BRANCH STANDARD

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ELECTRICAL APPLIANCE REGULATION

PART IV – DISTRIBUTION EQUIPMENTS AND DISTRIBUTION SUBSTATION

(This translation is for reference only)

Construction Publishing House

ELECTRICAL APPLIANCE REGULATION

PART IV – DISTRIBUTION EQUIPMENTS AND DISTRIBUTION SUBSTATION

CHAPTER IV.1

Electrical distribution equipments – Voltage up to 1,000V

Scope

IV.1.1. This part of the regulation is applied for electrical distribution equipments with voltage up to 1,000V both indoor and outdoor, including: electrical distribution board, control board, relay board, electrical cabinet, main bus and assemblies.

For electrical distribution equipments of special structures, it is required to follow regulations specified in Part VII of the Code of Electrical Installation.

General requirements

IV.1.2. It is required to select the conduct wire, main bus, electrical appliances, tools and structures both in normal working condition (working voltage, current, accuracy level…) and in short-circuit condition (heat and electrical influence, limited power outage…).

IV.1.3. Every distribution circuit, distribution board should have clear indication about its tasks.

The indication should be easily notified from front and back side of the board when operating at both sizes.

IV.1.4. It is required to arrange different current circuits (alternate and direct current) and different voltages of the distribution system to easily identify.

IV.1.5. Relative positions of phases and poles in the same distribution system should be similarly installed. The main bus should be painted with color specified in Chapter I.1. of the Code. Arrangements of electrical distribution equipments should leave space for installing mobile protection grounding device.

IV. 1.6. All metallic parts of the distribution equipments should be painted or coated with anti-corrosion substance.

IV.1.7. Grounding should be carried out in compliance with regulations in Chapter I.7 of the Code.

Installation of electrical equipments and electrical tools

IV.1.8. Electrical equipments should be arranged in a manner that when they are operated, sparks or electrical arc generated will not cause any harm to the operator, or to cause fire, damage to nearby equipments or cause short-circuit between phase and phase or phase and earth.

IV.1.9. Circuit breakers should be arranged in such a manner that they cannot switch on the circuit due to gravity. Moving elements of the breaker generally should not carry any voltage after the current is cut off.

IV.1.10. Knife-switch directly controlled by hand (not having actuator) which is used for switching on and off the load current, of which the blade points toward the operator should have non-aperture enclosure made of fireproof material.

The knife-switch only used for isolating the voltage can be openly installed provided that non-staff can not touch it.

IV.1.11. There should be clear indication about “on” and “off” position on the actuator of the circuit breaker.

IV.1.12. It is required to anticipate ability of switching off the current for each low-voltage circuit breaker when repairing or assembling it by arranging knife-switch or other breaker at necessary position.

It is not required to install the circuit switch before the low-voltage breaker for each exposed circuit in following cases:

- The low-voltage breaker has clamped contact end which can be withdrawn.
- For fix-mounted low-voltage breaker which can be safely dismantled in positive condition by using insulation tool.

Mentioned above circuit breakers do not require special actuator (i.e. lever actuator).

IV.1.13. Screw type fuses should be arranged so that the conductor wire connects to the contact screw while the conductor wire leading to receiver connects to the enclosure.

Main bus, conductor wire, electric cable

IV.1.14. Distance between bare conductors fixedly connected to different poles and distance between these portions to non-conducting metallic elements should not be less than 20mm calculated from surface of the insulator and not less than 11mm in the air.

Distance from the bare conductors to the protection enclosure should not be less than 100mm for lattice enclosure and 50mm for panel enclosure.

IV.1.15. In the electric board and cabinet placed on dry area, the conductor wires which do not have protection case but their insulating enclosures can bear a working voltage no less than 660V can be positioned on a metallic surface coated by anti-corrosion paint in adjacent manner with each other. In that situation, for dynamic circuit, it is required to take into account the coefficient of decrease in load current as regulated in Chapter II.1 of the Code.

IV.1.16. Plain conductor wire and conductor bar for grounding do not need insulation.

IV.1.17. Installation of electrical wire for control circuit, meter circuit… should meet requirements in Chapter III.4 of the Code. Arrangement of electric cables should meet requirements in Chapter II.3 of the Code.

Structure of electrical distribution equipments

I.IV.1.18. Frame of the electrical board is made of fireproof material; enclosure and other parts are made of fireproof material or slow-burning matters. Moderator board and similar control board do not need to meet above requirement.

IV.1.19. Distribution equipments should be arranged and installed in such a manner that vibration generated by them or from other source will not cause any damage to contact ends and cause error in calibration of the equipments.

IV.1.20. For insulators used for directly installing plain conduction elements, their surfaces should be protected from moisture (by coating, painting…).

Distribution equipments installed at outdoor area, dusty, wet and very wet area… should be protected from environmental influences. It is not allowed to use insulation materials which have moisture retaining characteristic (i.e. marble, cement, asbestos)

Installation of distribution equipments in electric chamber

IV.1.21. In the electric chamber (see Chapter I.1 of the Code), pathway before and behind the electric board should meet following requirements:

1. Width: no less than 0.8m, height: no less than 1.9m. The pathway should not have any obstacle for people and equipment travelling. For exceptional case due to protrusion of constructional structure, the pathway's width should not be less than 0.6m.

2. Distance from the exposed portion of plain conductor (i.e. blade of the breaker when cutting current) which is arranged along the pathway or at an reachable height (lower than 2.2m) to the house wall or to uncovered opposite equipments which do not have plain conductor should not be less than:

- 1 meter for the electric board of 7m length, or 1.2m for the electric board of over 7m length at voltage of less than 660V.
- 1.5 meter at voltage from 660V and above.

Length of the electric board in above cases is considered to be length of the pathway between two rows of board (cabinet) or between a row and the wall.

3. Exposed plain conductors at both sides of the pathway and at a reachable height (less than 2.2m) should be spaced from each other with distance no less than:

- 1.5m at voltage less than 660V.
- 2m at voltage from 660V and above.

4. It is required to have protection enclosure for plain conductor with distance less than values stated in 2 and 3.

IV.1.22. To provide enclosure for plain conductors, it is able to use lattice with mesh size not greater than 25x25mm or to use panel or both types.

Height of the enclosure should not be less than 1.7m.

IV.1.23. The pathway for operating and controlling electric boards should have two exits when the electric board is longer than 7m. The exit behind the electric board can lead to chamber of the board or other chambers.

When the pathway is wider than 3m and the electric chamber does not contain any oil electrical equipments, the second exit is not required.

Door of distribution chambers should lead to outside area or other chambers (except for chamber where equipments used for voltage over 1000V are installed), and the door should have automatic lock which can be unlocked without key from inside. Width of the door should be no less than 0.75m and its height should not be less than 1.9m.

Installation of distribution equipments in production chamber

IV.1.24. In chambers where lay people can come in and out, the exposed plain conductor of distribution equipments should be cover by panel enclosure.

When using distribution equipment having plain conductor, enclosure is required. The enclosure should be lattice type, panel type or both types and should not be lower than 1.7m. Distance from the enclosure to the plain conductor should not be less than 0.7m; for panel enclosure, the requirement as in IV.1.14.

Width of the pathway should meet requirements in IV.1.21.

IV.1.25. Ends of conductor wire and cable should be placed inside the equipment.

IV.1.26. Built-up enclosure should be firmly mounted to be opened by tools only. The door should be key lock type.

IV.1.27. Installation of complete distribution equipment and complete distribution substation should follow regulations in Chapter IV.1.

Installation of outdoor distribution equipments

IV.1.28. Outdoor distribution equipment should be installed at a minimum height of 0.3m from ground base surface; for electric cabinet, this minimum height is 0.5m.

There should be dryers inside electric cabinet to ensure normal working condition of electrical tools, relay, meter…

CHAPTER IV.2

DISTRIBUTION EQUIPMENT AND DISTRIBUTION SUBSTATION WITH VOLTAGE OVER 1000V

Scope and definition

IV.2.1. This part of the Code is applied for fixed distribution equipments and distribution substations with voltage over 1000V to 220kV.

This part is not applicable for specialized distribution equipments and distribution substations as well as mobile electrical equipments.

IV.2.2. Distribution equipments are the equipments used for receiving and distributing electricity, including breaker, protection equipment, automatic meter, conductor bar and auxiliary devices (compressed air, battery…). The outdoor distribution equipments are those equipments of which the whole elements or main elements are placed outside the door.

Indoor distribution equipments are the equipments installed inside the house.

IV.2.3. Complete distribution equipment is the equipment which has already been assembled or ready for installation, including the whole or one part of completely or partially closed block of cabinets in which electrical devices, protection devices and auxiliary tools have been set up.

- Indoor complete distribution equipment is the complete distribution equipment installed inside the house.
- Outdoor complete distribution equipment is the complete distribution equipment installed outside the house.

IV.2.4. Distribution substation is an electrical structure used for transforming electricity and distributing electric power. It consists of transformers or other electric converters, electric distribution equipment, control equipments and auxiliary equipments.

There are two types of distribution substation: outdoor distribution substation and indoor distribution

substation.

IV.2.5. Property-abutting distribution substation is the substation constructed adjacent to main house.

IV.2.6. Inner distribution substation is the substation constructed right within the main house territory.

IV.2.7. Distribution substation for workshop is the substation constructed in area of production works (indoor or semi-indoor).

IV.2.8. Complete distribution substation is the substation consisting of transformers and element sets (complete outdoor or indoor distribution cabinet…) which have been assembled or ready for assembly.

Complete distribution substation and its elements arranged inside the house will be considered to be indoor equipments, arranged outside the house will be outdoor equipments.

IV.2.9. Pole mounted distribution substation is outdoor substation of which the whole elements are installed on structures or mounted on pole of transmission line without any enclosure.

IV.2.10. Distribution substation is the structure to receive and distribute electric power at a same voltage level without causing any change in form and level of voltage.

IV.2.11. Electric chamber is the chamber where electric equipments and main bus are placed. Closed block is the chamber blocked at all sides and having panel door.

Enclosure chamber is the chamber of which all hollows are completely or partially sealed (by lattice enclosure or both lattice and panel enclosure).

Combustion chamber is a closed chamber to install equipments which requires limitation in consequences caused in accidental incidence. This chamber should have door lead to open area or to combustion hall.

IV.2.12. Operation lobby is the entrance pathway along row of electric chamber or complete distribution cabinet, which is used to operate electrical equipments or main bus.

Combustion hall is the hall toward which the door of combustion chamber leads.

General requirements

IV.2.13. Electrical equipments, conductor portions, insulation portion, contact ends, enclosure, load bearing structure, insulation distance and other distance should be selected and installed so that:

1. In normal working condition, forces causing heat increase, arc and other incidences (fire ignition, gassing…) will not cause any harm or damage to equipments or cause short-circuit between phases, phase and earth, or cause any danger to operator.
2. In abnormal working condition, it is able to minimize damages due to short-circuit.

3. When interrupting the current for a certain circuit, electrical equipments, conductor and elements of that circuit can be safely checked, repaired and replaced without affecting normal working condition of abutting circuits.

4. Ensuring easy movement of electrical equipments.

Requirement in point 3 above is not applied for electrical distribution equipments in the distribution substation when repairing process needs complete cut-off from power source.

IV.2.14. When using isolator or circuit breaker for switching on/off transformer's no-load current, charge current or balance current of transmission line, earth current, gap among conductor portions, between conductor portions and the earth should meet requirements in this Chapter and in relative regulations.

IV.2.15. When selecting electrical equipments, conductor portion, insulation portions, it is required to follow condition of kinetic stability and thermal stability. For the breaker, it needs additional requirements to consider breaking ability and to follow regulations in chapter I.4 of the Code.

IV.2.16. Structure for installation of electrical equipments stated in IV.2.15 should be able to bear impact generated by the equipments' mass, by the wind in normal condition as well as impact arising due to short-circuit.

Constructional structures nearby electric conductor portions accessible by the operator should not get a heat over 50^{o}C due to current influence, for inaccessible structures, they should not be hotter than 70^{o}C. For structures at conductor portions of alternate current 1000A and lower, heat checking and requirements is not required.

IV.2.17. In all circuits of distribution system, isolating blade of the isolator should be placed visibly to ensure isolation of electrical equipments (breaker, circuit breaker, current transformer, shunt transformer…) of every circuit from the main bus as well as from other power sources.

This requirement is not applied for complete distribution system on trolley, high frequency reactor and communication capacitor, shunt transformer at output end, lightning resistance at output of the transformer, at output line and at transformer with cable input. In particular cases, due to structure or layout, current transformer can be placed before isolator to isolate the rest equipments of this circuit from power source.

IV.2.18. Breaker or its actuator should have firm and visible indicator to show its working position (on and off). It is not allowed to use light signal to be the only indicator of the breaker. If the breaker does not have open contact point and its actuator is isolated from it, there should be a position indicator on both the breaker and its actuator.

IV.2.19. When arranging distribution equipments and distribution substation at area where ambient air contains harmful substances for equipment and breaker bar or reducing insulation, it is required to have

method to ensure safe operation of the equipment.

- To use additional insulation
- To use main bus made of material against environmental influence or coated with protective material.
- To arrange equipment at main wind direction.
- To use simplest layout
- To use closed-type distribution system
- To prevent dust and granular gas penetrating into chamber of distribution equipment.
- When installing outdoor distribution system near the beach, saline water, chemical utility… and at area where aluminum can be corroded by the time, it is required to use special steel-cored aluminum wire coated with anti-corrosion material.

IV.2.20. When arranging distribution equipment at 1000m of sea level elevation, distance of insulating air, insulator series and internal insulation of the equipment should be selected in compliance with requirements in IV.2.52, 53; IV 2.81, 82 and adjustment should be considered to fit with decrease in insulation due to decrease in atmospheric pressure.

IV.2.21. Main bus of distribution equipment and distribution substation is usually aluminum wire, steel-cored aluminum wire, steel wire, duct or aluminum bar, aluminum alloy… which are used in electrical engineering.

Bus duct is only used as required in Chapter II.2 of the Code.

IV.2.22. Phase of electrical equipment, main bus of distribution equipment and distribution substation should be symbolized in accordance with requirements in Chapter I.1 of the Code.

IV.2.23. Distribution equipment of voltage over 3kV should be interconnected to eliminate ability of:

- Switching on circuit breaker, circuit switch, isolator while switching on the earth blade, causing short-circuit.
- Switching on earth connector with the main bus while the main bus still carries charges.
- Switching on and off the circuit breaker, isolator in charged situation if not allowed by structure of the equipment.

Earthing blade at wire side of the line isolator only needs mechanical interconnection with actuator of that isolator, and the blade should be locked at cutting off position.

For distribution equipments with simple arrangement layout, it is recommended to use key mechanical

interconnection. For the rest cases, electronic interconnection can be used.

Actuator of the isolator should have lock when it is at off and on position for the case the isolator is placed at crowded area.

IV.2.24. Distribution equipments and distribution substation voltage over 1000V should use fixed earth blade to ensure safety for earthing of equipments and the main bus. Mobile earthing is not generally used.

The earth blade should be painted in black while its actuator is painted in red color. Other actuators are painted in the same colors with the equipments.

At the position where the fixed earthing blade can not be used, there should be contact for mobile earthing connection on the conductor main bus and the earthing main bus.

When there is shunt transformer and the main bus requires earthing blade, the earthing blade of isolator of the shunt transformer will be used.

IV.2.25. Lattice enclosure or lattice and panel enclosure of the conductor or electrical equipments should be 2m high (for outdoor distribution equipments and outdoor transformer), and 1.6m high (as regulated in IV.2.56, IV.2.57), or 1.7m high for indoor distribution equipments.

The lattice enclosure should have mesh size not greater than 25x25mm, and the enclosure has lock. The external enclosure should meet requirements in IV.2.38. Bottom edge of the outdoor enclosure is 0.1m to 0.2m above ground surface. For the case of indoor installation, this edge is adjacent to the floor surface.

It is allowed to use barrier at entrance to chamber of other breaker, transformer and electrical equipments so that the operator will stand before the barrier and check the whole chamber when the power is on.

Main bus should be arranged at elevation of 1.2m and be removable. When floor of the chamber is over 0.3m from ground surface, distance between the door and barrier should not be less than 0.5m and there should be place for observation at the door.

IV.2.26. When conductor wire and conductor bar are deformed due to temperature change or vibration…, there may be mechanical stress arising harmful to the wire, the bar or insulator. Then, it is required to have method against arising of mechanical stress (by using flexible joint plate, reducing wire tension force…).

IV.2.27. Indication of oil level, oil temperature of the transformer and oil equipments and other indicator of the equipments should be arranged for easy and safe access and observation without requiring current interruption (e.g. at the pathway, at entrance to the chamber).

To sampling the oil, distance from ground surface to sampling valve of the transformer or oil equipments should not be less than 0.2m or there should be suitable solution.

IV.2.28. Conductor wire of the protection circuit, measuring circuit, signal circuit and illumination circuit

placed on oil equipments should have oil-resisting insulation.

IV.2.29. Outdoor transformer, reactance coil and capacitor should be painted in light colors to reduce the heat of sunshine. Paint should be weather-shield and oil-resisting type.

IV.2.30. Distribution equipments and distribution substation should be electrically illuminated.

Illumination system should be arranged in a manner to ensure safe and convenient operation and management.

IV.2.31. Distribution equipments and distribution substation should be equipped with telephone line corresponding with operation system.

IV.2.32. It is required to arrange master layout of the distribution equipment and distribution substation on an area not being flooded or subsided.

IV.2.33. When arranging and structuring both outdoor and indoor distribution systems, it is required to consider ability of using mechanical devices, including special device for assembly and repair.

IV.2.34. Distance from distribution equipments and distribution substation to trees higher than 4m should be long enough so that if the tree falls down, it will not cause any damage to the equipments and main bus.

IV.2.35. For distribution equipments and distribution substation abutting residential area and industrial works, it is required to have solution reducing noise of electrical equipments in working status (transformer, synchronous compensator).

IV.2.36. It is required to provide water well or domestic water supply for distribution substation and distribution equipments having frequent watchmen.

IV.2.37. For distribution substation and distribution equipment systems already having water supply system, it is required to build detritus pit. If there is no water sewer, it is allowed to build exhaust system (deposit tank, filter tank).

For distribution substation not requiring frequent watchmen and not having domestic water system, it is able to use two-compartments latrine.

When arranging distribution substation voltage over 110kV abutting water supplying and draining system (within space of 0.5m), there should be water system and water closet area inside the central control house.

IV.2.38. Area of distribution substation should have surrounding enclosure over 1.8m height. When arranging auxiliary works (repair workshop, warehouse…) within territory of the outdoor distribution substation, and when arranging outdoor distribution equipments and distribution substation in area of electric utility, industrial factory, there should be enclosure for each set of 1.6m height.

The enclosure can be grid or bar.

Enclosure is not required for:

- Indoor distribution substation in area of industrial factory already having enclosure.
- Indoor distribution substation in urban area and in waste land.
- Distribution substation mounted on the pole (see IV.2.133).

IV.2.39. Metallic structures of indoor and outdoor distribution system, distribution substation and underground portion of the metallic structure as well as reinforcement concrete portions should be protected against corrosion.

IV.2.40. At the outdoor distribution system and distribution substation, there should be a system for collecting and exhausting oil leaking from oil warehouse and machine chamber in normal working condition as well as oil leaking from transformer and breaker when they are repaired or performing other functions. This is to prevent oil from penetrating into abutting water source and cultivated land.

IV.2.41. At the distribution substation, in all cases, we should try to use alternate current source to be operation source because it is simple and cheap, but it should ensure reliable performance of the equipment.

Outdoor distribution equipment system

IV.2.42. Along the breaker in an outdoor distribution system with voltage over 110kV, there should be a pathway for movement of equipment and machines to provide mobile repair and maintenance of the mobile stations. The pathway should have width and height not smaller than 4m.

For narrow area of industrial factory, this requirement is not applied.

IV.2.43. It is required to connect flexible conductor wire at the span by pressing, to connect down guy and branches on the span, to connect with binding posts by soldering or pressing. When connecting branches at the span, it is not allowed to cut the conductor wire of the span.

It is not allowed to solder and twirl the conductor wire. It is allowed to use bolt connection at binding post and branches toward lightning resister, communication capacity, shunt transformer and temporarily assembled equipment in the case usage of irremovable joint needs much effort in dismantling the main bus.

At the system of main bus of outdoor distribution equipment voltage up to 220kV, it is allowed to use single insulator string, for voltage of 220kV, it is able to use double insulator string of which there will be separate hook into the structure.

Single insulator string is allowed for outdoor distribution system voltage over 220kV when there is no other circuit below.

For outdoor distribution system with voltage up to 220kV, it is able to use double insulator string if the single string does not meet mechanical requirement.

It is not allowed to use partition insulator string except for the case it is used to be insulator string for hanging high frequency reactor.

Installation of flexible main bus and lightning resister into guy lock should meet requirements and have longevity as in Chapter II.5 of the Code.

IV.2.44. Branch from the main bus system usually arranged under the main bus. The main bus in a span should not exceed two or more sections or other main bus system.

IV.2.45. Wind force acting on the main bus and structure as well as estimated temperature of the air should be determined in compliance with regulations in chapter II.5 of the Code.

When determining force acting on the flexible main bus, it is required to calculate mass of insulator strings and down branches of the equipments and the distribution substation.

When determining the force acting on the structure, it is required to calculate the additional force due to weight of equipped people and assembling tools as follows:

- 200kg when using suspension insulator for binding post.
- 150kg when using suspension insulator for intermediate post
- 100kg when using post insulator.

IV.2.46. Coefficient of mechanical safety (corresponding with temporary stress) for flexible main bus under force as in IV.2.45 should not be less than 3.

IV.2.47. Coefficient of mechanical safety (corresponding with testing force) for the suspension insulator under force as in IV.2.45 should not be greater than 4.

IV.2.48. Estimated mechanical force acting on the fixed main bus which is placed on the post insulator in short circuit circumstance should be in compliance with regulation in chapter I.4 of the Code.

IV.2.49. Coefficient of mechanical force (corresponding with damage force) for auxiliaries to connect the flexible main bus under force stated in IV.2.45 should not be less than 3.

IV.2.50. Post for connecting the main bus of outdoor distribution equipment should be concrete reinforcement or steel. For the case using steel material, it is required to have anticorrosion solution.

IV.2.51. Post for connecting the main bus of outdoor distribution equipment is constructed and calculated similarly to intermediate post or end binding post as in Chapter II.5 of the Code.

The intermediate post temporarily used as the end post should have down guy for reinforcement.

IV.2.52. Number of suspension insulators in each string and number of post insulators at clean or little dusty area should be values in table IV.2.1 when using insulator imported from Russia.

When using insulator imported from other countries, selection of amount of the insulators depends on similar condition.

When selecting amount of insulators, it is required to follow regulations in IV.2.80.

IV.2.53. When using rigid main bus, distance between conductor portion and earth portion A (p-d), distance between conductor portion and other phases (p-p) should not be less than values in table IV.2.2 (figure IV.2.1).

If the equipment is installed on mountain at elevation over 1000m, distance between phase and phase, between phase and earth portion should be increased in comparison with values in Table IV.2.2.

Table IV.2.1. Amount of insulators for connecting the main bus

Code of insulator	Amount of insulators (piece) for nominal voltage (kV)					
	6-10-15x	20	35	66	110	220
1	2	3	4	5	6	7
П □ 6- B (ПМ-4.5)		3	5	7	8	15
П □ 6B		3	4	6	7	14
П С 6- А (ПС – 4.5)		3	5	7	9	16
П С 6- В		3	4	7	9	16
П С12-А						
ЩН-10	1					
ОН ЩТА – 10 (ЩТА-10)	1					
ОНС -10-500	1					
ОНС – 10- 2000	1					
ОНС – 20 -500		1				
ОНС – 20 -2000		1				
ОН ЩТ -35 – 100		1	1	2	3	
ОН ЩТ 6 – 35 – 200						
(ЩТ – 35)		1	1	2	3	5
ЩО – 35		0	1			
ЩТ О – 110			1		1	
ЩТ О – 220						1
ОС - 1		1	2	3	5	

(x – 15kV network with direct earthing neutrality)

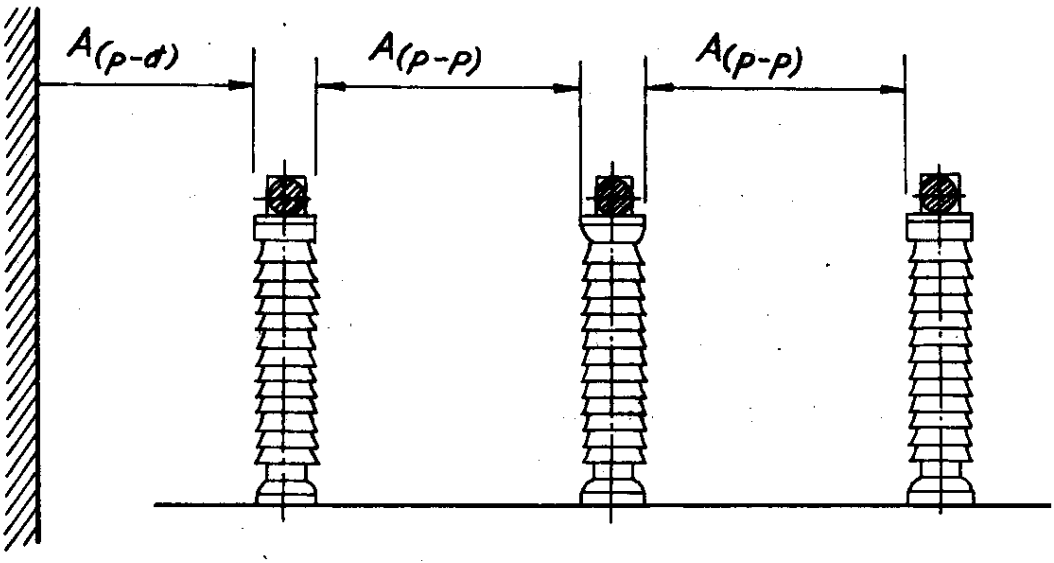


Figure IV.2.1 *– Minimum distance between conductor parts of different phases and between these parts with the earthing part, for the rigid main bus*

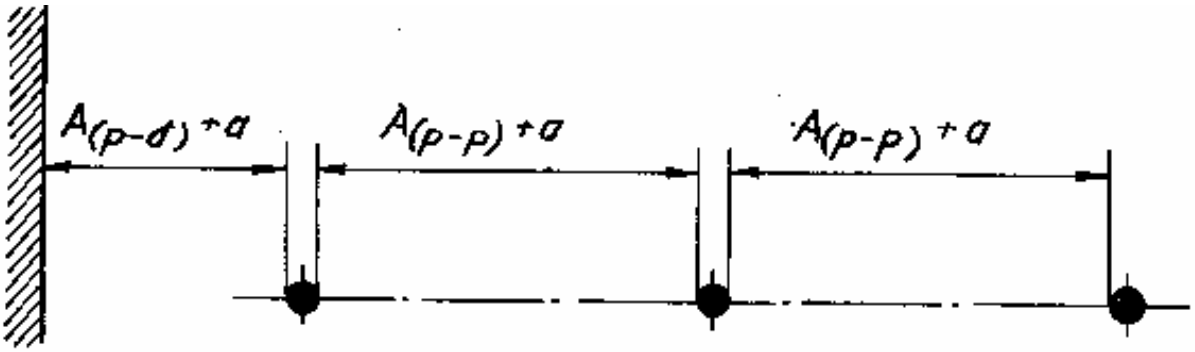


Figure IV.2.2. *Minimum distance between conductor parts of different phases and between these parts with the earthing part, for the flexible main bus*

IV.2.54. When using flexible main bus, the distance between conductor part and the earthing part $A_{(p\text{-}d)m}$, between conductor parts $A_{(p\text{-}p)m}$ arranged on a horizontal plane (Figure IV.2.2) should not be less than:

$$A_{(P\text{-}d)m} = A_{(p\text{-}d)} + a$$

$$A_{(p\text{-}d)m} = A_{(p\text{-}p)} + a$$

Where: $a = f \sin x$

f: sagging of the wire at temperature + 25°C (m)

$$x = \text{arctg}\,\frac{P}{Q}$$

Q: Mass of a meter of conductor wire (kg/m)

P: Wind pressure on a meter of conductor wire (daN/m).

Wind speed is 60% of the value used for calculating constructional structures.

IV.2.55. When the 3-phase short circuit current is equal or greater than 20kA, it is required to check the flexible main bus of the distribution system to prevent ability that phases move to each other or discharge due to vibration impact by the short circuit current.

Minimum distance between live phases at the moment they move nearest to each other under impact of the short circuit current should not be less than the minimum ambient distance of overhead transmission line, corresponding with the maximum working voltage as in Chapter II.5 of the Code.

When using multiple flexible wires in a phase, there should be positioning clip.

IV.2.56. Horizontal distance from live parts or from insulation parts to the internal enclosure/enclosure should not be less than values stated in table IV.2.2, the size $A_{(P-d)}$ (for the enclosure's height of 2m), and B (for the enclosure's height of 1.6m).

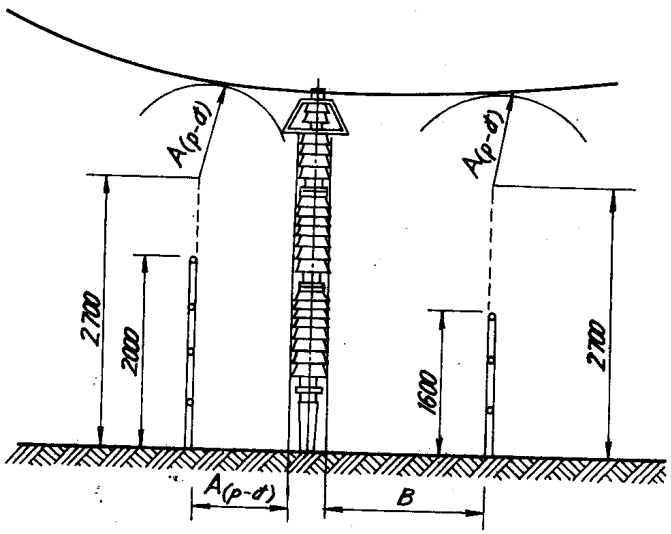


Figure IV.2.3. *Minimum distance from conductor part and live insulator to the fixed enclosure*

When arranging these parts higher than the enclosure, above mentioned distance should still be ensured to an elevation of 2.7m in the plane of the enclosure (see figure IV.2.3).

Distance from the position of 2.7m elevation on the plane of the enclosure should not be less than the size $A_{(p-d)}$

IV.2.57. Conductor parts (output, main bus, branches…) do not required internal enclosure when they are arranged on a surface of an elevation not smaller than values in Table IV.2.2 for the size D (figure IV.2.4).

The unenclosed conductor part connecting capacity of high frequency communication device, remote control and filter should be arranged at an elevation of over 25m. The filter should be arranged at suitable elevation so that when it is repaired (calibrated), it does not need to cut off the power source connecting to it.

Enclosure is not required when elevation from bottom edge of the insulator to the floor surface is not less than 2.5m (Figure IV.2.4).

When this elevation is less than 2.5m, the fixed enclosure is required as regulated in IV.2.26. Distance from the enclosure to the transformer and electrical devices is not less than values stated in IV.2.56.

Installation of outdoor transformer abutting household's wall should be carried out in accordance with regulations in IV.2.68.

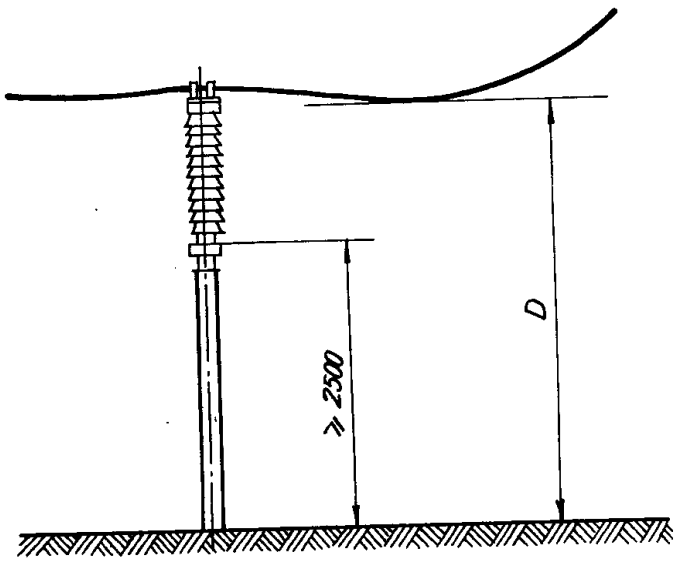


Figure IV.2.4. *Minimum distance from unenclosed conductor part and from the bottom edge of the insulator to the ground surface*

Note:

1. *For live insulator, insulation distance is calculated basing on distribution of electricity at different positions on the surface. When there is no information about potential graph, linear law on potential distribution will be applied along insulator from nominal voltage (at live side) to zero (at earthing side).*

2. *Distance from the conductor part or live insulator to the frame of transformer on the rail installed on concrete floor of hydroelectric plant can be less than B, but not less than* $A_{(p\text{-}d)}$.

3. *Distance* $A_{(p\text{-}d)}$ *and* $A_{(p\text{-}p)}$ *of the equipment with voltage of 220kV arranged at elevation over 1000m should be adjusted for practical condition.*

IV.2.58. The unenclosed conductor part should be arranged so that distance from this part to outside case of mobile machines for assembling, repairing and testing (see IV.2.42) and outside of carried equipments should not be less than values in table IV.2.2 of size B (see figure IV.2.5).

Table IV.2.2. Minimum distance (mm) from conductor part to other parts of outdoor distribution equipments and distribution substation as in figure IV.2.1 to IV.2.10

Order of figure IV.2	Distance	Symbol	Insulation distance					
			Up to 10-15	20	35	66	110	220 -230
1	2	3	4	5	6	7	8	9
1 2 3	From conductor part or from live insulator to earthing structure	$A_{(P-d)}$	200	300	400	600	900	1800
1 2 3 5 9	Between conductor wires of different phases From conductor part or live insulator to the fixed internal enclosure up to 1.6m high, to the carrying frame of equipment	$A_{(p-p)}$ B	220 950	330 1050	440 1150	690 1400	1000 1650	2000 2950
6	Between conductor parts of different circuits on different planes when repairing the lower circuit without interrupting current of upper circuit	C	950	1050	1150	1400	1650	3000
4	From unenclosed conductor part to ground or each household when the wire is at maximum sagging	D	2900	3000	3100	3300	3600	4500
6 7 8	Between conductor parts of different circuits on different planes	E	2200	2300	2400	2600	2900	3800
9	From contact point and from the isolator blade at the off position to the wire connected to the second plate	F	240	365	485	750	1100	2200
10	Between conductor parts of different circuits on horizontal plane when repairing this circuit without interrupting other circuit; from conductor part to the top edge of external enclosure; between live parts to houses and works							

When this height is less than 2.5m, there should be enclosure as regulated in IV.1.26, distance from the enclosure to the transformer and electrical devices should not be less than value stated in IV.2.56.

Installation of outdoor transformer near wall of household should be performed in accordance with regulation in IV.2.68.

IV.2.59. Distance between the abutting unenclosed conductor parts of the circuits arranged on different

planes (in parallel or perpendicular) in vertical direction should not be less than the size C, in horizontal direction should not be less than size E (figure IV.2.6 and IV.2.2). When circuits have different voltages, C and E sizes will be the size at higher level voltage. The size C is for repairing the lower circuit without interrupting the upper circuit, the size E is for repairing the circuit at this side without interrupting current of the circuit at the other side.

If not taking into consideration the repair with stated conditions, distance between conductor parts of different circuits on different planes should follow regulations in IV.2.53; IV.2.54. Then it is required to consider the ability of wires moving next to each other during operation (due to wind, temperature impact).

IV.2.60. Distance between conductor parts of different circuits arranged in a common horizontal plane is determined in accordance with the circuit with higher voltage and should not be less than value in table IV.2.2 Size E (see figure IV.2.7).

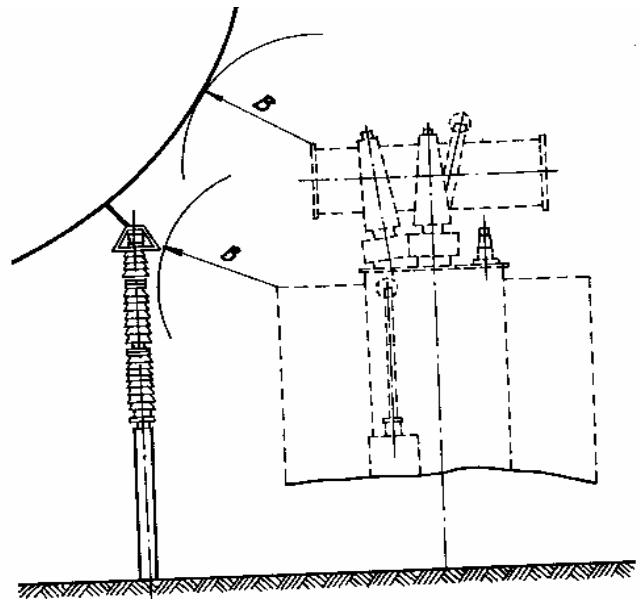


***Figure IV.2.5**: Minimum distance from conductor part to the equipment being carried.*

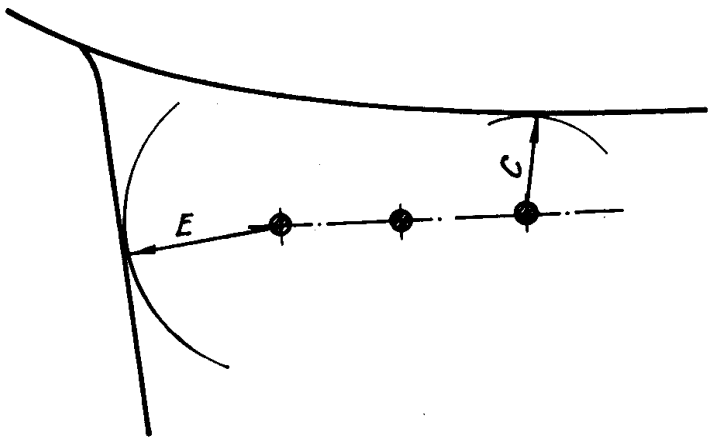


***Figure IV.2.6**: Minimum distance between conductor parts of different circuits on different planes when repairing the lower circuit without interrupting the current of upper circuit.*

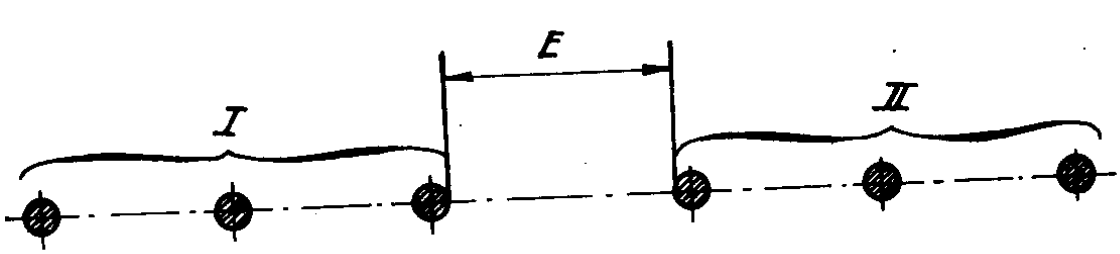


***Figure IV.2.7**. Minimum distance on horizontal plane between conductor parts of different circuits when repairing this circuit without interrupting other circuit*

IV.2.61. Distance from the conductor parts to the top edge of external enclosure should not be less than values in table IV.2.2 Size E (see figure IV.2.8). Vertical distance from the conduction circuit to the land area outside territory of the distribution substation should not be less than values in IV.2.86.

IV.2.62. Distance from contact points and isolator at off position to the earthing portion should not be less than values in table IV.2.2, size $A_{(p-d);}$ to the main bus of same phase connected to the second plate, should be size F; for other main bus, should be size B (see figure IV.2.9).

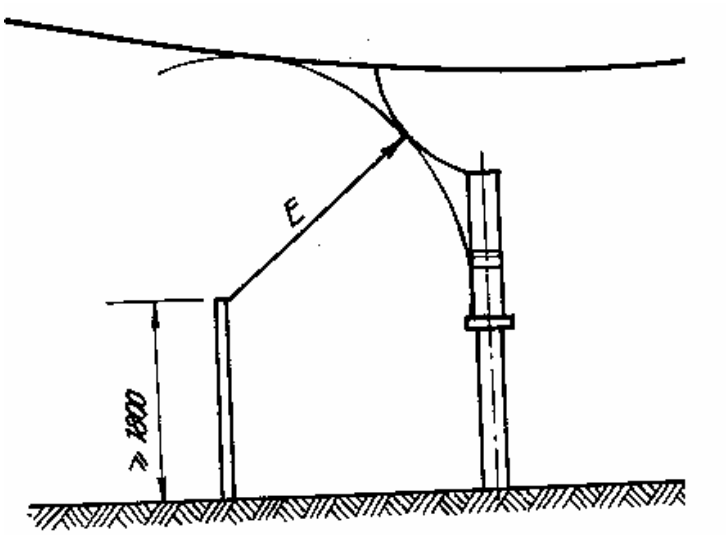


Figure IV.2.8. *Minimum distance from the conductor part to the top edge of external enclosure*

IV.2.63. Distance from conductor parts of outdoor distribution equipments to the house or constructional works (distribution house, control house, maintenance tower of transformer…) should not be less than value in table IV.2.2, size E. Vertical distance between conductor parts and mentioned works should not be less than the size D (figure IV.2.10, see IV.2.87 for more information).

IV.2.64. It is forbidden to install overhead transmission line for illumination, communication and signal line under and above conductor parts of outdoor distribution equipments.

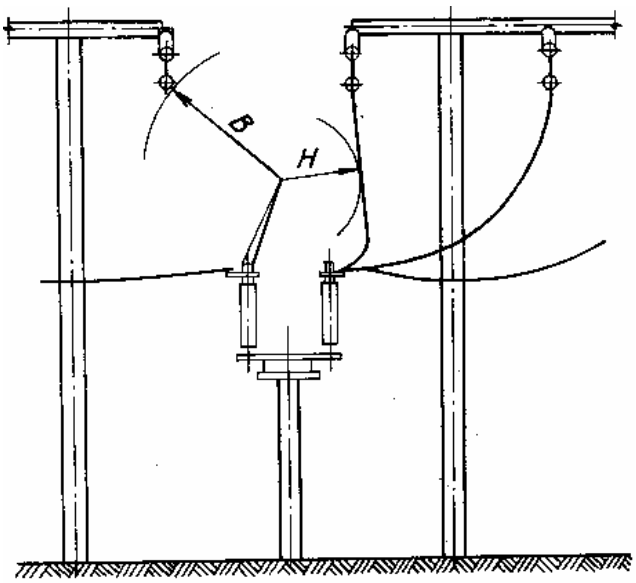


***Figure IV.2.9**. Minimum distance from contact points and isolator at off position to earth part and live part*

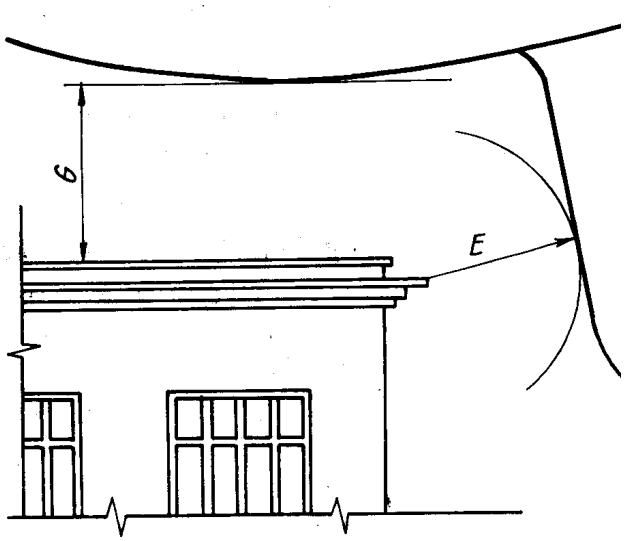


***Figure IV.2.10**. Minimum distance between conductor parts to house and works*

IV.2.65. Distance between outdoor distribution equipments to water cooling facility of the distribution substation should not be less than value in table IV.2.3. For reforming constructional works, it is able to reduce sizes in table IV.2.3 but not over 25% in reduction.

IV.2.66. Distance from the equipments having oil for each weight unit equal to or greater than 60kg to production house type C, D, E in the industrial factory area, leading to auxiliary works (repairing workshop, warehouse) in area of the power plant and distribution substation, to the household, public works (excluding type D and E in IV.2.68), should not be less than:

- 16m when house and constructional works of fire resistance level of I and II.
- 20m when house and constructional work of fire resistance level of IV and V.

Fire resistance level of the house and constructional works are in accordance with the "Temporary standard for fire protection and prevention for designing and constructing domestic and industrial works" (TC.11.63), the fire prevention distance from house of transformer repairing workshop having oil system or oil warehouse to the protection enclosure of outdoor distribution system should not be less than 6m.

Distance from electricity distribution to other production house of the electric power plant and the distribution substation should not be less than 7m.

Above distance is not applied in the case the wall of the electric distribution house leaning on wall of other works which have fire resistance level of 2.5 hours.

Distance from hydrogen warehouse to house of distribution substation and post of the overhead transmission line should not be less than the size stated in table IV.2.4.

Distance from the hydrogen warehouse to outdoor distribution system, transformer and synchronous

compensator should not be less than 50m.

Table IV.2.3. Minimum distance between outdoor distribution equipment to the water cooling equipment

Name of the water cooling equipment	Distance (m)
- Spray-type cooling tower and outdoor cooling tower. - Normal cooling tower and by one fan - Cooling tower with fan and bulkhead	80 30 42

Table IV.2.4. Minimum distance from hydrogen warehouse toe the distribution substation house and post of overhead transmission line

Number of tank in the warehouse (unit)	Distance (m)	
	To the distribution substation house	To the post of overhead transmission line
Under 500	20	
Over 500	25	1.5 times of the post height

IV.2.67. Distance from the oil equipments of outdoor distribution arrangements in power plant and distribution substation toward the house of distribution equipments, house of electrical board, compressed air and synchronous compensator assembly should only be determined in accordance with technological requirements and it should not be increased as sited by fire prevention and protection condition.

IV.2.68. When installing oil-immersed transformer for production over 10m far from the production wall of type D and E as in TC.11.63 and when installing outside scope of size B (see figure IV.2.11), there is no special requirements for house wall, door and window.

When above distance is smaller than 10m within scope of size B, it is required to meet following requirements:

1. Within the height e (to the cover of transformer) there should not be any window.
2. When the distance d is smaller than 5m and the house of fire resistance level IV and V, the house's wall should be fire prevention wall with fire resistance level of 2.5 hours and protrude over the roof at least 0.7m.
3. When the distance d smaller than 5m and the house of fire resistance level I, II and III, and when the distance d from 5m and above with all fire resistance level, at an elevation from e to e + g, it is able to construct a glass orifice of which the structure or glass and frame should have fire resistance level

no less than 0.75 hour and made of fireproof material; for the elevation over e +g, window is allowed with the wing opened inward, covered by metal grid with mesh size no less than 25x25mm.

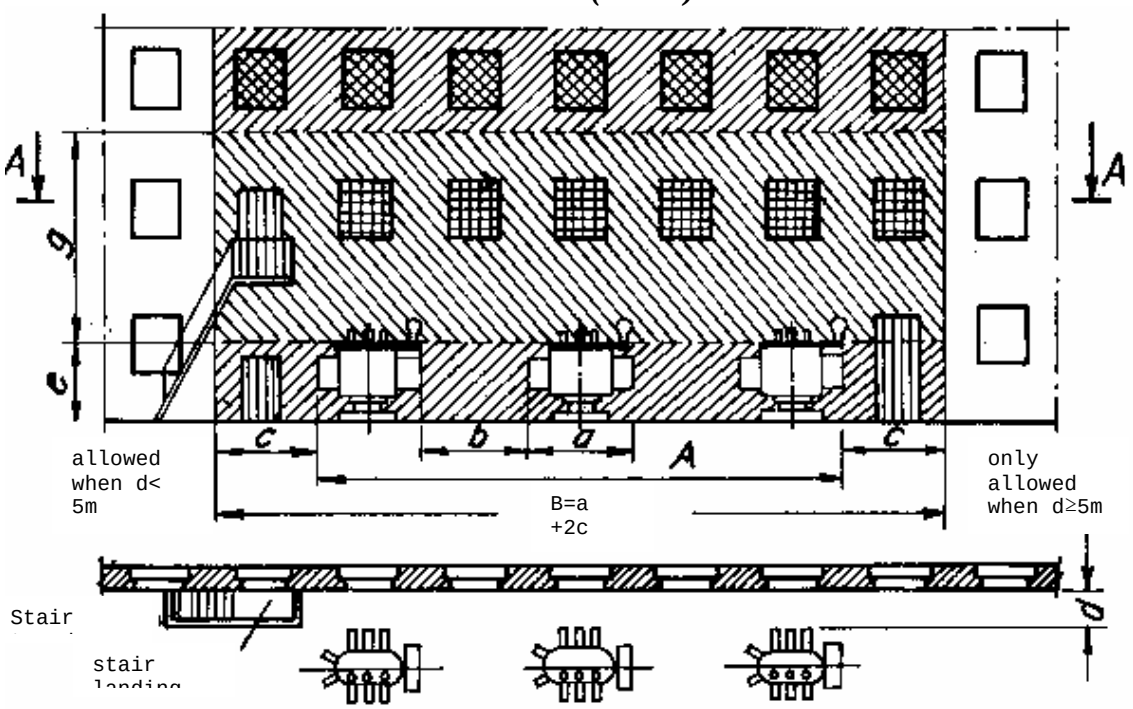
4. When the distance d up to 5m at an elevation less than e, and when d from 5m at any elevation, it is allowed to construct door of fireproof material or slow-burning material with fire resistance level no less than 0.75 hour.
5. When the distance d is up to 5m, it is not allowed to build ventilation door on the wall; when the distance d up to 5m at elevation of c, it is able to build wind thrust.
6. For distance b, see IV.2.222, the distance d should not be less than 0.8m.
7. Along all transformers, there should be pathway with width no less than 3m, or pathway for fire protection for every transformer.

Sizes a, b, c, d and A in figure IV.2.11 are calculated from the most protruded portion of the transformer at an elevation less than 1.9m from ground surface. When output of each transformer is:

- Up to 1800kVA, then c ≥ 1.5m; g ≥ 8m
- Over 1800kVA, c ≥ 2m, g≥ 10m.

These values are also for outdoor complete distribution substation.

Solution 1 (b <4m)



Solution 2 (b≥ 4m)

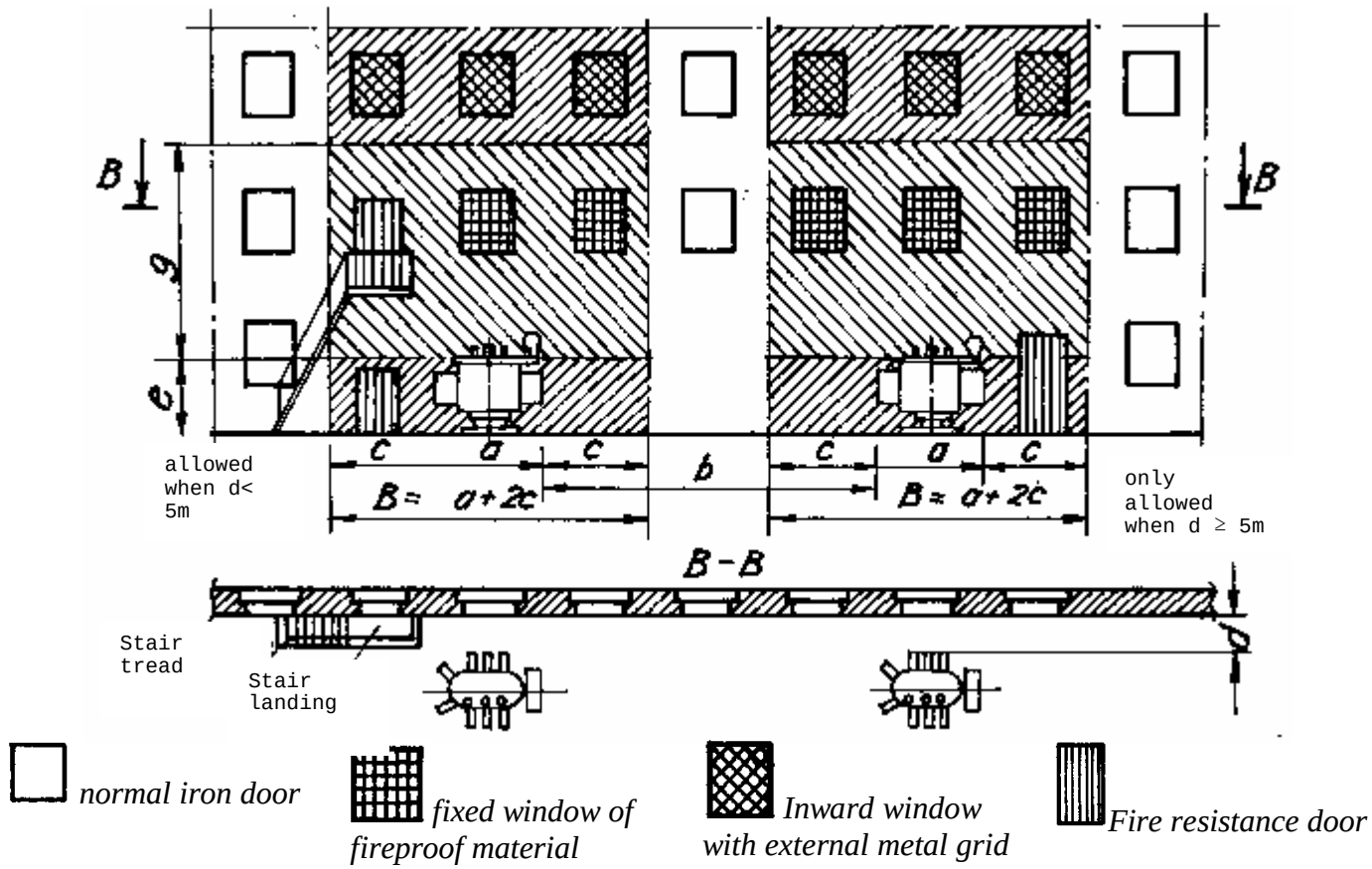


Figure IV.2.11. *Requirement for installation of oil outdoor transformer abutting production house of type D and E*

IV.2.69. To prevent oil burning and fire spreading due to failure of the power transformer fails (the reactor coil) which has oil volume over 1000kg per machine and due to failure of oil breaker voltage over 110kV, there should be oil collector, oil exhauster and oil tank meeting following requirements:

1. Size of the oil collector should be wider than size of each equipment at least:

- 0.6m when the oil volume up to 2000kg.
- 1m when the oil volume over 2000kg to 10000kg
- 1.5m when oil volume over 10000kg to 50000kg
- 2m when oil volume over 50000kg.

Size of the oil collector can be 0.5m deduction at the side of wall or bulkhead.

Capacity of the oil collector is measured to be 100% oil content in the transformer (reactor).

For tank-type breaker, capacity of the oil collector is 80% oil content in each tank.

2. Oil collector and oil pipeline should be arranged so that the oil (water) can not flow from this pit to other pit, overflowing into cable gutter or other underground works, causing any fire spreading or choke at the oil pipe.

3. For transformer (reactor coil) with output up to 10MVA, it is allowed to use oil collector pit without oil exhauster. In that case, the oil collector pit should be deep enough to contain the whole oil amount in the equipment and be separated by metal grid of which the top surface is coated with clean gravel or blast with grain size of 50÷70mm of at least 0.25m thick.

   Water and oil are pumped from the collector pit by mobile pump.

   When using oil collector pit not having exhaust, it is required to use a device to determine oil (water) presence in the pit.

4. The oil collector pit having exhaust can be deep type (with bottom deeper than surrounding foundation) or normal type (bottom equal to surrounding foundation). When using the deep-type collector pit, arrangement of enclosure can be not necessary if capacity of the collector pit as in 1 is ensured.

   The normal type collector pit should have enclosure with height no less than 0.25m but not over 0.5m from elevation of surrounding foundation surface.

   In the oil collector pit (deep-type and normal type), there should be a layer of gravel or blast with granular size of 30-70mm of at least 0.25mm thick.

5. When installing oil equipment inside the house with concrete reinforcement roof (in the structure), there should be oil exhaust system.

6. The oil exhaust system should ensure to bring out oil and water amount (only water sprayed out from fixed fire extinguishing equipments) to safe area (not causing fire for the construction and equipment), 50% oil amount and the whole water amount should be exhausted completely in a time period not over 0.25 hour.

   The oil exhaust system can be underground pipeline or emerged system.

7. Oil container tank should contain the whole oil content of an equipment with maximum oil volume, and the tank should be sealed type.

IV.2.70. In the distribution substation which has transformers voltage 110kV and output of each of them over 63MVA, and transformers voltage 220kV with each output of 40MVA and above, or distribution substation with synchronous compensator, water pipe should be used from available pipeline or from separate water pipeline for fire protection. In the distribution substation with transformers voltage 220kV and output less than 40MVA, it is required to install water supply pipeline from outside source. It is allowed to replace water source for fire protection by water tank from other supplying source.

At the distribution substation with voltage 35-110kV and output of each transformer less than 63MVA, water supply and water tank for fire protection are not necessary.

IV.2.71. Foundation of distribution substation and oil equipments should be built of fireproof material.

IV.2.72. In the transformer, rail is not allowed. If there is a railway branch, it should lead to foundation of the transformer (autotransformer).

IV.2.73. In area of outdoor distribution equipment and distribution substation, there should roadway for car. This roadway is constructed to have solid pavement leading to the control central, indoor distribution system, outdoor complete distribution system, along breaker of the distribution system 110kV, compressed air station, oil processing house, material warehouse, pumping station, water tank, hydrogen warehouse and repairing tower for transformer.

The internal roadway has width of at least 3.5m. When determining size of the road, it is required to consider ability of mobilization of mechanical equipments in IV.2.74.

IV.2.74. Outdoor complete distribution equipment and outdoor complete distribution substation should meet following requirements:

1. At elevation of 0.3m higher than the site and should have place for performance.
2. Can easily mobilize and move the transformer, trolley base of the complete cabinet.
3. Ensure cooling status of equipment.

In addition, the outdoor distribution equipment and distribution substation should meet requirements in IV.2.13, IV.2.14, IV.2.15, IV.2.16, IV.2.18, IV.2.25, IV.2.28, IV.2.30, IV.2.33, IV.2.36, IV.2.39, IV.2.40, IV.2.225, IV.2.226.

Sections of outdoor distribution equipment and outdoor complete distribution substation connecting with each other by open main bus and connector bars should also meet requirements from IV.2.43 to IV.2.73.

Installation of indoor distribution equipment and distribution substation

IV.2.75. House, distribution chamber and chamber of transformer should have fire resistance level of I and II as in TC.11.63.

IV.2.76. Distance from individual distribution house to production house, industrial factory, to domestic house, to public house, should not be less than:

- 7m, when abutting house and works have fire resistance level of I and II
- 9m, when abutting house and works have fire resistance level of III,
- 10m, when abutting house and works have fire resistance level of IV, V.

In case of narrow space, above distance value can be reduced, when there is no door leading to industrial factory on the wall of distribution under agreement of local fire protection department.

There is no regulation for distance of industrial house and floor of distribution substation or indoor distribution substation.

Special requirements for distribution substation adjacent to public works or civil works are stated in Chapter VII.1 of the Code.

IV.2.77. It is allowed to construct distribution substation adjacent to available house, and use wall of the house to be wall for the substation, but there should be solution to protect waterproof coating layer at the share wall when the substation subsides. When installing equipments on available house wall, it is required to consider ability of the distribution substation's subsidence.

IV.2.78. Indoor distribution system with voltage up to and over 1000V should be arranged in separate chamber. This requirement is not applied for complete distribution substation voltage up to 35kV. Equipments with voltage up to and over 1000V can be arranged in common chamber if distribution equipments or distribution substation are of the same authority.

Chamber of distribution equipments and transformers… should be separated from other managing and supporting chamber (for exceptional cases, see chapter IV.3-V.1, VII.5 of the Code).

IV.2.79. It is not allowed to arrang chamber of transformer and distribution equipment:

1. Under wet technological line, bathroom, water closet…, except when it is very pressing then there should be solution to prevent water penetration into the chamber of transformer and distribution equipments.
2. Right under or above room area in which there are presences of 50 people in 1 hour. This requirement is not applied for dry chamber of transformers or chamber containing incombustible substances.

IV.2.80. Insulator of input and insulation supporting the outdoor conductor (main bus arm) of power generator 6 and 10kV should be 20kV; 13.8÷ 24kV should be 35kV. When arranging insulators in the area not having dirty air, selection of nominal voltage should take into consideration of dirt.

Suspension insulator of indoor distribution equipment and distribution substation voltage 35-220kV also have same amounts as for outdoor distribution system (see IV.2.52).

IV.2.81. Distance between plain conductor part of different phases, distance from plain conductor to earthing structure, enclosure, floor, ground surface and distance between unenclosed conductor parts of different circuits should not be less than value in Table IV.2.5, figure IV.2.12 – IV.2.15. It is required to check movement of the flexible main bus at the indoor distribution system due to impact of short-circuit current as in IV.2.52.

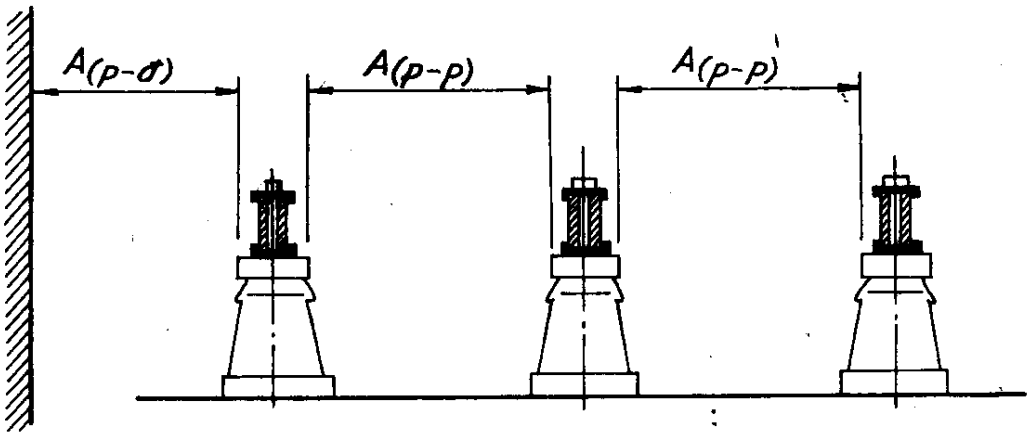


***Figure IV.2.12**: Minimum distance between conductor bars of different phases (as in table IV.2.5)*

Table IV.2.5: Minimum distance from conductor parts to other parts of indoor distribution equipment system

Order of figure	Distance	Symbol	Insulation distance (mm)							
			Nominal voltage (kV)							
			3	6	15	20	35	66	110	220
IV.2.12	From conductor parts to earthing structure and parts of the house.	$A_{(p-d)}$	63	90	120	180	290	600	700	1700
	Between conductor bars of different phases	$A_{(p-p)}$	70	100	130	190	320	650	800	1800
IV.2.13	From conductor parts to the panel enclosure	B	95	120	150	210	320	600	730	1730
IV.2.14	From conductor parts to lattice enclosure	C	165	190	220	280	390	700	800	1800
IV.2.14	Between unenclosed conductor parts of different circuits	D	2000	2000	2000	2200	2200	2600	2900	3800
IV.2.15	From unenclosed conductor parts to the floor	F	2500	2500	2500	2700	2700	3100	3400	4200
	From unenclosed output of the house of distribution equipment to the earth when the output end is not within territory of outdoor distribution system, and when there is movement below	G	4500	4500	4500	4750	4750	5300	5500	6500
IV.2.14	From contact point and plate of the isolator at off position to the wire connected to the second plate of the isolator	F	80	110	150	220	350	750	900	2000

IV.2.82. Distance from contact point and isolator at off position to the wire connected to the second plate should not be less than F value in table IV.2.5 (Figure IV.2.14).

IV.2.83. Plain conductor parts which can be carelessly touched should be parted or enclosed…

When the plain conductor parts arranged outside the partition and lower than size E in table IV.2.5, lattice enclosure will be required. Height of pathway under the lattice enclosure should not be less than 1.9m (figure IV.2.15).

For the case the conductor parts arranged higher than the enclose up to 2.3m from the floor but lower than size E, it is required to arrange a distance from the enclosure surface as size C in table IV.2.5 (Figure IV.2.14).

The unenclosed plain conductor connected the capacitor of high-frequency communication device, protection device and filter should be arranged at elevation of 2.2m and above. The filter should be arranged at proper elevation for convenient repair and calibration without requiring interruption of power from the connected equipments. Enclosure is not required for electrical tools when elevation from the bottom edge of the insulator to the floor is not less than 2.2m.

It is not allowed to use bars to enclose conductor parts in open chamber.

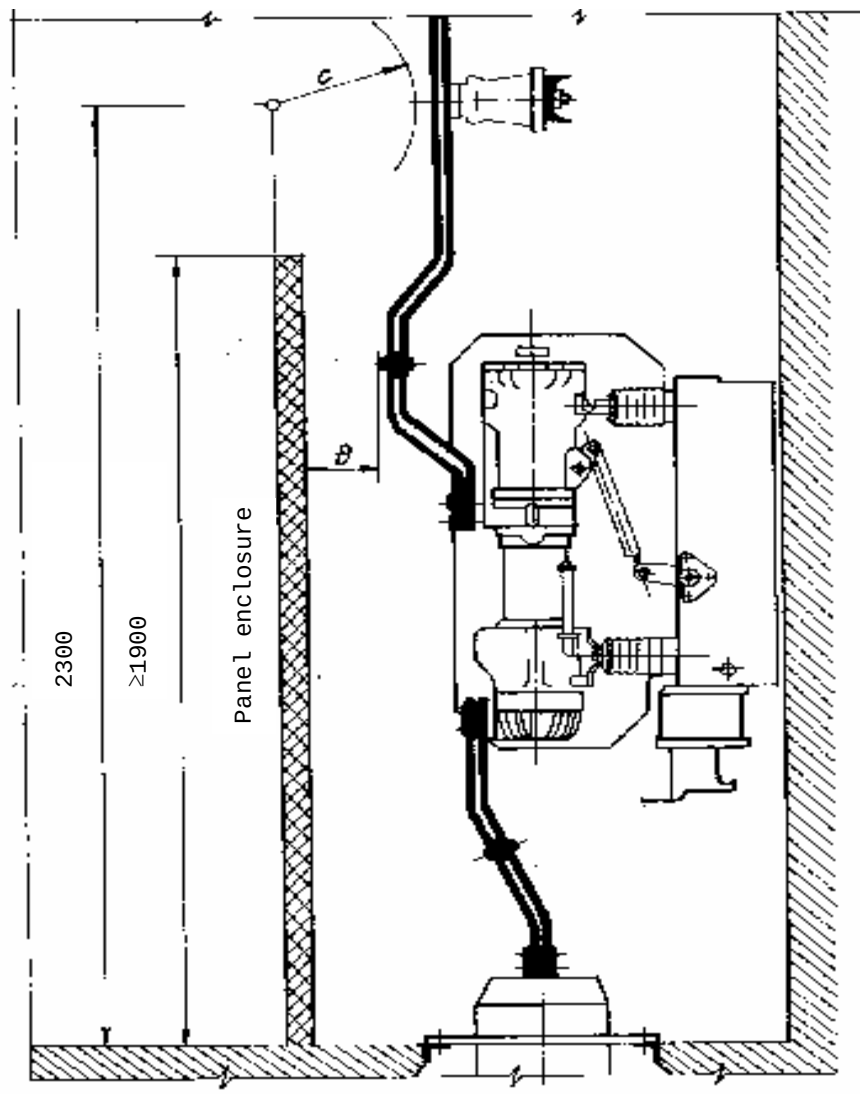


***Figure IV.2.13** – Minimum distance from conductor part to the panel enclosure (as in table IV.2.5)*

IV.2.84. Unenclosed plain conductor part of different circuits at elevation over value stated in table IV.2.5,

size E, should be arranged so that after power interruption at a certain circuit (i.e. a section of main bus), the circuit can still be repaired and checked safely under live status of abutting circuits. Distance between unenclosed conductor parts along two sides of the lobby should not be less than size D in table IV.2.5 (Figure IV.2.14).

IV.2.85. To manage and move equipments easily, width of the lobby between enclosures should not be less than:

1m when arranging equipments at one side.

1.2m when arranging equipments at both sides.

In the management lobby where there are presences of actuator of breaker, isolator, then dimension of the lobby should be added 1.5m and 2m more.

When length of the management lobby up to 7m and equipments are arranged at both sides, width of the lobby can be reduced to 1.8m.

Width of the management lobby in chamber of complete distribution system and distribution substation should be regulated in Chapter IV.2.

Width of combustion hall should not be less than 1.2m.

In the management lobby and combustion hall, allow to have structure protrusion not over 0.2m.

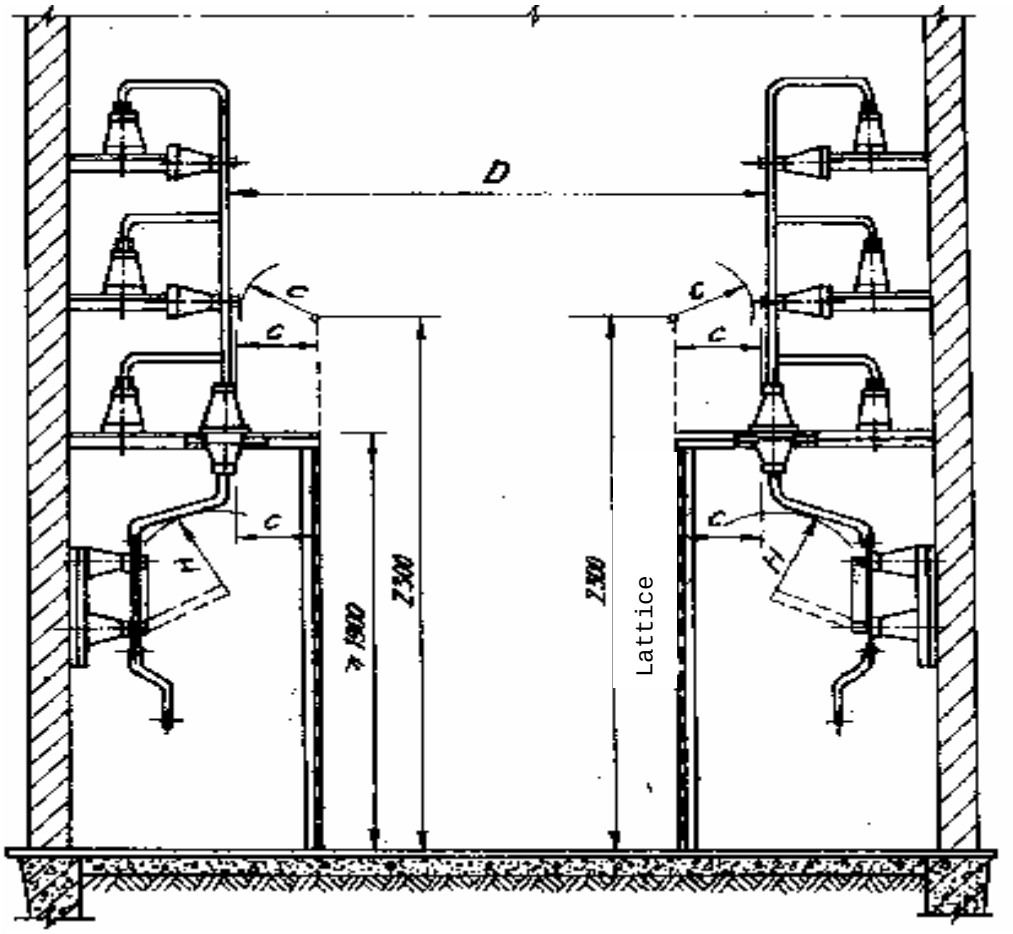


Figure IV.2.14 *– Minimum distance from conductor part to the lattice enclosure and between different circuits (table VI.2.5)*

IV.2.86. When the overhead transmission line into the house of distribution system does not pass across roadway or area trespassing by vehicles and people, distance from the lowest position of the conductor wire to ground surface should not be less than size G in table IV.2.5 (figure IV.2.15).

When distance from conductor wire to the ground surface is smaller than above values, there should be a enclosure of 1.6m height under the line, with distance from ground surface (outside the enclosure), not smaller than size G

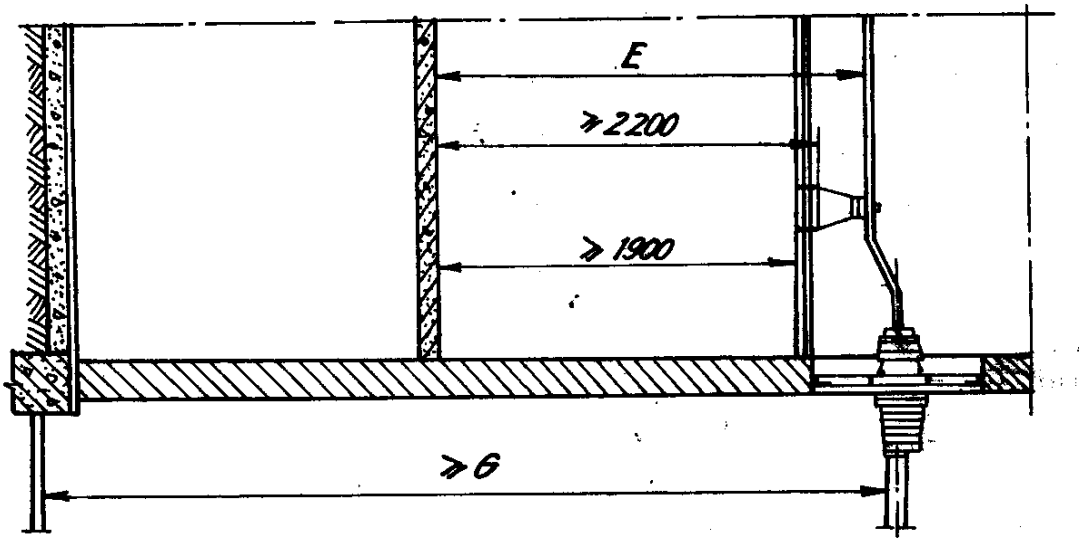


***Figure IV.2.15** – Minimum distance from unenclosed conductor part and from bottom edge of the insulator to the floor, and height of the pathway; from unenclosed output ends of the house for distribution equipments when the output end is not within outdoor distribution and when there is no movement of equipment below.*

When the overhead transmission line leading into house of distribution equipment passes across roadway or area of people and vehicle trespassing, distance from the bottom point of the wire to the cross section should be as regulated in chapter II.5 of the Code.

For overhead transmission line leading from distribution equipment inside the house toward outdoor distribution system, the above mentioned distance will be as in table IV.2.2, size D (figure IV.2.4).

Distance between two abutting outputs of two circuits not having enclosure should not be less than size E, table IV.2.2.

IV.2.87. Wire line toward the house of distribution equipment when passing the roof should have a distance from the roof no less than value in IV.2.63.

IV.2.88. Chamber of distribution system should have door as following regulation:

1. When the chamber is up to 7m long, a door is required.

2. When the chamber is 7m to 60m long, there should be two doors at both sides. It is allowed to arrange the door far from the end wall up to 7m.

3. When the chamber is over 60m, in addition to the doors at both ends, there should be an auxiliary door from it to any position of the control lobby or combustion lobby spacing a distance not greater than 30m.

The door can open to outside, to the staircase toward other production chamber which has fireproof wall and ceiling and does not contain any explosive, combustible material and equipment. This door can also lead to other chambers of the distribution system by fireproof door or slow-burning door material a fire resistance

rating of no less than 0.6 hour. In multi-storey house where the distribution equipment sits, the second door and auxiliary door can open toward the balcony which leads to outside fire exit.

IV.2.89. The combustion lobby which is too long should be divided into sections of less than 60m using fireproof bulkhead of which the fire resistance rating is not less than 1 hour and it should have door leading to outside area or to staircase.

IV.2.90. Floor of the chamber where distribution equipments are installed should be of the same elevation. Structure of the floor should not generate any cement dust (see IV.2.117). It is not allowed to build edge on the door connecting chambers and lobby. For exceptional case, see IV.2.95, IV.2.96, IV.2.98 and IV.2.99.)

IV.2.91. Door of the chamber of distribution equipments should open outwardly or connect to other chamber. The door should be automatically locked and unlocked from inside without using a key.

Door between chambers of a distribution system or between abutting chambers of two distribution systems should be default at closing status, but it can be easily opened from both sides.

Door between two chambers of distribution equipments of different voltages can be open toward the chamber having low voltage up to 1000V.

Door lock of chamber where distribution equipments are installed should be unlocked by one key. The key of the chamber of distribution equipments can not be used to unlock other distribution chambers.

It is not required to use automatic lock for distribution substation at urban area of 10kV voltage and lower.

IV.2.92. Door (gate) of the chamber where oil equipments are placed, with oil volume greater than 60kg should be made of low-burning material of which the fire resistance rating is not smaller than 0.75 hour; if this door leads to other chambers not belonging to the distribution substation, or when it is arranged within the combustion hall and in chamber of distribution equipment. In other cases, the door can be built of combustible material and has lower fire resistance level.

Gates with flap wider than 1.5m should have auxiliary door if it is used as exit and entrance for operator.

IV.2.93. It is recommended not to provide a window for the chamber of the distribution equipments if it does not have window at unprotected area. In case requiring natural illumination, glass brick and steel glass can be used. The window frame of distribution chamber and distribution substation can be made of combustible material.

Window in the distribution chamber should not be opened. The window is protected by grid with mesh size not greater than 25x25mm.

IV.2.94. In a same chamber where there is distribution equipment voltage up to and over 1000V, it is allowed to have an oil-immersed transformer with output up to 630kVA, or two oil-immersed transformers each of which has output of 400kVA. But this should be separated from other chambers by fireproof wall

and fire resistance level of 1 hour.

Conductor part over 1000V should be enclosed as regulated in IV.2.93. Multiple –input interrupter should be installed in accordance with regulations in IV.2.96.

IV.2.95. In chamber of distribution equipments having exit toward the combustion hall, it is allowed to install oil-immersed transformer with oil volume up to 600kg. Open chamber is allowable for the shunt transformer but there should be edge or slope roof to keep the whole oil volume inside the transformer.

IV.2.96. Oil-tank breaker with oil volume over 60kg should be installed in combustion protection chamber with exit leading to outside or combustion hall.

Oil-tank breaker with oil volume from 25 to 60kg can be installed both in open and combustion chamber. Then it is required to choose the breaker with backup output of 20%.

Oil-tank breaker with oil volume up to 25kg, less-oil breaker and no-oil breaker should not be placed in open chamber.

When the less-oil breaker with oil volume at each phase of 60kg and above, in each chamber there should be edge to keep the whole amount of oil.

Breakers installed in open chamber should be separated from each other by fireproof partition or bulkhead. These breakers are also separated from actuator by fireproof bulkhead or partition. Upper edge of the bulkhead or panel partition should be at least 1.9m height from floor surface.

It is not required to install protection plate for air breaker.

IV.2.97. In the combustion hall, there should not be any equipment having open conductor.

Combustion hall should have exit as in IV.2.89.

IV.2.98. In indoor distribution substations adjacent to production house or inside production house, inside chambers of transformer, oil breaker and oily equipment having oil volume of 600kg per tank, when these chambers are arranged on the first floor and have exit door to outside, the oil collector pit is not required.

When oil volume per tank is greater than 600kg, we should construct oil collector pit or stop at the door, ventilation door by using fireproof material in order to keep 20% oil volume of the transformer or equipment. There should be solution to prevent oil from flowing via cable gutters.

IV.2.99. When arranging chambers right on the basement, from the second basement and when the door opens toward combustion hall, then there should be oil collector pit under the oil-immersed transformer, breaker and equipment as follow:

1. When oil volume per tank is 60 to 600kg.

a. Constructing pit to contain the whole oil volume.

b .Constructing a stop or ramp to keep the whole oil volume.

2. When the oil volume per tank is greater than 600kg

a. Constructing oil collector pit containing at least 20% of total oil volume of the transformer or equipment, and there should be oil exhaust toward the common exhaust system.

Oil exhaust pipe from the oil collector pit under the transformer should have diameter of at least 10cm.

Oil exhaust pipe should have protective grid at the side of oil collector pit.

b. Constructing oil pit without exhaust to the common exhaust system. Then, the oil collector pit should have enclosure and there should be a layer of gravel or blast of 25cm thick above the enclosure. The oil collector pit should contain the whole oil volume, and the oil level should be lower than the enclosure 5cm. Upper surface of the gravel layer in the oil collector pit should be lower than the ventilation aperture of 7.5cm.

Bottom of the oil pit slopes 2% toward collecting center.

Area of the oil pit should be greater than area of the transformer or equipment.

3 .When oil volume in each tank of transformer or equipment less than 60kg, edge should be built to keep the whole volume of oil.

IV.2.100. At the chamber of transformer and reactor, ventilation should be required to release heat generated by the machines. In normal working condition (considering overload), maximum calculated environmental temperature should not make temperature of transformer and reactor exceed maximum allowable temperature of those equipments.

Chamber of transformers and reactor should be ventilated so that temperature difference between air in and air out not greater than 15^{o}C (for transformer), 30^{o}C (for reactor with current over 1000A), 20^{o}C for reactor with current greater than 1000A.

When temperature exchange is not ensured by natural ventilation, forced ventilation should be applied and there should be signal to check performance of this ventilation method.

IV.2.101. Combustion hall and management lobby of open chambers or complete cabinet which contain equipments having oil or other substances should have emergency exhaust fan controlled from outside and independent from other ventilation systems.

Emergency exhaust fan should ensure 5 exchanging times per hour for the air in the chamber.

IV.2.102. In the chamber with frequent watchman from 6 continuous hours and above, the temperature

should be ensured not lower than 18^{o}C and not less than 20^{o}C. Ventilation system can be installed directly at position of the watchman. In the chamber of control cabinet and distribution system, temperature level should be ensured as regulated by the manufacturer.

IV.2.103. Aperture between floors, wall, bulkhead and even cable orifice should be sealed by slow-burning material with fire resistance level not less than 0.75 hour.

To prevent penetration of birds and rotten into chambers, orifices on outside walls should be covered by net with mesh size of 10x10mm.

IV.2.104. Cover of gutters should be made of fireproof material and installed at the same elevation from the floor. Mass of each cover should not be greater than 50kg.

IV.2.105. In general, it is not allowed to install cable of other circuit passing by the chamber of equipments and transformers. For special cases, the cable should run in pipe. Only when requiring for connecting (connect to measuring transformer) and only at short section, then conductor wires of lightning circuit, control circuit, measuring circuit can be placed in the chamber and near plain conductor elements.

IV.2.106. It is allowed to install closed ventilation pipe (with no vent, inspection orifice) in the chamber of distribution equipments. It is also allowed to install waterproof ventilation pipe via the chamber.

IV.2.107. Installation of complete distribution system, complete distribution substation in chambers should follow regulations for distribution substation of the workshop.

Distribution substation for workshops

IV.2.108. This chapter is applied for distribution substation of the workshop with voltage up to 35kV, excluding other electro-thermal equipments. (see chapter VII.5 of the Code).

IV.2.109. The distribution substation for workshop can be arranged on the first and second floor of the main production area, depending on type I or type II as regulated in TC11: 1983. When it is arranged in other house, it should be agreed by fire protection department.

For distribution substation having no-oil equipment, permission is not required. Distribution substation for workshop can be arranged in dusty and chemical chamber, but it is required to ensure safe operation of all equipments.

IV.2.110. Transformer and distribution equipments can be arranged in separate chamber or openly installed in production chamber.

In case of open installation, conductor parts of the transformer should be enclosed while distribution equipments are protected in closed cabinet.

Installation of complete distribution system and complete distribution substation in machine chamber is

performed in accordance with regulations in chapter VI of the Code.

IV.2.111. In each distribution substation for workshop, complete distribution substation openly installed, oil-immersed transformer with total output not greater than 3200kVA can be installed. Total output of distribution substation for workshop (complete with oil-immersed transformer) at the second floor should not exceed 1000kVA.

Oil-immersed transformer and complete distribution substation are not allowed to be higher than the second floor 2m.

Distance between oil-immersed transformer of complete distribution substation as well as distance between transformers should not be less than 10m.

For distribution substation for workshop and complete distribution substation which has dry transformer or fireproof insulator, there is no limitation on output, amount and distance between them and machine floor. Installation of complete distribution substation with oil-immersed transformer over 3200kVA output, or when distance between them is smaller than 10m, every case should have agreement by the fire protection department.

IV.2.112. There should be oil pit under the transformer as in IV.2.99.

IV.2.113. Distribution substation for workshop generally uses no-oil breaker or less-oil breaker.

Oil-tank breaker is only used in enclosed chamber under following conditions:

1. Amount of breakers: not greater than 3.
2. Oil volume in each breaker not over 60kg.

IV.2.114. If the surrounding air is normal; the air in the workshop can be used for ventilation of the chamber.

To ventilate the chamber of transformer in dusty area or in abnormal air condition (containing electric charge or corrosive substance), it is required to use outside air, or to filter the air. In chamber with fireproof ceiling, direct exhaustion from the chamber of transformer is allowed within the workshop.

In the chamber with fireproof ceiling, air from chamber of transformer should be exhausted via the pipe protruded from the roof at least 1 meter.

IV.2.115. In case of forced ventilation, when interrupting current for the transformer, ventilation equipment should also be cut off.

IV.2.116. When the complete distribution substation is installed in separate space, ventilation of the transformer should be in accordance with IV.2.100.

IV.2.117. Floor of the distribution substation should not be lower than floor of the workshop. The floor for

the complete distribution system and complete distribution substation should ensure that frequent movement of trolleys will not cause damage to the floor surface.

IV.2.118. Partition for chamber of the oil-immersed transformer and oil tank breaker should have fire resistance level no less than 0.6 hour.

IV.2.119. When arranging the distribution substation near the pathway inside the workshop, or near mechanical carrier, there should be solution to prevent the distribution substation from sudden impact (by using signal light, frame, enclosure…).

Complete distribution system and distribution substation are generally arranged in dead area of mechanical carrier.

In the workshop with greater internal movement, or when the site is full of equipments, materials and products, it is required to enclose the complete distribution system and distribution substation. In this case, there should be a pathway inside the enclosure, with width no less than value in IV.2.121.

IV.2.120. Width of the pathway along the complete distribution equipment and distribution substation, along the wall of distribution substation which have ventilation or door, should not be less than 1m. The pathway should ensure convenient movement of transformer and other electrical devices.

IV.2.121. Width of the pathway for controlling and repairing trolley distribution equipment and distribution substation should ensure convenient movement, performance and rotation of equipment during exploitation process.

When installing the complete distribution equipment and distribution substation in separate space, width of the pathway is determined as follows:

-Equal to length of the trolley of the distribution equipments, together with at least 0.6m long when it is arranged in a row.

- Plus at least 0.8 m when arranged into two rows.

In each case, the width of the aisle shall not be less than the value stated in IV.2.120 and the local narrow places must not obstruct the movement of the trolley.

Back aisles for full distribution cabinets and full transformer station must have width of at least 0.8 m; this value can be reduced maximum 0.2 m at the positions of local projections. Where full distribution cabinets and full transformer stations are placed in production rooms, the width of the common aisle shall be determined according to the arrangement of production equipments; however, the ability to move the largest parts of the full distribution equipment and full transformer station must be ensured and in all cases this width should be not less than lm

IV.2.122. Height of the production compartment shall not be less than the height measured from the highest part of full distribution installation (full transformer station) plus 0.8 m to the ceiling and 0.3 m to the ceiling beams. The height of the compartment can be reduced if it still ensures the safety and convenience for replacement, repair or correction of full distribution installation and full transformer station.

IV.2.123. Pavement for transportation of full distribution installation and full transformer station must be calculated according to the maximum load of the equipment. Aperture of door must fit the size of the equipment.

Pole mounted transformer station

IV.2.124. This chapter applies to pole mounted transformer station with voltage of up to 35kV and capacity of no greater than 400kVA.

IV.2.125. Transformer shall be connected to high voltage grid through fuse with isolation blade or cut-out fuse. The actuator of isolation blade must be equipped with locking unit.

IV.2.126. Transformer must be placed at a height of at least 4.5 m measured from the conducting part to the ground. For operating transformers placed at the height of at least 3m, there should be working platform and ladder.

For transformer station installed on a single pole, working platform and ladder can be omitted.

IV.2.127. When isolation blade or cut-out fuse is cut, the live parts must be at the height of no less than 2.5m above working platform for substation of up to 15kV, and of no less than 3.1m above working platform for substation of 35kV. Location for closing or opening isolation blade or cut-out fuse must be able to be seen clearly from working platform.

IV.2.128. Low voltage electrical system of transformer must be placed in closed cabinet. For turning off the transformer to the low voltage side, equipment incapable of discontinuing must be located visibly.

IV.2.129 Conductors between transformer and electric board, between electric board and low voltage overhead line must be protected from mechanical damage (placed in tube, shielded…) and must be carried out in accordance with regulation stated in chapter 1.2 QTĐ.

IV.2.130. Distance from the ground to the output of overhead line with voltage of up to 1000V must be at least 4.0 m.

IV.2.131. Substation must be at least 3m away from buildings of fire resistance level I, II, III and at least 5m away from buildings of fire resistance level IV, V.

IV.2.132. Where technical conditions allow, pole mounted substation shall be installed in combination with overhead line.

IV.2.133. In areas where pole mounted substation can be bumped into by vehicles, there must be protective piles.

Protection against lightning

IV.2.134. Substation and outdoor distribution installation of 20-220kV voltage must be protected against direct lightning strokes.

Protection against direct lightning strokes is unnecessary for outdoor substation of 20-35kV voltage equipped with transformers of 1000 kVA capacity per each set.

IV.2.135. Building used for locating distribution installation and substation should be protected against direct lightning strokes. Metallic roof or reinforced concrete roof used for locating distribution installation and substation must be grounded.

IV.2.136. For oil processing system, synchronous compensator station, electrolysis chamber, storage room for hydrogen containers located within the area of substation, protection against direct lightning strokes must be carried out in accordance with "Rules for the design of lightning protection for architectural construction"(QP XD 46-71).

IV.2.137. Protection against direct lightning strokes for outdoor distribution installation and substation is usually done by using anti-lighting metal arranged on building structures. High poles (overhead line poles, poles for installation of floodlight…) are considered lightning poles. Allow the locating of anti-lightning metals on gate poles that are near the transformers or airflow distribution electric resistance coils satisfying the requirements of IV.2.136. Anti-lightning metals can be arranged on building structures of 110kV voltage distribution system if the equivalent resistivity reaches 1000Ω.m not depending on the area of the ground wire belt; more than 1000 Ω.m to 2000 Ω.m - when the area of the ground wire belt is at least 10,000m^2.

From poles with lightning needles of 110kV outdoor distribution system, must ensure that lightning current running to the ground belt shall be of no less than 2-3 rays. In addition to that, there should be 1-2 ground piles of 2.5-5.0m length locating at a distance of no less than the length of the ground piles from the poles with lightning needles.

Allow the installation of lightning needle on building structure of 35kV distribution system when the equivalent resistivity of earth in lightning season is up to 500Ω.m, not depending on area of grounded belt, over 500Ω.m to 750Ω.m if area of ground belt is of at least 10,000m^2.

From poles with lightning needles in 35kV outdoor distribution system, must ensure that lightning current running to the ground belt shall be of no 3-4 rays. In addition to that, there should be 2-3 ground

piles of 2.5-5.0m length locating at a distance of no less than the length of the ground piles from the poles with lightning needles.

Chain insulators on gate poles of 35kV distribution system are equipped with lightning wires or needles and on the end pole of 35kV overhead line, two more insulators should be added to the quantity specified in IV.2.1 if lightning wires of overhead line are not connected to the station.

Distance from structures of outdoor distribution system equipped with lightning needles to conductive parts must not be less than the length of the insulator chain.

IV.2.138. On gate pole of transformer, gate pole of current diversion reactor and structure of outdoor distribution system locating far away from transformer or using corrective mechanism of grounded loop circuit of less than 15m, lightning needle can be installed if equivalent resistivity of earth in lightning season is less than 350 Ω.m and satisfies the following conditions:

1. Arrange valve type lightning arrester right on the outputs of the wire roll of 3-35kV transformer or outputs of no more than 5m across the conductor's length.

2. Make sure to ground from pole for installation of lightning needle to common ground belt with 3-4 rays.

3. Must install 2-3 grounded piles on grounded loop circuit at the distance of 3-5m away from pole with lightning needle.

4. In 20kV and 35kV substations equipped with lightning needles on gate poles of transformers, resistance of ground loop circuit must not be greater than 4Ω, not taking into account the ground parts outside the ground belt of outdoor distribution installation.

5. Ground wire of valve type lightning arrester and transformer to ground loop circuit should be so arranged that the ground point of valve type lightning arrester would lie between the ground point of ground wire of gate pole with lightning needle and the ground point of transformer.

IV.2.139. Protection of outdoor distribution system from direct lightning strokes, if cannot be carried out by installing lightning needle on building structure, can be carried out by using independent lightning pole with specific earth resistance of no greater than 80Ω.

Under the ground, the distance between individual ground equipment and ground loop circuit of outdoor distribution substation must be:

$$S_d \geq 0.2\ R_c \text{ (but no less than 3m)}$$

Where:

S_d – The underground distance, measured in m.

R_c – Grounding impulse resistance of independent lightning arrester, measured in Ω, when the impulse current of lightning is 60kA.

The in-air distance from independent lightning arrester with its own grounding system to conductive parts of grounding structure and devices of outdoor distribution system (substation) must be:

$$S_k \geq 0.12\ R_c - 0.1\ h \text{ (but no less than5m)}$$

Where:

S_k – in-air distance, measured in m.

h – height from the ground to top of lightning needle, measured in m.

Grounding of independent lightning arresting pole can be mounted with loop circuit of general grounding if the conditions for installing lightning needle on building structures of outdoor distribution system (substation) are satisfied. (see IV.2.137).

Distance measured from the connection between grounding of independent lightning pole (or lightning wire) and general ground loop circuit of substation to the grounding point from transformer (electrical reactor) to that loop circuit must not be less than 15m (calculated according to the main ground loop circuit). The connecting from independent grounding to general ground loop circuit of 35-100kV outdoor distribution installation must be includes 1-3 rays.

Grounding of independent lightning arrester with floodlight must be connected to general ground loop circuit of substation.

Where the conditions stated in IV.2.138 are not satisfied, the following requirements must be added:

1. 3-4 ground piles of 2.5-5 m length must be installed at the distance of 5m away from the lightning pole.

2. If the distance along ground loop circuit measured from grounding point of lightning pole to grounding point of transformer (electrical reactor) is greater than 15m but does not exceed 40m, valve type lightning arresters must be installed near the outputs of up to 35kV wire coil.

In-air distance measured from independent lightning pole with grounding mounted to general ground loop circuit of the substation to conductive parts shall be determined by:

$$S_k \geq 0.1H + m$$

Where:

H – Height above the ground of conductive part, measured in m

m – Length of insulator chain, measured in m.

IV.2.140. Lightning wire of overhead line with voltage of at least 110kV is often connected to ground structure of outdoor distribution system (substation). Lightning wire of overhead line shall be connected to ground structure of outdoor distribution system when equivalent resistivity of earth measured in lightning season is up to 750 Ω.m – not depending on area of ground loop circuit of substation, over 750 – 1000 Ω.m when area of ground loop circuit of substation is 10,000m^2 or greater.

Pole with lightning wire of outdoor distribution installation of at least 35kV mounting to lightning wire must be connected to ground axis in 2-3 rays. Beside that, 3-5 ground piles of 3-5 m length must be installed at the distance of no less than the length of the ground pile measured from this pole.

Ground resistance of the end pole of 35kV overhead line to substation must not be greater than 10Ω.

Lightning wire of overhead line, if is not allowed to be lined to the substation, shall end at the last pole of the wire line. The overhead line section entering the substation which is without lightning wire shall be protected by lightning needle arranged inside the substation, on overhead line pole or near the overhead line. Positions for mounting ground wire of structures that are equipped with lightning wires or lightning needles to the general ground system of the substation must be at least 15m away from mounting position of the transformer (impedance coil), determined according to the main ground belt.

IV.2.141. Protection of overhead line parts mounted to substation and outdoor distribution installation must also be in accordance with regulations stated in 1.1.5 QTĐ.

IV.2.142. Installation of lightning needle on structure of outdoor distribution system is not allowed within the distance of 15m from:

- Transformer connected by flexible conductor or bare conductor bar to rotating machine.

- Bare conductor busbar and column used for supporting flexible conductor connected to rotating machine.

Gate pole of transformer with bare conductor bar or flexible conductor connected to rotating machine must be arranged within the protected area offered by independent lightning pole or lightning needle located on building structure.

IV.2.143. Where pole for installation of floodlight is used as a lightning arrester, the conductor section supplying electric for the floodlight (from the position where the cable gets out of the cable channel to the floodlight pole and along the shaft of the floodlight pole) must be metallic sheathed cable, if not, the cable must be inserted in metal pipe. The section that near the lightning pole of this cable line must be directly buried under the ground for a distance of at least 10m long.

At position where cable enters the cable channel, metallic sheath and steel belt of cable and cable conduit must be connected to the general grounding of the station.

IV.2.144 Protection against direct lightning strokes for overhead line sections that enter stations of 35kV voltage and above must be done with lightning wire. Length of wire section that is protected, ground resistance of pole, number of wire and protection angle of lightning wire must meet the requirements specified in table IV.2.6.

Lightning wire must be connected to the earth of each pole except for cases stated in chapter II.5.QTĐ. In areas with little lightning, ground resistance of pole in comparison with the multiples specified in table IV.2.6 can be increased as follow:

- 1.5 times if lightning happens for less than 20 hours per year.

- 3 times if lightning happens for less than 10 hours per year.

If grounding cannot be carried out in accordance with the requirements, extended ground wire shall be used.

In areas with earth resistivity of more than 1000Ω.m, overhead line sections entering the station can be protected by independent lightning pole, ground resistance of the pole is not regulated.

IV.2.145 In areas where the number of lightning hours in a year is no greater than 60 hours, protection by lightning wire can be omitted for overhead line sections entering 35kV station, substation with two transformers of up to 1800kVA capacity or with one transformer of up to 1800kVA which has backup source at low voltage side. Then poles of section of no less than 0.5km entering the station must be grounded with ground resistance taken according to the numbers specified in table IV.2.6. Where wooden poles are used for sections that enter the station, beside of the above requirement, insulator pedestal grounding must be carried out on the length of 0.5km and expulsion type lightning arrester must be installed on the first pole counted form the side of the wire line.

The distance measured from valve type lightning arrester to transformer must not exceed 10m.

35kV overhead line section entering a substation that has one transformer of up to 1600kVA capacity without backup power source at the low voltage side must be protected by lightning wire of no less than 0.5 km length.

IV.2.146 Expulsion type lightning arrester CSO1 must be installed on the first pole of the section entering 35-320 kV substation from the side of the wire line in the following cases:

1. Wooden poles are used on the entire trace.

2. Steel pole or reinforced concrete pole is used for the part that enters the station; the other poles on the overhead line trace are wooden poles.

3. Wooden poles protected in accordance with article IV.2.145 QTĐ are used for the part that enters

the 35kV station.

Installation of expulsion type lightning arrester CSO1 can be omitted if steel poles or reinforced concrete poles are used for the entire overhead line trace.

Ground resistance of pole used for installation of expulsion type lightning arrester must not be greater than 10Ω when the earth resistivity is not greater than 1000Ω.m and must not be greater than 15Ω when the earth resistivity is greater.

For 35-100kV overhead line that is not protected by lightning wire over the entire route and in lightning season, a side of its can suffer from a long blackout, the second expulsion type lightning arrester (CSO2) should be installed on the gate pole entering the substation or on the first pole of the overhead line at the side where blackout can occur.

Distance from CSO2 to electric cutout must not exceed 60m.

IV.2.147. For overhead line that is temporarily operated at voltage lower than the nominal voltage, at the first pole of the protected section connected to the substation, defined from the wire line side, expulsion type lightning arrester with voltage corresponding to the temporary working voltage of the overhead line. Where there is no expulsion type lightning arrester (CSO) using voltage level or where there is unsuitability of short circuit current, arrangement of protection gaps or short connecting of some insulators of insulator chains on 1 to 2 adjacent poles is acceptable (when there is no industrial contamination, brine contamination). The number of insulators in the insulator chain that are not short connected must be able to ensure the insulation level to be compatible with the temporary working voltage of the overhead line. On overhead line using reinforced insulation due to environmental conditions, if the overhead line section which goes into the station lying within the area using reinforced insulation, CSO that is compatible with the working voltage of the overhead line shall be installed on the first pole of that protected overhead line. When there is no CSO of the right voltage or not enough to cut the short circuit current, protection gaps can be used.

IV.2.148. Choosing of expulsion type lightning arrester according to short circuit current shall be as follow:

1 – For up to 35kV grid (with non-grounded neutral point or grounded via arc-suppression coil)the upper limit of the current that can be cut by expulsion type lightning arrester must not be smaller than the maximum 3-phase short circuit current, and the lower limit must not be greater than the minimum 2-phase short circuit current.

2 – For 110kV grid where short circuit current to earth is great, the expulsion type lightning arrester shall be chosen in accordance with the greatest 1-phase or 3-phase short circuit current and in accordance with the smallest 1-phase or 2-phase short circuit current.

Where there is no expulsion type lightning arrester satisfies the required numbers of short circuit current, main protection gaps shall be designed. In 220kV overhead line using wooden poles, when there is no expulsion type lightning arrester, insulator pedestal grounding must be done on 1-2 pole(s) and the quantity of the insulator must be equal to the quantity used for metal pole

See table IV.2.7 for the dimension of the main protection gaps.

Table IV.2.6 Protection of overhead line sections connected to substation

Voltage	Section entering substation using II-shaped poles			Section entering substation using single pole			Ground resistance of pole shall not exceed (Ω)		
Rated of overhead line	Length of protected wire section (km)(1)	Number of lightning wire	Protection angle of lightning wire must not exceed (degree)	Length of protected wire section (km)(1)	Number of lightning wire	Protection angle of lightning wire must not exceed (degree)	When earth resistivity is (Ω-m) (2)*		
							Up to 100	100 ÷ 500	Above 500
35	0.5 – (3)x 1 – 2	1	25 - 30	1-2	1	30-25	1Ọ	15	20
66	1.5 – 2	1	25 - 30	1-3	1	30-25	10	15	20
110	1.0 – 3	2	25 - 30	1-3	1	30-25	10	15	20(4)
220	2 – 3	2	25	2-3	2	25	10	15	20(4)

- (1) Determination on the length of the protected wire line includes the calculation of the distance between lightning arrester and device under protection specified in table IV.2.8.*

- (2) On 110-220kV overhead line section using double-circuit single-pole, ground resistance of the pole shall not be greater than 5; 10 and 5 Ω, corresponding to equivalent resistivity of earth of up to 100 Ω..m; 100-500 Ω..m and over 500 Ω..m*

- (3) Only used for substation with transformer of up to 1000kVA capacity.*

- (4) For II-shaped pole locating on area with resistivity of over 1000Ω..m, ground resistance can be over 20Ω but no greater than 30Ω.*

IV.2.149. In 3-35kV overhead line using wooden poles, ancillary protection gaps must be designed on ground wire of the main protection gaps at the distance of at least 2m above the ground. The sizes of ancillary gaps are specified in table IV.2.7.

Table IV.2.7 – Dimensions of ancillary protection gaps

Rated voltage (kV)	Size of main protection gap (mm)	Size of ancillary protection gap (mm)
3	20	5
6	40	10
10	60	15
20	140	20
35	250	30
66	450	-
110	650	-
220	1350	-

IV.2.150. Valve type lightning arrester must be installed in distribution station with voltage of 35kV and more connected to overhead line.

When choosing valve type lightning arrester, must combine its protective characteristic with equipment insulation; and quench voltage of valve type lightning arrester must be compatible with the voltage at the position of the lightning arrester in case of single-pole earth fault. Where the distance between lightning arrester and equipment to be protected is increased, in order to reduce the quantity of lightning arrester to be installed, lightning arrester with higher-than-required characteristic can be used but still in combination with equipment insulation.

Distance determined by conductor from lightning arrester to transformer and equipment must not exceed the values specified in tables from IV.2.8 to IV.2.10.

Determination of maximum allowable distance between valve type lightning arrester and equipment to be protected must be made on the basis of the number of wire line and valve type lightning arrester connected to the distribution station (substation) in normal working condition.

Quantity and installation position of valve type lightning arrester must be determined in accordance with the calculation current connection diagram and the quantity of overhead line and transformer. Then, during start-up period or transitional period that lasts longer than or equal to the lightning season, the distance measured from the equipment to be protected to the valve type lightning arrester must still fall within the permissible range.

Break-down and repairing condition are not need to be taken in to consideration.

IV.2.151. Valve type lightning arrester shall be connected directly to the transformer (automatic voltage design) without switching devices for protection in the following cases:

1. Wire coils of different voltage levels of transformers with auto-voltage transformation communication.

2. 220kV wire coil of transformer with decreasing main insulation level

Distances from valve type lightning arresters to transformers (autotransformers), to equipments must be taken in accordance with table IV.2.8 ÷ IV.2.10 if the equipments used are of the Soviet Union. Where the equipments used are of countries other than the Soviet Union, the distance values shall be determined according to their functions.

In cases where this distance is greater, valve type lightning arrester should be installed on the busbar.

IV.2.152. When transformer is connected by 110kV cable to the busbar of distribution station by, at the connection with the busbar there must be a valve type lightning arrester, the ground end of the valve type lightning arrester must be connected to the metal sheath of the cable.

When busbar of distribution station is connected to transformer by some cable lines, a set of valve type lightning arrester must be installed on the busbar of the distribution station, the installation location of the valve type lightning arrester should be as near the cable stay joint as possible.

IV.2.153. The unused low voltage windings and medium voltage windings of power transformer must be “star” or “delta” connected and CSV shall be used to connected to the poles of the phases with earth. For protecting unused low voltage magnetic core windings, the current shall be one phase or one neutral point away from the grounding, or CSV compatible with voltage level of each phase shall be installed.

For unused windings that are often connected to cable line with ground metal sheath of 30m length or more, installation of protection is not required.

IV.2.154. Valve type lightning arrester must be installed for protecting neutral points of 110-220kV windings of transformer with lower insulation in comparison with insulation level of the output and operated with its neutral points not regularly grounded. Isolation blade must not be placed at transformer’s neutral when the neutral point of the transformer is not allowed to be isolated from earth.

IV.2.155. 3-20kV distribution station connected to overhead line must be protected by valve type lightning arrester installed on the transformer or the busbar.

Table IV.2.8 : Maximum permissible distance between valve type lightning arrester and protected equipment of 35-20kV voltage

Rated voltage (kV)	Type of overhead line connected to substation	Length of overhead line section protected by lightning wire (km)	Distance to transformer (m)												Distance to other equipment (m)							
			Dead end station				Station connected to 2 overhead lines				Station connected to at least 3 overhead lines				Dead end station				Station connected to 2 overhead lines			
			Lightning Arresser group III		Lightning Arresser group II		Lightning Arresser group III		Lightning Arresser group II		Lightning Arresser group III		Lightning Arresser group II		Lightning Arresser group III		Lightning Arresser group II		Lightning Arresser group III		Lightning Arresser group II	
			1 x PBC	2 x PBC	1 x PBMr	2 x PBMr	1 x PBC	2 x PBC	1 x PBMr	2 x PBMr	1 x PBC	2 x PBC	1 x PBMr	2 x PBMr	1 x PBC	2 x PBC	1 x PBMr	2 x PBMr	1 x PBC	2 x PBC	1 x PBMr	2 x PBMr
1	2	3	4		5		6		7		8		9		10		11		12		13	
35	Gate pole (including wooden pole with CSO at the beginning section)	0.5	20	30			30	40			35	45			23	40			30	50		
		1.0	40	60			50	100			90	120			75	100			100	150		
		1.5	60	90			80	100			120	150			100	130			125	200		
		2	75	100			100	150			150	180			125	150			150	200		
	Steel pole and reinforced concrete pole	1.0	20	30			30	40			40	50			40	60			50	100		
		1.5	30	50			50	60			60	70			60	90			80	120		
		2	45	700			70	90			90	100			70	120			90	150		
110	Gate pole (including wooden pole with CSO at the beginning section)	1.0	30	50	40	100	50	70	60	120	70	90	80	125	120	140	130	180	130	150	140	190
		1.5	50	80	70	150	70	90	80	160	90	110	100	175	140	170	150	200	200	200	180	200
		2	70	110	90	180	80	120	100	200	110	135	120	250	170	200	180	220	200	200	200	220
		2.5	90	165	120	220	95	150	125	250	125	180	135	250	190	200	220	250	200	200	200	250
		3.0	100	180	150	250	110	200	160	250	140	200	170	250	200	200	530	250	200	200	250	250
	Steel pole and reinforced concrete pole	1.0	15	20	20	50	20	30	30	35	30	400	40	100	70	90	180	100	100	130	120	170
		1.5	30	55	40	80	40	60	50	100	50	70	60	130	110	130	120	160	150	180	160	200
		2	50	70	70	120	60	90	70	150	70	100	90	190	120	150	140	180	200	200	180	250
		2.5	65	100	90	160	70	115	100	200	80	125	120	250	130	200	160	230	200	200	200	230

1	2	3	4		5		6		7		8		9		10		11		12		13	
150	Gate pole	2	30	70	20 60	65 80	50	90	60 70	100 130	90	120	90 110	110 140	90	160	100	210	150	220	200	280
		2.5	40	90	35 80	75 100	70	120	70 90	140 170	110	160	100 130	150 190	100	180	120	250	170	280	250	350
		3	50	110	80 90	100 120	90	150	90 120	170 200	120	200	120 150	180 220	120	200	160	280	190	310	270	400
220	Steel pole and reinforced concrete pole	2	20	50	10 40	35 60	30	50	35 50	60 80	50	70	45 65	65 80	60	90	75	130	90	120	100	150
		2.5	30	70	15 60	70 80	45	80	65 80	90 110	70	100	80 95	90 110	80	120	100	180	120	160	140	220
		3	40	90	40 85	90 100	60	100	85 100	110 130	85	130	100 120	120 140	100	160	140	250	150	200	180	300

In 3-10kV distribution station, when transformer is connected with busbar by cable, the distances measured from valve type lightning arrester to transformer and other equipment are not restricted (see IV.2.136 for exceptions). When the transformer is connected to the busbar of 3-10kV distribution station by bare wire, the distances measured from valve type lightning arrester to transformer and other equipment must not exceed 60m if wooden poles are used for the connection section, and must not exceed 90m if the poles used are steel poles or reinforced concrete poles.

The 3-20kV overhead line entering the station must not be protected by lightning wire.

3-20kV overhead line section using wooden poles, which is 200-300m away from the substation, must be equipped with expulsion type lightning arrester. (CSO-1)

On 3-20kV overhead line whose a side can suffer from a long blackout during lightning season, the second expulsion type lightning arrester (CSO2) should be installed on the structure of the substation or on the last pole of the overhead line at the side where blackout can occur.

Distance from CSO2 to electric cutout must not exceed 60m.

Ground resistance of CSO1 and CSO2 must not exceed 10Ω when the earth resistivity is up to 1000Ω.m and must not exceed 15Ω when the earth resistivity is of greater value. Lightning pole is not required to be installed on 3-20kV overhead line section entering the station using steel poles or reinforced concrete poles. Steel poles or reinforced concrete poles that are up to 200-300m away from the station must be grounded with ground resistance of no greater than the values specified in table II.5.22.

Protection of 3-20kV substation whose the low voltage side of up to 1000V voltage is connected with 3-20kV overhead line must be done by using valve type lightning arrester installed on both the low voltage and the high voltage side.

Where the capacity of the transformer is up to 630kVA, installation of xpulsion type lightning arrester is not required on overhead line section entering 3-20kV station using wooden pole.

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

IV.2.156. Cable with voltage of 35-220kV and of under 1.5 km length must be protected by valve type lightning arresters or expulsion type lightning arresters installed at the both ends of the cable section. Cable with voltage of 35-10kV shall be protected by lightning valve of PBC type (group III) and cable with voltage of 220kV shall be protected by lightning valve of PBMT type (group II)

If the equipments used are originated from other countries, they must be of similar technical characteristics.

If the length of the cable exceeds 1.5km, installation of lightning arrester can be omitted.

In cases where a 3-20kV overhead line is connected to the station by using a cable section of up to 50m length, a set of CSO1 must be installed at the position where the cable is connected with the overhead line.

If wooden poles are used for the overhead line, the second expulsion type lightning arrester (CSO2) must be installed at 200-300m away from the end point of the cable section.

For cable of over 50m length, at its connection with overhead line, there should be an expulsion type lightning arrester instead of a valve type one.

Lightning arrester should be connected by the shortest route to the cable metal sheath and connected to the earth pole. Ground resistance must not exceed the values specified in IV.2.155.

IV.2.157. Protection for 35-110kV branch-connecting substation with transformer of up to 40000kVA capacity whose distance to the main power line without lightning wire is shorter than the length specified in tables IV.2.6 and IV.2.8 can be carried out in accordance with the following diagram (figure IV.2.16):

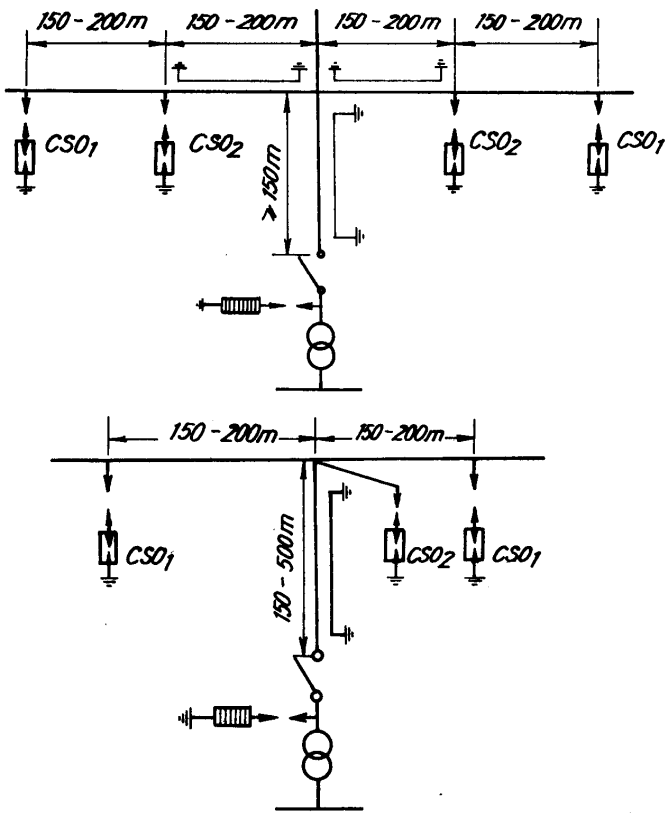


Figure IV.2.16: Diagram of protection against atmospheric overvoltage for substation connected to overhead line by branches of up to 150m and over 150 m length. a) when the branch is of up to 150m length; b) when the branch is over 150m length

- Place the valve type lightning arrester inside the substation, at the distance of no more than 10m from the power transformation.

- The branch line going into the substation should be protected by lightning wire over its entire length. Where the length of the branch line is less than 150m, lightning wire or lightning pole shall be used for protecting a pole range of the main line at both sides of the branch line.

- On overhead line using wooden poles, install CSO1 and CSO2 with ground resistance of each set of CSO not exceed 10Ω; where:

- CSO2 is located on the first pole of the lightning wire to the side of the overhead line, or between the boundaries of the part protected by lightning pole.

- CSO1 is located on the unprotected part of the overhead line, at 150-200m away from CSO2.

When the length of the branch line is greater than 500m, installation of CSO1 is not required. Protection for substation where the distance between valve type lightning arrester and transformer exceeds 10m shall be in accordance with the requirements specified in IV.2.142, IV.2.150. Allow the use of simple protection in accordance with the above requirement for substations that are connected in series with overhead line using short connecting sections (figure IV.2.17). In this case, the transformer must be protected by valve type lightning arrester of PBMr type (group II).

The simple diagram must not be used for protecting substation connected to a newly reconstructed overhead line.

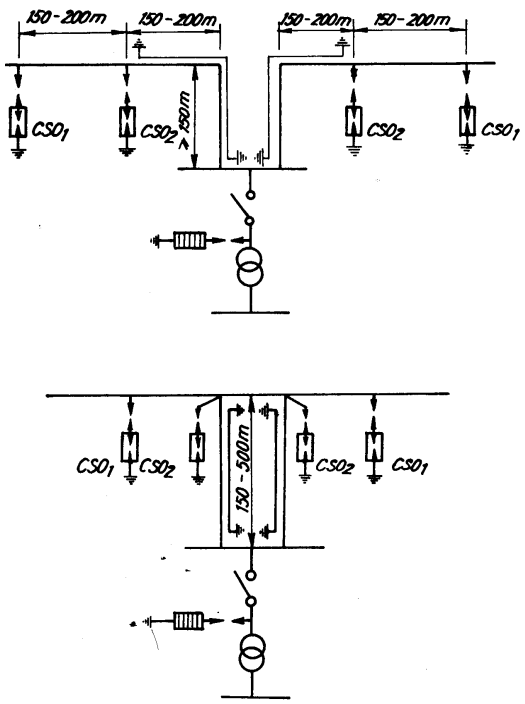


Figure IV.2.17 Diagram of protection against atmospheric overvoltage for substation connected in series between overhead line with sections, that goes into the substation, of 150m length a) and over 150 m length b)

IV.2.158. In areas with earth resistivity of 1000Ω.m and above, ground resistance of CSO1, CSO2 with voltage of 35-110kV installed for protecting transformers that are connected to the branch lines from overhead line or short connecting sections can be greater than 10Ω, but no greater than 30Ω. In that situation, the ground loop circuit of CSO2 shall be connected to the ground loop circuit of the substation.

IV.2.159. Line isolation blade used for overhead line of 35kV and 110kV voltage at branching point must be directly installed on pole with CSO2. If line isolation blade is installed on branching pole without CSO, must install CSO on the same pole used for installing isolation blade. In all cases, CSO must be installed on the same pole with isolation blade and from the same source side.

IV.2.160. For protecting isolation blade installed on 3-20kV wooden pole overhead line, CSO must be installed right on that pole from the source side.

IV.2.161. If the overhead line using steel poles or reinforced concrete poles is protected by lightning wire over the entire route, the branch line must also be protected by lightning wire over its entire length if there is requirement on power supplying for important sub-loading. If wooden poles are used for the branch line, CSO must be installed at the point where the branch line is connected with the overhead line.

IV.2.162. For protecting 3-10kV switching station, CSO must be installed at the end pole of each power supplying overhead line using wooden poles. In this case, lightning arrester shall be connected to he grounding of switching station.

Note:

1. This list is calculated for valve type lightning arrester manufactured by the Soviet Union. Other lightning arresters shall be considered to be of similar type as specified in this table.

2. Distance from valve type lightning arrester to electrical equipments, except for transformer, is unrestricted when the number of parallelly operated overhead lines is at least 7 lines for voltage of 110kV, at least 4 lines for voltage of 220kV.

3. Distance to 220kV transformer with regular main insulation shall be recorded above the horizontal line, with reinforced main insulation shall be recorded below the horizontal line.

4. When valve type lightning arrester of group I is used instead of valve type lightning arrester of group II, the distance to the 220kV transformer with regular main insulation can be increased by 1.5 times.

5. The permissible distance is measured to the nearest valve type lightning arrester.

IV.2.163. Allow the connecting of overhead line using steel or reinforced concrete to electrical generator and synchronous compensator with capacity of each machine is up to 50,000kVA. Overhead line using wooden poles can be connected to electrical generator and synchronous compensator with capacity of each machine is up to 25,000kVA. Connecting of overhead line to electrical generator and synchronous

compensator with capacity of over 50,000kVA must be through an isolation transformer.

IV.2.164. Protect electrical generator, synchronous compensator, electric motor of over 3,000kVA capacity connected to overhead line using valve type lightning arrester group I and capacitor with capacitance of no less than 0.5 μF for each phase. Besides that, it is necessary to protect the overhead line section connected to the power station (substation) with lightning resistance level of no less than 50kA.

Valve type lightning arrester should be located on busbar (busbar section) with generator voltage for protecting: electrical generator (synchronous compensator) with capacity of 15,000kVA and below at busbar of the distribution station, for protecting electric motor of over 3000kw capacity, at the outputs of electrical generator (synchronous compensator) with capacity of over 15,000kVA.

Protection of electrical generator (synchronous compensator) with brought out neutral, without loop insulation and with bar winding of at least 20,000kVA capacity can be done by using valve type lightning arrester installed at the electrical generator (synchronous compensator) neutral with the machine's rated voltage instead of 0.5μF capacitor at each phase.

Installation of protection capacitor is not required if the total capacitance of 100m long cable connected to electrical generator (synchronous compensator) is capable of creating capacitance of at least 0.5 μF for each phase.

IV.2.165. If rotating machine and overhead line of power station or substation are commonly connected to the busbar, then lightning protection for that overhead line section shall be done in accordance with the following requirements:

1. The overhead line section using reinforced concrete poles must be equipped with lightning wire of at least 300m length; and an expulsion type arrester must be installed at the beginning of the line section (figure IV.2.18a). Poles of overhead line protected by lightning wire must be equipped with wooden beams, providing that the distance from the position for hanging porcelain insulators to the pole is not less than 1m. Wire of the overhead line should be hanged on the insulator chain (supporting insulator station) with insulation level of 35kV. Ground resistance of CSO must not exceed 5Ω, ground resistance of pole with lightning wire should be 10Ω.

At the beginning of the line section, CSV group IV can be used instead of CSO. Then the ground resistance of the lightning arrester must not exceed 3Ω. On wooden pole overhead line, CSO should be installed at 150m away from the section with lightning wire toward the line. Ground resistance of lightning arrester must not exceed 5Ω.

2. Overhead line connected to power station and substation via 0.5km long cable shall be protected as overhead line connected by cable (see article 1) and shall be equipped with valve type lightning arrester group IV at the position for connecting the overhead line with the cable. Lightning arrester shall be

connected by the shortest route to the metal sheath of the cable and connected to the ground system. Ground resistance of the lightning arrester must not exceed 5Ω.

3. If the overhead line section is already protected against direct lightning strokes by high rise buildings, tree or other high constructions over a part of at least 300m length, the hanging of lightning wire is not required. Then, a valve type lightning arrester group IV should be installed at the beginning of the protected overhead line section (toward the line). Ground resistance of the lightning arrester must not exceed 3Ω.

4. When the reactor is connected with the overhead line, protection against direct lighting stroke by using lightning wire must be performed over the length of 100-150m of that overhead line section (figure IV.2.18b).

CSO should be installed at the beginning of the line section protected by lightning wire, CSV group IV should be installed near the reactor. The ground resistance of the CSO should not exceed 10Ω.

5. When overhead line is connected to the busbar of a distribution station equipped with rotating machine through a reactor and a cable section of over 50m length, it does not required protection against direct lightning stroke. At the position for connecting the overhead line with the cable, must install a CSO with ground resistance of no greater than 5Ω and before the reactor, must install a CSV group IV (figure IV.2.18c)

6. Overhead line connected to busbar of power station (substation) equipped with rotating machine of less than 3,000kVA capacity using steel pole or reinforced concrete poles over the length of no less than 0.5 km with ground resistance of the poles not exceed 5Ω shall require installation of valve type lightning arrester group IV at 150m away from the power station (substation). Ground resistance of the lightning arrester must not exceed 3Ω. In these cases, installation of lightning wire for the overhead line is not required.

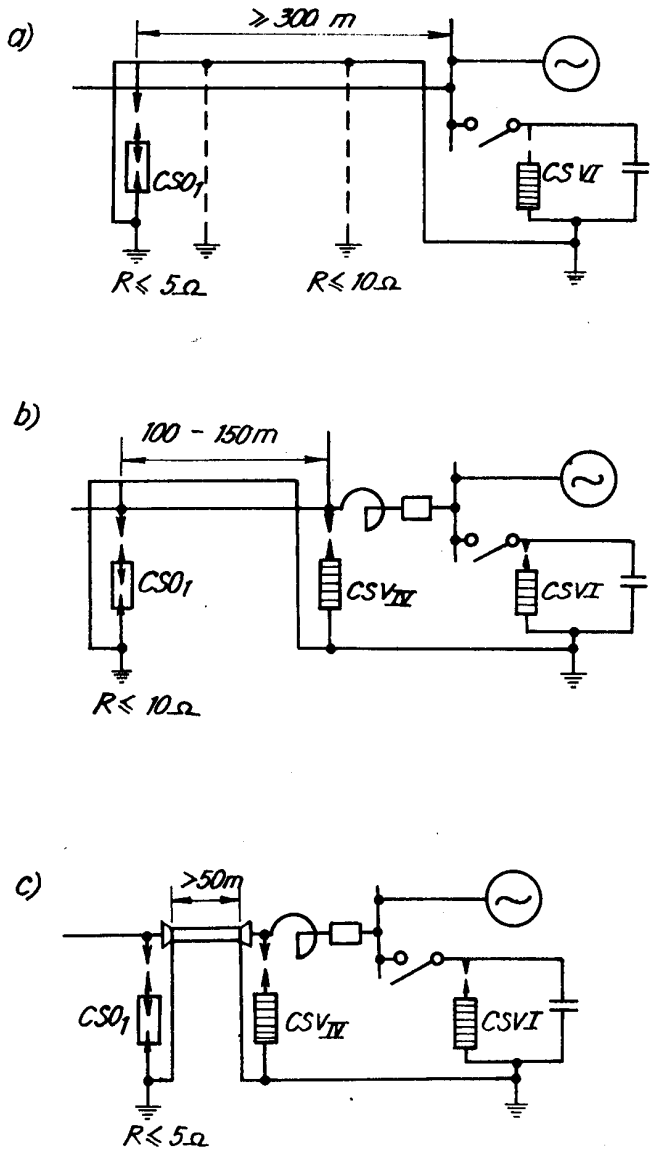


Figure IV.2.18 : Diagram of protection against atmospheric overvoltage for rotating machines

IV.2.166. When bare conductors are used for connecting electrical generator (synchronous compensator) with the transformer, these conductors must lie within the protection range against direct lightning stroke of the lightning arresters and the constructions of the power station (substation). The distance from the ground points of lightning arresters to the ground points of conductor installation structures must not be less than 20m (determined by ground wire).

If bare conductor lies outside the protection range of lightning arrester in outdoor distribution station, it shall be protected from direct lightning stroke by using independent lightning pole or lightning wire hung on individual pole with protection angle of no greater than 20^0. Independent lightning pole and pole for hanging lightning wire shall be connected to individual grounding system.

In cases, where connection is made with the grounding system of the distribution station, the connecting point must be at least 20m away from the grounding point of the conductor rod.

The air distance measured from the independent lightning poles and the poles for hanging lightning wire to conductive parts or ground parts of the conductor rod shall be no less than 5m.

The underground distance between the independent grounding system and the ground busbar of the conductor rod shall be no less than 5m.

IV.2.167. When bare conductor is used for connecting substation of industrial factory with distribution station of power plant where the capacity of each generator is up to 120 MW, that conductor shall be protected against direct lightning stroke in accordance with IV.2.166.

When bare conductive rod is connected with distribution installation at generator voltage through reactor, a valve type lightning arrestor group IV shall be installed before the reactor.

For protecting the electrical generator from lightning wave travelling through conductive rod and from overvoltage, induction must install valve type lightning arrester (CSV) group I and capacitor incapable of protecting all three phases. The capacitance shall be no less than 0.8MF for voltage of 6kV; no less than 0.5 MF for voltage of 10kV and no less than 0.4 MF for 13.8-20kV.

Installation of protection capacitor is not required if the total grid generator capacitance on the generator voltage busbar is of adequate value.

When determining the grid capacitance, in this case, only cable sections of up to 750m length is taken into account.

IV.2.168. Overhead line is allowed to be connected to electrical motor of up to 3,000kW capacity with reliable backup if protection against direct lightning stroke is not installed on the overhead line section connected to that motor, then two set of CSO must be installed on the overhead line section at 150-250m away from the station busbar. (see figure IV.2.19a)

Ground resistance of CSO must not exceed 5Ω.

For overhead line section going into the station of over 250m length using steel poles or reinforced concrete poles, if the ground resistance of the poles on this section does not exceed 10Ω, the installation of CSO is not required.

When the connecting section is cable of any length, beside CSO1 and CSO2 installed on the line, there must be CSV group IV installed right before the cable section. Grounding of CSV must be connected to the metal sheath of the cable (figure 19b).IV.2.196

For electric motor, CSV group I and 0.5MF protection capacitor must be installed on each phase.

Intrinsic overvoltage protection

IV.2.169. As to medium voltage distribution grids of 6-35kV with arc-suppression coils, phase-to-ground capacitances of phases must be balanced by reasonably arranging phases and their high frequency communicative capacitors.

Difference between phase-to-earth capacitances does not exceed 0.75%. Location of the arc-suppression coil must be selected subject to structure of the network, the grid's ability which separates itself into stand-alone subnetworks, probability of fault types, or the impact on railway signals and wire communication lines.

Never connect an arc-suppression coil to power transformers in the following cases:

a) Transformers are connected to busbars with fuses.

b) Transformers are connected to the grid in which the capacitive current is only compensated by one line. Rating of the arc-suppression coil is chosen, taking account of the development in the next ten years.

IV.2.170. For high voltage transmission grids (110-220kV) with earthed neutral points, and in which insulation levels of 110-220kV windings of power transformers are reinforced, it is unnecessary to apply intrinsic overvoltage limiting methods.

220kV windings of power transformers and auto-transformers which have normal insulation levels, are to be protected from intrinsic overvoltage risk with magnetic blowout type SA (РВМГ type or the corresponding) which is placed as required in IV.2.151 section.

IV.2.171. As to medium voltage distribution grids of 3-35kV without arc-suppression coils and generators, a synchronous compensator with the stator winding which is water directly cooled, can be disconnected from arc-suppression coils or above generators, synchronous compensators when automatical trippings, detecting earth points, testing and periodic maintanance for equipments, circuits which prevent neutral point self-deflection must be employed: it is to connect a resistance of 25 Ohms which a current of 4A flows through in a long period to V-connected winding on the secondary side of 3-35kV voltage transformers for testing the grid's insulation capacity.

As to grids of 3-35kV, which can be disconnected from the grid containing arc-suppression coils, or generators and a synchronous compensator with the stator winding which is water directly cooled, it is to connect a resistance of 25 Ohms to V-connected winding on the secondary side of voltage transformers for testing the grid's insulation capacity, and attach a device which can isolate that resistor from the winding.

Besides, for a generator-transformer unit and a synchronous compensator-transformer unit, such another

resistance is used to connect automatically in parallel with the permanent resistor when ferromagnetic resonance process occurs. For grids and wiring diagrams of 3-35kV, there is no need to measure phase-to-earth voltages (isolation tests) or zero sequence voltage, thus, a voltage transformer with the unearthed primary winding should be used.

For grids and wiring diagrams of 3-35kV, which install arc-suppression coil or generator (synchronous compensator) with stator winding cooled directly with water, protection against neutral point self-deflection is not necessary.

Compressed air system

IV.2.172. In order to supply compressed air to electric equipments (Air circuit breakers, compressed air actuator of disconnector switches and oil circuit breakers), arrange air compressing equipments in distribution substation in power plant and station providing that if any component and any compressor is out of order or repaired, there is no effect on normal operating mode of compressed air system.

IV.2.173. Compressed air coming to equipments must be dried and removed mechanical impurities. Moisture of compressed air must match requirements of equipments.

IV.2.174. To obtain compressed air which is dry enough, the compressed air system must have two levels of pressure:

a) Compressed pressure which is applied for compressor and compressed air tank is selected in accordance with essential moisture in the distribution substation.

b) Operating pressure (nominal) which is applied for compressed air distribution grids is selected appropriate to nominal air pressure of equipments in the distribution substation.

The system under compressed pressure and the one under operating pressure are contacted via a pressure relief valve.

IV.2.175. Compressed air tank which has the pressure of up to 5MPa (50at) must be installed spring safety valve, pressure gauge indicating via a three-way valve, relief valve, hole with nut to release air in hydraulic tests, inspection door for observation and cleaning, flanged connections for connecting air tubes and tube-sinking to attach to support post.

At least three compressed air tanks are connected in series to ensure that air is at a drier level.

IV.2.176. Pressure relief valve must maintain the pressure of air distribution system and air tank of circuit breaker (CB) in regulated range of the manufacturer to ensure normal tripping capacity and reliable operation of CB in the mode that autoreclosing fails.

Efficiency of pressure relief valve and air distribution system is insure that compressed air pressure in air tanks is recovered for at most 3 minutes (up to minimum permissible pressure value accordant with operating conditions of CB); it is possible for CB to trip simultaneously in the unsuccessful autoreclose cycle.

Pressure relief valve in the normal operating mode ensures that a small amount of air can flow through to compensate the loss of air due to leakage and drying blow-off in the system after the valve.

IV.2.177. Check valve is installed between water-oil separator and air tank.

IV.2.178. For each nominal pressure value of equipments in distribution substation, use individual air distribution system to which air is supplied from compressed air device through at least one pressure relief valve.

IV.2.179. Use electronic-controlled pressure relief valves. Open/Close automatic controlling of pressure relief valves does not depend on operating modes of air compressor.

IV.2.180. Capacity of air compressors (the pressure of up to 5MPa) must be chosen in providing that:

a) These machines can continuously run half an hour after two-hour shutdown.

b) After 0.5 working hour, compressed pressure of air tank, which has reduced itself due to leakage and drying blow-off in the system during two-hour shutdown of the air compressor, must be resumed. Backup compressor must be available, not taking account of the number of compressors.

In order to supply compressed air to CB of substations, distribution substations in enterprises allows using the air supply from compressed air system of enterprise if conditions in this chapter are matched:

In the case that the substation has one oil-type CB which uses compressed air actuator, apply only one air compressor (no backup one).

IV.2.181. The amount of air reserve in tanks must be enough to add into equipments in operating and faulty modes.

The volume of tanks need to compensate adequately the resultant amount of air loss (when the compressor does not work) as follows:

a) In the operating mode, in order to dry CB and system air leakage for two hours when compressed air is cut off, remaining air pressure is enough to keep the moisture of compressed air as required in electric equipments.

b) In the faulty mode, to recover pressure in the air tank of air CB (up to minimum permissible pressure value accordant with operating conditions of CB) when the maximum number of CBs are tripped in the normal operating mode due to actions of protection and autoreclose functions at that time.

Meanwhile, the minimum pressure of compressed air in the tank must be higher than the nominal pressure of compressed air in equipments: 20-30% for equipments with up-to-5MPa compressors.

IV.2.182. During design, assume the initial time of fault along with mass tripping of CBs at the same time when the air compressor operates (that is, when the pressure in the tank reduces to starting pressure of the compressor).

IV.2.183. Air compressor is completely automatically operated without routine operators.

Air compressor is controlled automatically to maintain the pressure in the tank of the CB in prescribed limits.

Automatic control diagram of air compressor needs to anticipate automatic start and stop of operating compressors in order to backup, automatic blowing (oil and water) of oil-water separator, automatic pressure relief valve control and air compressor unit protection in the case of problems and failure.

Compressed air system must be installed signal warning device in normal operating mode.

IV.2.184. Compressed air tank must conform to “Safety practice code of pressure dividers” (1973).

IV.2.185. Compressed air tank is located outdoor, 0.7-1 metre away from walls and should be in the shady side. There is no need to install weather proof on compressed air tanks. Possibility of accessing any compressor also is taken account in order to avoid influencing on normal operation of other compressors.

It is allowable that compressed air tank is installed in the separate room of installing area for distribution equipments, which uses air CBs.

IV.2.186. Discharge valve of oil-water separator of air compressor must be connected into oil drain system to individual sump.

Discharge pipe must have enough diameter and slope to avoid clogging and to increase the pressure of oil-water separator when all discharge valves are operated at the same time.

IV.2.187. Air which is sucked into the air compressor is filtrated by a filter installed on the compressor.

IV.2.188. There is a room for repairing and lifting devices for installation and repair works in air compressor compartment.

IV.2.189. Temperature of the air compressor compartment must be at least 10^0C in winter and at most 35^0C in summer. Fan must be installed to exhaust residual heat from the compartment.

IV.2.190. Compressor unit need to be installed on insulator against walls.

IV.2.191. Floor of air compressor compartment are made of glazed tile or the corresponding material.

Walls are plastered and oil-painted until the height of oil-painted parts is at least 1.5 metres.

IV.2.192. The air compressor compartment must have reversed doors; the lock must be self-latched; and the door can be opened from inside without keys.

IV.2.193. Compressed air distributing pipe system generally is arranged as ring chain which are isolated by check valves.

IV.2.194. When the pressure raises 10% in comparison with nominal pressure, safety valve must work to protect air distribution system.

The safety valve should be placed at the ends of centre line of distributing pipe system, next to the panel which attachs pressure gauge.

IV.2.195. Water separator is located outside the compressor compartment, at the ends of air supply centre line to air distribution system.

Water separator must have discharge valve and flanged tees which connect to air inlet and air outlet.

IV.2.196. Air pipe and air distribution device must be arranged so that they can be accessible during operation.

IV.2.197. Conduit of compressed air distribution system can be exposed on pipe racks in cable tunnels, cable troughings along with cables; and be wall-mounted or roof-mounted in closed compartment.

Air conduit is placed in a slope of 0.3% and a discharge valve is installed at the lowest point of the conduit.

Branch conduit to equipments are placed in a slope of 0.3% to main conduit.

IV.2.198. To eliminate distortion due to temperature, there are expansion pieces which have the same diameter as the centre line has.

IV.2.199. Pipes of air compressors, compressed air distribution system and branch to control panel use seamless steel. Pipes from control panel to tank of CB are made of copper.

Air conduit from control panel to compressed air actuator of disconnector switch can be made of steel.

Radius of curvature of steel air pipe is not less than 4 times of pipe outer diameter.

High pressure air pipe section which penetrates through walls to outdoor air tanks is heat-insulated on the part going through walls and the part from walls to tanks.

IV.2.200. Steel air pipes are connected together by welding, to equipments with flanges.

Pipes which have inner diameter of 5-8mm are connected with flanges or thread unions.

IV.2.201. Inner side of compressed air tanks and separators are rust-removed, cleaned and covered with antirust paint.

Inner components of valves which are located after filer in control panel of air CB must be made of stainless steel.

IV.2.202. Outer side of air tank and water separator which are located outdoor must be covered with light-colour paint.

IV.2.203. Brake valve, filter, check valve and pressure gauge on branch to air CB are located in separate distribution panel (attached to CB) which has a electric dryer.

IV.2.204. Every component of air compressor must be accessible for disassembling and cleaning.

Oil system

IV.2.205. In order to operate oil equipments of substations, electricity services need to build centralized oil systems which consist of reservoirs for containing and handling oil of oil pump, oil filters and regenerators, mobile air filters and removers in oil transportation containers.

Location and scale of centralized oil systems must be followed to plans which are built by electricity services, validated by electricity companies. Power plants need have oil system consisting of oil store and oil handling systems.

Oil store must have:

a) 4 turbine oil pans and 4 insulating oil tanks for thermal power plants
b) 3 turbine oil pans and 3 insulating oil tanks for hydroelectric power plants

Volume of each turbine oil pan is not less than that of oil system of one generating set plus additional oil for all generating sets in thermal power plant for 45 days, or plus 10% of oil of one generating set in hydroelectric power plant.

Volume of each insulating oil tank is equal to the oil amount of the largest transformer plus 10% of reserve oil volume.

IV.2.206. Substations with the voltage of at least 110kV, which have tank-type oil CBs with voltage of at least 110kV, need have oil stores which have two fixed insulating tanks outdoor.

Volume of each oil tank is at least enough to contain the oil amount of the largest transformer or that of 3 phases of the largest oil CB plus the additional oil amount which is added to the equipment (at least 1% of the total amount of oil in equipments and transformers in substation).

Do not build oil store in substations which have tank-type oil CBs in the following cases:

a) Transport system between substation and oil handling center of system is feasible.

b) The number of oil CBs in substation is not more than two.

c) Substations are located in the center of the city.

IV.2.207. Substation with synchronous compensator has to build two fixed turbine oil pans independent of the quantity and volume of insulating oil tanks.

Volume of each oil pan is not less than 110% of the volume of oil system of the largest compensator in the substation.

IV.2.208. Other step down transformers need not build oil store and oil system. Oil of these transformers is taken from centralized oil system with mobile oil tanks and oil tank cars.

IV.2.227. Along with haul road at the position of transformer which has the weight of 20 tons, cleats are placed to secure capstan, guide pulley, block when transformer is pulled.

IV.2.228. If transformer is installed indoor, gap distance between protruding parts at the height of 1.9 metres is not less than:

a) 0.3 metre from walls and dividing walls for transformers which possess a capacity of up to 400kVA; 0.6 metre for larger transformers.

b) 0.6 metre from doors or exits for transformers which possess a capacity of up to 400kVA; 0.8 metre for transformers which possess a capacity of from 400kVA to 1800kVA; and 1 metre for other larger transformers.

IV.2.229. Floor of oil transformer compartment must have a slope of 2% to oil collecting pit.

IV.2.230. Doors of transformer compartment must meet requirements mentioned in section IV.2.92. Barriers which are at 1.2-metre height can be placed right behind these doors (to observe the transformer without entering the room).

IV.2.231. Disconnector switches, load breaker switches with fuses, surge arresters, arc-suppression coils and cooling devices of transformer can be installed in the compartment.

IV.2.232. Each compartment of oil transformer must have separate exit or ways to next rooms which contain flameproof floor, walls, and dividers; and have no equipments, materials which are explosive and combustible.

IV. 2.233. Horizontal distance from doorcatch of adjacent transformer compartment and indoor substation to the nearest window and door of the compartment is not less than 1 metre.

It is impermitable to transport a transformer, which has a capacity of more than 100kVA, away from transformer room on the intrinsic aisle between houses, which is less than 5 metres. This rule is not applied

for compartments which are on the aisle inside the producting compartment.

IV. 2.234. Ventilation system of transformer room has to ensure that heat which transformer generates is released, and that it is not connected to other ventilation systems. Vent casing uses flameproof material which has fire-resistant limit of 0.75 hour.

Vent and air hole must be placed so that stagnant water in vent can not flow into the transformer; or there is another method which prevents water coming to the transformer.

Air hole must be covered with a screen which has meshes (1cm x 1cm) to prevent rainwater penetrating.

IV.2.235. Vent of adjacent transformer compartment which has flameproof casing, but has combustible roof, is at least 1.5 metres far away from walls, or is arranged in series when combustible structures of the roof are protected by flameproof dividers which are at least 0.6 metre higher than the roof. In this case, mouth of vent on the roof must not be in opposite to windows. Do not locate air hole on the wall which is below the protruding part of the combustible roof or below the aperture of door of the house.

If there is any window on the door or air hole of transformer compartment, an apron which protrudes out at least 0.7 metre must be mounted below the window. The width of apron is at least 0.8 metre larger than that of both window leaves

IV.2.236. Transformers which have forced cooling components must have automatic cooling system start/stop components.

Cooling system is started automatically in accordance with temperature of the top oil film or temperature of transformer windings and load current values, no matter how many oil temperature is.

IV.2.237. Outer cooling system (DU type of Soviet Union) is placed not to obstruct transformer moving from the footing and to enable repair of itself to work when transformer is in operation.

Air flow of cooler does not aim at the transformer body.

IV. 2.238. Transformer coolers are arranged in order to be accessible, removable from transformer, separately removable from the cooling system, and to move transformer without oil discharge from coolers.

IV.2.239. Outer oil pipes of forced cooling system (DU-type and U-type of Soviet Union) must be made of stainless steel or material.

Arranging oil pipes around transformer does not obstruct transformer operation, coolers and takes the least work to move transformer. Working platform and ladder are equipped to easily access valves and air fans, if necessary.

IV.2.240. To test oil pump of forced cooling system (DU-type and U-type of Soviet Union) and water

pump, each pressure gauge is installed next to each pump. If screen filter is installed, press gauges are attached at both ends of filter.

IV.2.241. Outer cooling system contains single cooler or double cooler which are aligned must be placed on the same footing.

Group of coolers can be arranged directly on footing or track when they move with their wheels.

IV.2.242. Control panel of motors in forced cooling system (DU-type and U-type of Soviet Union) must be out of oil collecting pit.

Do not hang the control panel against transformer body.

IV.2.243. Transformer with forced cooling system need to equip warning signal when oil circulating, cooling water and air fan systems are out of work, or predicting device when spare cooling and spare power supply systems start.

IV.2.244. Absorbing chamber which filtrates transformer oil and is placed on forced cooling system (DU-type and U-type of Soviet Union) need to be located indoor and can alter local absorbent.

IV.2.245. Actuating cabinet of on load tap changer (OLTC) must be installed automatic electric dryer.

IV.2.246. Expansion cover which contains transformer protecting nitrogen must be protected from sunlight.

IV.2.247. In order to repair transformer without disassembling the core of transformer which has a voltage of up to 220kV when housing and disassembled part weigh at most 25 tons, it should be noticed that housing and disassembled parts are lifted by mobile crane or combined gate pole. In this case, it is possible to move transformer casing or core, to cover the core with tent.

IV.2.248. It is necessary to equip fixed devices for repairing without disassembling the core of transformer (weighing tower, crane) in outdoor distribution substations of power plant when transformers can not be transported to repair area or compartment; or large transformers are far from repair area under difficult transport conditions.

IV.2.249. At substation with a voltage of up to 220kV containing transformers whose casing can not be removed and core weighes more than 25 tons, it is necessary to have fixed or semi-fixed lifters and tracks to move transformer from footing to repair position for repairing transformer.

IV. 2.250. If outdoor transformer is arranged along with machine hall of the power plant, ensure that transformer move to repair area without removing transformer, bushings, busbar supporting structure, busbar lifting gate pole, etc.

IV. 2.251. It is necessary to have a road for crane truck or other vehicles for transformer assembly at its installation position.

IV. 2.252. Crane must be able to lift transformer casing.

Chapter IV.3

Battery

Scope

IV.3.1 This section of the regulations is applicable to stationary acid battery and is not applicable to other type of battery.

IV.3.2 Battery compartment of explosion hazard type N.1A is the compartment where battery charging is performed with voltage of each battery case of over 2.3V. Battery compartments operating in regular trickle charging mode or charging mode with voltage of each battery case lower than 2.3V shall be considered to be with explosion hazard only during forming charge process or during process of charging after being repaired with voltage of each battery case of over 2.3V; in normal operation mode with voltage of each battery case of below 2.3V, that compartment shall not be considered as compartment with explosion hazard.

Electric part

IV.3.3 Choosing of electrical heating equipment, compartment lighting bar, electric motors for ventilating fans, conductors and installation of such equipments in the primary and secondary compartments must be in accordance with regulations specified in Chapter VII 3.QTĐ.

IV.3.4 Battery charger must have sufficient capacity and voltage to charge the battery to 90% of nominal capacity for a period of not more than 8 hours, when the battery was previously discharged in 30 minutes.

IV.3.5 Battery equipment must be equipped with voltmeter and ampere meter at charging circuit, trickle charging circuit and battery.

IV.3.6 When generator motor set is used for charging and trickle charging, equipment for turning off the motor set in case of reverse current must be prepared.

IV.3.7 In battery circuit, there should be an automatic switch (circuit breaker) to protect the circuit devices.

IV.3.8 Strickle charger must ensure stable voltage on the battery busbar within the limit of ± 2%.

IV.3.9 Battery device using charging mode of no greater than 2.3V for each case must be equipped with a device that does not allow the voltage to increase to the level of over 2.3V for each battery case.

IV.3.10 Adapter used for battery charging and trickle charging must be connected to AC source through induction transformer.

IV.3.11 DC Busbar must be equipped with a device in charge of checking the insulation regularly for insulation resistance value and sending signal when the insulation resistance of each pole decreasing to 20

kilos ohm in 220V voltage grid, 10 kilos ohm in 110V voltage grid, 5 kilos ohm in 48V voltage grid and 3 kilos ohm in 24V voltage grid.

IV.3.12 Battery devices must be equipped with interlock for preventing the battery from being charged to the voltage of over 24V for a battery case when the ventilation equipment does not work.

IV.3.13 Emergency lamps must be installed in the battery compartments.

IV.3.14 Batteries must be placed on carriers or in cabinets. Vertical distance between the carriers or the cabinets must ensure the convenience for operating the batteries. Where 2 cells glass container is not used, it shall be considered to be 1 battery.

IV.3.15 Battery carrier must be manufactured, tested and marked in accordance with requirements of standards or technical conditions. The carrier must be painted to be protected against the effects of electrolytes.

IV.3.16 Battery must be insulated from carrier and the carier must be insulated from the ground by the insulating buffers in capable of withstanding electrolyte and acid vapor.

IV.3.17 Aisles for operating the batteries should have width of not less than 1 meter when the batteries are arranged on two sides and 0.8m when the batteries are arranged on one side.

IV.3.18 Distance between conductive parts of the battery shall be no less than 0.8m when normal operation voltage (not charging) is from 65V to 250V, 1m when the voltage is over 250V.

When the batteries are arranged into two closed rows, the voltage between conductive parts of two adjacent batteries located in different rows must not exceed 65V under normal operation (not charging).

IV.3.19 Busbar of battery must be copper, aluminum, or bare steel bar.

Joints and branching positions of copper busbars must be ignition welded or soldered while that of aluminum, steel busbars must be fusion welded. The joint between the battery and the busbar should be tin-plated. The joints between the busbar and the wall entrance conductor must also be fusion welded.

IV.3.20 Bare busbar must be prepared with two layers of acid resistant paint and when the paint is dry, it shall be painted red at positive terminal (+) and painted blue at negative terminal (-). A thin layer of Vaseline should be applied before pouring the electrolyte into the battery.

IV.3.21 Distance between the separated bare busbars and distance from the busbars to structures of the buildings and to other ground parts shall not be less than 50m.

IV.3.22 Bare busbars placed and secured on the insulation.

Distance between supporting points of busbars of any shape must not be greater than 2m. Mechanical and electrical strength of insulations, insulation accessories items, details for securing the

busbars on placing structures must be able to withstand the long-term effect of electrolyte vapor.

Supporting structures are not required to be grounded.

IV.3.23 Plate supporting the wall entrance bar going out from the battery compartment must be able to withstand the effects of electrolyte vapor. If using paraffin soaked asbestos cement plate, ebonite plate, etc.

The use of plates made from stone or materials of layering structure is not allowed.

IV.3.24 Wire connected from the board for connecting wire to the door of the battery compartment to the commutator and DC distribution board must be single core cable or bare busbar.

Construction part

IV.3.25. Stationary battery must be placed in individual compartment. Stationary battery can be located in the same compartment with several sets of acid battery.

IV.3.26. Battery compartment must be production compartment level G and must be located in a building with fire resistant rate of at least level II_c (according to TC.II.63)

Door and window frames can be made of wood.

IV.3.27. In battery compartment, natural light should be used for lightning, clouded glass or white painted glass should be used for windows.

Battery compartment is allowed to be located in dry basement and use lightning system other than natural lightning.

IV.3.28. When sealed mobile battery (for example: car battery) and battery with voltage of up to 60V and total capacity of no greater than 72A are used for stationary electrical equipment, they can be placed in the same individual compartment which is natural ventilated or placed in the same production compartment which is free from fire and explosion hazard, in a ventilated metallic cabinet. Then the fire and explosion hazard level of the production compartment shall remain unchanged.

IV.3.29 Mobile battery under discharging mode or regular trickle charging mode which is charged at the position other than the position for placing the battery and sealed stationary battery (with cap) charged to voltage of 2.3V per case can be placed in the common production compartment that is free from fire and explosion hazard with the condition that ventilation hoods must be installed above the battery cases. Then the fire and explosion hazard level of the production compartment does not need to be changed.

IV.3.30 Battery comparrtment must be:

1. Arranged near charging equipment and DC distribution board.

2. Protected from dust, vapor and gas entering and water permeating through the roof.

3. Convenient for travel and operation.

4. Away from sources of vibration.

IV.3.31 Accessway to battery compartment must goes through a buffering compartment. The accessway must not directly lead to living compartments.

The size of the buffering compartment must be so designed that its door opening to the battery compartment can only be opened or closed when its door opening to the adjacent room is already closed. The buffering area must not be less than $1.5m^2$.

The door of the buffering compartment must be designed to be opened outward, equipped with self locking device and can be opened from the inside without key.

On the door, there must be board stating: “No fire” “Battery compartment” “Flammable” “No smoking”

IV.3.32 Next to the battery compartments, there must be individual rooms for storing acid, Battery plate partitions, and electrolyte preparation equipments, with area of no less than $4m^2$.

IV.3.33 Commonly, the ceiling of battery compartment must be flat. Where the conditions specified in IV.4.42 are satisfied, the ceiling can be designed with protruding structures or inclination.

IV.3.34 Floor of battery compartment must be concrete floor of real flatness and paved with acid bricks (joint finishing is done with acid resistant material or asphalt).

When placing battery rack on the asphalt layer, must prepare a reliable supporting panel made from acid-resistant material. Battery rack must not be placed directly on the asphalt floor, baseboards inside acid and battery compartment must be made by acid resistant materials.

IV.3.35 Walls, ceilings, door frames and window frames, inner and outer surfaces of ventilation duct, metal structures, etc must be painted with acid resistant paint.

IV.3.36 When battery is located in a cabinet equipped with air exhaust equipment, the inner surface of the cabinet must be painted with acid resistant paint.

IV.3.37 In battery compartment with rated voltage of over 250V, the aisle must be designed with wooden floor for creating insulation between human beings and the floor.

IV.3.38 When using ventilating equipment that is not stationarily placed inside the battery compartment must design spaces for placing the equipment and for connecting the equipment with ventilation duct.

Sanitary engineering part

IV.3.39 Battery compartment where charging process is carried out with the voltage of each box exceeding 2.5V must be equipped with stationary forced ventilation system. In battery compartment working with

regular trickle charging mode and air charging of up to 2.3V voltage for each box, non-stationary or stationary forced ventilation system should be used during charge forming and overcharge checking.

Beside that, must use natural ventilation system ensuring the exchange of at least 1 time the air volume of compartment per 01 hour. Where natural ventilation cannot afford for air exchanging, forced ventilation shall be used.

Consumption of clean air (V) shall be determined by the following formula:

$V = 0.7\ I_m.n$

Where:

V – measured in m^3/h

n – the number of batteries

I_m – The greatest charging current (A)

IV.3.40. The battery compartment ventilation system shall service the battery compartment and acid compartment only.

Gas shall be discharged through correctly installed exhaust pipe protruding at least 1.5m out from the roof, the exhaust pipe must be protected from rain.

This ventilation system should be connected to smoke flues or general ventilation system.

IV.3.41. Forced exhaust equipment must be of explosion-proof type.

IV.3.42. Gas must be exhaust from both the upper part and the lower part of the battery compartment at the side opposite to the hi-velocity supplying air flow. If the ceiling consists of compartments that are partitioned into multi-parts, gas must be exhausted from each part. If the ceiling is inclined, exhaustion must be performed from the highest part. The upper edge of the upper air duct must be no more than 100mm away from the ceiling, and the lower edge of the lower duct must be no more than 300mm away from the floor. Air flow from ventilation channel must not blow directly to the surface of battery electrolyte.

Metallic air ducts must not be located above the battery.

Velocity of the airflow in acid and battery compartment when the ventilation system is operating must satisfy the sanitary standards in designing industrial constructions.

IV.3.43. The winter temperature in battery compartment at the height for placing battery must not be less than 10^0C.

In substation where there is no regular watchman, if the battery is used only for turning on and off electric machines, the temperature mentioned above can be reduced to no lower than 0^0C.

IV.3.44. In power plants and substations that are equipped with water pipelines, faucet and basin for collecting water must be arranged near the battery compartment.

On the basin, there must be a signboard stating: “Do not place acid and electrolyte here”