THE SOCIALIST REPUBLIC OF VIETNAM

MINISTRY OF INDUSTRY

REGULATIONS
ON ELECTRICAL INSTALLATIONS

PART III

POWER DISTRIBUTION DEVICES AND ELECTRICAL SUBSTATION

11 TCN - 20 - 2006

HANOI – 2006

CONTENTS

PART III

POWER DISTRIBUTION EQUIPMENT AND ELECTRICAL SUBSTATION

Chapter III.1

POWER DISTRIBUTION EQUIPMENT, VOLTAGE UP TO 1 KV

Chapter III.2

POWER DISTRIBUTION EQUIPMENT

AND TRANSFORMER SUBSTATION WITH VOLTAGE ABOVE 1KV

Chapter III

BATTERY

PART III

POWER DISTRIBUTION EQUIPMENT AND ELECTRICAL SUBSTATION

Chapter III.1

POWER DISTRIBUTION EQUIPMENT, VOLTAGE UP TO 1 KV

Scope

III.1.1. This chapter applies to power distribution equipment (PDE), voltage up to AC 1 kV and up to DC 1.5 kV, indoor and outdoor, including: distribution, control panel and cabinet, relay and the output from the bus bar.

General requirements

III.1.2. To select wires, bus bars, electrical equipment, electrical meters and other structures under normal working conditions (working voltage and current, degree of accuracy, etc.) and the short circuit (thermal and electrical impact, maximum cutting capacity etc).

III.1.3. At the distribution panel, cabinet, the duties of each circuit and panel must be specified.

The duties list is placed on the front or back side of the electrical panel, cabinet. In case that the panel, cabinet operate on both sides, the list must be placed in the reverse side.

III.1.4. To arrange the circuits of the equipment so that the AC circuit, DC circuit and circuits having different voltage levels, etc. can be distinguished clearly.

III.1.5. Corresponding positions between the poles and phases in the distribution system must be arranged in the same way. The bus bars should be painted the colors according to the provisions indicated in the Chapter I.1 - Part I. The PDE should have a room to connect the mobile grounding devices.

III.1.6. All metal parts of the PDE must be painted, plated or coated with corrosion protection materials.

III.1.7. The grounding must be done under the provisions outlined in the Chapter I.7 - Part I.

Installation of power distribution equipment

III.1.8. The equipment shall be installed so that when operating, the electrical spark or arc in the equipment will not cause danger to the operator, to damage to the nearby equipment, to cause short circuit between phases or between the phase and the ground.

III.1.9. The switching devices must be arranged so that they can not switch off itself by the action of gravity. Normally, the moving element of the circuit breaker should not be energized after switching.

III.1.10. Knife-switch which is controlled manually (without no transmission device) for switching the load current and the contacting points toward the operator must have the protective case without holes or slits and the cover should be made of fire-proof materials..

If the knife-switch is only used for electrical insulation purpose, it is permitted to have slits providing that the unauthorized people can not access.

III.1.11. On the moving element of switching devices, the signs indicating the positions "ON" or "OFF" must be shown.

III.1.12. It is required to foresee the ability of switching off for each breaker for repairing or dismantlement. For this purpose, in the necessary positions, to place other knife-switch or other breakers.

It is not necessary to place circuit switching devices (knife-switching, fuse) before each outgoing line of the distribution panel, cabinet in the following cases:

• Circuit breaker withdrawable type.

• Fixed circuit breaker, during the repairing or dismantlement time of the circuit breaker, the switching off is carried out by the device of the circuit breaker group or by the entire distribution equipment.

• Fixed circuit breaker, if the dismantlement activity is ensured safe when the circuit is energized.

III.1.13. The screw socket type fuse must be arranged so that the power cord is connected to the bottom of the socket, and power cord to the electrical equipment is connected to the shell of the socket.

Bus bar, conductor and cable

III.1.14. The distance between the fixed un-insulated conductive parts and different poles, as well as between them and the un-energized un-insulated metal parts should not exceed 20mm on the surface of the insulating materials and 12mm in the air.

The distance from the energized parts to the trellis guard-net must be not less than 100mm, and 40mm to the panel’s guard-net which can be removed.

III.1.15. In the electrical panel cabinet located in the dry room, the wires that do not have the mechanical protection layer but insulated and can withstand the voltage 660V or above can be placed on metal surface being protected against corrosion and can be placed closely. Meanwhile, for the power circuit, to take into account the current reduction factor in accordance with provisions specified the Chapter II.1 - Part II.

III.1.16. The conductors and the bare bars used for grounding can not be insulated.

III.1.17. The control, measuring circuits, etc. must comply with the requirements outlined in the Chapter II.4 - Part II. The cable laying must comply with the requirements outlined in the Chapter I.3 - Part I.

Structure of power distribution equipment

III.1.18. Electrical panel should be made fire-proof materials, the over and other parts could be made of non-flammable or slow-burning materials. This requirement does not include electrical control board or boards of same kind.

III.1.19. The PDEs must be located and installed so that the shocks generated when the equipment operates, including the vibration caused by external impact do not affect the joints and do not cause the disturbance and unusual work of equipment and electric instrument.

III.1.20. If the surface of insulating materials easily get humid, and is not insulated coated, and on that there are energized equipment, it is required to protect it against moisture contamination (by impregnation or coating, etc.).

It is not allowed to use insulating materials that easily get humid (e.g. marble, cement, etc.) for equipment placed in humid room and for outdoor equipment.

For equipment that is place in the humid, dusty, extremely humid room and outdoors, it is required to protect them reliably against destroying impact of the ambient environment.

Installation of PDE in the power room

III.1.21. In the power room (see Chapter I.1 - Part I), the front lobby and rear operating corridor of the panels must meet the following requirements:

1. The corridor width must be greater than or equal to 0.8 m and its height must be greater than or equal to 1.9 m, in the corridor there must be no obstacles to the traveling and moving of equipment. In particular places where the building structures jut out blocking the aisles, the width of aisle should not less than 0.6 m.

2. The distance from the un-insulated energized parts which are not protected by guard-net, jut out most (for example: the cutting blade in the position OFF), located at the reachable height (under 2.2 m) on the side of the aisle, to the opposite wall or to the un-insulated energized parts of equipment which are not protected by guard-net, must not be less than the following values:

• With the voltage below 660V: 1.0 m in case that the length of the electrical panel cabinet row is up to 7m; and 1.2 m in case that length of the electrical panel cabinet row is over 7m.

• With the voltage 660V and above: 1.5 m.

In this case, the length of the electrical panel cabinet row is the length of the aisle between two rows of cabinets or between the row of cabinets and the wall.

3. The smallest distance between from the un-insulated energized parts which are not protected by guard-net and placed at the height below 2.2 m 2 on both side of the aisle must be:

• 1.5 m with the voltage below 660V.

• 2 m with the voltage 660V or above.

4. The un-insulated energized parts at the distance less than the value shown in the points 2 and 3 above need to be protected by guard-net.

5. The un-insulated energized parts which are not protected by guard-net, placed above the aisle should be at the height of at least 2.2 m.

III.1.22. To guard the un-insulated energized parts, it is possible to use the guard-net with holes whose size is not larger than 25x25mm, or to use the enclosed the guard-net without hole or the combination of both types. The guard-net height should not be less than 1.7 m.

III.1.23. The operating aisle of the electrical panel cabinet row with a length above 7m must have two doors. If the width of the operating aisle is longer than 3m and in the power room, there is not oil electrical equipment, the second door is not required.

The doors of the power distribution room must be opened to the outside or to the neighboring rooms (except the room with the PDE of over 1 kV AC and 1.5 kV DC). The doors must be self-closing from the inside and can be opened without the key. The width of the door should not be less than 0.75 m and its height should not be less than 1.9 m.

Installation of PDE in workshop

III.1.24. For the room where is located PDE is accessible for un-professional staff, to place guard-net to separate the energized parts.

In the case that the PDE has the un-insulated and energized parts, the guard-net is required. The guard-net may be the mesh type, closed type or mixed type, with a height of at least 1.7 m. The distance from guard-net are mesh type to the un-insulated energized parts of the equipment should not be less than 0.7 m, while for the guard-net closed type it should be in accordance with the Article III.1.14. The width of aisle should be in accordance with the requirements set out in the Article III.1.21.

III.1.25. The last part of the wires and cables must be put in the panel cabinet or equipment.

III.1.26. The guard-net removable type should be fixed to not be removed without using special tools. The door must be locked with keys.

III.1.27. The installation of PDE and the substation full set type should be in accordance with the requirements outlined in Chapter III.2.

Installation of outdoor PDE

III.1.28. When installing the outdoor PDE, to comply with the following requirements:

1. The equipment should be installed on the plane at an altitude of at least 0.3 m above the base; for electrical panel cabinet: At least 0.5 m.

2. Inside the cabinet, if requested, to arrange on-site drying to ensure the normal operation of the devices, relays, measuring instruments and power counting instrument in accordance with the requirements of current standards.

Chapter III.2

POWER DISTRIBUTION EQUIPMENT

AND TRANSFORMER SUBSTATION WITH VOLTAGE ABOVE 1KV

Scope and definitions

III.2.1. This chapter applies to fixed power distribution equipment (PDE) and voltage transformer substation (VTS) with voltage from 1 kV to 500 kV AC.

This chapter does not apply to special-use PDE and VTS under special conditions and mobile electrical equipment.

III.2.2. PDE is the equipment used for acquisition and distribution of electricity, including switchgear, control, protection, measurement instruments, conductors, insulators, architectural structures and auxiliary equipment (air compressors, batteries, etc.).

Outdoor PDE is the PDE whose devices or facilities are primarily located outside the building.

Indoor PDE is the PDE placed inside the building.

III.2.3. PDE full set is the electrical equipment that had been assembled or their parts are available for assembling, assembled into blocks, including all or a portion of the cabinet or blocks that are equipped with electrical equipment, control, protection, measuring devices and auxiliary equipment.

Indoor PDE full set is the PDE full set that is placed inside the building.

Outdoor PDE full set is the PDE full set that is placed outside the building.

III.2.4. VTS is the substation of transformers that to connect two or more power grids with different voltages. Additionally, VTS has the PDE, the control, protection and measuring devices and auxiliary equipment.

Types of TS: Outdoor and indoor.

III.2.5. Abutting VTS means the VTS that is located close to the main building.

III.2.6. Indoor VTS is the VTS that is placed within the main building.

III.2.7. Workshop VTS is the VTS placed in the factories (located in the same room or in a separate room).

III.2.8. VTS full set is the VTS equipped with the voltage transformers and blocks (indoor or outdoor full set power distribution cabinets, etc.) that had been assembled in whole or in blocks.

The VTS full set placed inside the building is called indoor VTS full set, outside the building called outdoor VTS full set.

III.2.9. On-pole VTS is the outdoor VTS whose all high-voltage devices are placed on the pole or on the overhead structure of the pole, at an altitude enough for electricity safety, without surrounding guard-net.

III.2.10. Gas Insulated Substation (GIS): Station that is equipped with the electrical equipment that is covered, gas (not air) insulated.

III.2.11. Switching station means the station which is equipped with switchgear, conductor and without power transformer.

III.2.12. Power compartment means the compartment that contains electrical equipment and conductive bars.

Closed compartment is the compartment that is covered all sides; its door is a solid panel (without trellis).

Guarded compartment means the compartment whose doors, holes are guarded completely or partially (by a steel grid or grid combined with panel).

Explosion-preventing compartment means a closed compartment used to contain the equipment which should be separated to limit the effects of the incident, its door is opened to outside or to exit way.

III.2.13. Operation corridor means the corridor that goes along the power compartment or PDE cabinet for operator to manipulate the equipment.

Exit way is the way that the door of the explosion-preventing compartment opens to.

General requirements

III.2.14. Electrical equipment, conductive parts, insulators, clamps, barriers, bearing structure, insulating distance and other distance must be selected and installed so that:

1. In the normal working conditions, the static and dynamic force, heat, electric arc and other phenomena (ignition, gas, etc.) do not cause damage to equipment, architectural structures, and short circuit between phases or between phase and ground and danger to humans.

2. In the abnormal working conditions, there is the ability to limit the damage caused by the short circuit.

3. When switching off the power of any circuit, electrical equipment, conductive parts and the structure the circuit, the check, replacement and repair could be carried out safely, without affecting the normal working mode of the neighboring circuit.

4. To ensure the easy and safety transportation of equipment.

The requirements set out in the point 3 do not apply to PDE in the station that is not powered during the repair.

III.2.15. When using open-style isolator for the no-load current of voltage transformer, the charging current or balanced current of power transmission lines, the distance between the conductive parts and between the conductive parts and the earth must be meet the requirements outlined in this chapter and of the corresponding technical guidelines.

III.2.16. When selecting electrical equipment, electrical parts, insulators, to consider the dynamic stability, thermal stability conditions, and for breaker, to consider the switching capacity and it is required to comply with the provisions outlined in Chapter I.4 - Part I.

III.2.17. The structure for installation of electrical equipment stated in the Article III.2.16 must withstand the active forces caused by the weight of equipment, by the wind in normal conditions, as well as the impact generated during the operation and by the short circuit.

The temperature caused by the current of the structures in the vicinity of the conductor that people can touch or can not touch should not exceed 50^{o}C and 70°C respectively. It is not necessary to check the temperature of the structures in the vicinity of the conductive parts with the DC nominal voltage 1kA or below.

III.2.18. In the circuit of PDE to place the isolating device of which the cutting element is visible to know that it separates the electrical equipment (circuit breakers, current transformers, voltage transformers, fuses, etc.) at each circuit from the conductive bar as well as from other power sources.

This requirement does not apply to the PDE full set (including GIS), radio-frequency choke and communication capacitor, capacitive voltage transformer located at the bus bar and the output line,

lightning arrester placed at output line of voltage transformer or the output line or at the voltage transformer whose input line is a cable.

In individual cases, as per required by the structure or diagram, it is possible to place current transformer before isolator used to switch the remainder of equipment of this circuit from the power resource.

III.2.19. The circuit breaker or its drive must have a visible and robust working indicator. It is not allowed use light as the unique indicator of the working position. If the drive is separated by wall from the breaker, an indicator on the breaker and the drive is required.

III.2.20. If PDE and VTS are located in the area where the air contains substances harmful to equipment and the conductor, reducing the insulation level, to take measures to ensure the equipment reliability and safety, such as:

• To use the enhanced insulator.

• To use conductive materials which can withstand the impact of the environment or to be painted for protection?

• To arrange them against the direction of harmful wind.

• To use simple diagrams.

• To use closed type PDE and VTS or GIS.

• To take anti-dust, harmful gases and water vapor measures for PDE room.

For the outdoor PDE and VTS placed near the coast less than 5 km, chemical factories etc., where, according to the long-term operational experience, aluminum is corroded, it is required to use or aluminum or aluminum alloy wires with corrosion protection, or to use copper conductors.

III.2.21. For PDE and VTS placed at the elevation 1,000 m above over the sea level, the insulating air gap, insulators and insulating material of the equipment must be selected according to the requirements stated in the Article III.2.52 , 53, III.2.88, 89, consistent with the decreased insulating ability due to the atmospheric pressure reduction.

III.2.22. PDE and VTS conductors are commonly aluminum wire, steel-core aluminum wires, aluminum tubes or bars, aluminum alloy, copper wires, copper or copper alloy bar.

When the pipe is used, it must be sealed.

The conductive bar can only be used when they meet the requirements outlined in Chapter II.2 - Part II.

III.2.23. The phase symbols of electrical equipment, conductive bar of PDE and VTS must conform to the requirements stated in Chapter I.1 - Part I.

III.2.24. For PDE with voltage 6 kV or above, the interlock is required to avoid the following abilities:

• The circuit breaker is switched off, while the earthing blade of the isolator is still grounded.

• The earthing blade to the conductive bar is switched off when the conductive bar is still charged.

• The isolator is switched off and on when its structure and technical characteristics do not allow doing it.

At the earthing blade at the line of the isolator, to place just the mechanical interlock with the drive of that blade and to lock earthing blade with the foreign lock when the blade is at the position OFF. If the interlock is electrical, monitoring equipment is necessary to make sure that the lines are not energized before switching off the earthing blade.

For the PDE which have a simple schema, it is recommended to use the mechanical interlock. For the remaining cases, to use the electromagnetic type interlocks.

The drive unit of isolator must have a room to put a lock at OFF position and at ON position when the blade is placed in a location that people can access.

III.2.25. For PDE and VTS with voltage above 1kV, it is recommended to use fixed earthing blade to ensure the safety of the grounding of equipment and bar, usually the mobile earthing blade is not used.

The earthing blades must be painted black; the drive of the earthing blade should be painted red, while the other drives must be painted the color of equipment.

In the places where the fixed earthing blade can not be used, there must be on the conductive bar and the grounding bar must have points to connect the mobile earthing wire.

It is recommended to combine the bus bar with the isolator (if any) of the bus bar voltage transformer or the isolator of the communication breaker.

III.2.26. The height of fabric type guard-net or fabric and panel mixed type of the conductive parts or electrical equipment must be 1.8 m compared with the base of outdoor PDE and VTS (taking into account the requirements of the Article III.2.63, III.2.64). For indoor PDE and TS, the height must be 1.9m.

The smallest size of the mesh of the fabric is 10 x 10mm and not larger than 25x25mm and the guard-net must be equipped with a lock.

The guard-net must be made of fire-proof materials. The outer guard-net must comply with the requirements stated in the Article III.2.38.

It is allowed to use the barriers at the entrance to the breakers' room, VTS and other electrical equipment for the operator to stand outside the barriers to observe the power devices when they are energized.

The barriers must be placed up to the height of 1.2 m and can be moved out: If the base of the room is more than 0.3 m above the ground, the horizontal distance from the bars to the door must not be less than 0.5 m or to there must be a place in front of the door to observe the equipment.

III.2.27. In some necessary cases, to take measures against the corresponding force (using the soft connector plate, reducing wires tension, etc.) to prevent the deformation of the wires and bars due to temperature changes, vibration etc. that can generate dangerous mechanical stress to the wire, conductor or insulator.

III.2.28. Oil level, oil heat indicator of for VTS and oil equipment and other indicators must be placed in the locations that facilitate observation and safety, without switching of the power (e.g. in the aisle, at the entrance to the room). In special cases, it is allowed to use mirrors.

To take oil samples, the distance from the floor or ground to the sampling valve of the VTS or to the oil equipment should not be less than 0.2 m or appropriate measures should be taken.

III.2.29. The wires of the protection, measuring, signaling circuits, etc. and of the lighting equipment must be oil-resistant insulated.

III.2.30. TS, reactance windings, capacitors and other electrical equipment located outdoors must be painted bright enough to reduce the heat by direct solar radiation. The paint must withstand the effects of the atmosphere and oil.

III.2.31. PDE and VTS must be illuminated by electrical light.

The independent backup emergency lighting source is identified by each specific project.

The lighting equipment must be located so as to ensure the safe and convenient operation.

III.2.32. PDE and VTS must be equipped with communication equipment in accordance with the requirements of the operation of the system.

III.2.33. To ensure the base of the PDE, VTS against the flood/inundation, the landslides etc. in accordance with the provisions of the current construction regulations.

III.2.34. To pay attention to the possibility of using motorized means to transport, assemble and repair the PDE.

III.2.35. The distance between the PDE and VTS to over 4 m high trees must be long enough to avoid the tree collapse causing the problem.

II.2.36. For PDE, and VTS located in residential areas and industrial projects, to take measures to reduce noise caused by electrical equipment (transformers, synchronous compensator etc.) caused (see Chapter I.1 - Part I.)

III.2.37. For PDE and VTS with regular on-duty operator, there must be water supply and toilet. In PDE and VTS located far from residential areas, the rest rooms are required.

For VTS with voltage 110kV or higher, with irregular on-duty operator, near water supply (up to 0.5 km), there should be a system of water supply and toilet.

III.2.38. For outdoor PDE and TS, the guard-net with the height at least 1.8 m is required. The guard-net may be higher than 1.8 m as per the special requirements of the substation. For auxiliary works (repair shop, warehouses, etc.) within the outdoor VTS area, and for PDE or VTS within power plants, industrial plants areas, there must be internal guard-net 1.8 m high.

The guard-nets may be close, open or fabric types.

The guard-net is not necessary for:

• Indoor TS.

• VTS close-type.

• VTS on the pole (see also Article III.2.140).

III.2.39. The metal structure of indoor, outdoor PDE and TS, and underground sections of metal structures and exposed metal parts of reinforced concrete must be protected against corrosion.

III.2.40. In oil PDE, VTS and equipment (except VTS on the pole), the oil collection system is required

III.2.41. For TS, it is recommended to use the AC power as the equipment operation source, if it is simple and inexpensive while the reliability of work of equipment is still ensured.

Outdoor distribution and voltage transformer substation

III.2.42. Along the circuit breakers in the outdoor system with the voltage 110kV or higher, there must be a way for the circulation of assembling, repairing and testing facilities. The width of the way should not be less than 3.5 m (see Article III.2.80).

In the narrow space, it may not comply with this width, but to ensure the safety distance to the electrical equipment as per required by the Article III.2.65.

III.2.43. The soft wire must be connected by compression tap. The joints, branch joints between the poles, the connection at the clamp wires to devices made by compression tap or slot welding. When connecting the branches, do not cut the wire of the pole span.

It is not allowed to connect by means of soldering (tin, silver etc.) and to twist wires. It is allowed to connect by specialized bolts or connectors at the clip and at the wires to the equipment.

The connector between the copper and aluminum wire must be the specialized (against the electrochemical corrosion).

The insulator string to hang the conductive bar of the PDE is usually single. If the single insulator string does not meet the application requirements of the mechanical load, to use double insulator string.

It is not allowed to use insulator string to split wires (disconnecting), except the case to use as insulator string to hang the high-frequency choke.

The connection of the soft conductive bar and lightning wires to the cable tightening and supporting lock should satisfy the requirements on the durability outlined in Chapter II.5 - Part II.

III.2.44. The shunt lines from the system are often below the conductive bars. The shunt lines in the same pole span are not allowed to be above two or more segments or other conductive bars systems.

III.2.45. The wind load effecting on conductors and structures, as well as the calculation temperature of the air must be determined in accordance with the provisions outlined in Chapter II.5 - Part II.

When determining the force acting on the soft conductive bar and the top of insulating material of the equipment or TS, to calculate the weight of the insulator strings and shunt lines down the equipment and the TS.

When determining the force acting on the structure, to also calculate the weight of people who carry tools and assembly facilities as follows:

• 250 kg for the 500 kV pole.
• 200 kg when using the suspended insulator for tightening pole up to 220kV.
• 150 kg when using the suspended insulator for supporting pole up to 220kV.
• 100 kg when using post insulated.

III.2.46. The mechanical safety factor (compared with tensile stress) for the soft conductive bar, under the active force as stated in Article III.2.45, should not less than 3.

III.2.47. The mechanical safety factor (compared to allowed collapse load) for the suspended insulators under the load corresponding to the requirements stated in Article III.2.45, should not less than 4.

III.2.48. The calculation mechanical force transmitted from the hard conductive bar to the post insulator at the short circuit must be taken under the provisions outlined in Article I.4 I.4.16 Programs - Part I.

III.2.49. The mechanical safety factor (compared to allowed collapse load) for accessories of the soft conductive bars when the loads correspond to the requirements given in Article III.2.45, should not be less than 3.

III.2.50. The pole that holds the conductive bars of the outdoor PDE should be the reinforced concrete or steel, if it is steel, to take measures against corrosion.

III.2.51. The pole that holds the conductive bars of the outdoor PDE should be as the last tightening pole or support poles as specified in the Chapter II.5 - Part II.

The intermediate pole that is temporarily used as last pole should have the tightening reinforced wire.

III.2.52. The insulation of substation should be selected by the standard of the insulation surface distance (16mm/kV, 20mm/kV, 25mm/kV or 31mm/kV), calculated by the highest effective voltage under operation, depend the environment condition, and not lower than the insulation of the power lines connected to the substation.

The number of suspension insulators of the substations should be selected by:

• The formula in the Article II.5.54 - Part II, plus 01 insulator for 220kV or below substations. According to the Article II.5.57 - Part II, plus 02 or 03 insulators for 500kV substation.

• For the gate pole of 35V substation connected to the overhead lines with lightning wire that does not go to the station, to increase the number of insulators by 2 (under Article III.2.144).

III.2.53. If the hard bus bar is used, the smallest gap N between the energized parts to the earthing parts or between the energized parts of different phases, should not be shorter than the values specified in the Table III.2.1 and the Table III.2.6 (Figure III.2.1.)

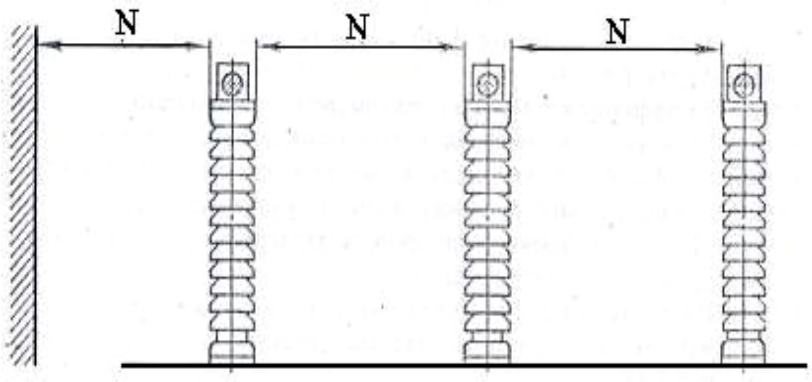


Figure III.2.1: The smallest gap between the conductive parts the different phases and between them and the grounding parts, for hard bus bars

III.2.54. If the smallest gap between the energized parts is under anti-phase condition, to take the value that is 20% larger than the values given in Table III.2.1 and III.2.2.

Table III.2.1: The smallest gap of indoor and outdoor substations for voltage levels up to 220kV

Nominal voltage of the system (kV)	Highest voltage of equipment (kV)	Voltages that withstand the short-duration industrial frequency (kV)	Voltages that withstand lightning impulse 1,2/50μs (peak value) (BIL) (kV)	Smallest gap phase-phase and phase-earth N (mm)	
				Indoor	Outdoor
6	7,2	20	60	130	200
10	12	28	75	130	220
15	17,5	38	95	160	220
22	24	50	125	220	330
35	38,5	75	180	320	400
	40,5	80	190	350	440
110	123	230	550	1100	
220	245	460	1050	2100	

Notes:

• The voltage that withstands the short duration industrial frequency is the sinusoidal value of the industrial effective frequency of about 48Hz - 62Hz within the time of 01 minute.

• The smallest gaps for the voltage levels greater than 35kV indoor and outdoor are the same.

• The smallest gap is taken according to voltage levels that withstand the highest lightning impulse for each voltage level.

III.2.55. The smallest gap between the energized parts that have different insulation levels, should be at least equal to 125% of the gap of the higher insulation level.

III.2.56. If the conductor is displaced by the impact of short-circuit strength, the gap should be at least 50% of the smallest gaps indicated in the Table III.2.1 and III.2.2.

Table III.2.2: The smallest gaps of the substation of the voltage of 500kV

Nominal voltage of the system (kV)	Highest voltage of equipment	Voltage that withstands the short-duration industrial frequency (kV)	Voltages that withstand lightning impulse 1,2/50μs (peak value) (BIL) (kV)	Voltage that withstands the nominal switching impulse phase-earth 250/2500 μs (kV)	Smallest gap phase-earth N_{p-e} (mm)		Voltage that withstands the nominal switching impulse phase-phase 250/2500 μs (kV)	Smallest gap phase-phase N_{p-p} (mm)	
					Conductive bar - earth	Pole-earth		Conductive bar – Parallel Conductive bar	Pole – Conductive bar
500	550	710	1800	1175	3300	4100	2210	6100	7400

III.2.57. If the conductor is displaced by the wind, in the most unfavorable case, the gap should be at least equal to 75% of the smallest gaps stated in the Tables III.2.1 and III.2.2.

III.2.58. If one of insulator strings is broken, the real gap it must at least equal to 75% of the smallest gaps in stated in Tables III.2.1 and III.2.2.

III.2.59. If the neutral point is not grounded in the work that is powered by auto-connected TS, the insulation level of the low voltage side is to be taken as the insulation level of the high voltage side. The requirement of the insulation of the neutral point is determined by the method of grounding of the neutral point that was used.

III.2.60. When the soft bus bar is used, the gap between the energized parts and the grounding parts or between energized parts of the phases N_m (with U≤ 220kV), arranged in a horizontal plane (Figure III.2.2) should not be not less than:

$$N_m = N + a$$

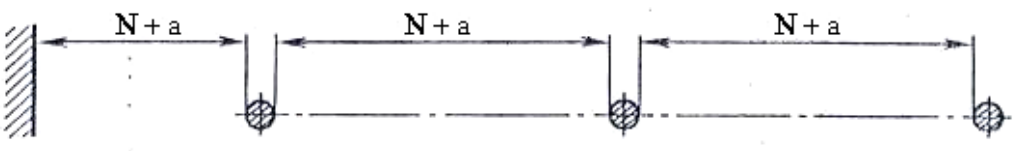


Figure III.2.2: The smallest gap between the conductive parts the different phases and between them and the grounding parts, for soft bus bars

Where:

a = fsinx

f = sag of the conductor in the annual average temperature +25^{0}C (m)

x = arctg(P/Q)

Q = Weight of 1m of conductor (daN/m)

P = Wind pressure on 1 meter of conductor (daN/m), the wind speed is equal to 60% of the values for the calculation for the construction structures.

Particularly for the voltage 500kV, when using soft conductive bars, the gap between phases is: $N_{(p-p)m} = N_{(p-p)} + a$; and $N_{(p-e)m} = N_{(p-e)} + a$

III.2.61. If the equipment is located at the elevations above 1.000 meters over the sea level, the gap N and Nm have to be increased for every 100m by 1000m, the gap by 1.4%.

III.2.62. The smallest gaps between the energized phases and at the time when they are nearest under the impact of short-circuit current should not be smaller than the smallest gaps required in the articles III.2.56 and III.2.60.

If in a phase there are multiple soft wires, the clamp or the positioning frame between the wires are required.

III.2.63. The horizontal gap between the conductive parts or the insulating parts that have energized parts and the fixed internal guard-net is defined as follows (Figure III.2.3):

• For the blind guard-net, the lowest height is 1800mm, the smallest gap is:

$$B_1 = N$$

• For high-voltage equipment, Um> 52kV, protected by trellis or holed guard-net with the protection grade IP1XB (for IP code, see Annex II.1 - Part II), the lowest height of 1800mm, the smallest gap is :

$$B_2 = N + 100 \text{ mm}$$

• For high-voltage equipment, Um≤ 52kV, protected by trellis or holed guard-net with the protection grade IP2X, the lowest height of 1800mm, the smallest gap is:

$$B_3 = N + 80\text{mm}$$

For soft trellis, to increase the above gap, as they could stir.

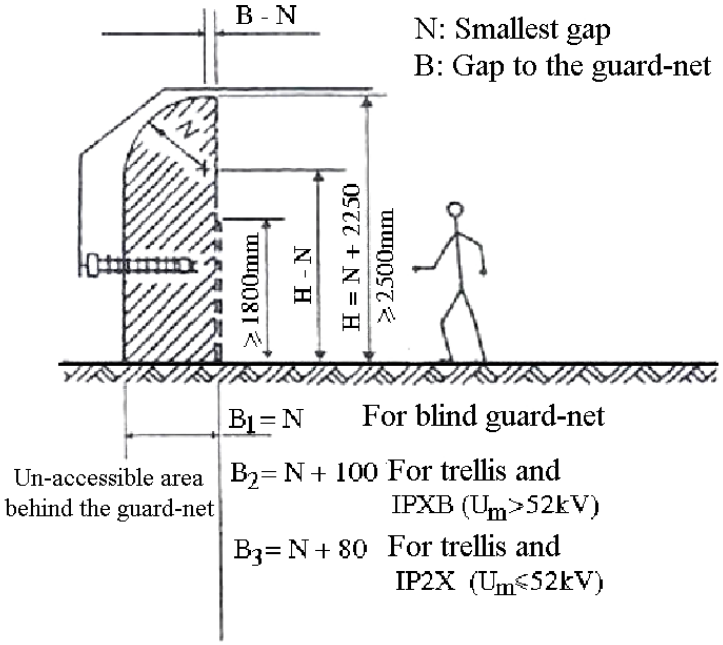


Figure III.2.3: Protection against the contact to the energized by guard-net (in mm)

III.2.64. Regulation on the smallest gap between the carrying power parts and travel area in the substation:

a. The height of carrying power part of the bus bar and the shunt to the equipment in the substation to the roads should not be smaller than the value H ′below (calculated at the biggest sag of the line) (Figure III.2.4)

$$H' = 4300mm \text{ when } Um \leq 52kV$$

$$H' = N + 4500mm \text{ (minimum: 6000mm) when } Um > 52kV$$

b. The height between the energized parts of conductor connected from the bus bars to the equipment and the travel area (without road) should not is smaller than the value H below:

$$N + H = 2250mm \text{ (minimum: 2500mm)}$$

c. The conductive parts without guard-net connecting the capacitor dividing type of the high frequency communication equipment, remote control and protection equipment to the filter must be placed at the height at least 2.5m. The filter should be located at the appropriate height so that when repairing, setting it is not necessary to switch off the equipment that is connected to it.

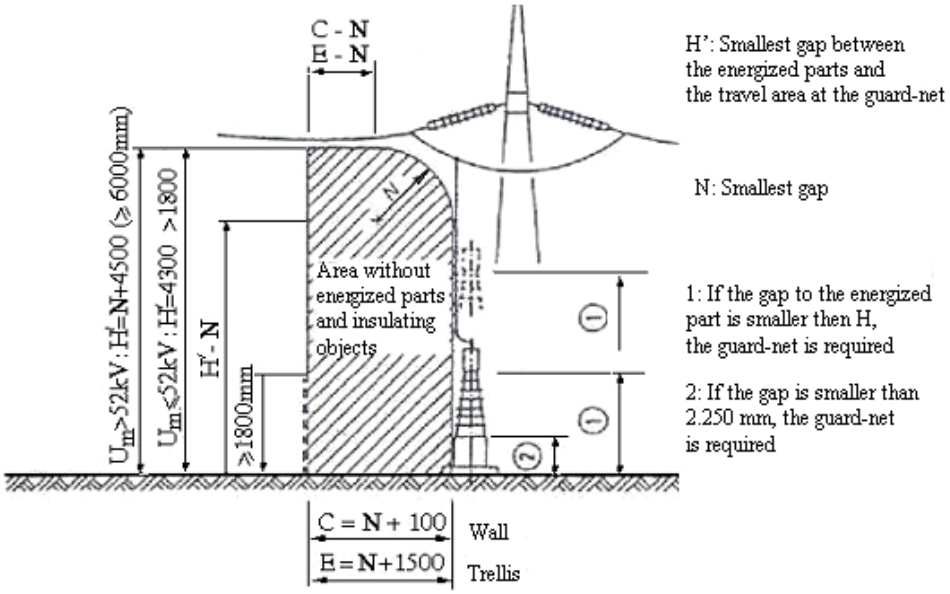


Figure III.2.4: Limited gaps and smallest height of the guard-net of the substation (in mm)

d. The guard-net is not required if the height from the bottom edge of the insulation part to the ground of the sub stations is from 2250mm(Figure III.2.6).

When this height is less than 2250mm, the guard net is required in accordance with the provisions set out in Article III.2.26. The gap from the guard-net to the VTS and electrical equipment shall not be smaller than the values specified in Article III.2.63.

For outdoor VTS located near the wall of factory, to comply with the provisions specified in the Article III.2.74. and III.2.75.

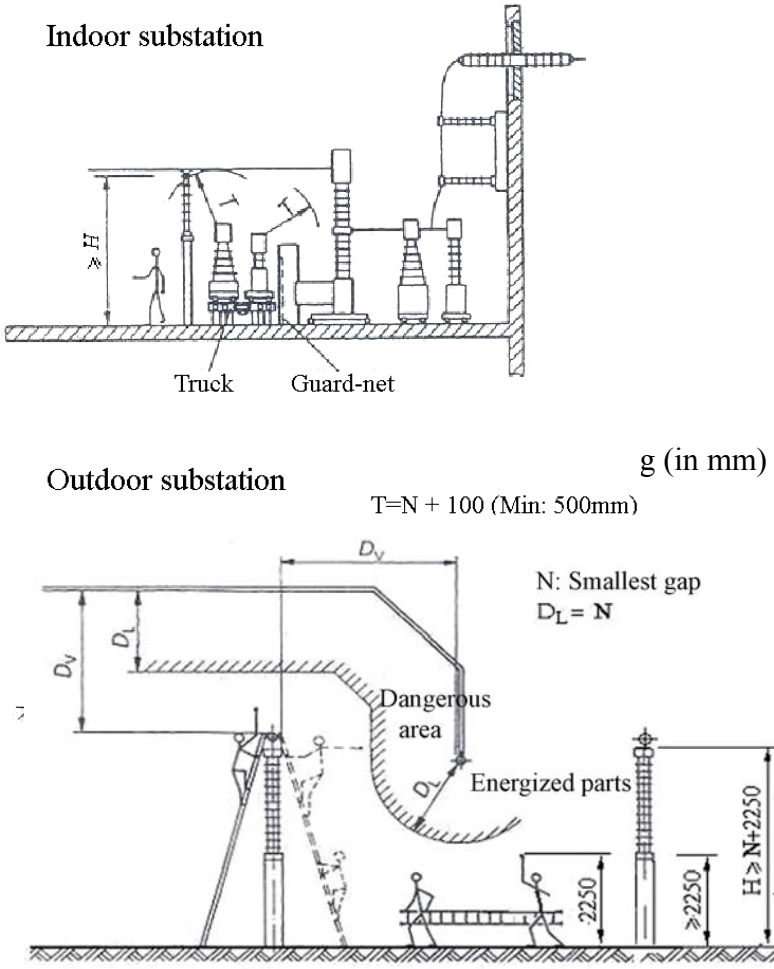


Figure III.2.6: Smallest working height and distance (in mm)

III.2.65. Conductive parts must be arranged so that the gap from it to the overall dimensions of the vehicle (see Article III.2.42) and transportation equipment is not smaller than the value:

N T = +100 mm (Min: 500mm) (see Figure III.2.5).

III.2.66. The smallest gap D_V between the conductive parts without guard-net, when fixing this circuit, it is necessary to switch off others, is defined as follows:

D_V = N + 1000mm when U ≤ 110kV

D_V = N + 2000mm when U> 110kV (see Figure III.2.6)

When the circuits have different voltages, the distance of D_V is taken by the highest voltage.

If the repair is not done in the conditions mentioned above, the gape between the conductive parts of different circuits in different planes, is taken according to the provisions set forth in clause III.2.53, III.2.60 and III .2.61. Then, to consider the possibility that the wires can move each close to other under operation (due to the effects of wind, temperature, etc.).

III.2.67. The gap value between the conductive parts of the different circuits in a horizontal plane is determined by a highest voltage circuit and not lower than the values specified in Table III.2.1 and III.2.2.

III.2.68. The gap from the conductive parts to the inner edge of the guard-net surrounding the substation (minimum height: 1800mm) is not lower than the following values:

C = N +1000 mm for the blind guard-net.

E = N +1500 mm for the holed guard-net or trellis (see Figure III.2.4)

III.2.69. The gap value between the contacts, the blade of the isolator in OFF position and the ground must not be smaller than the values specified in Table III.2.1 and III. 2.2; and the conductive bar of the same phase connected to the second phase: to comply with the Article III.2.54; and the other conductive bar: to comply with the Article III.2.60.

III.2.70. The gap between the energized parts of the outdoor PDE and works (power distributing, control room, control tower of VTS etc. (see Figure III.2.7) should not be lower than the following values (at largest sag):

• To comply with the Articles III.2.64, III.2.66 when energized parts are above the roof that people can access.

• N + 500mm, when energized parts are above the roof that people can not access..

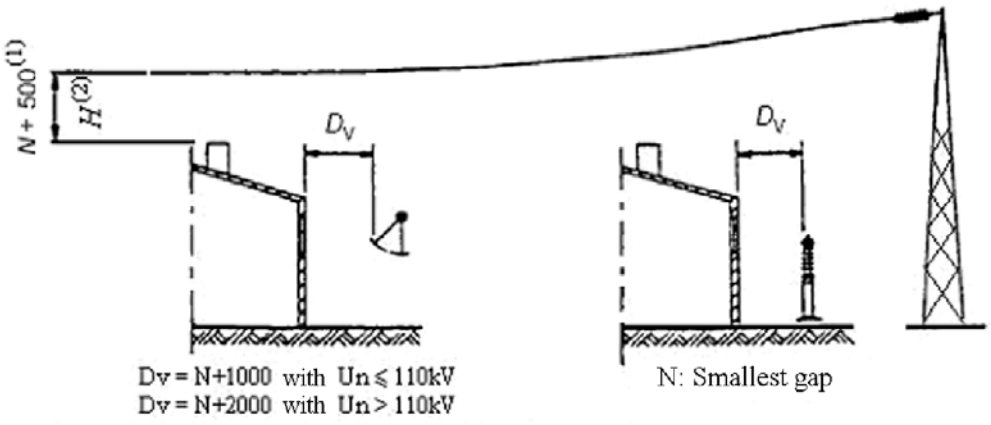
• $O_2 \geq$ N + 300mm (minimum 600mm) horizontally, from the edge of the roof that people can access to when energized parts (see Figure III.2.7).

• When the bare conductor is near the building inside the power operation area, to ensure the smallest gaps below, calculated when the sag and deviation of the line are largest:

o D_V when the outer wall has window without guard-net.

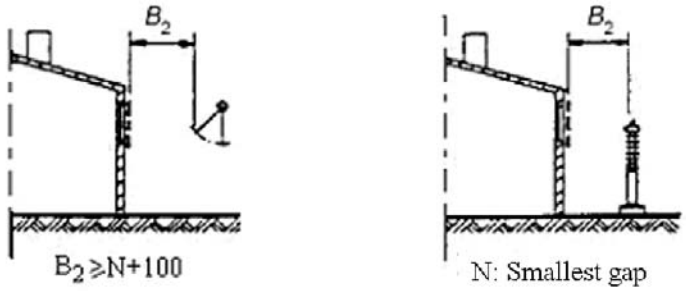
o B_2 when the outer wall has window with guard-net.

o N when the outer wall no window.

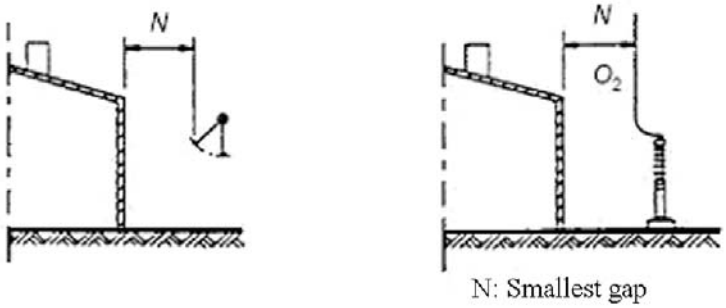


Note: (1): Roof that can not be accessible when the conductor is energized
(2): Roof that can be accessible when the conductor is energized

1. The wall that has the window without guard-net



2. The wall that has the window with guard-net



Note: O2 ≥ N + 3 (Min. 600 mm) if the roof is accessible when the conductor is energized

3. Wall without window

III.2.71. It is prohibited to place aerial wire for lighting, communication, and signal purpose above and below the energized parts of carrying of outdoor PDE.

III.2.72. The distance value between the outdoor PDE to the substation cooled by water should not be lower than the values specified in Table III.2.3.

Table III.2.3 Smallest distance between the outdoor power equipment and the substation cooled by water

Substations cooled by water	Distances, m
Substations cooled by water spray and outdoor cooling tower	80
Tower cooled by fan	30
Tower cooled by sectional fans	42

III.2.73. The distance from the equipment whose oil volume in each unit of equipment equal to or greater than 60kg to the workshop of D grade (According to the Code TCVN 2622-1995) in the industrial area, to the auxiliary works (repair shop and warehouses) in the power plants and VTS area (except the grade D and E, see Article III.2.75) should not be shorter than:

• 16m - while the building and works belong to the fire-resistance level I and II.

• 20 meters - while the building and works belong to the fire-resistance level III.

• 24m - while the building and works belong to the fire-resistance level VI.

• For the distance to the dangerous and explosive works, to comply with the current fire safety regulations.

For the fire-resistance level of the buildings and works, to refer to the Code TCVN 2622-1995.

The fire-resistance distance from the VTS repair shop, building of the oil supply system as well as from the oil storage to the outdoor PDE's fence should not be shorter than 6m.

The distance from the power distribution room to the other workshops of power plant and VTS should not be shorter than 7 meters.

The above distances may not apply when the wall of the power distribution room are towards to the buildings of other works that can withstand the fire within 2.5 hours.

The distance from the hydrogen storage to the buildings of VTS and overhead lines poles should not be shorter than the distances specified in Table III.2.4.

The distance from the hydrogen storage to the PDE, outdoor transformer, and synchronous compensator should not lower than 50m.

Table III.2.4: Smallest distance from the hydrogen storage to the buildings of VTS and overhead lines poles

Number of hydrogen bottles in the storage (bottle)	Distances	
	To the buildings of VTS	To the overhead lines poles
Up to 500	20 m	1.5 times of the height of the pole
Over 500	25 m	-

III. 2.74. The distance from the oil equipment of the outdoor PDE in power plants and from VTS to the PDE's room, electrical panel room, air compressing room and the synchronous compensator unit is only determined by the technological requirements, not by the conditions of fire prevention and fighting.

III.2.75. The gap between the outdoor VTS of over 1MVA or between them and other works (buildings, etc.) shall not be lower than G value in the Table III.2.5.

If the above gag can reach the value G:

• Between the voltage transformers : to put the wall that can withstand the fire over 60 minutes (see Figure III.2.8a).

• Between the transformer and the building: Or the wall of the building can withstand the fire over 90 minutes (see Figure III.2.8b) or to put a wall that can withstand the fire over 60 minutes.

Table III.2.5: The gaps between the VTS or between them and the works

Nominal capacity, MVA	Gap G, m
From 1 to 10	3
From 10 to 40	5
From 40 to 200	10
Above 200	15

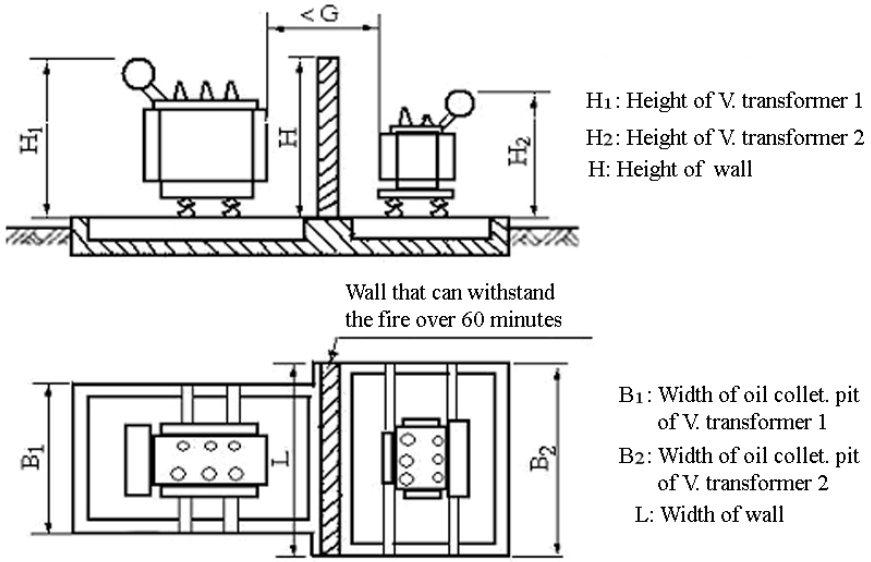


Figure III.2.8 a: The wall between voltage transformers, placed outdoor

$$\text{If } H_1 > H_2 : H \geq H_1$$

$$\text{If } B_2 > B_1 : L \geq B_2$$

For VTS up to 1MVA placed outdoor, the gape G value should not be lower than 1.25 m.

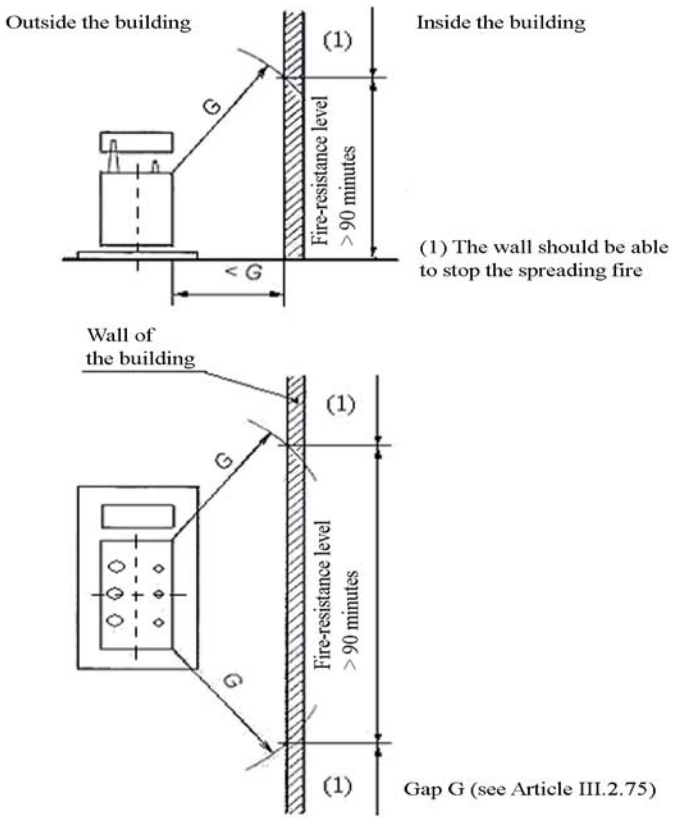


Figure III.2.8b: Measures to take to prevent fire between transformer and building

Table III.2.6: Smallest gap between the energized parts to other parts of the outdoor PDE

Figure numbers	Distances	Symbols	Smallest insulator gap (m) under nominal voltage, kV					
			To 15	22	35	110	220	500
III.2.1	• Phase-Earth • Phase-phase	Np-e Np-p	0,22	0,33	0,44	1,1	2,1	3,3 (4,1) (1) 6,1 (7,4) (2)
III.2.3	From the energized parts to the edge of the internal guard-net: • Blind guard-net, height ≥ 1,8m • Trellis, height ≥ 1,8m	B1 B2,3	0,22 0,3	0,33 0,41	0,44 0,52	1,1 1,5	2,1 2,2	4,1 4,5
III.2.4	From the energized parts to the edge of the surrounding guard-net: • Blind guard-net, height ≥ 1,8m • Trellis, height ≥ 1,8m	C E	1,22 1,72	1,33 1,83	1,44 1,94	2,1 2,6	3,1 3,6	4,2 5,6
III.2.5	From the energized parts to the road for vehicle inside the substation	H’	4,3	4,3	4,3	6,0	6,6	9,6
III.2.5 III.2.6	From the energized parts to the travel area (without the road for vehicle inside)	H	2,5	2,58	2,69	3,35	4,35	6,35

III.2.5	From the energized parts to the transportation facilities	T	0,5	0,5	0,54	1,2	2,2	4,2
III.2.6	From the energized parts of different circuits, when one circuit is being fixed, the others are still energized	Dv	1,22	1,33	1,44	2,1	4,1	6,1

Notes: (1) Minimum gap phase - phase between poles – bars for 500kV voltage is 7.4 m.

(2) Minimum gap phase-earth between poles- bar for500kV voltage is 4.1 m.

III.2.76. To prevent the leakage of oil and to limit the spread of fire when the voltage transformer is damaged (choke winding), for the transformer that has the volume of oil over 1,000 kg (each) and oil breaker with voltage from 110kV, the oil collecting pit is required. The oil trough and oil collecting pit must meet the following requirements:

1. The size of the collecting pit must be larger then the size of each equipment at least:

• 0.6 m when the volume of oil is up to 2.000kg

• 1 meter when the volume of oil is from 2.000kg to 10.000kg

• 1.5 m when the volume of oil is from 10.000kg to 50.000kg

• 2 m when the volume of oil is over 50.000kg; the oil collecting pit size can be reduced 0.5 m towards the wall, and it is under 2m far from the voltage transformer.

The capacity of oil collecting pit is as follows:

• Equal to 100% of the oil volume in the voltage transformer (choke winding) and to 80% of the oil volume in each barrel of oil breaker, if the oil collecting pit has no oil drainage system and common oil collecting pit.

• Equal to 20% of the oil volume in the voltage transformer (choke winding) in each barrel of oil breaker, if the oil collecting pit has the oil drainage system and common oil collecting pit.

2. To arrange the oil collecting pit and oil (water) trough so that the oil can not go from one pit to others, to the troughing or to other underground works, cause the spread of fire, block oil trough.

3. It is allowed to use the oil collection pit of blind-type. If the oil collecting pit is deep enough to contain the full volume of oil inside the transformer and is covered by a metal net at the top, over the net is overlaid a layer, at least 0.25 m thick, of clean gravel or crushed stone with size from 30 to 70mm.

The water and oil of the oil collecting pit may be pumped out.

An instrument to determine whether oil and or water are in the oil collecting pit is required.

4. The oil collecting pit can be of the buried type (its bottom is deeper than the surrounding ground surface) or the regular type (its bottom is on the ground .) For the oil collecting pit of buried type, the edge is not necessary, if the capacity stated in the section 1is ensured.

For the regular type oil collecting pit, the edge is required. The height of the edge should not be smaller than 0.25 m, but not be 0.5 m higher than the surrounding ground surface.

The oil collecting pit (buried type or regular type) should be covered with a layer of clean gravel or stone size 30 - 70mm and thick at least 0.25 m.

5. For oil transformer placed in the house or building with reinforced concrete ceiling, the oil drainage system is required.

6. The oil drainage system must ensure to clear off the oil and water (only the water that the fire fighting equipment vomit out) to the safe place far away from the fire with the volume of 50% of the oil to be freed up in less than 0.25 hours.

The oil drainage system can be underground pipes, ditches.

7. The common oil collection pit must contain the entire volume of oil of the equipment that have the biggest volume of oil and it must be of close type.

III.2.77. In the VTS that have the 110kV transformers with the capacity above 63MVA each, in 220 KV substation with capacity above 40MVA each transformer and in VTS that have synchronous compensators, to install the fire-fighting water supply conduit connected to the water supply conduit available outside or to the internal water supply.

In VTS that have the 220kV voltage transformers with the capacity below 40MVA each, to install the fire-fighting water supply conduit connected to the water supply conduit available outside.

It is allowed to replace the fire-fighting water supply conduit by the fire-fighting water tank that are supplied from the water-distribution system for other purposes.

In the VTS with the voltage from 35kV to 110kV, whose each transformer has the capacity lower than 63MVA, the fire-fighting water supply and conduit are not necessary.

III.2.78. The base of VTS and oil equipment must be of fire-proof materials.

III.2.79. Commonly, there is no rail-way in VTS. If the branch line goes to the substation, it should go to the voltage transformer.

III.2.80. In outdoor PDE and VTS area there must be a road. The road go to the control room, to the room or the place where is located the full set of PDE along the voltage transformers, the PDE's breaker with the voltage 110kV and above, compensators, air compressing stations, the oil handling station, materials storage, pumping stations, water tanks, hydrogen storage, voltage transformer repairing and control tower.

The width of road should be at least 3.5 m. When determining the size of the road, to consider the possibilities to use the transportation facilities outlines in the Articles III.2.65 and III.2.81.

III.2.81. The outdoor VTS full set , PDE, the outdoor GIS station must meet the following requirements:

1. They are located higher than the ground at least 0.3 m and have space to operate.

2. The voltage transformer, GIS equipment, the trolley of full set cabinets can be pulled out for the transportation.

3. The cooling of the equipment is ensured.

Besides the above requirements, the full set outdoor PDE, VTS must meet the requirements set out in the Articles III.2.14÷ 19, 26, 29, 31, 34, 37, 39, 40, 212.

The sections of full set outdoor PDE and VTS that are connected by the connecting rod must also meet the requirements set out in Articles III.2.43.÷ 80

Indoor PDE and VTS

III.2.82. The power distribution building and room, voltage transformer room should have the fire-resistance level I or II according to the Code TCVN 2622-1995.

III.2.83. The distance from the independent power distribution room to the workshop and works of industrial enterprises, to resident houses, to public house should not be less than the requirement for transportation and fire protection distance in set out in the Code TCVN 2622-1995.

In the cramp conditions, it is allowed to reduce the distance above mentioned fire protection distance, when the wall of the power distribution room is without windows and have no door towards the surrounding houses and works, with the consent of the local agency of fire prevention and fighting.

The distance between the VTS that are adjacent or inside the buildings, located along the perimeter of the industrial buildings are not specified.

The specific requirements for the VTS that is adjacent or inside the public or civil houses, should be in accordance with the current construction regulations.

III.2.84. For the VTS that is adjacent to the existing building and the wall of the building is used as the wall of the substation, an agreement is required and special measures are required to take to prevent the damage to the common wall.

III.2.85. The indoor PDE with the voltage up to 1 kV and above 1 kV usually is place in an individual building. The above requirements do not apply to the VTS full set with the voltage up to 35kV. It is allowed to locate the equipment with the voltage up to 1 kV and above 1 kV in common rooms, if that PDE or VTS is managed by one body.

The PDE, voltage transformer rooms etc. must be isolated from the management office and others .

III.2.86. Do not locate the voltage transformer and PDE room:

1. Under the wet production line, bathrooms, toilets etc. unless it is absolutely necessary, in this case to take measures against water infiltration into the voltage transformer and PDE room.

2. Underneath or on the room that over 50 people gather during the 1t hour. This requirement does not apply to dry or containing non-flammable voltage transformer room.

III.2.87. The lead-in insulator and the insulator of the outdoor conductor rod of the generator with the terminal voltage 6 and 10 kV are: 20kV, 13.8÷ 24kV: 35kV. When choosing the said insulators for the areas with polluted air, to consider the level of contamination for the selection of their insulation distance.

III.2.88. For the smallest gap phase - phase and phase - earth of the energized parts, to take the values in the table III.2., the gap from the bare energized parts to the guard-net, floor, ground and the gap between the energized parts without guard-net to the different circuits should not be lower than the values specified in the Table III.2.7 and Figure III.2.9 - III.2.11. To check the displacement of the soft conductors PDE in the room by the effects of short circuit current as specified in Article III.2.56 and 60.

III.2.89. The gap between the contacting bars and blades of the isolator in ON position to the conductor that are connected to other contacting bars should not be smaller than the values given in Table III.2.7 F (Figure III.2.10).

Table III.2.7: Smallest gap between the energized parts and the other parts of the indoor PDE

Figure numbers	Distances	Symbols	Smallest insulator gap (m) under nominal voltage, kV						
			6	10	15	22	35	110	220
III.2.9	From energized parts to the blind guard-net	B	0,12	0,15	0,15	0,21	0,32	0,73	1,73
III.2.10	From energized parts to the trellis	C	0,19	0,22	0,22	0,28	0,39	0,8	1,8
III.2.10	Between the energized parts without guard-net of different circuits	D	2,0	2,0	2,0	2,2	2,2	2,9	3,8
III.2.11	From energized parts to the floor	E	2,5	2,5	2,5	2,7	2,7	3,4	4,2
III.2.11	From the output without guard-net of the PDE to the ground outside the area of the outdoor PDE and without road.	G	4,5	4,5	4,5	4,75	4,75	5,5	6,5
III.2.10	From the contacting bar and blade of isolator at OFF position to the conductor connected to the other contacting bar.	F	0,11	0,15	0,15	0,22	0,35	0,9	2,0

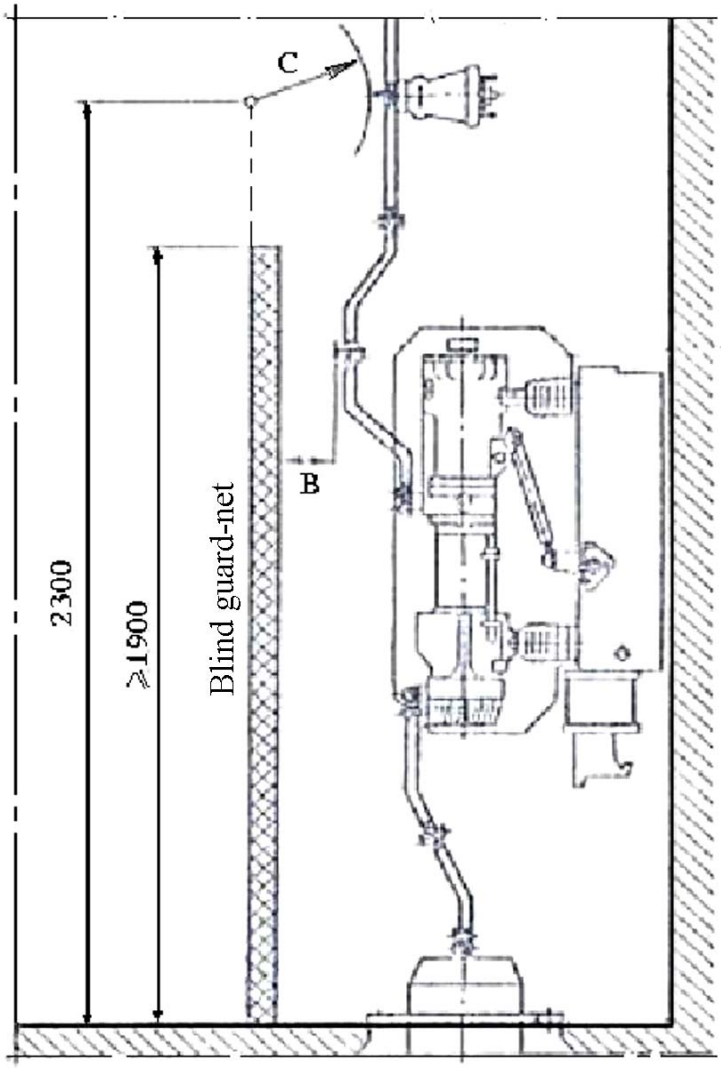


Figure III.2.9: Smallest gaps from the energized parts to the blind guard-net

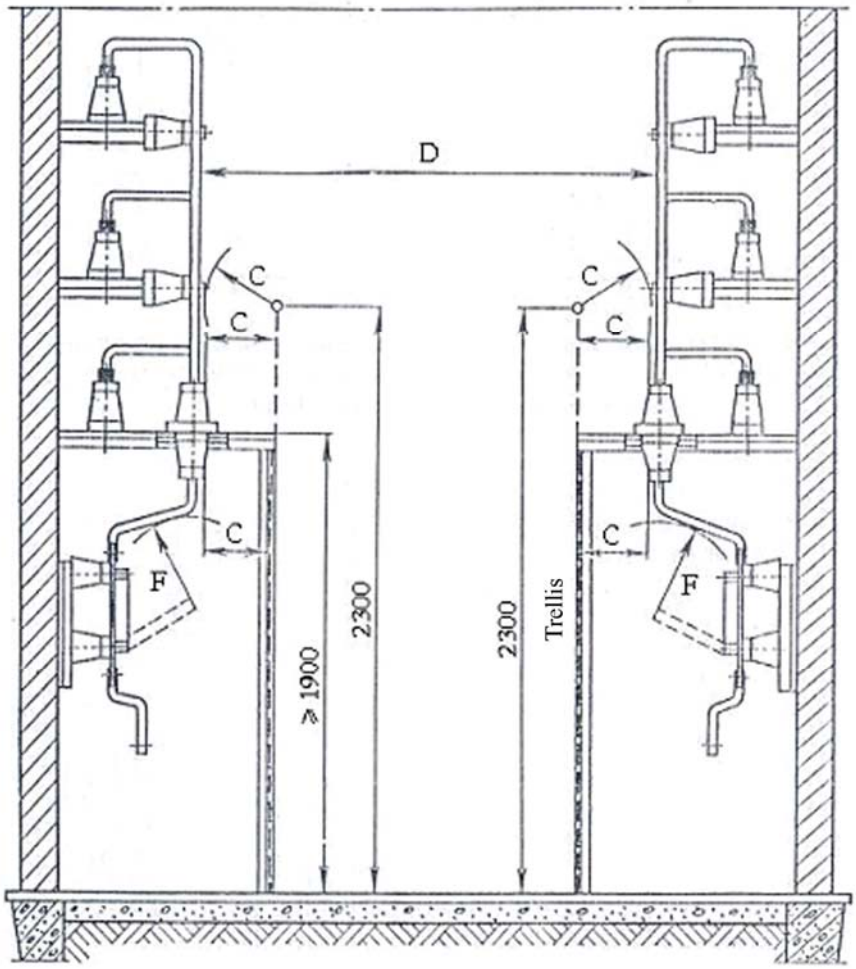


Figure III.2.10: Smallest from the bare energized parts to the guard-net and different circuits having no guard-net

III.2.90. The bare energized parts that can be touched unintentionally must be placed in the compartment or protected by guard-net, etc.

If the bare energized parts is place in a compartment lower the distance E specified in the Table III.2.7, it must be protected by guard-net. The height of the path under the guard-net should not be lower than 1.9 m (Figure III.2.11).

The energized parts with guard-net should be located 2.3 m high to the floor, but lower than the distance E, must be located far from the guard-net's plane with the distance of the table III.2.7 C (Figure III.2.10).

The energized parts without guard-net that connect the capacitors for high frequency communication control and protection equipment to the filters must be located at the height of 2.2 m or more. The filters should be located at a height suitable for repairing/setting without having to switching of the equipment

that are connected to. The guard-net is not necessary for the equipment if the height from the bottom edge of the insulator to the floor is not lower than 2.2 m, if the above requirements are met.

To only use the barriers at the entrance to the room as per the provisions of the Article III.2.26. No barrier is allowed to shield the energized parts of the open compartment.

III.2.91. The energized parts without guard-net of different circuits should be located at the height higher than the distance E specified in the Table III.2.7, to arranged the space D so that when fixing any single circuit, the other circuits are always energized.

The gaps between the energized parts without guard-net located on both sides of the operation corridor should not smaller than the D value in the Table III.2.7 (Figure III.2.10).

III.2.92. To manage and move equipment favorably, the width of the operation corridor between the guard-net should not be lower than:

• 1 meter when the equipment located on one side.

• 1.2 m when the equipment located on both sides.

If the operation corridors have the driven units of circuit-breaker, isolator, the said distances must increase to 1.5 m and 2m. When the length of the operation corridor is up to 7 meters and equipment are located on both sides, it is allowed to reduce the width of the operation corridor to 1.8 m.

The width of aisles in the room of full-set PDE, GIS and VTS should comply with the requirements specified in the Articles III.2.126 ÷ 128.

The width of the exit way should not be lower than 1.2 m.

In the operation corridor and the exit way, the structural protrude length should not more than 0.2 m.

The height of room of full-set of PDE, GIS and the VTS full set should comply with the requirements specified in Article III.2.129

III.2.93. At the place the overhead lines go inside the room of PDE that are not located near the road or at the place where transportation vehicles do not pass by etc. the gap between the lowest point of the conductor to the ground should not be not smaller than distance G in the Table III.2.7 (Figure III.2.11).

If the gap between the conductor and the ground is lower than the above mentioned values, at the conductor side the guard-net 1.6 m high is required.

At the place the overhead lines go inside the room of PDE that are located near the road or at the place where transportation vehicles not pass by etc. the gap between the lowest points of the conductor to the ground should comply with the provisions outlined in Chapter II.5 - Part II.

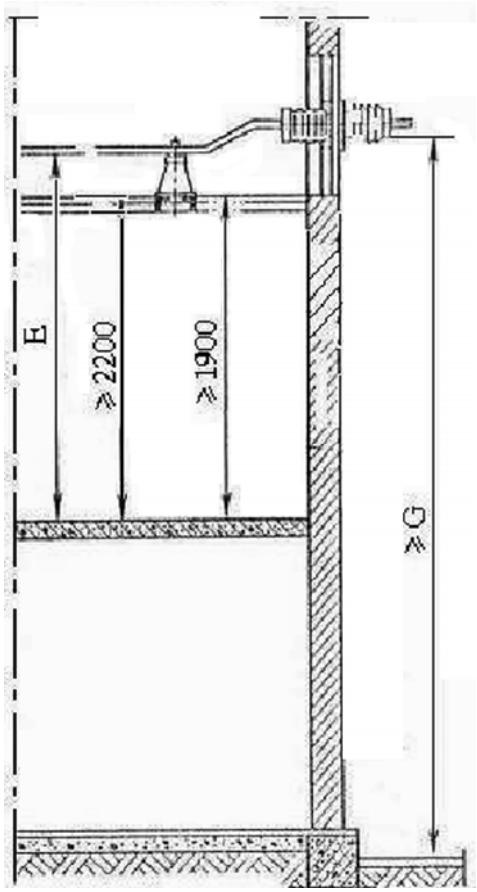


Figure III.2.11: Smallest gap between the bare energized parts without guard-net (E) and from the bottom edge of the insulator to the floor. Lowest height of the aisle; smallest distance from the wire out without guard-net of the room of PDE to the ground when the wire out place wire is not within the outdoor PDE and when there is no transporting way under (G).

For the overhead lines coming from the indoor PDE to the voltage transformers area, the above mentioned gap should be:

N + 2250mm (Min.: 2500mm)

The gap between two lines close together of two circuits, if they are without guard-net, should not be shorter than the distance stated in the Article II.5.50 - Part II.

III.2.94. For the conductor going into the room of PDE, if it must pass the roof of that room, the gap to the roof should not be lower than the values stated in the Article III.2.70.

III.2.95. The PDE room must have door and must comply with the following requirements:

1. If the PDE room length is up to 7 meters, one door is allowed.

2. If the PDE room length is from 7 m to 60 m, two doors at to ends are required. It is allowed to put the door 7 meters far from the gable.

3. If the PDE room length is over 60m, besides the doors at the ends, the additional doors are required, providing that the distance from any point of the operation corridor or exit way to the doors is not greater than 30m.

The doors can open to the outside; to the stairs of neighbor rooms that have non-flammable walls and ceiling, no equipment, flammable, explosive materials, to the other PDE room.

The doors must be made of fire-proof or non-flammable materials that have the fire-resistance level that is not less than 0.6 hour.

In the multi-storey PDE room, one of two doors at the two ends and the auxiliary door should be able open to the balcony that have the fire ladder.

III.2.96. The explosion exit ways that are too long should be split into sections with length lower than 60 m, by deflector plates that have the fire-resistance level not less than 1 hour and doors according to the Article III.2.98. The explosion exit ways must have doors opening to the outside or stairs.

III.2.97. The floors of the PDE rooms should have the same height. The structure of the cement floor should not dust (see also Article III.2.124). Do not make the door edge between the rooms and at the corridors (For exceptions, see Article III.2.103, 104, 106, 107).

III.2.98. The door of the PDE room should be able to open outwards to other rooms, the door must be locked automatically and from the inside it can be opened without the key.

Doors between the compartments of the same PDE or between the rooms close together of two PDE should have the self-positioning mechanism in the close position, but can be opened easily from the two sides.

The doors between two PDE rooms having different voltage, one of them has the low voltage up to 1 kV, is allowed to be opened to the low voltage room.

The PDE rooms of the same voltage level must be opened with the same key. The access doors of the PDE room and other rooms should not be opened with the same key.

Do not use the lock that can be unlocked automatically for PDE in city with voltage 10 kV or lower.

III.2.99. Door (gate) of the compartment of oil transformer with the oil volume greater than 60kg must be made of non-flammable materials which can resist fire not less than 0.75 hour, if this door is opened to other rooms which do not belong to the TS, or when they are put between the explosion exit way and PDE rooms. In other cases, the doors can be made of materials that have lower fire-resistant level.

The gate with the wing with length over 1.5 m should have wicket if it is used as the entrance for people.

III.2.100. PDE room should not have windows. In areas not being protected, the windows are not allowed. To get natural light, it is allowed to use glass tiles or glass reinforced.

The PDE room window should be of closed-type.

If the window is protected with a trellis with mesh size larger than 25x25mm outside, the windows that can be opened to the inside are allowed.

Do not to put the window to get light on the roof.

III.2.101. In the same room with PDE 1 kV and above, it is allowed to set up oil voltage transformer with a capacity up to 630kVA or two oil voltage transformers, capacity 400kVA each, but they must be separated from the rest of the room by the deflector plates with fire-resistance level of 1 hour.

The bare energized part voltage over 1kV must be protected by guard-net in accordance with the Article III.2.90. The oil breaker must be located under the provisions of Article III.2.104.

III.2.102. Equipment related to the startup of electric motors, synchronous compensators etc. (Circuit breaker, reactor startup, voltage transformer etc.) can be located in one room without deflector plates between them.

III.2.103. In the PDE room that have door opening to the explosion exit way, it is allowed to put voltage transformer with oil volume up to 600kg.

For the measuring transformer that is not dependent on oil volume, it is allowed to be located in the open compartment, but the edge or slope are required to keep the entire volume of oil stored in the transformer.

III.2.104. The bulk-pole circuit breakers that have more than 60kg of oil weight should be placed in a separate explosion-preventing compartment with door opening to the outside or to the explosion exit way.

The bulk-pole circuit breakers that have oil weight from 25kg to 60kg can be located in the open or explosion-preventing compartment. When placing the breakers in the open or explosion-preventing compartment with door opening to the explosion exit way, to select the breaker having the back-up rated making capacity of 20%.

The bulk-pole circuit breakers that have oil weight to 25kg, small-oil-volume circuit-breakers and oil-free circuit breakers can be placed in the open compartment.

For small-oil-volume circuit-breakers that have 60 kg of oil or more, in each compartment to build the edge to keep the entire volume of oil.

The circuit breakers placed in the open compartment must be separated by non-flammable deflector plates, in line with the Article III.2.14. This breaker must also be separated from the drive by non-flammable deflector plates or aprons. The top edge of these non-flammable deflector plates or aprons must be at least 1.9 m higher than the floor.

The apron is not needed for the air circuit breakers

III.2.105. In the explosion exit way should not be placed equipment that have bare energized parts.

In the explosion exit way must have exit way in accordance with the Article III.2.96.

III.2.106. The oil collecting pit is not required for VTS in the separate room, VTS close to or in the workshops, in the voltage transformers room, oil circuit breaker and oil equipment with the oil weight in a barrel up to 600kg, when these compartments are located on the ground floor and have doors opening to the outside.

To build oil collection pit or edge, of fire-proof materials, to keep 20% of the volume of oil when the volume of oil in a barrel is greater than 600kg. To take measures against the oil flowing into the cables ditches.

III.2.107. When placing the oil circuit breakers and equipment in the compartments in the basement, in the first floor and upwards and the doors open to the explosion exit way, to do the followings under them:

1. If the oil volume in the voltage transformer or one each barrel is lower than 60kg, to only build edge or slope to keep the entire volume of oil.

2. If the volume of oil in a barrel is from 60 to 600kg:

a. To build pit to contain the entire volume of oil.

b. To build edge or slope towards the inside to keep the entire volume of oil.

3. If the volume of oil in a barrel is greater than 600kg:

a. To build pit containing at least 20% of the entire volume of oil of the voltage transformer or oil drainage way to the common oil collecting pit.

The diameter of waste oil tube of the oil collecting pit under the voltage transformer should be at least 10 cm.

The waste oil tube must be protected at the oil collecting pit side.

b. If the oil collecting pit have no drainage way to the common oil collecting pit, the oil collecting pit should be protected by trellis, under the trellis is sprayed crushed stone or gravel 25 cm thick. The oil collecting pit must contain the entire volume of oil and the oil level must be lower than the trellis 5 cm.

The top surface of crushed stone or gravel in the oil collecting pit must lower than ventilation hole 7.5 cm. The oil collecting pit bottom must have a slope of 2% towards the absorption hole. The surface area of the oil collecting pit must be greater than the bottom area of the voltage transformer or equipment.

III.2.108. For the voltage transformer and reactor room, to take ventilation measures. At the normal operation (taking into account the overload), the maximum temperature of the environment should not make the voltage transformer and reactor temperature to exceed the allowed maximum temperature of the said equipment.

If the heat exchange can not done by natural ventilation, the forced ventilation is required.

III.2.109. For the explosion exit way and operation way of open compartments or full set cabinets containing oil or synthetic insulating liquid, the exhaust ventilation system controlled from the outside and not related to the other ventilation system is required.

The emergency exhaust fan must ensure the exchange the volume of air 5 times greater than the volume of air of the room within 1 hour.

III.2.110. For the rooms with regular operator in duty from 6 hours, to ensure that the room temperature is not lower than 18^0C and over than 28^0C. The temperature of the room where are located PDE and control panel should comply with the manufacturers' requirements.

III.2.111. The holes between floors, through walls, deflector plate including cable passing holes must be sealed with non-flammable materials with fire-resistant level not less than 0.75 hours.

To prevent animal to enter in the room, the holes to the outside must be covered with trellis with mesh size 10x10mm.

III.2.112. Ditch covers must be made of non-flammable, anti-slipping, stumbling materials, and are sealed. They must be at the same height with the floor. The weight of each cover should not be greater than 50kg.

III.2.113. Usually it is not allowed to lay cables of another circuits going through the compartment where are located equipment and voltage transformer, in special cases, the cable must go through the tube. Only in the necessary case that the connection is required (e.g. connection to the measuring transformer), is allowed to place the wire of lighting control, and measuring network in the compartment and near the bare energized parts.

III.2.114. It is allowed to place in the PDE room the ventilation pipes welded together without vent-hole, or flanged connections, valves, inspection doors. It is allowed to place across the room the waterproof ventilation pipe lines.

Workshop voltage transformer substation

III.2.115. This section applies to workshop voltage transformer substation with voltage up to 35 kV.

III.2.116. The voltage transformer substation may be located on the ground floor and the on second floor in the main production room or sub production room category I or II according to the fire protection Code TCVN 2622-1995.

It is allowed to place voltage transformer substation in the room which is dusty and contain hazardous chemicals, but to take measures outlined in the Article III.2.121 to ensure that safe working conditions of the equipment.

III.2.117. The voltage transformer, PDE can be placed in the individual room, or on the open space in the workshop.

When placed on the open space, the energized parts of the voltage transformer must be covered and PDE is also arranged in closed cabinets or security.

III.2.118. In each workshop where is located the full set voltage transformer, to comply with the following requirements:

1. In the full set substation placed in the open space, the oil voltage transformer with the total capacity of not more than 3.200kVA can be placed.

The distance between the full set oil voltage transformers as well as between the voltage transformers in compartments without guard-net should not be lower than 10 meters.

The distance between the separate room of the different substations or between the close rooms where are located the oil voltage transformers is not specified.

2. In a room of workshop voltage transformers it is recommended to place one full set substation (It is allowed to place no more than three full set substation) of oil voltage transformers with a total capacity that does not exceed 6.500kVA.

The volume of oil voltage transformers placed in a close room should not exceed 6.5 T.

3. The guard-net of the room where located the substation of oil voltage transformers or the close compartment of oil voltage transformers and oil equipment with the weight of oil from 60 kg or more must be made of non-flammable materials which have the fire-resistance of at least 0, 75 hour.

4. The total capacity of oil voltage transformers located on the first floor should not be greater than 1.000kVA.

It is allowed to place the full set substation with oil voltage transformers and oil voltage transformers on the second floor and upwards.

5. For the workshop and full-set voltage transformers having dry voltage transformers or non-flammable insulated there is no limit in capacity, number, distance between them and as well the floor of location.

III.2.119. Under the oil voltage transformers and equipment, the oil collecting pit is required in accordance with the Article III.2.107 hole.

III.2.120. To use only bulk oil circuit-breaker in the close compartment with the following conditions:

1. The number of the circuit-breakers is not greater than 3.

2. The oil volume in each breaker is not more than 60kg.

III.2.121. When installing a ventilation system for voltage transformer compartment in the substation located in the production room with the normal ambient air, it is allowed to use in the workshop air for ventilation.

In order to ventilate the voltage transformer compartment in the dusty room or in the room whose the air containing conducting or corrosive substances, it is requires to take the air from outside or the air must be purified.

In the workshop with non-flammable ceiling, it is allowed to eject directly the air from the voltage transformer compartment to the workshop.

In the workshop with slow-burning ceiling, the air exhaust from voltage transformer compartment to should be discharged through the pipe or well which protrude above the roof at least 1 m and are done in accordance with the Article III.2.220.

III.2.122. In case of forced ventilation for the voltage transformer compartment, when switching off the voltage transformer, it is not required to turn off automatically the ventilation equipment.

III.2.123. For the full set voltage transformer located in the individual room, the ventilation for the voltage transformer must be in accordance with the Article III.2.108.

III.2.124. The VTS floor should not be lower than the workshop's floor. The floor of the compartment of the full set of PDE and VTS should ensure that the moving of the trolley will not damage the floor.

III.2.125. The door of oil voltage transformer compartment and the compartment of bulk oil circuit breaker should have the fire-resistance level not less than 0.6 hour.

III.2.126. When placing the VTS next to the transport way of workshop including the way of lifting vehicles, to take measures to protect them against collision (by light signals, guard-net).

The PDE full set and VTS are usually located in the death area of lifting vehicles.

In workshops with the high frequency of internal transport, or when the ground is crowded with equipment, materials, finished products, so to protect the PDE full set and VTS by barriers. In this case

there must be walkways between the barriers, their width should not lower than the values stated in the Article III.2.128.

III.2.127. The width for aisle along the PDE full set , TS, along the wall of VTS that has doors or vents, should not be less than 1m. In addition, the ability to move the transformer and other electrical equipment by the aisle should be ensured.

III.2.128. The width of aisle for the control and repair of the PDE full set trolley type and the VTS full set must ensure the moving, turning of the trolley and the smooth working.

If the PDE full set and VTS are located in the separate room, the aisle width is determined as follows:
• It's equal to the length of trolley of the PDE full set plus at least 0.6 m when they are located in a row.

• Plus at least 0.8 m when the located in two rows.

In each case, the aisle width shall not be less than the values stated in the Article III.2.127 and the width of narrow segments should not be smaller than the diagonal length of the vehicle, otherwise obstructing the movement of trolleys.

The walkway at the rear to observe and open the PDE full set and VTS should have the width at least 0.8 m, it is allowed that the width of narrow segment can be decreased, but not more than 0.2 m.

When the PDE full set and VTS are located in the workshops, the common aisle width is determined by the arrangement of production equipment, but the transporting of big parts of the PDE full set and VTS should be ensured and in all cases the width should not be less than 1m.

III.2.129. The height of the room should not be lower than the height from the top of the PDE full set (TS full set) plus 0.8 m to the ceiling and 0.3 m to the beam. It is allowed to reduce the height of the room if it is still safe and convenient for replacing, repairing, setting of PDE full set and VTS full set.

III.2.130. The load of the surface of the way and the floor to move PDE full set and VTS full set is calculated according to the highest load of equipment. The size of the doors must be consistent with the size of the equipment.

On-pole voltage transformer substation

III.2.131. This section applies to the on-pole VTS with the voltage up to 35 kV and the capacity not greater than 630kVA.

III.2.132. The voltage transformer connected to the high-voltage grid via fuse plus isolator or cutout, the drive of isolator must be locked.

III.2.133. The voltage transformer must be placed at a height of at least 4.0 m from the energized parts to the ground. At the places where the operation from the ground can not be done, the operation floor at the height of 2.5 m or above can be made.

III.2.134. After the switching off by isolator or cutout, the energized parts at the high-voltage side should be at the height not less than 2.5 m from the operation floor for the up to 22kV VTS and not less than 3.1 m for the 35 kV VTS . The ON or OFF positions of the isolator or cutout must be seen clearly from the operation floor.

III.2.135. The low voltage control panel of VTS must be placed in closed cabinets. At the low-voltage side, to place the breaker whose the OFF position can be seen.

III.2.136. The wire between the VTS and control panel, between panel and low voltage overhead lines must be protected from mechanical damage and must be performed as the provisions specified in Chapter I.2 - Part I.

III.2.137. The distance from the ground to the output of overhead lines, voltage to 1 kV should be at least 4.0 m for the bare wire and 3.5 m for the shielded wire.

III.2.138. VTS must be located at least 3 meters far from building having the fire resistance level I, II, III and at least 5m far from building having the fire resistance level IV and V.

III.2.139. The on-pole VTS can be placed on the pole of overhead lines if it is allowed technically.

III.2.140. At the place where vehicles can crash into VTS, the safeguard measurements are required.

Lightning protection

III.2.141. The outdoor VTS and PDE voltage 22 - 500 kV must be protected against the direct lightning strikes.

The protection against direct lightning strikes for outdoor VTS voltage 22 - 35 kV VTS having the voltage transformer with capacity to 1600kVA each and does not depend on the number of lighting hour in the year.

III.2.142. The VTS and PDE room should be protected against direct lightning strikes. The metal roof of PDE and VTS room must be earthed.

III.2.143. For the oil treatment system, sync compensator station, electrolysis room, hydrogen tank storage, located on the VTS area, the protection against the direct lightning strikes must comply with the current standards for lightning protection for buildings.

III.2.144. For the protection against direct lightning strike on the outdoor VTS and PDE, it is allowed to use the lightning conductor placed on the building structure or the down conductor. It is allowed to use

the high pole (overhead lines pole, headlight pole etc.) as lightning pole. It is allowed to place the lightning conductors on the pole near the VTS or circuit reactor if the requirements of Article III.2.145 are met.

It is possible to place the lightning conductor on the structure of the PDE with voltage 110kV and above if the earth resistance meets the standards.

For the pole with lightning conductor at the outdoor PDE voltage 110kV and above, to ensure that the wires for the stroke current going to the common grounding circuit are not less than 2 or 3. In addition, 1-2 additional earth terminals 3-5m long are required and the distance between them and the poles having the lightning conductor should not be shorter the length of the earth terminals.

For the pole with lightning conductor at the outdoor PDE voltage 35 kV, to ensure that the wires of the stroke current going to the common grounding circuit are 3 or 4. In addition, 2-3 additional earth terminals 3-5m long are required and the distance between them and the poles having the lightning conductor should not be shorter the length of the earth terminals.

The number of insulator strings on the gate pole of PDE voltage 35 kV having earth wire or lightning conductor and on the last pole of the overhead lines 35 kV should be increased by 2 more than the number required of the lines, if the earth wires of the overhead lines do not go to the substation.

The distance in air from the structure of outdoor PDE having the lightning conductors to the energized parts should not be smaller than the length of the insulator strings.

III.2.145. If the gate pole of the voltage transformer, the gate pole of the circuit impedance and the outdoor PDE are far away from the VTS or electrical resistance in the common grounding circuit less than 15 m, it is possible to place the lightning conductor when the equivalent resistivity of the ground on the lightning season is smaller than 350Ωm and to comply to the following conditions:

1. To place the lightning arrester valve type on the output of the winding of the voltage transformer 6 - 35 kV or at the point that is far from the output less than 5 m.

2. To ensure that the grounding from the pole with lightning conductor to the common ground circuit is performed by 3-4 wires.

3. 2-3 earth terminals 3 to 5 meters long are required on the common ground circuit that are 3 - 5 m far from the pole with lightning conductors.

4. In the VTS to 35 kV with the lightning conductor placed on the gate pole of the voltage transformer, the resistance of the grounding equipment should not be greater than 4Ω (not taking into account the grounding parts out of the grounding circuit of the outdoor PDE); if on the gate pole of the voltage transformer there is no lightning conductor, to apply the Article I.7.34 - Part I.

5. The earthing wires of the lightning arrester valve type and the voltage transformer that are connected to the ground circuit should be arranged so that the grounding point of the lightning arrester valve type is located between the grounding point of the ground wire of the gate pole with the lightning conductor and the grounding point of the voltage transformer.

III.2.146. For the protection against direct lightning strikes on outdoor PDE, if for the reason that the lightning conductor can not be installed on the building structure, to use the independent lighting rod with the individual earth resistance not greater than 80Ω.

The distance in the earth between the individual grounding equipment and the common ground circuit of the outdoor VTS should be equal to:

$$Se \geq 0,2xRc \text{ (but not less than 3m)}$$

Where:

Se - Distance in the ground in meters.

Rc - Impulse earth resistance of the independent lighting rod in Ω of the set when impulse current of the lightning is 60 kA.

The distance in the air from the independent lighting rod that have individual grounding system to the energized parts of the grounding structure and equipment of outdoor PDE (VTS) must be equal:

$$S_k \geq 0,12\ R_c + 0.1H \text{ (but not less than 5m)}$$

Where:

S_k: Distance in meters in the air.

H: Height in meters from the top of the lightning conductor to the ground.

The independent lighting rod can be connected to the common ground circuit of the VTS when the conditions for the instillation of the lightning conductor on the structure of the outdoor PDE (VTS) are met (see the Articles III.2.144 and 145) .

The distance from the earthing points of the independent lighting rod (or lightning wire) to the common ground circuit of the VTS to the earthing point from the voltage transformer (electrical impedance) to that said common ground circuit should not be less than 15 meters, calculated by the common ground circuit.

For the connection form the independent grounding point to the common ground circuit of the outdoor power distribution equipment voltage 35-110kV, 2-3 wires are required.

The independent lighting rod with headlights must be connected to the common ground circuit of the VTS.

If the conditions stated in Article III2.145 are not met, the following requirements must be added:

1. 3-4 earth terminals 3 - 5 meters long should be added at the point 5m far from the lighting rod.

2. If the distance along the common ground circuit from the grounding point of the lighting rod to the grounding point of the voltage transformer (electrical impedance) is longer than 15m long but shorter than 40 m, to place the lightning arrester valve type near the output of the up to 35kV winding of the voltage transformer.

The distance in the air from the grounded independent lighting connected to the common ground circuit of the sub station to the energized parts is determined as follows:

$$S_k \geq 0,1\ H + L$$

Where:

H - Height in meters from the energized parts to the ground.

L - Length in meters of insulator strings.

III.2.147. The lightning pole of the overhead lines voltage 35kV should not be connected to the grounding structure of the outdoor VTS (PDE).

The lightning pole of the overhead wires lines is not allowed to enter the substation, it stops at the last pole of the line.

The earth resistance of the last pole of the overhead lines 35 kV before the sub station should not be greater than 10Ω.

The overhead lines going to the substation which are not equipped with the lightning pole must be protected by lightning conductor installed inside the substation, on the pole of overhead lines or near the overhead lines. The junction point of the earthing wire of metal structure or the earth line into the common ground system of the substation should be far from the junction point the voltage transformer (reactor) at least 15 meters, calculated by the common ground circuit.

However, to protect the wire from last pole of the overhead lines to the substation against the lightning, the lightning pole of the overhead lines wires can go to the substation, but at its end must be separated from the ground by a series of insulator strings under the insulating standards of the overhead lines 35 kV.

The earth line of the overhead wires 110 kV or above can be connected to the grounding structure of the outdoor VTS when the earth resistance of substation meet the standards.

The pole with the earth line of the outdoor VTS 110kV or above which have the earth line of the overhead lines connected to, should be connected to the main grounding circuit by 2-3 wires. Also,

additional 2-3 earth terminals 3-5 m long are required, the distance between them and this pole should be at least equal to length of the earth terminal.

III.2.148. The protection of the overhead line segments connected to the outdoor VTS and PDE must comply with the provisions in the Chapter II.5 - Part II.

III.2.149. It is allowed to install the lightning conductor on the structure of outdoor VTS within the area less than 15 meters from:

• The voltage transformer connected by soft wires or bare conductive bars to the rotating machine.

• The bare conductive bars that are connected to the supporting poles of the soft wires connected to the rotating machine.

The gate pole of the voltage transformer that have bare conductive bars or soft wires connected to the rotating machine should be located within the area of the protection of the independent lightning pole or of the lightning conductor located on the building structure.

III.2.150. When using the headlights column as the lightning pole, the wires that power the headlights (the wires coming from the cable trough to the headlight pole and going along the pole) must be the metal shielded wires, otherwise, they must pass through the metal tube. The segment of the said wires that go near the lightning column must be buried at least 10 meters long.

At the place where the cables enter the cable trough, the metal shields, metal belts and tubes for passing of the cables must be connected to the common ground circuit of the substation.

III.2.151. To protect the overhead lines 35 kV going to the 35 kV VTS with the capacity of the voltage transformer greater than 1600kVA against the direct lightning strikes, it is required to use the earth line. The length of the protected segment of the overhead line 35kV LINES is from 1 to 2km. The following conditions must be satisfied for this segment:

• The shielding angle of lightning wire ≤ 30°.

• The maximum allowable earth resistance of the pole is 10Ω (when the resistivity of the ground is 100 Ωm), 15Ω (when the resistivity of the ground is from 100 to 500 Ωm), 20 Ω (when the resistivity of the ground is greater than 500 Ωm)

The earth line must be earthed at each pole, except the cases mentioned in the Chapter II.5 - Part II.

In the areas with the resistivity greater than 1000Ωm, it is allowed to protect the segment of the overhead lines going to the substation by the independence lightning pole, the earth resistance of the pole is not specified.

III.2.152. For the areas where the lightning hours in a year are not more than 60 or VTS 35 kV with 02 voltage transformers, capacity up to 1.600kVA, or 01 voltage transformer, capacity up to 1.600kVA but having the backup power supply for the sub-load from the low-voltage side, it is allowed not to protect against lightning by the lightning wire for the last segments of the overhead lines to the substation. In this case the length of the segments that enter the substation is not less than 0.5 km, the column must be grounded with the earth resistance values stated in the Article III.2.153. The distance from the lightning arrester valve type to the voltage transformer should not be greater than 10m.

III.2.153. The protection against the lightning for the CS1 line on the pole at the beginning of the line protected by the earth line to substation from the line.

For the overhead lines 35 kV protected by the earth line at the substation and on the lightning season they can be broken down for long period at one side, to protect against lightning for the CS2 line at the gate pole or at the first pole of the overhead lines of the side which can be stricken by the lightning.

The distance from the CS2 line to the breaker should not exceed 40 meters for 35 kV overhead lines.

On the last pole of 110 and 220 kV overhead lines, to earth the poles with the electrical resistance less than 5; 10; 15Ω when the corresponding resistivity of the ground is to 100, over 100 to 500, over 500Ωm.

On the areas that are stricken seldom by the lightning, it is allowed to rise the earth resistance of the last poles of the 110 - 220 kV overhead lines going to the VTS as follows:

• By 1.5 times if the lightning hours are less than 20.

• By 3 times if the lightning hours are less than 10.

For the last pole placed on the area where the resistivity is above 1000Ωm, the earth resistance is allowed to be above 20Ω but it should not exceed 30Ω.

III.2.154. For overhead lines that operate temporarily at the voltage lower than nominal voltage, at the first pole of the protected segment connected to the substation, at the line, to place the lightning arrester for the line with the corresponding voltage to the working temporary voltage of the overhead lines. If the lightning arrester has no appropriate voltage or the short circuit current is inappropriate, it is possible to use the protective gap or the shunt (short-circuit) for some insulators of the strings insulators at 1 to 2 adjacent poles. The number of insulators without shunt in the string should ensure the appropriate levels of insulation to the working temporary voltage of the overhead lines. For the overhead lines to the substation located in the area of the reinforced insulation, on the first pole of the segment of the protected overhead lines, to place the lightning arrester for the line that is in line with working voltage of

the overhead lines. If the lightning arrester has no appropriate voltage or the short circuit current is inappropriate, it is possible to use the protective gap

III.2.155. For the VTS 6 kV or above connected to overhead lines, to place the to put the lightning arrester valve type.

When selecting the lightning arrester valve type, to combine its protective properties with the insulation of equipment and the voltage that extinguishes the discharge of the lightning arrester valve type must be compatible with the voltage at the location of the lightning arrester at the earth-fault single phase. When increasing the distance between the lightning arrester and the protected equipment to reduce the amount of the lightning arresters, it is possible to use the lightning arrester having the characteristics better than the requirements, but the combination with the insulation of equipment is always required.

The distance from the lightning arrester valve type to the voltage transformer and equipment is as shorter as possible, but not greater than 10m.

Otherwise, the calculation of the biggest allowable distance between the lightning arrester valve type and the protected equipment should be based on the number of lines and the lightning arrester valve type connected to the VTS in the normal working mode. If the said distance is greater than the calculated distance above, the additional lightning arrester valve type on the bus bar are required.

The number and the installation location of the lightning arrester valve type should be selected upon the electrical connection diagram, the number of overhead lines and voltage transformers at all modes of operation of the substation. Not to take into account the incident and problem fixing modes.

III.2.156. The lightning arrester valve type can be connected directly to the voltage transformer (including the electric resistance windings) without isolator.

III.2.157. When connecting the voltage transformer to the bus bar of the PDE with one or more cables 110 kV and above, at the connection points between the cable and the bar, to place the lightning arrester valve type, the grounding point of the lightning arrester valve type should be connected to the metal shield of the cable.

III.2.158. The low and medium voltage windings which are not in use of the voltage transformer (self-dual transformers) must be connected in star or in triangle and the lightning arrester valve type is connected to each phase using. The protection of low voltage winding which is not in use is done by grounding one of the tops of the triangle, one of the phases of the star or the neutral point, or by setting the lightning arrester valve type in line with the voltage in each phase.

For the winding which is not in use but regularly is connected to the cable whose the length of metal shield is 30 meters or more, the additional lightning arrester valve type is not necessary.

III.2.159. To place the lightning arrester valve type to protect the neutral point of windings 110 - 220 kV of the voltage transformer whose the insulation is lower than the insulation level of the output and operate in the mode that the neutral point is not grounded. It is prohibited to place the isolator at the neutral point of the voltage transformer which is not allowed to be isolated from the ground.

III.2.160. The circuit reactor coil 500 kV must be protected against the atmospheric over-voltage and the internal overvoltage caused by the lightning arrester or by the anti-overvoltage device located in the circuits of the electrical resistance coil.

III.2.161. At the power distribution substation voltage 6 - 22 kV when the VTS is connected to the bus bar by cable, the distance from the lightning arrester valve type to the VTS and other equipment is not limited (For the exception, see Article III.2.145). When connecting the VTS to the bus bar of the power distribution sub station 6 - 22 kV by the bare lines, the distance from the lightning arrester valve type to the VTS and other equipment should not exceed 90m.

The segment of the overhead lines voltage 6 - 22kV going to the substation is not protected by the earth lines.

For the overhead voltage LINES 6 - 22kV that could be switched off for long time in the lightning season, to place the lightning arresters for the lines on the structure of the substation or on the last pole of the overhead lines at the side that power is can be switched off for long time. The distance from the lightning arresters to the breaker should not be greater than 15m.

The earth resistance of the lightning arresters for the lines should not be higher than 10Ω when the resistivity of the ground is up to 1000Ωm and 15Ω when the ground resistivity is higher. For the segment of overhead lines voltage 6 - 22kV going to the substation with the metal or reinforced concrete poles 200-300m far away from the substation the grounding with earth resistance no greater than 10 Ω is required.

To protect voltage the VTS 6 - 22 kV connected to the overhead lines voltage 6 - 22kV, to use the lightning arresters valve type located both at the high and low voltage sides.

If the lightning arrester valve type is located in the same compartment with the voltage transformer, the lightning arrester should be placed before the fuse.

III.2.162. If the segment of the cable 35kV - 220kV inter-connected to the overhead lines is shorter than 1.5 km, both ends must be protected by the lightning arresters valve type. If the cable length is greater than 1.5 km, the lightning arrester valve type is not required.

Where the cable is connected to the overhead lines voltage 6 - 22 kV going to the substation by a cable with length up to 50 meters, at the connection point between cable and the overhead lines, the lightning arrester valve type is required.

When the cable is longer than 50 meters, in at the connection point with the overhead lines, the lightning arrester valve type is required.

The lightning arrester should be connected by the shortest distance to the metal shield of the cable and the grounding poles. The earth resistance should not be greater than the values stated in Article III.2.161.

III.2.163. For the VTS having voltage transformer with capacity up to 40MVA connected to the overhead lines 35-110kV without earth line, when the branch has short length, the substation can be protected by following simple diagram (see Figure III.2.13):

• To place the lightning arrester valve type in the station as close as possible to voltage transformer and the distance should not exceed 10 meters.

• To protect the entire length of branch lines into the substation by the earth line, when the branch length is below 150 meters, to use the earth line or lightning rod to protect the segment between columns of the main lines on both sides of branches.

If the length of the branch is greater than 500m, the lightning arrester for lines 1 is not necessary. To protect the VTS when the distance between the voltage transformer and the lightning arrester valve type is greater than 10 meters in accordance with the requirements stated in the Articles III.2.149 and III.2.155.

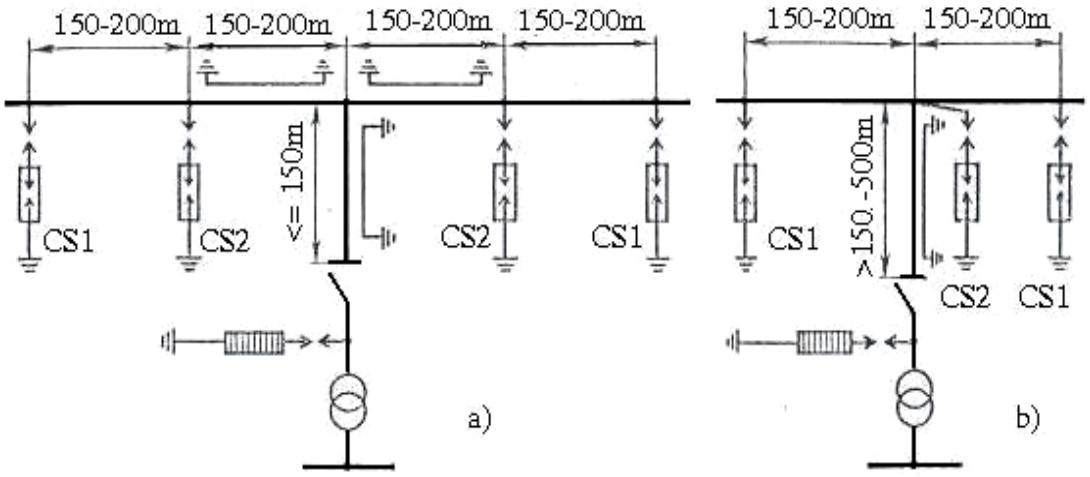


Figure III.2.13: Diagram to protect against the atmospheric overvoltage for the voltage transformer connected to the overhead lines by the branches

a) Branch length to 150m

b) Branch length above 150m to 500m

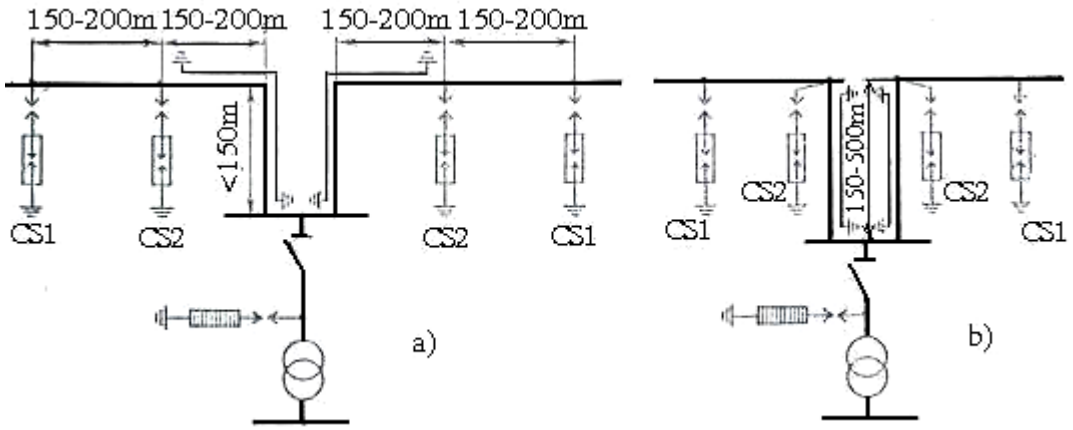


Figure III.2.14: Diagram to protect against the atmospheric overvoltage for the voltage transformer connected to the overhead lines by the branches going to the substation.

Branch length: To 150m (a) and above 150m (b).

It is allowed to use the simple protection as required above for the substation connected to the existing overhead lines by two short branches (Figure III.2.14). In such case the voltage transformer must be protected by the lightning arrester valve type.

It is not allowed to use simple diagrams to protect the VTS connected to the new overhead lines. III.2.164. In the area of ground resistivity above 1.000Ωm, the earth resistance of the lightning arrester 1 and 2 voltage 35 - 110 kV installed to protect VTS connected to the existing overhead lines by branches (Figure III.2.13) or by short cables (Figure III.2.14), may be greater than 10Ω but not greater than 30Ω In such case the grounding circuit of the lightning arrester 2 must be connected to the common grounding circuit of the substation by the grounding pole.

III.2.165. For the overhead lines voltage 35 - 110 kV with the isolator mounted at the branching poles, the lightning arrester for the lines should be placed. In all cases the lightning arrester for the lines must be placed on the same pole with the isolator at the power source side. III.2.166. If the overhead lines are protected by earth line along the entire length, all the branches must also be protected by earth line.

Lightning protection for electrical rotating machineries

III.2.167. It is allowed to connect the overhead lines to the generators and synchronous compensator with capacity up to 50MW each (50MVA). It is allowed only to connect the overhead lines to the generators and synchronous compensator with capacity greater than 50MW (50MVA) through isolating transformer .

III.2.168. For the protection generators, synchronous compensators, electric motors, power greater than

3MW (3MVA) connected to the overhead lines, to use the lightning arrester valve type and capacitors having capacitance not lower than 0.5μF each phase. Besides, to protect the segment the overhead lines connected to the power plant (VTS) at the lightning-resistance level not lower than 50kA. The lightning arrester valve type should be placed in the bus bars at the voltage of generator to protect the generator (synchronous compensator) with a capacity of 15MW (15MVA) or less, at the bus bar of the power distribution substation to protect the electric motors capacity greater than 3MW, at the output of the generator (synchronous compensator) capacity greater than 15MW (15MVA). For the protection of the generator (synchronous compensator) having the neutral wires that go out, having no grommet (bar winding-type generator) with a capacity of 20MW (20MVA) and above, the lightning arrester valve type located at the neutral side of generator (synchronous compensator) at the nominal voltage of the generator can be used to replace the capacitors 0.5 μF in each phase. The capacitor is not required for protection if the total capacitance of the cable (length is up to100 meters) connected to the generator (synchronous compensator) is over 0.5 μF for each phase. III.2.169. If the electrical rotating machineries and the overhead lines are connected together to the bus bars of the power plants or to the voltage transformer, the said overhead lines should be protected against lightning according to the following requirements:

1. The header of the overhead lines should have the earth line at least 300m long. At the header of the line must have the lightning arrester for the lines (Figure III.2.15a). The cables of overhead lines must be placed on the insulator with electrical insulation level of 35 kV. The earth resistance of the lightning arrester should not be greater than more 5 Ω, the earth resistance of the pole having earth line should not be greater than more 10 Ω.

At the header of the line the lightning arrester valve type can be placed instead of lightning arrester for the lines. In such case, the earth resistance of the earth line should not be greater than 3Ω.

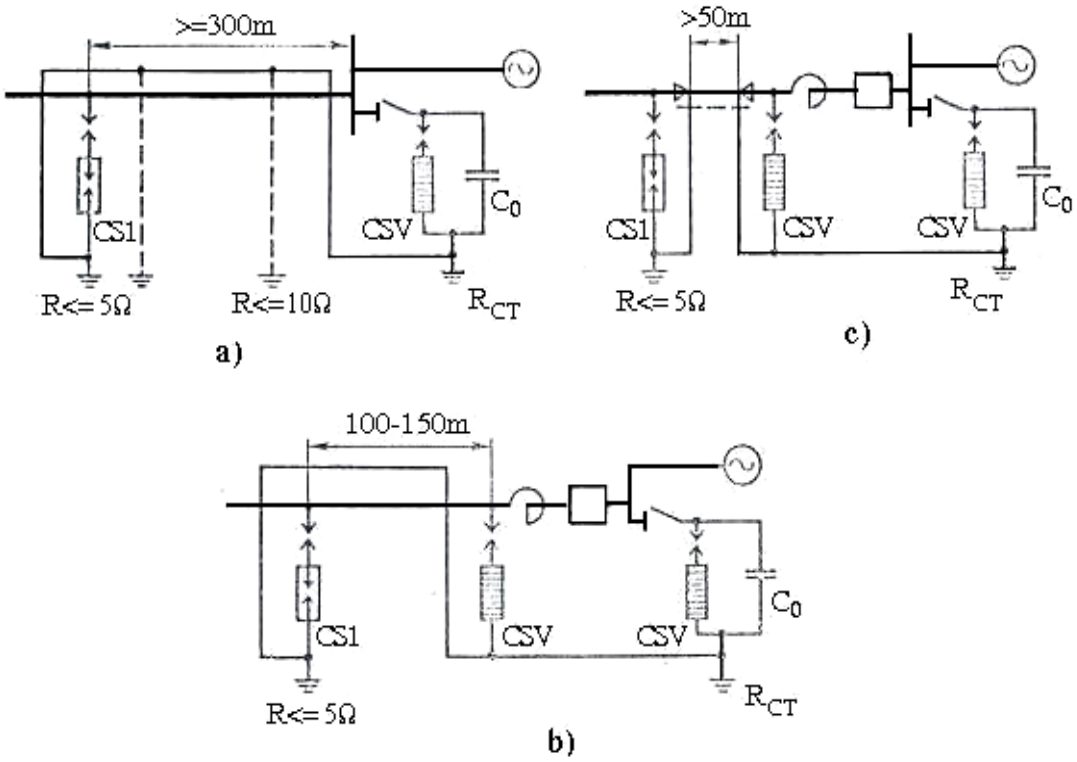
2. The overhead lines that are connected to power plant or VTS through a cable long 0.5 km shall be protected as overhead lines without cable (see Section 1) and the lightning arrester valve type should be added at the connection point between cable and overhead lines. The earth line is connected by the shortest distance to the metal shell of the cable and connected to the grounding system. The earth resistance of the earth line should not be greater than 5 Ω.

3. If the overhead lines are longer than or equal to 300m and protected against direct lightning strike by the high buildings, tree or works, the earth line is not required. In such case, in the section of overhead lines that is protected (toward the line) the lightning arrester valve type is requires. The earth resistance of the earth line should not be greater than 3 Ω.

4. When connecting the overhead lines to the bus bar of the substation having the electrical rotating machineries through the reactance, the overhead lines are from 100 – 150 m, the said overhead lines must be protected against direct lightning strikes by earth line (Figure III.2.15b). At the header of the line which is protected by a earth line, the lightning arrester should be placed, at the reactance: lightning arrester valve type. The earth resistance of the lightning arrester for the lines should not be greater than 5Ω.

5. When connecting the overhead lines to the bus bar of the substation having the electrical rotating machineries through the reactance, the cable is longer than 50 m, the protection against the lightning for the section of overhead lines near the substation. At the connection point between the overhead lines and the cable the lightning arrester for the lines with the earth resistance not greater than 5 Ω is required, and before the reactance the lightning arrester valve type is required (Figure III.2.15c).

6. If the segment of the overhead lines connected to the bus bar of the power plant (VTS) having the electrical rotating machineries capacity lower than 3MW (3MVA) is not shorter than 0.5 km and the earth resistance of the pole not greater than 5Ω, the lightning arrester valve type must be placed on that segment of the overhead lines and far from the power plant (VTS) 150m. The earth resistance of the earth line should not be greater than 3Ω. In this case the earth line for this segment of the overhead lines is not necessary.



overvoltage for electrical rotating machineries

III.2.170. When connecting the generator (synchronous compensator) to the voltage transformer by the open conductive system, the conductive parts of this system must be in the area of protection against direct lightning strike of the lightning rods or works of the power plant (VTS). The distance from the grounding points of the lightning rods to the grounding points of conductive system should not be smaller than 20 m (by the earthing wire).

If the conductive system is not in the area of lightning protection of outdoor substation, the protection against direct lightning strike by independent lightning rod or earth line mounted on the separate pole with protection angle which does not exceed 20^{o}. The independent lightning rod and the earth line must be connected to the separate grounding system. In case that they are connected to the common grounding circuit of the substation, the connection point must be far away from the grounding point of the conductive system at least 20m.

The air gap between the independent lightning rod or the pole where mounted the earth line to the conducting part or grounding parts of the conductive system shall be not lower than 5m.

The distance under the ground between the individual grounding system or the underground part of the independent lightning rod to the grounding system or the underground part of the conducting system shall be not lower than 5m.

III.2.171. When connecting the VTS of the industrial enterprises to the power distribution substation of the power plant with capacity to 120MW per generator by open conducting system, the protection against direct lightning strikes on the wire should be carry out in accordance with the Article III.2.170.

When connecting the bare conductive bar to the PDE at the voltage of the generator through the reactor, before the reactor the lightning arrester valve type is required.

To protect generators against the transmission of lightning waves through the conductive bar and against the induced overvoltage, to place the lightning arrester valve type and capacitor to protect for all three phases. At the nominal voltage 6 kV - the capacitance of the capacitor should not be lower than 0.8 μF, 10 kV - not lower than 0.5μF and 13.8 - 20kV - not lower than 0.4μF.

The capacitor is not required for protection if the total capacitance of the generator and the cables connected to bus bar of the generator is equal to the value required. In this case, when determining the capacitance of the cable, to determine only the capacitance of the cable with length to 750m.

III.2.172. It is allowed not to protect against direct lightning strikes to the overhead lines if the overhead lines are connected to an electric motor whose capacity is up to 3MW and it has certain redundant power supply.

The lightning arrester for the segment of the overhead lines which is 250 meters long if the earth resistance of the pole in this section does not exceed 10Ω.

For the cables going to the substation have any length, before the cable the lightning arrester valve type must be placed. The grounding wire of the lightning arrester valve type must be connected to the cable's metal shell.

For electric motors, to place the lightning arrester valve type and capacitor 0.5 μF in each phase.

Protection against internal overvoltage

III.2.173. In the 6 - 35 kV power grid, if the compensation for the capacitive current between phases and ground is required, to balance that capacitive current by placing the phases and high-frequency communication capacitor appropriately. The difference of the capacitance of phases to the ground should not exceed 0.75%.

The position of arc-suppression coil must be chosen in accordance with the followings: the structure of the grid, the ability to divide the grid in to independent parts, the probability of incidents, affects to the automated circuit of the railway and to the communication line.

Do not place the arc-suppression coil on the voltage transformer in the following cases:

a. The voltage transformer is connected to the bus bar through the fuse.

b. The voltage transformer is connected to the grid by just one line.

The capacity of the arc-suppression coil is chosen on the total value of the earth-fault capacitive current, taking into account the development of the grid.

III.2.174. In the 110 - 220 kV grid with neutral earthing and the 110 - 220 kV coils of the voltage transformer or autoconnected transformer have the increased insulation, the measures to limit the internal overvoltage are not required.

The 220 kV coils of voltage transformer or autoconnected transformer with the normal insulation must be protected against internal overvoltage by lightning protection equipment as required by the Article

III.2.175. In the 6 - 35 kV grid with the arc-suppression coil or generator (synchronous compensator) with the stator winding cooled directly by water, the protection against the auto-sliding from the neutral point is not required.

In the 6 - 35 kV grid without the arc-suppression coil or generator (synchronous compensator) without the stator winding cooled directly by water and in the 6 - 35 kV grid that can be separated from the arc-suppression coil or from the above generator (synchronous compensator) as well, when switching-off automatically and testing to find the touchdown point, testing and repairing the facilities periodically, to

take measures against the sliding from the neutral point by placing a 25Ω impedance withstanding the permanent current 4A in the open triangular coil at the secondary side of the 6-35 kV voltage transformer, together with the device that can separate the resistor.

Also, in the diagram of the combination generator – voltage transformer and synchronous compensator – voltage transformer, there must be a second resistor that will be automatically in parallel with the regular resistor when the ferromagnetic resonance occurs.

In 6 - 35 kV grid that the measuring the voltage phase to ground (checking the insulation) or zero sequence voltage is not necessary, to use a voltage transformer with primary coil that is not grounded.

III.2.176. In the 500kV power grid, depending on the length and number of overhead lines, grid diagram, breaker type, capacity of the voltage transformer and other parameters, to take measures to limit the voltage rise and to equip the devices to protect against the close-open circuit overvoltage on the basis of calculating the overvoltage. The allowable voltage rise of the 500kV equipment should be determined depending on the effecting time.

III.2.177. In the 500kV power grid, the close-open circuit overvoltage must be limited to the values in the Table III.2.2.

To limit the close-open circuit overvoltage that are harmful to equipment, to use on the overhead lines the combination of the lightning arresters valve type, electromagnetic voltage transformers or other equipment and to combine the measures to limit the voltage rise that is persistently high (Placing the reactance coil, taking measures on the diagram, automatizing the system).

The protective device against overvoltage of the 500kV equipment must be selected on the basis of calculating the internal overvoltage in the electrical system.

III.2.178. For the 220 and 500kV PDE with air breakers, to take measures to eliminate the ferromagnetic resonance overvoltage generated when connecting the voltage transformers and the voltage divider capacitance type of the breaker.

Pneumatic system

III.2.179. The pneumatic system must be designed in accordance with the current standards on techniques safety related to the pressure vessel and pneumatic system.

The pneumatic system must be equipped with the gauges and alarm signals to ensure the safe and reliable operation.

III.2.180. The pneumatic system must be able to supply air with the relative humidity that is appropriate to the type and operating pressure of the devices provided in all environmental conditions. If necessary, it can also provide air drying equipment.

The pneumatic system must be designed so that water can be discharged from all containers or from the water collection pits during operation.

III.2.181. The pneumatic system must be designed to operate with minimum and maximum power in all environmental conditions in order to achieve the compatibility of the switching devices and systems.

The air compressor must be cooled and protected appropriately.

The pressure vessels and pipes must be protected against corrosion inside and outside.

The functions of all components of the pneumatic system should be indicated on their covers. The different pressure values must be mentioned on the pipes, tanks and diagrams of operation.

III.2.182. The pneumatic system must have the isolation and discharge points, it is allowed to section for the maintenance and in accordance with the requirement in operation and safety.

The pipes that are often under pressure should be protected against damage due to direct effects of the arc.

To arrange the pneumatic system to ensure safety to operator to inspect, monitor and operation.

III.2.183. The pressure relief valve should be able to maintain air pressure of the air distribution equipment and the air storage container of the breaker within the requirements of the manufacturer to ensure switching ability and the reliability of operation of the circuit breakers in the unsuccessful auto-switch of reverses mode.

The productivity of the pressure relief valve and air distribution equipment must be able in less than 3 minutes to recover the pressure of the compressed air (to the minimum allowable value of the pressure under the working conditions of the breakers).

III.2.184. Between the oil and water separator and the air storage container the back-pressure valve is required.

III.2.185. Capacity and operating mode of the compressor must be selected to meet the requirements of the breakers and operating modes of the power system.

III.2.186. The air reserved in storage tanks must be enough to add to the electrical equipment in normal working and false mode.

The storage tank should ensure the adequate compensation for the total consumed air.

III.2.187. The pneumatic equipment must be completely automatic without the regular operator.

The pneumatic equipment should automatically maintain the pressure in the air container within the required limit.

The pneumatic system must be equipped with signaling devices for the abnormal working mode.

III.2.188. The compressed gas containers must conform to safety regulations on the pressured containers.

III.2.189. The compressed gas containers must be placed outside and far from the walls 0.7-1m. It is required to foresee the ability that when any compressed air containers is removed, this does not affect the normal working of the other containers.

III.2.190. The bleed valves of the water and oil separator of the air compressor shall be connected to the oil exhaust system to their own oil collecting pit.

The diameter and the slope of the exhaust pipe must be big enough to avoid the ability to be blocked up.

III.2.191. The air intaken on the air compressor must be filtered through the filter located in the compressor.

III.2.192. The outside of the air container and the outdoor water separator must be brightly painted.

III.2.193. All parts of compressed air equipment should ensure the safe access for inspection, dismantling, repair and cleaning.

Oil system

III.2.194. For the operation and maintenance of oil equipment of the VTS, a group of oil treatment us system including oil tank, oil treatment device for oil pumps, filters and oil recovery devices, filters and air treatment device, oil tanks transport facilities could be planned.

The location and size of the concentrated oil system should be in accordance with the approved plan.

III.2.195. At VTS with synchronous compensator, to build two fixed oil storage container for the turbines, regardless of the number and capacity of oil insulated container.

Capacity of each oil container should not be less than 110% of capacity of the oil the system of the biggest synchronous compensator in the substation.

III.2.196. In other VTS the oil storage and oil system is not required. The supply of oil to the VTS system will be from the concentrate oil system.

III.2.197. The fixed oil pipe to the oil breakers and voltage transformer. For the oil discharge and loading for equipment, the pipeline and mobile oil storage container must be used.

III.2.198. For the large industrial plants or industrial complex with electrical equipment using oil in bulk, the individual oil system is required.

III.2.199. The oil container must be equipped with the air filter, the oil level indicator and the exhaust valves and pipes.

III.2.200. The distance from oil tank of the outdoor oil stock to:

a. The works of power plant and VTS (including service station) should not be less than 12 meters for the oil stock with total capacity to 100 tons, 18m for the oil stock with total capacity over 100 tons.

b. For the houses and public houses, the distance should be increased by 25% of the distance mentioned in the point a.

c. The oil processing system: Not less than 8m.

d. The hydrogen storage: Not less than 20m.

Installation of power transformer capacity

III.2.201. This section applies to the installation of fixed voltage transformer (including autoconnected) and oil reactor (including arc suppression coil) having the voltage 6 kV or above located indoor and outdoor. It does not apply to voltage transformer of special use.

The voltage transformer, reactance coils are referred to as voltage transformer. The installation of auxiliary equipment for the voltage transformer (electric motors of cooling system, measuring instruments, control devices, etc.) must comply with the relevant provisions of these Regulations.

III.2.202. The selection of the parameters of the voltage transformer should satisfy its working mode. To consider the possibility of short-and long-term overload. This requirement applies to all coils of the voltage transformer.

III.2.203. The voltage transformer should be arranged to check easily and safely the oil level without switching off the power.

If the common light is not enough, to arrange the light source in place to check the oil level in the night time.

III.2.204. To arrange so that the access to gas relay of the voltage transformer is safe to observe and to take oil sample without switching off the power. If the height from ground to the voltage transformer is over 3 meters, a fixed ladder is required.

III.2.205. It is allowed to place the lightning arrester valve type voltage under 35 kV on the body of the voltage transformer .

III.2.206. For the voltage transformer on the wheel, its bed must be equipped with guiding plates. To fix the voltage transformer on a guiding plates, to place the shields in two side wheels of the voltage transformer .

On the transformer bed, a place for the lifting jack is required.

III.2.207. If required by the manufacturer of voltage transformer, the inclination of the oil voltage transformer should be ensured according to the instruction so that the generated gas can reach the gas relay.

III.2.208. When mounting the auxiliary oil tank on the other structure, to locate it so that it does not impede the moving of the voltage transformer from its base.

In that case, the gas relay must be placed close to voltage transformer so that while standing at the fixed ladder the operator can access to it conveniently and safety.

It is possible to mount the auxiliary oil tank on the gate pole of the compartment of the voltage transformer.

III.2.209. The explosion vent of the voltage transformer should not be directed to the equipment near it. To meet these requirements, when necessary, it is allowed to place a shield opposite the mouth of the vent.

III.2.210. The 500KV voltage transformer doesn't depend on the capacity, for the 220kV voltage transformer with capacity 200MVA or above the fixed automatic fire fighting equipment is required.

III.2.211. The startup of automatic fighting equipment must be done both by automatic remote from the control panel and manually at the location which is safe in terms of fire prevention.

For the group of voltage transformers single phase, to only start the fire fighting system at the phase which is broken down?

III.2.212. The indoor oil voltage transformer should be placed in the individual room (For exceptions, see the Article III.2.101) on the ground floor) which is separated from the other rooms and its doors open directly to the outside; it is allowed to place the oil voltage transformer on the first floor and at the place 1 meter lower than the ground floor in area which is not flooded, but the voltage transformer should be able to be transported to the outside, and there must be the oil exhaust system as per the regulations for the voltage transformer with the oil volumes over 600kg.

The voltage transformer which is placed higher than the first floor and lower than the ground floor 1 meter should be the voltage transformer dry type or the voltage transformer loaded with the non-flammable insulating materials. For the voltage transformer located in a room the Article III.2.86. must be complied.

It is allowed to place two oil voltage transformers, capacity 1.000kVA each in the same room if these two transformers have the same functions, a common control panel and their protection is the same and they are considered as one group.

It is allowed to place up to 6 voltage transformers dry type or the voltage transformers loaded with the non-flammable insulating materials in one room, providing that they do not affect the repair and operation conditions.

III.2.213. For the indoor voltage transformer, the distance between the most protruding part of the voltage transformer (at the height of 1.9 m from the floor) to:

a. Walls and partition walls - not shorter than 0.3 m for voltage transformer with capacity up to 400kVA, 0.6 m for voltage transformer with a greater capacity.

b. Door or protruding part of the wall at the entrance - not shorter than:

• 0.6 m for the voltage transformer with a capacity up to 400kVA.

• 0.8 m for voltage transformer with a capacity over 400 kVA to 1.600kVA.

• 1.0 m for the voltage transformer with a capacity over 1.600kVA.

This does not apply to the voltage transformer installed in the full-set stations of the high voltage 22kV or below.

III.2.214. The floor of the compartment of the oil voltage transformer should have the slope of 2% toward the oil collecting pit.

III.2.215. Door (gate) of the compartment of the oil voltage transformer should meet conditions stated in the Article III.2.99. Immediately after the door it is allowed to place the barriers at the height of 1.2 m to ensure the safety to the operator who observes the voltage transformer from the outside.

III.2.216. In the compartment of the voltage transformer, it is possible to install disconnector, fuse, sub-switch, lightning arresters, arc suppression coil and cooling equipment of that voltage transformer.

III.2.217. Each compartment of oil voltage transformer must have its own escape way to the outside or to the adjacent rooms which have inflammable floors, walls, and which do not contain flammable equipment or materials.

III.2.218. The horizontal distance from the entrance of the compartment of the voltage transformer of the abutting VTS or indoor VTS to the nearest window or door of the room should not be less than 1m.

III.2.219. The ventilation system of the compartment of the voltage transformer must ensure the extraction of the heat that is generated by the voltage transformer (see Article III.2.108) and must not be connected to other ventilation systems.

The wall of the air duct must be made of inflammable material which can resist fire within 0.75 hours, pipes and vents must be arranged to prevent standing water in the pipe from flowing into the VTS and to take measures against the water coming into the voltage transformer.

The vents must be covered with trellis with mesh of size 1x1cm and must be water-resistant.

III.2.220. The air duct of the compartment of the abutting voltage transformer having inflammable wall, but flammable roof should be at least 1.5 m from the walls or protected by inflammable walls with the height at least 0.6 m. The mouth of the air duct in this case is not necessary to be higher than the roof.

Do no place the air duct mouth facing the windows of the buildings.

Do no place the air duct mouth on the wall that is bellow the protrusive parts of the roof made of flammable material or holes in the wall of the adjacent building.

If above the door or the mouth of the air duct of the compartment of the voltage transformer there are windows, a shield protruding at least 0.7 m under windows is required. The shield must be wider on each side window at least 0.8 m.

III.2.221. The voltage transformer having the forced cooler should be equipped with the automatic start and stop for the cooling system.

The cooler should start up automatically in the temperatures of the top layer of the oil or of the winding voltage transformer and the value of the load current of the voltage transformer.

III.2.222. The outside cooler of the voltage transformer must be arranged so as not to impede the moving the voltage transformer from its base and the repair can proceed when the voltage transformer is working.

The hot air of the cooler should not be towards the body of the voltage transformer.

III.2.223. When arranging the valves of the cooler of voltage transformer, to ensure the convenient access to them. The cooler must be able to be removed from voltage transformer, to be dismantled and when transporting the voltage transformer, the discharge of the oil of the cooler is not required.

III.2.224. The outside oil pipeline of the forced cooler must be made of stainless steel or corrosion-resistant materials.

The outside oil pipeline of the forced cooler of the voltage transformer should not impede the operation and maintenance of the voltage transformer and cooler, and ensure the cost effective of moving voltage transformer. When necessary, the floor and stairs are required to reach easily the valve and the fan.

III.2.225. In order to check the oil pump and water pump of the forced cooler, to install a pressure gauge on each pump. If the pump has the strainer, the pressure gauges must be installed at both input and output of the strainer.

III.2.226. The external cooler single or double type placed in a row should be on the same base.

The coolers group type can be placed on the base or on the tracks if their transportation on the wheels is desired.

III.2.227. It is allowed to place the control cabinet on the body of voltage transformer if the cabinet can withstand the vibration of the voltage transformer.

III.2.228. The voltage transformer having the forced cooler should be equipped with signaling system warning when the oil, water circulating system, cooling fan stop working or sending alarm to switch off automatically the standby cooler reserve or backup power source.

III.2.229. The absorber for cleaning oil of the voltage transformer placed at the forced cooler should be indoor if requested by the manufacturer and the absorbent material could be replaced in place.

III.2.230. The drive cabinet of the voltage regulator under load must be equipped with the electric dryer.

III.2.231. The sun protection for the expansion tank containing the nitrogen protecting of the oil of the voltage transformer is required.

III.2.232. When repairing the inner part of the voltage transformer, if the lifted part is under 25 tons, to use the mobile crane or combining with the gate poles. To take measures to move the cover or the inner part of the voltage transformer and tents to cover them.

III.2.233. At the VTS having the voltage transformer that the cover can not be removed and the inner parts is heavier than 25 tons, if the mobile crane can not be used, to consider the appropriate measures.

III.2.234. For the outdoor voltage transformers located along the machine rooms of the power plant, to consider the ability to move voltage transformers to the repairing area without removing the voltage transformers, removing insulator at the input, structural supports of the conducting bars, gate poles, etc.

III.2.235. The way for the mobile crane or other means of transport is required to remove, install, repair the voltage transformers at their location.

Chapter III

BATTERY

Scope

III.3.1. This chapter applies to acid battery fixed type and alkaline batteries used in electrical works

III.3.2. The room where the battery bench is located (known as battery room) is considered as the fire hazardous and explosive room of class A (As per the Code TCVN 2622-1995) when the voltage of each battery is greater than 2.3 V. The battery room in regular trickle charge or charge mode but the voltage of each battery is lower than 2.3 V is only considered as the fire hazardous and explosive room when

after charging or charging after repair, the voltage of each battery exceeds 2.3 V. In the normal operation mode, if the voltage of each battery is below 2.3 V, the battery room is not the fire hazardous and explosive room.

Electrical issues

III.3.3. The power of the batteries must be capable of supplying electricity to the permanent and short-range DC sub load.

The DC power supply used for the communication of the substations should be from their own batteries. The equipment which is protected by two main protecting devices must be powered by DC power supply from two bus bars operating independently.

For the important 220 kV node sub station and 500kV substation, two battery sources which operate regularly are required.

III.3.4. The selection of electrical drying equipment, lights for battery room, electric motors for the ventilation, electrical circuits and the installation of these in the main and auxiliary battery room must be conducted according to the current regulations.

III.3.5. The charging device for acid batteries must have sufficient capacity and voltage to charge up to 90% of nominal capacity over a period that does not exceed 8 hours, after the batteries had been fully discharged according to the procedure.

The selection of the alkaline batteries should be in accordance with the manufacturer's instructions.

III.3.6. The battery room must be equipped with the switch key and the ampere meter in load, sub-load circuit of the battery bench.

III.3.7. When using the engine-generator unit for the charge and trickle charge, the breaker should be equipped to switch off the countercurrent when it occurs.

III.3.8. The protection by switch is required for the battery circuit.

III.3.9. The trickle charger should ensure the stable voltage on the bus bar of the battery bench within the limit of ± 2%.

III.3.10. The charger should be equipped with the device that prevents the increase of the voltage beyond the limit specified by the manufacturer.

III.3.11. The connection of the rectifier for trickle charge and charge to the AC power supply should be through the isolation transformer.

III.3.12. For the DC bus bar, the measuring instrument is required for the regular checking of the insulation resistance values and sending alarm signals when the insulation resistance value of each pole

is decreased to 20k Ω in the 220V power grid, to 10k Ω in the 110V grid, to 5k Ω in the 48V grid, to 3k Ω the 24V grid.

III.3.13. The battery must be lit when the incident occurs.

III.3.14. The batteries must be placed on racks or robust cabinets.

When placing batteries, to make sure that all batteries of the bench are reachable. Make sure that the distance between the benches, to the walls or to cabinet walls are enough to ensure the easy access for the operation and maintenance.

Battery bench must be strong enough to bear the weight of the batteries.

III.3.15. The battery rack should be manufactured tested and marked in accordance with the requirements of current standards or other technical conditions. Rack must be protected against the effect of the electrolyte by a sustainable coating.

III.3.16. The battery must be insulated with the racks and racks should withstand the electrolyte and other corrosive chemicals.

The rack for the battery with voltage to 48V can be without insulating pad.

III.3.17. The passage for the operation and maintenance of acid batteries bench must have a width of not less than 1 meter when the batteries located on two sides and 0.8 m when the batteries located on one side.

III.3.18. To make sure that the space above the batteries is least 200mm for easy access and add solution to the batteries. To make sure that the distance between the cabinet wall and the batteries (if placed in a cabinet) is enough so that the short circuit could not occur. The vent pipe above of the batteries should rotate 180^{o} for easy addition of solution.

III.3.19. The bus bars of the battery bench must be the bare copper bar or copper single-core cable having the chemical corrosion resistant insulation cover.

The joint and the branching point of the copper bars, copper cables should be welded or soldered (by tin, copper, etc.). The joint between the bus bar and cable to the battery must be plated with tin. The joint between the bus bar and the conductor going through walls must be welded.

III.3.20. The bare bars must be painted with two layers of chemical corrosion resistant paint and after the paint has been dried, to paint the positive (+) red and the negative (-) blue. In the places that can not be painted, to apply a layer of vaseline before pouring the electrolyte into the battery.

III.3.21. The distance between the bare conductors that are near to others is determined by calculating the mechanical strength. The said distance and the distance from the bus bar to the parts of the building and the other grounding parts should not be less than 50mm.

III.3.22. The bus bar must be fixed tightly to the insulator.

The distance between the support points of bus bars of any shape is determined by calculating the mechanical strength, but not longer than 2m. The structure, insulator, accessories, accessories for fixing the bus bar must have the electrical and mechanical strength, resistant to permanent effects of the electrolyte vapor.

The grounding for the supporting structures is not required.

III.3.23. The plate that holds the bar going through the wall must withstand the permanent impact of the electrolyte vapors. It is not allowed to use the stone plates and plates made of laminated structure materials.

III.3.24. The connection between the plate at the output of battery room to the switchgear and the power distribution panel should be done by single-core cable or bare conductive bar.

III.3.25. During the transportation, to ensure that the batteries are fixed and the vents of the battery are sealed. Also to follow the specific instructions and recommendations of the manufacturer about installation, operation, maintenance and safety.

Installation issues

III.3.26. The fixed battery bench must be placed in separate room or cabinet.

It is allowed to put together a number of batteries in a room.

III.3.27. The acid batteries room is considered as the fire hazardous and explosive room of class A, so it must be built in accordance of the Code TCVN 2622 - 1995 on fire prevention and protection.

The batteries can be placed on the rack, fixed on the floor or in cabinets

III.3.28. Batteries must be installed in the dry and clean room, prevented form high temperature and sunlight.

If the batteries placed in closed room or compartment, the proper ventilation is required.

III.3.29. The sealed batteries cell type (e.g. car batteries), total capacity not exceeding 72Ah and powering the fixed electrical equipment, could be placed in their own room ventilated by natural air or in the fire hazardous and explosive workshops or in ventilated metal cabinet. If the above conditions are met, the fire hazardous and explosive level of the workshop is not changed.

III.3.30. The batteries bench with the voltage of each battery is lower than 2.3 V can be placed in the common workshop which is not the fire hazardous and explosive, providing that there must be lid for ventilation above the batteries. In such case the fire hazardous and explosive level of the workshop is not changed.

III.3.31. The battery room should:

1. Be located close to the charging devices and DC power distribution panels.

2. Be against dust and water infiltrating from the outside.

3. Facilitate the management and operation.

4. Be placed far away from the source of the shock.

III.3.32. At the door of the batteries room there must be the notice "Battery room – No fire."

III.3.33. Next to the batteries room, there must be extra space for tools, equipment for operation and maintenance.

III.3.34. The ceiling of the batteries room must be flat. Protruding or tilt parts on the ceiling are allowed if the conditions in Article III.3.43 are met.

III.3.35. The floor of the batteries must be flat and acid resistant.

III.3.36. Walls, ceilings, doors, inner and outer sides of the ventilation pipes, made of metal etc. must be painted with acid resistant paint.

III.3.37. If the batteries are located in the cabinet or closed room, the space for the escape of air and limiting the condensation during the charging.

The inner side of batteries cabinet should be painted with acid resistant paint.

For alkaline batteries, to make sure that the amount of hydrogen in the batteries room or cabinet should be lower than 4%.

In addition, the calculation of ventilation for the batteries room must comply with the instructions of the manufacturer.

III.3.38. For the batteries with the nominal voltage to 250V, the aisle should be insulated.

III.3.39. If the ventilation devices in the batteries temporary, there must be room for these devices and their junction to the ventilation pipe.

Sanitary issues

III.3.40. The acid batteries room with the voltage of each battery greater than 2.3 V must be equipped with fixed forced ventilation system. For the batteries working with the regular trickle charging mode and the voltage of each battery is 2.3 V, to use the fixed or not fixed forced ventilation system during the normal charge or charge for test.

In addition, to use natural ventilation system to ensure the exchange of air volume at least once in 1 hour. If the natural ventilation can not satisfy meet the exchange of air, it is required to use the forced ventilation.

The air volume exchanged for the forced ventilation (V) in 1 hour is determined by the formula:

$$V = 0,07nI_n$$

Where:

V: Calculated in m^3

n: Number of batteries

I_n: Maximum charging current (A).

III.3.41. The ventilation is used only for the batteries room and auxiliary space.

It is prohibited to connect this ventilation system to the chimney flue or to the general ventilation system of the building.

III.3.42. The forced ventilation system should be of explosion-proof type.

III.3.43. To exhaust the gases in both the upper and lower parts of the acid battery room on the opposite side to the clean air blowing into. If the ceiling has the protruding structure that is divided into several compartments, to exhaust the gas in each compartment. If the ceiling is inclined, to exhaust gas at the highest place. The air flow rate in the batteries room and in the room containing acid, the ventilation system must satisfy the hygiene standards in the industrial buildings.

III.3.44. If the manufacturer's instructions are not available; the temperature of the batteries room should be maintained from 10^oC to 30^oC for the efficiency and durability of the batteries.

III.3.45. Water pipes must be placed in the batteries time, the faucet and the water basin are required.

On the basin there must be the notice: "Do not pour the electrolyte or acid!"

Annex III.1

Table III.2.1: The smallest gap of indoor and outdoor substations for voltage levels up to 220kV

Nominal voltage of the system (kV)	Highest voltage of equipment (kV)	Voltages that withstand the short-duration industrial frequency (kV)	Voltages that withstand lightning impulse 1,2/50μs (peak value) (BIL) (kV)	Smallest gap phase-phase and phase-earth N (mm)	
				Indoor	Outdoor
6	7,2	20	60	130	200
10	12	28	75	130	220
15	17,5	38	95	160	220
22	24	50	125	220	330
35	38,5	75	180	320	400
	40,5	80	190	350	440
110	123	230	550	1100	
220	245	460	1050	2100	

Notes:

• The voltage that withstands the short duration industrial frequency is the sinusoidal value of the industrial effective frequency of about 48Hz - 62Hz within the time of 01 minute.

• The smallest gaps for the voltage levels greater than 35kV indoor and outdoor are the same.

• The smallest gap is taken according to voltage levels that withstand the highest lightning impulse for each voltage level.

Table III.2.2: The smallest gaps of the substation of the voltage of 500kV

Nominal voltage of the system (kV)	Highest voltage of equipment	Voltage that withstands the short-duration industrial frequency (kV)	Voltages that withstand lightning impulse 1,2/50μs (peak value) (BIL) (kV)	Voltage that withstands the nominal switching impulse phase-earth 250/2500μs (kV)	Smallest gap phase-earth N_{p-e} (mm)		Voltage that withstands the nominal switching impulse phase- phase 250/2500μs (kV)	Smallest gap phase-phase N_{p-p} (mm)	
					Conduc-tive bar - earth	Pole-earth		Conductive bar – Parallel Conductive bar	Pole – Conductive bar
500	550	710	1800	1175	3300	4100	2210	6100	7400

Table III.2.3 Smallest distance between the outdoor power equipment and the substation cooled by water

Substations cooled by water	Distances, m
Substations cooled by water spray and outdoor cooling tower	80
Tower cooled by fan	30
Tower cooled by sectional fans	42

Table III.2.4: Smallest distance from the hydrogen storage to the buildings of VTS and overhead lines poles

Number of hydrogen bottles in the storage (bottle)	Distances	
	To the buildings of VTS	To the overhead lines poles
Up to 500	20 m	1.5 times of the height of the pole
Over 500	25 m	-

Table III.2.5: Smallest gap between the energized parts to other parts of the outdoor PDE

Figure numbers	Distances	Symbols	Smallest insulator gap (m) under nominal voltage, kV					
			To 15	22	35	110	220	500
III.2.1	• Phase-Earth • Phase-phase	Np-e Np-p	0,22	0,33	0,44	1,1	2,1	3,3 (4,1) (1) 6,1 (7,4) (2)
III.2.3	From the energized parts to the edge of the internal guard-net: • Blind guard-net, height ≥ 1,8m • Trellis, height ≥ 1,8m	B1 B2,3	0,22 0,3	0,33 0,41	0,44 0,52	1,1 1,5	2,1 2,2	4,1 4,5
III.2.4	From the energized parts to the edge of the surrounding guard-net: • Blind guard-net, height ≥ 1,8m • Trellis, height ≥ 1,8m	C E	1,22 1,72	1,33 1,83	1,44 1,94	2,1 2,6	3,1 3,6	4,2 5,6
III.2.5	From the energized parts to the road for vehicle inside the substation	H’	4,3	4,3	4,3	6,0	6,6	9,6
III.2.5 III.2.6	From the energized parts to the travel area (without the road for vehicle inside)	H	2,5	2,58	2,69	3,35	4,35	6,35
III.2.5	From the energized parts to the transportation	T	0,5	0,5	0,54	1,2	2,2	4,2

	facilities							
III.2.6	From the energized parts of different circuits, when one circuit is being fixed, the others are still energized	Dv	1,22	1,33	1,44	2,1	4,1	6,1

Notes: (1) Minimum gap phase - phase between poles – bars for 500kV voltage is 7.4 m.

(2) Minimum gap phase-earth between poles- bar for500kV voltage is 4.1 m.

Table III.2.6: Smallest gaps between the energized parts and the other parts of the indoor PDE

Figure numbers	Distances	Symbols	Smallest insulator gap (m) under nominal voltage, kV						
			6	10	15	22	35	110	220
III.2.9	From energized parts to the blind guard-net	B	0,12	0,15	0,15	0,21	0,32	0,73	1,73
III.2.10	From energized parts to the trellis	C	0,19	0,22	0,22	0,28	0,39	0,8	1,8
III.2.10	Between the energized parts without guard-net of different circuits	D	2,0	2,0	2,0	2,2	2,2	2,9	3,8
III.2.11	From energized parts to the floor	E	2,5	2,5	2,5	2,7	2,7	3,4	4,2
III.2.11	From the output without guard-net of the PDE to the ground outside the area of the outdoor PDE and without road.	G	4,5	4,5	4,5	4,75	4,75	5,5	6,5
III.2.10	From the contacting bar and blade of isolator at OFF position to the conductor connected to the other contacting bar.	F	0,11	0,15	0,15	0,22	0,35	0,9	2,0