinet is required, it shall be placed indoor, in a house, built by bricks with concrete or iron sheet roof.

+ The entrance pillars and the fence-wall are built by bricks or concrete and the entrance leaf made by steel, painted by anti-corrosive paint.

CHAPTER III

MEDIUM VOLTAGE LINE

A. Overhead Lines

3-1. Conductors

3-1.1. Conductor Type

1) The type of conductor is selected by the working environment conditions and the requirements for mechanical strength, durability and safety.

2) The conductor type mainly used for medium-voltage lines is steel-core bare aluminium (ACSR). Aluminium conductors without steel core can be used with the cross section > 120 mm^2 depending on the mechanical-durability requirement for each line.

When selecting the conductor cross-section, it is necessary to carry out techno-economic calculations for comparisons.

3) Aluminium conductors (without steel-core) with cross-section up to 95mm^2 should not be used for medium-voltage lines and with any cross-section for the neutral wire and conductors in span crossing river and railway.

4) When a power lines are passing salty polluted areas (up to 5km from sea side), or industrial dust areas (up to 1.5km from manufactory) with metal eroding active elements, anti-erosive conductors should be used.

3-1.2. Cross-section of Conductor

3-1.2.1. Criteria for Conductor Cross-section Selection:

1) The conductor cross-section is to be selected to satisfy the demand in the long term planning development up to 10 years in the area.

2) The conductor cross-section is to be selected with regard to i) density of economical current, ii) permitted voltage drop, iii) permitted current carrying capacity for the conductor, iv) mechanical durability and v) working environment in accordance with regulations of the Norm of electric equipment-11TCN-18-2006.

3) When selecting the conductor cross-section, it is necessary to pay attention to the requirements of standards in design, construction and operation of the network in the future.

3-1.2.2. Other Requirements:

1) Main lines, supplying large load centres, are constructed as meshed nets with conductor cross-section of the lines of at least 120mm^2 and usually operated in open mesh.

2) For main lines, supplying many communes, with a length of more than 20km in delta regions or more than 40km in mountainous regions, the cross section should be at least 95mm^2.

3) For lines with solid grounding neutral, the cross-section of the neutral conductor should be selected as one size smaller than the conductor cross-section for three-phase 4 wire lines and with the same conductor cross-section as for single-phase 2 wire and single-phase 3 wire lines.

4) For long lines, in selecting the conductor cross-section, there must be carried out a techno-economic calculation for comparison between increasing the cross section of the line and installing capacitors at the end of the line for keeping the voltage at a permitted level.

3-2. Insulators and Line Accessories

3-2.1. Insulator installation

1) To support conductors on the supporting poles of MV lines, pin-type, line-post or suspension insulators can be used, depending on conductor diameter and the requirement of mechanical strength.

2) When using pin-type or line-post insulators for supporting conductors, those should be arranged as described below:

+ On intermediate supporting poles, place one pin-type insulator for supporting one conductor.

+ On supporting poles of line part crossing traffic roads, other lines or houses, buildings where the people are often staying, it is necessary to place two pin-type insulators for supporting one conductor or one line post insulator.

+ On supporting poles with a small gliding angle on MV line with isolated neutral, and going on common poles with LV line, place two pin-type insulators along the line route.

+ On MV lines with solidly grounded neutral and built on common poles with LV lines it is permitted to place one pin-type insulator or one line-post insulator for supporting one conductor.

3) When using suspension insulators, place one insulator chain for supporting one conductor.

4) For lines with conductor cross-section □ 240mm^2, generally and for cross sections□ 120mm^2 in regions affected by heavy storms, it is advisable to utilise suspension insulators for the supporting of conductors.

5) At all locations of dead-end supports, angle anchor supports and straight anchor supports with conductors □ 70mm^2 it is necessary to use strain chain insulators for the anchoring of conductors.

6) At locations of crossing supports and crossing anchor supports with height more than 40m, it is necessary to use two suspension insulators or two strain chain insulators for the supporting of conductors and to add one insulating bowl for each 10m of additional pole height.

3-2.2. Insulator Type Selection

1) The pin-type or line-post insulators are to be selected in accordance with the rated voltage class of the distribution network. The 38.5kV insulator is used for 35 kV lines and

24 kV insulators for 22kV lines.

2) The pin-type insulators used are either of ceramic or glass (line post, Pine type or Pine post) according to the technical standards are given in TCVN-4759-1993 and TCVN-5851-1994. In case, the lines pass across polluted areas, anti-fog insulators should be used.

3) For supporting and staying conductors suspension insulators can be used, with ceramic or glass insulating bowls or preferably solid composite ones.

4) When using suspension insulators with ceramic or glass insulating bowls, the number of insulating bowls is to be selected in accordance with the working voltage, the level of the environmental pollution in the region and the technical characteristics of the insulator:

+ For insulating bowls with a leakage-current length ≥ 250 mm, the number of bowls in each chain supporting the line under normal conditions, should be selected as:

3 bowls for 35 kV lines

2 bowls for 22kV lines

Composite insulators, are selected by leakage-current length, which should be no less than 25mm/kV

+ On lines using suspension insulators, the number of bowls of staying chains should be one bowl more than that of supporting chains.

+ When power lines are passing polluted areas such as salty areas (up to 5 km from sea side), or areas with industrial dust (up to 1.5km from manufactory), or with metal eroding active elements, the number of the insulating bowls is increased with one more in each supporting and staying chain.

+ For lines using pin-type (supporting insulator) and suspension insulator (staying chain) with a leakage-current length of insulating bowls of more than 250mm, calculations of the number of bowls for each chain should be carried out with respect the insulating level between supporting and suspension insulators.

+ The selection of insulator type must be based on physical, mechanical, and environmental conditions, also considering transportation and construction as well as the future operation and maintenance. For lines of system voltage up to 35kV, selection of the number of insulating bowls for a chain or insulating height for line post insulators does not depend on the height of the lines above the sea level.

5) The safety factor of insulators (ratio between destroying mechanical load and maximum standard load) must not be less than 2.5 for line voltages up to 1kV and not less than 2.7 for line voltages of more than 1kV at an annual average temperature of not less than 5^0C. The safety factor shall be not less than 1.8 during abnormal operation.

3-2.3. Line Accessories

1) All metallic accessories of lines must be zinc-plated (by heat dipping method) and made in accordance with Vietnamese Standards. The safety factor of accessories must not be less than 2.5 during normal operation and not less than 1.7 during abnormal operation. The safety factor of pin-type insulator pins must not be less than 2 during normal operation and not less than 1.3 during abnormal operation.

2) Jointing of line conductors must be carried out with jointing tubes. Within every pole span, one joint only is permitted. It is not permitted to have joints in spans crossing rivers

and national roads or other important cross-spans.

3) Jointing of bypass wires on a pole position must be implemented by bolts.

4) The mechanical strength of anchoring locks and conductor joints must not be less than 90 % of the breaking force of the conductor.

3-3 Lightning Protection and Grounding

3-3.1. Lightning Protection and Grounding must be:

1) For overhead lines with voltage up to 35 kV it is unnecessary to set up lightning protection wires (except for the part of lines connecting to transformer substations with a capacity of □1600 kVA)

2) For overhead lines with system voltage □35 kV and isolated neutral, but without high speed earth fault protection, all poles must be grounded.

3) For overhead lines with system voltage □35 kV and grounded neutral or equipped with high speed earth fault protection, the crossing poles, the T-branch poles, the poles in a span crossing a road, rail-way or communication line and the poles, on which there are LV lines or other electric equipment installed, must be grounded.

4) For 35kV overhead lines protected by lightning wires for the parts entering into substations, which can be cut out for a long time on one side, during lightning season, it should be better to set up one more surge arrester on the first pole of the line to the substation on the side, where the line can be cut out.

3-3.2. Grounding Resistance and Grounding Type

1) The grounding resistance (R) at pole positions where equipment is installed and at poles of the line passing densely populated areas, must not be more than the values in following table:

The soil resistivity (ρ)	The grounding resistance (R)
$\rho \leq 100\ \Omega m$	$R \leq 10\Omega$
$100\ \Omega m < \rho \leq 500\Omega m$	$R \leq 15\Omega$
$500\ \Omega m < \rho \leq 1000\Omega m$	$R \leq 20\ \Omega$
$1000\ \Omega m < \rho \leq 5000\ \Omega m$	$R \leq 30\ \Omega$
$\rho > 5000\ \Omega m$	$R \leq 6.10^{-3} \times \rho/m\ \Omega$, but not more than 50 Ω.

2) The values of grounding resistance at poles (without equipment installed) of the line passing sparsely populated areas are as follow:

+ Not more than 30 Ω, if the soil resistivity is $\rho \leq 100\ \Omega m$
+ Not more than $0.3\rho/m(\Omega)$, if the soil resistivity is $\rho > 100\ \Omega m$ but not more than 50 Ω

3) For lines with lightning protection wire and pole height > 40m, the grounding resistance is selected as half of the values, given above and is to be measured, when the lightning

protection wire is disconnected

4) Grounding set (rods or combined rods and rungs) is to be implemented in accordance with article 2-4.2.

3-4 Switching Equipment for Protection and Sectioning of MV lines

3-4.1. 22kV lines

1) On 22kV bus bars of feeder substations, a circuit breaker must be installed for every feeder.

2) On main lines with a length of > 15 km and at the connecting end of a branch with a maximum load current I_{max}≥100A, 24 kV load disconnectors (LBS) must be installed with a nominal current of 200A or 400A.

3) In lines with a length of > 15km and a maximal current >100A, an auto-recloser should be installed in a position, not too close to the circuit breaker (at a distance of more than 5km) and after an important load.

4) In the connecting end of branches with a length of < 1km, it is unnecessary to install sectionalising equipment but they must be equipped with a bypass wire for flexible dealing with incident cases.

5) In the connecting end of branches with a length of < 1km and a maximum current of < 50A but supplying many customers a FCO must be installed. In the connecting end of branches with a length > 1 km and 50A ≤ I_{max} < 100A, a LBFCO or a combined FCO-LBS with a rated voltage of 24kV and a nominal current of 200A or 400A or a three-phase DS should be installed.

6) If utilising auto-reclosers, an ordinary disconnector can be installed on the source side of the reclosers and on both sides, if the line is located in a meshed net, in order to create an open space visible when the circuit is disconnected.

7) For MV networks with existing voltages of 15, 10 and 6kV, which will be converted to 22kV ones, the arrangement of protection equipment should be implemented as follows:

+ For existing 15kV networks with solidly grounded neutral, which are the same as for future 22kV networks, the protection and sectionalising is to be implemented as for the 22kV network, stipulated in item 3-4.1.

+ For existing 10kV and 6kV networks with isolated neutral operating, the protecting and sectionalising should be as follows:

> In the connecting end of lines with a length of about 10-20km or at branches with I_{max}≥100A, a 24 kV load break switches must be installed with a rated current of 200A or 400A
>
> In the connecting end of 3-phase branches with a length of > 1 km and connecting to the main circuit, a 3-phase 24 kV disconnector must be installed, but for shorter branches it is not necessary.
>
> Do not install FCO in the connecting end of branches, when the network is still operated at 10kV or 6kV

3-4.2. 35 kV Lines

1) On the 35 kV bus bar of feeder substations it is necessary to install 35kV circuit

breakers for each feeder line.

2) On main lines with a length of > 15 km and at T-off branches with a maximum load current of □100A, load break switches with a nominal current of 200A or 400A must be installed in order to sectionalise and locate faults. Sectionalising disconnectors should be placed in locations, where the load, the number of customers and the operational conditions are changing.

3) On distribution lines with a length of > 15km and maximum load current $I_{max} \geq$ 100A, 35kV reclosers should be installed in locations not too close to the feeder circuit breaker (at a distance of about 5km) and after important loads.

4) At the connecting end of three- and two- phase branches with a length of < 1km, it is unnecessary to install sectionalising equipment but they must be equipped with a bypass wire for flexible dealing with incident cases.

5) At the connecting end of 3-phase branches with a length of > 1km connecting to the main circuit it is necessary to install an ordinary disconnector, if the maximum load current is□30A and load break switches, if the maximum current is >30A. The nominal current of ordinary disconnectors and load break switches is 200, 300 or 400A.

6) For 35kV lines with isolated neutral, it is not permitted to use single-phase disconnectors and FCO at the connecting end of branches in order to limit the possibility of magnetic resonance.

7) For 35kV lines with solidly grounded neutral, at the connecting end of single phase branches and three-phase branches with a length of more than 1km, a FCO must be installed, if the maximum load current is <30A, or a LBFCO, if the maximum load current is > 30A, for detecting short circuit faults.

8) At the connecting end or the end of 35 kV lines connecting to a 110 kV substations or 35 kV substations with a capacity of □1600kVA, it is necessary to arrange a lightning protection wire with the length and technical solution corresponding to the regulations given in 11 TCN-19- 2006.

3-5 Poles

3-5.1. Pole type

1) Poles utilised for MV lines are mainly centrifugal concrete (in Vietnamese-BTLT) or pre-stressed centrifugal concrete (LT-DUL) poles with standard heights: 8.5, 9.0, 10.0, 10.5, 12.0, 14.0, 16.0, 18.0 and 20m. In special difficult circumstances such as at crossings and long spans, where there is a need of poles with a height of > 20m and where there is the need of poles with tension requirement over the capability of centrifugal concrete pole, it is permitted to utilise steel towers.

+ The pole height selection should be based on economic calculations and technical requirements, stipulated in the Norm of Electricity Equipment.

+ The centrifugal concrete poles (BTLT) are manufactured in accordance with the Vietnamese Standard TCVN 5847-1994.

BTLT pole dimensions and limiting tension requirement for pole head can be found in attached Annex.

2) The steel towers are made from geometric steel and protected from corrosion by a Zinc-

plating (by hot dipping) layer with a thickness of ≥ 80μm and manufactured in accordance with Vietnamese standards corresponding to the concrete requirements.

3) For centrifugal concrete poles, on every position the foot of the poles should be embanked by soil to a height of 0.3m.

3-5.2. General Plan of the Pole

1) MV lines, passing densely or planned densely populated areas should favourably be designed to include LV lines, later erected going on common poles.

2) Single poles can be utilised for straight, cross-span, and small angle supporting poles.

3) On the positions of big angles, terminals and long crossing spans (more than 200m), staying poles, requiring a tension over the ordinary loading capability of the poles, it is necessary to utilise double, gate form (∏) poles or steel towers. When the lines pass sparsely populated areas single poles can be utilised with stay wires and foundations but stay wire anchors must not be too close to roads and places, where people and domestic animals may often come in contact with the anchors.

4) On positions where the load requirement is great as for angle anchors, dead-end anchors and anchoring for crossing over large spaces of over 200m width, the gate-type pole diagram should be used.

5) On anchoring positions, where the lines cross large spans of > 400m and the topographical height can be maintained, it is better to utilise three (or four) separate poles, each pole supporting one conductor.

6) On positions, where lines cross large rivers, requiring pole height of more than 20m, steel towers can be utilised. The steel staying towers are utilised in special cases only.

3-5.3 The span lengths between poles are calculated for each specific project, but commonly, it can be selected from 100m to 150m for 22kV, and from 150m to 200m for 35kV lines.

3-5.4. For pole positions placed at locations where the soil erosion often happens (banks of a river, edges of a hill etc), the flood with a probability of 2% must be taken into count.

3-6. Hardware (Crossarms, Braces)

3-6.1 Crossarm Configurations

Depending on the specific load of the structure, the crossarm configuration can be selected as follows:

1) The horizontal crossarm configuration (insulators installed horizontally) is applied for straight, crossing supporting and single stay poles, when it is necessary to reduce the height of a pole.

2) The triangular crossarm configuration (insulators installed in a triangle) is applied for straight, crossing supporting and single stay poles, when it is necessary to reduce the corridor width, or to extend the phase-phase distance for prolonging pole spans.

3) The un-symmetric cross arm configuration (insulators installed on one side of the pole) is applied for locations, close to objects (houses, projects) with requirement for longer safety distances.

4) The Π-form cross arm configuration is applied for angle stay poles, with requirement for

high tensions and extension of phase-phase distances.

5) Single-phase crossarms are applied for crossing poles with single-phase pole scheme (one pole for each phase).

6) T-crossarms are applied for poles in the beginning of branches.

3-6.2. Materials of the Crossarms

- All the beams and crossarms of medium-voltage lines are made by steel, plated with zinc (by heat dipping method) with a thickness of not less than 80µm.

- The bolts, nuts and other accessories must be plated with zinc (by heat dipping method) and manufactured in compliance with Vietnamese standards.

3-7. Pole Foundations

3-7.1. Pole Foundation Types

3-7.1.1. Glass-type Foundations (or Inkpot-type Foundations)

- This type of foundation is to be applied for the areas, where the geological conditions of the ground doesn't allow to dig the foundation pits by vertical direction, the topographic conditions on the pole position is not flat, the surface of the pole base can easily be changed due to environment conditions and where the geological conditions is very changing along the line route.

- The depth of the buried part of the pole should be accepted as 10-12% of the pole height.

- The depth of the foundation bottom is given as the depth of the buried part of the pole plus 0.3 m.

- The foundation material is concrete with the Mark of 200, casting on site.

3-7.1.2. Box-type Foundations

- This type of foundation is to be applied in areas, where the geological condition of the ground is rather good, which allows digging the foundation pits by vertical direction, where the topographic condition of the pole position is rather flat and the surface of the pole base is hardly expected to be changed by environmental conditions.

- The depth of the buried part of the pole should be accepted as 10-14 % of the pole height.

- The depth of the foundation bottom is given as the depth of the buried part of the pole plus 0.3 m.

- The foundation material is the concrete with the Mark of 150, casting on site.

3-7.1.3. Well-type Foundations

- This type of foundation is to be applied for lines passing sand dunes, where there is a drifting phenomenon of the sand in the ground basis, and in cities and towns with very limited space for pole erection.

- The depth of the buried part of the pole should be accepted as 14-16 % of the pole height.

- The depth of the foundation bottom is given as the depth of the buried part of the pole plus 0.3 m.

- The foundation material is the concrete with the Mark of 150, casting on site.

3.7.1.4. Prevent Beam Foundation (Horizontal Beam)

- This type of foundation is to be applied in areas, where the topography is rather flat, the surface of pole positions is hardly expected to be changed by environmental conditions, the aesthetic requirement is not so high, the safety corridor of the line is not severely limited, the line is not directly affected by storm and where the geological conditions do not change so much along the route.

- The depth of the buried part of the pole should be accepted as 16-18 % of the pole height.

- The level of placing the prevent beam (position for bolting) is 0.5 m lower than the stable natural ground surface or at least 0.2 m above the pole bottom.

- It is possible to utilise the following forms for placing prevent beams:

  One upper beam for each supporting pole.

  Two upper parallel beams for supporting, stay poles, where the ground basis is weak and easily becomes sunk.

  Two upper perpendicular beams for stay poles with stay wires and poles of PMT.

  One upper beam and one bottom beam for supporting poles standing with the great tension, where the geological condition is poor.

- The beams are made of precast steel-core concrete with the Mark of 200.

3.7.1.5. Strengthening Soil Foundations (poles buried without foundation)

- This type of foundation to be applied for poles with not so high tension requirements and for single-phase branches in areas, where they are not affected directly by storm, the topography is steady, the surface of pole bottom is not expected to be changed by environmental conditions, the geological condition is very good and steady and where the pressure sustaining strength of the ground $R_N > 2$ Kg/cm^2, the density $\beta<0.7$, the friction angle $\varphi>15^o$ and is not starchy with water.

- The depth of the buried part of the pole should be accepted as 18-20% of the pole height.

- In constructing strengthening soil foundations it requires to keep the natural status of the ground basis in the surrounding area, and the backfilled soil must be compacted in compliance with regulations.

3.7.1.6. Cylindrical Foundations

- This type of foundation is applied for steel span crossing towers in good and steady geological locations with the pressure sustaining strength of the ground $R\geq1$daN/cm^2.

- The elevation of the upper surface of cylindrical foundations (on the position of placing the stay bolts) must be higher than the highest water level by 0.5 m. In the case, that the water level on the foundation position is too high, the foot of a steel tower must be protected by concrete cover.

- The cylindrical foundation must be built by concrete with the Mark of 200 and steel core (steel core C_2) with calculating intensity $R^{TT} \geq 2600daN/cm^2$.

- In designing cylindrical foundations it is necessary to calculate the final, un-symmetric sinking degree and the foundation hardness between the foundations.

3-7.1.7. Plate Foundations

- This type of foundation is applied for steel crossing span towers in locations with poor geological conditions and the pressure sustaining strength of the ground $R<1.0daN/cm^2$.

- In designing plate foundations, the selection of elevation of the upper surface, the mark of core-steel concrete, the solution for steel tower foot protection and the calculation for checking sinking degree, is to be applied similarly as for cylindrical foundations.

3-7.2. Special Treatment of Ground Foundation and Pole Foot

1) In cases, where the concrete foundations are always under the salt water level or the underground water contains corrosive active elements, it is necessary to utilise un-absorbent and anti-corrosive concrete with the Mark of ≥ 200.

2) The pole foot must be 0.3 m higher than the 2% frequent flood water level. In case, the concrete pole or steel tower foot is always under the salt water level or the water contains corrosive active elements, the permanent flooded part must be covered with an un-absorbent and anti-corrosive concrete with the Mark of ≥ 200, the thickness $\delta \geq 20$ cm and the height 0.3 meter above the highest water level.

3) In case, the pressure sustaining strength of the ground basis is too low (muddy soil or clay), the pole and foundation can be sunk over the permissible limit, depending on the geological allocation in the region and the pressure sustaining strength requirement, measures can be taken for strengthening the ground basis by piling with steel-concrete, bamboo, indigo piles or by load distributing sand bed.

3-8. Pole Stay

3-8.1. In order to support the sustainable loading capability for the poles and foundations on positions of straight, angle, and terminal, poles stay wires and stay foundations should be utilised.

3-8.2. The number of the stay wires and foundations is selected corresponding to the pressure sustaining strength requirement and the pole arrangement configuration.

3-8.3. The stay wires can be secured directly on the beam pole by bolts or collars or indirectly through a transition pole and fasten wires, in case of stay wires crossing over roads.

The stay wires must be connected with grounding equipment, with grounding resistance in accordance with Item 3-3.2 or they must be insulated by insulators of staying type at the rated voltage of the overhead line, with insulators placed at the height of no less than 2.5m above ground surface.

3-8.4. The stay wires can be made of steel cable or steel rod, plated with zinc (by heat dipping) with a minimal thickness of 80µm.

3-8.5. The length of stay wired depends on pole height and pole arrangement configuration.

3-8.6. The staying wire accessories must be made of plated zinc with minimal thickness of

80µm.

3-8.7. The staying foundations are to be buried under the natural ground level at a depth of 1.5-2m. The stay wires and foundations are connected with each other by tightening clamps.

3-8.8. Stay foundations are to be prefabricated by steel-core concrete with the Mark of 200.

B. Electric Cable

3-9. Cable Cross-section Selection

3-9.1. The cross-sections (S) of cables must be selected according to the dimensioning current density by the formula: $S = I_{max}/J_{kt.}$

where I_{max} = maximal current in the cable during normal operation. And J_{kt} = dimensioning current density, referred to in Appendix 1.

After this calculation, the cross-section is to be selected as the nearest standard cross section.

3-9.2. After the selection of the cross section, the cable is checked with regard to voltage drop and current carrying capacity.

3-9.3. The permissible load current value of a cable with voltage level up to 35kV and insulation rubber, XLPE and PVC, is taken as the value corresponding to the permissible value at a temperature of the cable core being 50^0C. In case, the manufacturers provide the permissible parameters or specific norms, their data should be accepted.

3-9.4. For underground cables, the permissible value of normal load current is calculated with the assumption, that the cable is placed in a trench with a depth from 0.7 to 1.0m, the soil temperature of 15^0C and the thermal resistivity of 120^0 cm.^{0}K/W.

In the case, if soil thermal resistivity is different from 120 cm.^{0}K/W permissible value of current of cable is corrected according to soil humidity as follows:

Soil feature	Thermal resistivity cm.^{0}K/W	Correction factor
Sand with humidity of more than 9%, sandy yellow clay with humidity of over 1%	80	1.05
Soil and sand with humidity 7-9%, sandy yellow clay with humidity 12-14%	120	1.00
Sand with humidity over 4% and less than 7%, sandy yellow clay with humidity 8-12%	200	0.87
Sand with humidity up to 4%,	300	0.75

gravel soil		

3-9.5. For underwater cables the permissible value of normal load current is to be calculated assuming a water temperature of 15^0C (see annex). For cables placed in air, the permissible value of normal load current is calculated with regard to space of not less than 35mm between cables when placed indoor, outdoor and in a trench and of not less than 50mm between cables when placed with any number of cables and an air temperature of 25^0C. For single cables placed underground in a pipe without artificial ventilation, the permissive value of normal load current is calculated as for cables, placed outdoor.

3-9.6. When cable lines pass areas with different environmental conditions, the section and configuration must be selected in accordance with the line section passing the area with the harshest environmental condition.

3-10. Cable Lay-out Mode, Cable Type Selection

3-10.1. For rural networks, the ordinary mode of cable installation is to place it under ground, following along the track or the roadside, limiting the crossing traffic roads. Along the underground cable route, warning tapes must be placed with a distance between them of up to 10 m.

3-10.2. Cables placed directly under ground or water, must be cables with steel cover, coated by a chemical anti-corrosive substance. In cases of cables with a cover that is not made of steel, it must sustain any mechanical effect in installing process, thermal effect in operation and the maintenance process.

For areas that are salty polluted, muddy, contained with slag cinder, construction materials corrosive substance, the cable core must be made of lead or aluminium with composite coating.

3-10.3. For areas that are salty polluted, muddy, contained with slag cinder, construction materials corrosive substance, the cable core must be made of lead or aluminium with composite coating.

3-10.4. For un-steady ground areas, cables with steel fibre cover must be selected and other measures must be taken to prevent harmful impact to the cable in the erection process (such as, estimation of additional length of cables, compressing the surrounding ground, staking, etc.).

3-10.5. In areas, where cable lines pass streams, warp, channels, the same cables as for under ground should be utilised. Cable pipes under ground and under water must be corrosively protected.

3-10.6. Cable lines are to be installed under ground in the following way: cable placed in a trench within (over and under) a smooth soil layer without any gravel, litter, or cement. Along the line length a protection layer for avoiding mechanical effect must be utilised, as covered by concrete panel with a thickness of more than 50 mm for 35kV cable lines, concrete panel or bricks (do not use silicate, hole and hollow bricks) or other strong enough materials for < 35kV cable lines. For cable lines up to 22 kV, when the cable is placed deeper than 1m, it is unnecessary to take protection measures, except in case the cable is passing under roads or railways. Along the line length, concrete stakes must also be placed for underground cable warning.

3-10.7. The depth of a cable trench must not be less than: 0.7m for 22kV and 1.0m for

35kV cables. For cables with a length of less than 5m or at the positions of connecting to buildings, crossing with underground constructions, it is allowed to reduce the depth to 0.5m.

3-10.8. The distance between underground cables and other structures and objects, are stipulated as follow:

1) Between parallel cables:

+ 0.10 m for cables of system voltage up to 10kV or between these and other LV cables.

+ 0.25 m for cables of system voltage up to 35kV or between these and other cables.

+ 0.50 m for cables of different operation managers or between power and communication cables

2) The distance from a cable (of any voltage level when the cable is placed underground) to buildings or structure foundations must not be less than 0.6m. Do not place cables directly under buildings or structure foundations.

3) When laying cables in forest or tree planting areas the distance from a cable to the foot of a tree should not be less than 2.0m. In case of an agreement between concerned management sides, the above distance can be reduced if the cable is placed in a pipe. When laying cables in an orchard with small tree foots, the above distance can be reduced to 0.75m.

4) The distance from a cable to the grounding equipment of a pole, should not be less than 5m and 10m for overhead lines of voltages over 1kV up to 35kV and from 110kV up, respectively. At narrow positions the above distances can be reduced but must be not less than 2m. For overhead lines of voltages up to 1kV, this distance should not be less than 1m and can be reduced to 0.5m for cables placed in insulating pipes at narrow positions.

5) In case of crossing railways or roads, cables must be placed in trenches or pipes along the breadth of ways plus 0.5m to both sides from the edge of the ways. The cable must be buried to a depth of at least 1m bellow the railway/road surfaces and 0.5 m bellow the drainages at both edges of the way.

6) When the cable crosses a ditch:

+ If the ditch is hollow the cable should be placed bellow the bottom of the ditch for at least 0.5m.

+ If the ditch is deep the cable should be placed in a pipe along the breadth of the ditch plus at least for 1.0m to both sides.

3-11 Installing Cable Joints and Terminations

3-11.1. The installation of cable joints and terminations must satisfy the requirements of material and the working and environmental conditions, avoiding moisture and harmful substances entering into the cable. Joint boxes and terminations for cables of voltages up to 35 kV must satisfy the requirements of technical standards, among these the possibility to withstand the test voltage (BIL) for the whole cable line route.

3-11.2. For cable lines of voltages over 1kV utilising flexible cables with XLPE, PE or EPR insulation (do not use PVC cable for underground line) and rubber cover, the joints must be carried out by the endothermic method and the joining parts must be coated by an anti-moisture layer or by a joint box type of winded tape with pumped epoxy resin.

3-11.3. The number of joints in one kilometre of a newly constructed cable must not be more than:

6 joints for a three-core cable with system voltage of 22-35kV.

3 joints for a single core cable.

3-11.4. Cables from the ground level to the height of 2m must be placed in a protecting pipe.

3-12. Cable Grounding

3-12.1. The metallic cover of a cable and its components must be grounded or connected to the neutral in accordance with general technical requirements. The metallic cover and metallic band must be connected and connected to the joint-box by flexible copper wire with a cross-section not less than 6 mm^2.

3-12.2. In the case, if on components of a cable are placed terminations and arresters; bands, cable metallic cover or box cover must be connected to the grounding equipment of the arresters. Do not utilise metallic cover of cable instead of grounding rod.

3-12.3. When connecting a cable to an overhead line on a line pole without grounding, it is allowed to utilise the metallic cover of the cable as grounding rod for the cable termination box.

CHAPTER IV
LOW VOLTAGE LINE

4-1. Conductor

4.1.1. Conductor Type

1) For lines, passing sparsely populated areas, far from buildings/houses and public facilities, bare aluminium conductors or in special case bare aluminium conductors with steel-core should be utilised.

2) For lines passing densely populated areas, close to buildings, houses and public facilities or trees and in polluted areas, Aerial Bundled Conductors (ABC) with aluminium core or aluminium conductors, covered by LV insulation should be utilised.

3) For lines passing salty polluted regions, the aluminium conductors with anti-corrosion grease should be utilised.

4) For regions with heavily salty pollution, close to the seaside, conductors to be utilised could be bundled copper or aluminium-alloy conductors.

5) The conductors from the transformer to the LV cabinet (400/230V) and from the cabinet to the feeders should be single or three-phase bundled copper cables, covered by PVC or XLPE-1kV.

6) The conductors going to meter boxes mounted on poles should be bundled copper cables with PVC or XLPE 1-kV.

7) The conductor entering into a multi-meter box, mounted in a house, is to be a copper cable or multi-fibre copper wire, covered by insulation for the outdoor part. The same applies for the electrical cables (mule or bundled cables) passing into protection tubes for the indoor parts.

8) The conductors before and after the meters to the consumers must be multi-fibre copper or aluminium wires, covered by insulation with a cross section corresponding to the maximum load of customers and, at least, not less than 2.5mm^2.

4.1.2. Cross-section of Conductors

4.1.2.1. Basis for determination of the conductor cross section is:

- To ensure the power supply to of the area for the next 10 year period.
- To ensure the voltage quality at the end of the network as prescribed in Chapter 1.
- To ensure that the economical and technical conditions in the power supply area are not exceeding the following lengths:

Line type	Power supply length (m)	
	Densely populated area	Sparsely populated area
Main line T-branch	800 500	1,200 800

- To ensure that the conditions for standardization of conductor cross sections in the design, construction, maintenance and operation are met.

4.1.1.2. Selection of conductor cross-section

Conductors of LV overhead lines in rural areas can be: Bare wires; Insulated covered wires; Fully insulated covered cables, aerial bundle cables (ABC) (commonly called electric cables)

The cross-section of conductors should be selected in accordance with the following guidelines:

1) For main lines:

+ In order to guarantee the mechanical durability, the conductors for main lines must be of multi-fibre type.

Depending on the maximal current of the line, the cross-section of conductors could be selected in the range of 50-70-95mm^2 and exceptionally 120mm^2, but not less than the cross-sections stipulated in the following table:

Conductor type	Cross-section (mm^2)	
	Lines crossing Communication routes and Communication lines of class No 1	The other cases
Aluminium	35	16
Aluminium steel core, Alloy	16	10
Copper	16	10

+ The cross section of the neutral conductor for a 3-phase, 4-wire line is to be selected not less than 50% of the phase conductor cross section. For 2-phase with phase voltage and single phase lines, the cross section of the neutral conductor is selected not less than 70% of the phase conductor cross section.

2) For branches:

+ The conductor for branches can be of single fibre type. The cross section of phase conductors must be selected corresponding to the maximum load of customers, but, at least not less than 2.5mm^2.

+ The cross section of the neutral wire is to be selected the same as for the phase conductors for branches or conductors for single phase loads.

3) Conductors entering a household meter boxes, mounted on LV poles are to be selected as follows:

+ 2x25mm^2 or 4x11mm^2 for boxes with 6 meters of 5/20A

+ 2x16mm^2 or 4x7 mm^2 for boxes with 6 meters of 3/9A (or 5/20A meter box)

+ 2x11mm^2 or 4x6 mm^2 for boxes with 4 meters of 3/9A (or 5/20A meter box)

+ 2x7mm^2 for boxes with 2 meters of 3/9A

4) The conductors coming to a multi-meter box, close to a house or far from low voltage poles, should be selected as 2x16mm^2, 2x25mm^2, or 2x35mm^2 depending on the number of meters and conductor length.

4-1.3. Conductor Arrangement on Poles.

1) Depending on specific requirements of the line corridor and the pole height the conductors could be arranged on the pole in horizontal or vertical plane. If the conductor is arranged in horizontal plane, the neutral wire must be on the same level as the phase wires. If it is arranged in vertical plane, the neutral wire must be placed lower than the phase wires.

2) The distance between conductors is to be selected in accordance with the guidelines given in Chapter 1. However, the distance between conductors on the pole position must satisfy the following requirements:

+ For bare conductors the distances between conductors must not be less than distances stipulated in the following table:

Pole spans (m)	up to 30	40	50	60	70	> 70
Distances between horizontal conductors (m)	0.20	0.25	0.30	0.35	0.40	0.50
Dist. between vertical conductors (m)	0.40	0.40	0.40	0.40	0.40	0.40

+ The distance from the conductor to the pole or beam must not be less than 0.05m.

+ For covered conductors, the distance between conductors and from conductor to pole or beam is allowed 50% of the distances in above table.

+ The distance between the line circuits on common poles must not be less than 0.4m.

+ An insulated cable, which cannot take mechanical forces, utilised for a main line, must be mounted on a tensioned suspension wire by fastening fibre. The tensioned suspension wire must be of non-corrodible metal or Zinc-plated. The fastening fibre is to be made of stainless steel with a diameter of 0.5 – 1.0 mm. The distance between fastening fibres is not to be less than 1.0 m.

3) In the case that low-voltage lines are going on common poles with medium-voltage lines it is permissible to install a low-voltage pole directly under the medium-voltage line.

In this case, the distance between medium voltage and low voltage conductors on the interposed pole shall be the same as on the common poles.

4) The distance between the low voltage and the medium voltage conductors (for the phase) along the line in normal operation must not be less than the distances given in item 5) of 1-10.1.

5) In case that low and medium voltage lines are on common poles and utilising a common solidly grounded neutral, it is not allowed to place the neutral below the phase conductors of the low voltage line and the cross section of the common neutral must be selected to satisfy the requirements for both the medium and low voltage lines.

6) When conductors of outdoor lighting lines are going on common poles with LV main lines, they are allowed to be installed under the neutral wire

7) Pole-mounted fuses must be placed lower than conductors for convenient repairing and replacement.

4-2. Insulators and Accessories

4-2.1. Insulators and Accessories

1) Insulators for LV lines in rural areas must be in accordance with regulated technical standards, and their mechanical safety factor (ratio between destroy load and maximal tension of the conductor) must not be less than 2.5

2) For LV overhead lines, depending on the conductor arrangement on the pole, the pin-type or line post type of insulators can be utilised

Pin-type insulators are installed as:

+ One pin-type insulator supporting one conductor on straight supporting pole.

+ Two pin-type insulators support one conductor on the angle stay and braking stay poles.

3) When utilising line post insulators, one insulator is placed for straight, angle supporting or staying conductors by direction, satisfying suspension tension requirements for an insulator on the pole position. In case, there are needs to place several conductors on an insulator, multi-shade or multi-buffer insulators must be utilised. Do not heap up conductors on an insulator. Insulators for supporting or staying conductors must be slung to the crossarms or racks.

4) All accessories as insulator pins, studs and cable clamps must be made in accordance with Vietnamese standards. The requirements on safety factor for accessories are applied in the same way as for medium-voltage lines.

5) LV conductors can be joined by pressuring, welding or clamping on positions, where joints are permitted.

6) The string for tying on insulator necks is single fibre aluminium wire with a cross-section of 3.5 mm^2.

7) On meter mounted poles, the conductor after the meter are to be installed on pin-type of ovoid insulators (do not utilise the click fuse) before going into the house. It is

categorically forbidden to wind a conductor round the pole, the insulator pin or the crossarm to avoid scratching of conductor, causing current leakage to the pole body and steel components.

8) If the meter is mounted at the house of a customer, the conductors coming to the house are to be installed on pin-type insulators placed on the steel or wooden supporting beam.

9) On wooden intermediate supporting poles the conductors coming to the meter can be screwed to pin-type insulators or hanged directly on the wooden pole with a notice to avoid scratching the conductor

4-3. Grounding

4-3.1. Grounding Positions

1) For independent LV lines, the lightning protection and repeated groundings are to be combined and placed by intervals of 200 – 250m in densely populated areas and 400 – 500m in sparsely populated areas.

2) For LV lines going on common poles with MV lines, the grounding is stipulated in Item 3-3.1.

3) All positions of T-branches, terminal staying, traffic road crossings or on poles where the conductor cross-section is changed must be grounded.

4) Installation of LV arresters is recommended for LV cabinet and for T-branch poles.

4-3.2. Grounding Resistance

1) For independent LV lines:

+ The grounding resistance must not be more than 50Ω for lines passing areas with a lot of buildings and trees, and where the risk for the line to be struck by lightning is small.

+ The grounding resistance must not be more than 30Ω for lines passing exposed areas.

2) For LV lines going on common poles with MV lines, the grounding resistance must not only satisfy the requirements for independent LV lines, as mentioned above, but also for MV lines.

3) All steel meter boxes with single insulators of meters must be grounded with a grounding resistance of not more than 50Ω. In case the meter boxes are made of composite or steel with double insulators, the box grounding is unnecessary.

4-3.3. Types of grounding

- Grounding by pile, beam rods or pile-beam combination sets:
- The technical requirements for grounding sets are as stipulated in 2-4.2.

4-4. Poles

4-4.1. Pole Types

1) The selection of LV poles must be based on the requirements for tension sustainability, aesthetics, and availability, conditions of transportation, maintenance, operation and economy.

2) LV line poles could be metallic; rectangular concrete, centrifugal concrete, pre-stressed centrifugal concrete or wooden, bamboo ones with anti-rotten treatment according to the

requirements depending on the specific feature of the line. The safety factor for steel and steel core concrete poles should not be less than 1.5, and for wood and bamboo ones it should not be less than 3.0.

+ For three- and single- phase main lines and branches:

Poles utilised for LV lines are to be rectangular concrete poles with a height of: 6.5m, 7.5m and 8.5m, or pre-stressed centrifugal concrete poles with a height of 8.0m and 8.5m. On special positions as a crossing span, the height of poles can be increased to 10m; 12 m.

Centrifugal concrete poles should be utilised only for lines: i) going on common poles with MV lines, ii) passing towns or areas with high aesthetic requirements; or going along national or provincial roads, iii) passing salty polluted areas and, iv) in areas, where it is impossible to transport rectangular poles to the construction site.

+ For branches to domestic customers:

In the case the distance from the line to a house is not more than 20m, the conductors (cables) can be placed directly from the pole to the house by staying the conductors (cables) tightly on the pole and the home gable.

When the distance is more than 20m, the conductors (cables) can be supported by a plated steel wires or intermediate supporting poles made by wood or bamboo fixed in the ground without foundations, the minimum height of the poles must be 5.0 m and the minimum diameter of the top part of the pole must be 80mm, if the conductors (cables) are not passing automobile roads.

4-4.2. General Design of the Poles

4-4.2.1. All straight, angle supporting poles are single poles.

4-4.2.2. Double poles are utilised for angle, terminal and T-branch stay poles with suspension loading requirements greater than the permitted loading limit. In case the lines pass sparsely populated, large square areas, where stay wires can be placed, the double poles should be replaced by single poles with stay wires and foundations for the stay poles. It is not allowed to place stay wires close to traffic roads or locations, where inhabitants and domestic animals are often passing. Stay wires can be steel cables or steel rods, zinc-plated or anti-corrosive painted with cross sections of not less than $25mm^2$.

4-4.2.3. In locations, where LV lines are going on common poles with MV lines (the lines constructed at the same time), the selection of the pole type and checking the tension sustainability of the pole structures should be considered in the technical document of MV lines.

4-4.2.4. In case, new LV lines are installed on an existing MV poles, it is necessary to check the physical-mechanical characteristics and structure of the poles and pole foundations and to take measures for tension sustainability reinforcement of the existing structures (if needed).

4-4.2.5. For LV lines, except 3-phase, 4-wire and single phase, 2-wire configurations, the single-phase, 3-wire configuration should be additionally developed.

The pole span of LV lines can be in a range of 30-70m, but exceptionally less than 30m or more than 70m.

4-5. Hardware (Crossarms and Braces)

4.5.1. Crossarm and Brace Configurations

Depending on the conductor arrangement on poles, the crossarm configuration can be selected as follows:

- Horizontal configuration (supporting or staying) for supporting and stay poles, when conductors are placed in a horizontal plane and pin-type insulators are utilised. There are two kinds of horizontal crossarms: the single kind utilised for supporting poles (each phase conductor placed on an insulator) and the double kind utilised for stayed, crossing poles (each phase conductor placed on two insulators.

- Rack for the poles, when conductors are placed in a vertical plane, along the pole trunk and utilising line post insulators.

4-5.2. Crossarm and Brace Material

- All crossarms and racks are to be made by geometric steel, zinc-plated (by heat dipping) with a minimal thickness of 80μm or covered by anti-corrosive paint. For branches to households the crossarms can be made by wood with anti-rotten treatment. The mechanical safety of steel crossarms, racks and wooden crossarms is not less than 1.5 and 3.0 respectively.

- Bolts and nuts are to be plated with zinc and made in compliance with Vietnamese Standards.

4-6. Pole Foundation and Stays

4-6.1. Foundation types

4-6.1.1. Box-type foundations

- This type of foundations are to be applied for regions, sustaining direct affect of storms, for areas where the ground basis geology along the line route is changing a lot, for areas where the topography is sloping and the foundation surface are easily changing by environmental conditions.

- The depth of other parts of poles to be fixed in the ground is to be 10% of the pole height. When constructing the foundations of centrifugal concrete poles, it is necessary to place a Mark of 200 concrete plate of 500x500x50mm size at the bottom.

- Box-type foundations are to be cast on site of concrete with the Mark of M100.

4.6.1.2. Well-type foundations

- This foundation is applied for the lines passing sandy dunes along the seaside, at river bank locations with sand drifting and difficult conditions for the construction.

- The depth of the part to be fixed in the ground is 14%-16% of the pole height.

- The well-type foundations are to be cast of concrete mass with the Mark of 200 and with a diameter of 600-700-800-1000mm.

- Concrete with the Mark of 100 should be utilised for the inside of the foundations.

4-6.1.3. Reinforced ground foundations (the pole fixed in the ground without foundation)

- This type is applied for supporting poles of branches with small cross section conductors, low-tension sustainability requirements and passing areas of flat topography and where the ground basis is good and has steady geological conditions, with a pressing sustaining strength $R_N \geq 2 daN/cm^2$, density $\beta < 0.7$, friction angle $\varphi > 15^o$ and not being friable in the water.

- The depth of the part of poles to be fixed in the ground is 12% - 15% of the pole height.

- When constructing reinforced ground foundations it is necessary to conserve the natural status and landscape surroundings. The soil for foundation holes must be poured by layers with a thickness of 0.2m each and solidly wedged with 0.4 m higher than the ground surface for avoiding erosion.

4-6.1.4. Beam-type foundations

- This type is applied for regions not directly under affection of storms, and for areas, where the geological conditions of the ground basis along the line routes is rather stable, and where the pole base is not affected by environmental fluctuations.

- The depth of the part of poles fixed in the ground is to be 16-18% of the pole height.

- The beam placing position (bolting position) must be 0.5 m bellow stable natural ground surface. The following beam arrangements can be utilised:

  One beam for supporting poles.

  Two beams parallel placed for supporting poles and perpendicularly placed for stay poles of the lines passing areas with poor geological conditions and easily sunk position.

- All beams are to be made by pre-cast reinforced concrete with the Mark of 200.

- The safety factor of pole fundaments must not be less than 1.3.

4-6.2. Treatment of foundation basis in special conditions

1) In case the pole foundations are often under salty water, or water contained with concrete corrosive elements, utilise glass-type foundations with elevation of the upper surface higher than the permanent level of salty water, and the foundation bottom elevation bellow the pole bottom for protecting the steel core concrete of the poles. In this case the foundation material must be un-penetrable and of anti-corrosive concrete.

2) In case the ground basis has too low pressing sustaining strength (muddy soil, clay, etc.), take measures for strengthening the ground basis by concrete, bamboo, indigo, piles or load distributing sand bed, etc.

4-6.3. Pole stays

1) In areas, where it is allowed to install stay-wires for supporting load sustainability of angle, straight and terminal stay poles, utilise stay-wire sets and stay foundations.

2) For the stay-wires utilise steel cable or slippery steel rods plated with zinc and with a length corresponding to the selected pole design.

3) The stay foundations are pre-cast by steel core concrete with the Mark of 200 and placed at least 1.5 m under the natural ground surface.

4) The regulations on design and construction of LV line stay-wires and foundations is the

same as for those of MV lines.

4-7. Aerial Bundled Cables (ABC)

4-7.1. Do not place LV ABC line under ground.

4-7.2. The ABC accessories must be appropriate with utilising requirements. In construction works the tools used must be in accordance with guidelines of the supplier.

4-7.3. In case ABC lines are going on common poles with other overhead lines of system voltage above 1kV, the ABC lines are considered as lines covered by insulation and the distance standards should be applied as those stipulated in Item 4-1.3.

4-7.4. The clearance distances for LV ABC lines are to be:

Not less than 6.0m and 5.0m to the ground, at maximum sagging, for densely and sparsely populated areas respectively.

On branches, entering into domestic customers, the distance by vertical plane to sidewalks or tracks is allowed to be reduced to 3.5m.

4-7.5. In case of placing ABC lines on building walls or along, inside structures, the distance from the cable to the wall or the structure must not be less than 5.0cm.

4-7.6. ABC technical characteristics are to be provided by the supplier or as referred to in the Annex.

4-8. Meters and Meter Boxes

4.8.1. Meters

4-8.1.1. Meter Types:

1) KVA meters of 3(9)A and 5(20)A are to be installed for domestic customers with a power consumption of up to 100 kWh/month and over 100kWh respectively.

2) KVA single-phase meters of 10(40)A and three-phase meters of 3x10(40)A, 3x10(30)A, 3x20(80)A and 3x50(100) are to be installed for enterprise and business customers with single or three-phase power consumption, respectively.

4-8.1.2. Meter placing positions:

1) All electrical consumption meters must be technically sealed off by lead from a state authorised agency and commercially sealed by lead by the power company.

2) The meters can be mounted on the poles; outdoor or indoor, but must ensure the objectiveness for both sides: the purchaser and the seller of electricity.

3) The meters are to be placed on a height of about 2.5 m if mounted on poles, and not less than 1.7m if mounted at houses.

4-8.2. Meter boxes:

1) Depending on practical requirements, a single- or multi-meter boxes should be utilised.

2) In each meter-box, a circuit breaker or fuse set of 20A, 30A or 40A must be installed, after the customer meter.

3) The meter-box is to be made of steel plates, covered by electrostatic paint, with single or double insulators of stainless steel plates with double insulators or of composite.

4) Meter-boxes are to be tight boxes (IP 43) with windows for reading figures, with opening possibilities for correcting and repairing fuses and circuit breakers etc. and with a lock for protecting purpose.

4-9. Safety Distances for LV Networks in Rural Area

4-9.1. Safety Distances:

1) For LV lines, the horizontal distances from the nearest conductor, at maximum deviation by wind, to parts of houses and other objects, should not be less than the distances stipulated in following table:

Characteristics of objects	Distances (m)	
	Bare Conductors	Insulated Conductors
Window, balcony, terrace, nearest part of bridges	3.0	2.5
Roof of buildings	2.5	1.5
Tight wall, trees	1.0	0,5
Tight wall and conductors placed on beams mounted on the wall with distance between beams less than 30 m	0.3	0.3
Petrol stations; fuel, chemical storages etc.	10.0	5.0

2) For cables, it is allowed to mount the cables directly to the wall or pass through a cable tube when placing along a bridge.

4-9.2. In the case, that LV power lines are crossing communication lines, the following requirements must be satisfied:

1) The power line must be placed above the communication lines and its conductors must not be connected on crossing spans.

2) The vertical distance from power conductors to communication conductors during conditions of no wind must be no less than 1.2m.

3) Power line poles that are higher than the communication cable (level I) must be of stay type with double conductors placed on two insulators.

4-9.3. Sound transmission lines and communication cables are allowed on common poles with LV lines if the following requirements are satisfied:

1) Having an agreement with the Electricity Management Unit.

2) Power lines are placed above other lines.

3) The vertical distance from power conductors to the conductors of sound transmission lines and communication cables is no less than 1.25m.

4) Sound transmission conductors and communication cables are placed on crossarms at a distance from poles of no less than 0.2m.

4-9.4. When LV lines are crossing HV lines the following requirements must be satisfied:

1) The HV conductors must be above the LV conductors and with a minimum cross section of $35mm^2$.

2) The vertical safety distances from the lowermost conductor of a HV line to the uppermost conductor of a LV line, under conditions of no wind, must be no less than the distances stipulated in following table:

Voltage level (kV)	Up to 15	22-35	66-110	220	500
Safety distances (m)	2.0	2.5	3.0	4.0	6.5

4-9.5. When LV lines are close to or parallel with HV lines or communication lines the horizontal distance between the nearest conductors, under condition of no wind, must not be less than 4m.

CHAPTER V

OFF-GRID POWER SYSTEM

5-1. Demand Forecast

5-1.1. Off-grid area is an area, where the national power grid at present and in about 5 years later is not available according to the Master plan for power development.

For such areas, the demand forecast should be better to implement by direct survey. In case, that a direct survey can not be done, the peak demand (P_{max}) in the evening time of an area, for example a village with about 30-50 households, may be defined as follows:

No	Customer category	Size	Peak load(night time)/customer(kW)
1	Households	1-3 people	0.35
2	Households	4-6 people	0.45
3	Households	more than 6 people	0.55
4	Farm	1-3 people	0.70
5	Farm	more than 3 people	1.00
6	Shop	2 people	0.20
7	Workshop	1-2 people	0.50
8	Workshop	more than 3 people	0.70
9	School	2 people	0.30
10	Health Clinic	2 people (*)	0.30

(*) It is estimated that there are 2 permanent teachers living in the school and there are 2 employees working and consuming electricity in the evening time in the Medical station.

Based on an estimate of the number of each customer category, the total maximum peak load ($\sum P_i$) of a village can be defined. Then the calculated peak demand (Pmax) for designing the network for the village is defined by multiplying the total maximum peak load with the simultaneous factor (Kdt) of 0.6-0.7.

5-1.2. Power and energy demand for irrigation and drainage is the same as stipulations made in 1-3.3.2 and 1-3.3.3.

5-2. Generation Facilities

5-2.1 In areas where the national grid does not exist at present and in the coming 5 years, depending on the demand forecast and renewable energy (RE) potential (micro-hydro, wind, solar, biogas, biomass), the local power generation facilities such as micro hydro plant (MHP), wind turbine, solar set (PV), diesel generator... or hybrid system combining these sources, can be developed. The capacity of the generation source (except for PV) must be selected to satisfy the electricity consumption, not only at present but also in 5-10 years in the future.

5-2.2 In Off-grid isolated networks, it is important that the generating facilities can control the voltage quality and are equipped with under voltage relays, which will trip the generation if the voltage is higher or lower than limitations set.

5-2.3 In case that the system has more than one generator, a synchronizing equipment must be installed for every generator to be operated in parallel.

5-2.4 At PV stations, due to being DC sources, DC/AC converters equipment must be installed to convert DC into AC for supply of customers and for connection of other AC facilities.

5-2.5 Materials and equipment, and construction and installation specifications for off-grid generation facilities must be utilised and applied in accordance withVietnamese Standards (TCVN) and International Standards (IEC).

5-3. Electricity Networks

5-3.1 In off-grid areas, depending on the distance of the power supply, the transmission and distribution networks must be erected at the standard voltage levels of 35kV, 22kV and 0.4kV for convenient connection with the national grid in the future.

5-3.2 For LV lines, which at present are suitable for single phase with 2 conductors, but in the future, when connected to the national grid, will become a three-phase main lines, their pole structures should better be selected as poles for three-phase four-wire lines temporarily utilised for two-wire lines installation for convenient changing in the future.

5-3.3 For LV lines from PV stations to households, cables with rubber insulation, with a cross section of 2x2,5 mm^2 or 2x6 mm2, with a maximal length of around 200 m, should be utilised.

The standards for materials, equipment and erection of off-grid electricity networks are the same as for on-grid areas as mentioned above.