Approved by
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Regulation of PJSC Rosseti «On a unified technical policy in the power grid complex»

(new edition)

Introduction

The Regulation of PJSC Rosseti "On a unified technical policy in the power grid complex" (hereinafter referred to as the Technical Policy) was developed in accordance with the regulatory legal acts of the Russian Federation (hereinafter referred to as the NLA), documents in the field of technical regulation of the Russian Federation, technical regulations of the Eurasian Economic Union and the Customs Union, taking into account the requirements of IEC standards and the current level of development of technology and technology, and is a fundamental document mandatory for use in PJSC Rosseti (hereinafter referred to as the Company) and mandatory for use in the activities of subsidiaries and dependent companies of PJSC Rosseti (hereinafter referred to as SDC) carrying out activities for the transmission and distribution of electrical energy, subject to its recognition as applicable (in whole or in part) by the management body of subsidiaries and dependent companies.

The technical policy is a set of goals, principles, effective technical, technological and organizational requirements and solutions that ensure an increase in the efficiency, reliability, safety, efficiency of transmission and distribution of electricity for the implementation of the Strategy for the development of the electric grid complex of the Russian Federation.

The technical policy is aimed at fulfilling the functions and tasks of the Company and solving problems in accordance with the Concept "Digital Transformation 2030".

The requirements of this Technical Policy apply to the operated and designed facilities of the power grid complex (hereinafter referred to as production assets) during new construction, reconstruction and technical re-equipment.

The provisions of the Technical Policy are taken into account within the life cycle of a production asset, considered as a set of the following stages:

stage "Design". At this stage, the development of detailed requirements for the production asset, technology of creation;

stage "Creation". It is the process of manufacturing, supplying and installing a production asset. The result of this stage is a production asset put into operation;

the "Operation" stage is the process of using a production asset for its intended purpose and maintaining it in a working condition with specified efficiency parameters through maintenance and repairs (hereinafter, MRO) and technical re-equipment and reconstruction (hereinafter, R&R). The main result of this stage is the intended use of the production asset with the specified operating parameters;

stage "Liquidation". The main result of this stage is the intended use of the production asset with the specified operating parameters.

Based on the provisions of the Technical Policy, internal corporate documents are developed and implemented, specifying the provisions, norms, requirements and recommendations of the Technical Policy in relation to the composition of the production asset, and regulating the procedure (rules) for organizing interaction in the field of maintenance and repair.

The implementation of the Technical Policy does not require additional funding; it is carried out within the framework of the agreed scenario conditions for the formation of business plans and investment programs, taking into account the approved consolidated price standards.

In the Technical Policy, terms and definitions are used in accordance with the legislation of the Russian Federation, departmental regulations and regulatory and technical documentation in the field of the electric power industry in accordance with Appendix 1.

The list of abbreviations accepted in the text of the document is given in Section 6 of the Technical Policy.

1. General provisions

1.1. Goals and main tasks of the unified technical policy in the power grid complex

The goals are:

• determination of the main technical directions and unification of technical and technological solutions that ensure an increase in reliability, efficiency and a decrease in the resource intensity of the operation of the power grid complex in the short and medium term, while ensuring adequate safety;

• transition of PJSC Rosseti to risk-oriented management based on the introduction of digital technologies and big data analysis;

• organization of implementation of advanced scientific developments and innovative solutions in the power grid complex.

Main goals:

• ensuring and increasing the readiness of electric grids for the transmission and distribution of electric energy to ensure a reliable supply of electric energy to consumers, the functioning of the wholesale and retail electric energy markets, the parallel operation of the UES of Russia and electric power systems of foreign countries;

• ensuring the delivery of capacity of facilities for the production of electrical energy to the grid;

• creation of conditions for connection to the electric grid of participants of the wholesale and retail markets on the basis of non-discriminatory access to electric grids;

• participation in improving the efficiency and development of systems for regime and emergency management of the UES of Russia;

• development and improvement of the structure of operational and technological management of power grid facilities;

• development and improvement of information and telecommunication infrastructure, increasing the observability of the electric network and the quality of information exchange with other subjects of the electric power industry;

• optimization and reduction of capital investments and operating costs and costs in power grid facilities by optimizing technical and technological solutions in the development of project documentation, the use of modern technologies and types of equipment, building structures and materials, reduction of the area occupied by power grid facilities;

• improving the efficiency of power grid assets management;

• increasing the energy efficiency of applied technologies, equipment, materials, systems and reducing technological losses of electrical energy in electrical networks;

• overcoming the tendency of aging of fixed assets of electric networks and electric grid equipment by means of their modernization, optimization of works on their reconstruction and technical re-equipment, as well as by increasing the efficiency of management of electric grid assets;

• development of automation of transmission and distribution of electrical energy, implementation and development of modern systems for monitoring the technical condition, diagnostics and monitoring of technological equipment, protection and automation systems, emergency automation, communication systems, engineering systems, commercial and technical metering of electricity, creation and development of digital substations and electrical networks;

• improving technologies and increasing the efficiency of operation, maintenance and repair of power grid facilities;

• provision, improvement and development of professional training of operating and maintenance personnel;

• minimization of environmental impact during new construction, reconstruction, operation, repair and maintenance of power grid facilities;

• ensuring safety during the operation of power grid facilities;

• formation of incentives for the development in the territory of the Russian Federation of the production of modern types of equipment, building structures, materials, as well as the development of scientific, technical and design potential.

• creation of conditions allowing to provide energy supply to consumers without creation / reconstruction of power grid assets.

Implementation of the goals and objectives of the Regulation of PJSC Rosseti "On a unified technical policy in the power grid complex" should not lead to an increase in investment and operating expenses of the company.

1.2. Structure and status of the Technical Policy

Management of a unified technical policy in the power grid complex.

1.2.1. Management of the Technical Policy of the Company is a systemic task and function of the Company, which on an ongoing basis ensures the fulfillment of the requirements of the technical policy in the Company and its subsidiaries and affiliates, control over compliance with the requirements of the Technical Policy in subsidiaries and affiliates, timely updating and revising the provisions of the Technical Policy.

1.2.2. The technical policy of the Company is approved by the Board of Directors of the Company.

The issue of approval of the Technical Policy of the Company is included in the agenda of the Board of Directors of the Company after the preliminary approval of the Technical Policy by the Technical Council of PJSC Rosseti.

1.3. Scope of the Technical Policy

The Technical Policy is a fundamental document, mandatory for use in the Company and mandatory for use in the activities of subsidiaries and dependent companies engaged in the transmission and distribution of electrical energy, provided that it is recognized as applicable (in whole or in part) by the management body of subsidiaries and dependent companies.

1.4. Formation and updating of the Technical Policy

1.4.1 The Technical Policy is subject to revision every five years.

1.4.2. Early revision, amendments and additions to the Technical Policy are carried out:

- in case of changes in the legislation of the Russian Federation that directly affect the provisions of the Technical Policy;
- in the event of new provisions and requirements of documents in the field of technical regulation, regulations of the Eurasian Economic Union (technical regulations of the Customs Union), directly affecting the provisions of the current Technical Policy;
- to ensure the achievement of the goals of the Company by decision of the management bodies of the Company.

2. Requirements for equipment, technologies and materials, complex systems

2.1. Substations and switchgears

2.1.1. Technical solutions for design, new construction and reconstruction of substations

2.1.1.1. When building a substation (TP, RP, RTP), it is necessary to be guided by the following basic principles:

- the construction structures of buildings and engineering structures of electrical substations, closed transformer substations, distribution substations and radio transformer substations must ensure the required reliability during the entire service life determined by the NTD or design documentation;
- during the construction of substations, standard solutions should, as a rule, be applied;
- at the stage of preparation of the PS as-built documentation and preparation of reporting documentation, it is necessary to prepare a layout in accordance with the rules for describing the objects of the information system used in the subsidiaries and dependent companies for the subsequent prompt introduction of changes in the architecture of the information system objects and the equipment database of subsidiaries
- building structures on which electrical equipment is installed must be

designed for electromagnetic, thermal and electrodynamic effects in normal and emergency modes of operation of the electrical network;

- reduction of substation areas by optimizing circuit-layout solutions, provided that the reliability and maintainability and safety of service are maintained;

- when choosing equipment and busbars according to the rated current, normal, repair, emergency and post-emergency modes of operation of the electrical network, as well as the overload capacity of the equipment, must be taken into account;

- KA and switchgear grounding disconnectors must be equipped with operational interlocking against incorrect actions during switching in electrical installations. When designing the operational blocking in the switchgear, software (logical) blocking in the connection controllers or controllers of the operational blocking by mechanical blocking in the switchgear must also be used;

- in cities with a high building density, with an appropriate feasibility study, it is allowed to build modular buried or underground substations.

2.1.1.2. The design of a closed-type substation with a voltage class of 35 kV must comply with the standards for technological design of alternating current substations with a higher voltage of 35-750 kV (latest edition).

2.1.1.3. Indoor switchgears (ZRU) of 35 kV and above with equipment in the design of a complete switchgear with air, combined or SF6 insulation (KRU / GIS) must be used in accordance with the technological design standards for alternating current substations with a higher voltage of 35-750 kV.

2.1.1.4. At 110-500 kV substations, it is possible to use gas-insulated conductors with an insulating medium based on SF6 gas with an appropriate feasibility study.

2.1.1.5. The use of hollow wires for busbarning is allowed during the reconstruction or expansion of existing power grid facilities.

2.1.1.6. Overpasses, galleries, collectors, cable channels should be used to lay 110-500 kV cables across the substation.

2.1.1.7. With new construction and reconstruction of substations, it should be possible to expand them in the future due to:

- increasing (auto) transformer capacity by replacing power T/AT with power T/AT of the next power (from a number of rated powers) or installing additional power T/AT (with appropriate justification);

- increasing the number of connections by reserving space.

The need for a possible expansion of the substation should be based on the approved schemes and programs for the development of the electric power industry for a period of 5, 7 and 15 years.

2.1.1.8. For heating substation buildings in the absence of a supply of thermal engineering communications, it is recommended to use fire-safe energy-saving electric heaters with thermostats.

2.1.1.9. At 110-500 kV substations, it is possible to use heat from power T/AT for heating industrial premises.

2.1.1.10. To supply the substation's own needs, including electric heating, it is possible to use modern solar energy technologies.

2.1.11. When constructing a substation within urban areas, it is advisable to place ventilation, air conditioning, solar panels and heaters (in areas with sufficient solar activity) on flat roofs if they are used.

2.1.1.12. To maintain the climatic conditions for the operation of the equipment in the premises of the buildings of the Central Substation and Substation 220 kV and above, it is recommended to use centralized climate control units.

2.1.1.13. The decision on the location of the reconstructed switchgears 110-750 kV substations should be made on the basis of a feasibility study. In the context of the development of settlements, as well as on the territory of industrial enterprises (or near them), the reconstruction of a 110-750 kV substation switchgear should be carried out, as a rule, at the same place.

2.1.1.14. When designing closed substations, transformers (AT, ShR) with a rated voltage of 110 kV and above should be installed in open areas, if necessary with an anti-noise barrier; installation of transformers (AT, ShR) in buildings is allowed with special justification and the development of comprehensive fire-prevention measures.

2.1.1.15. Lightweight prestressed reinforced concrete racks, solid blocks of heavy concrete, reinforced concrete piles, monolithic and screw piles should be used as foundations for equipment.

2.1.1.16. Monolithic and prefabricated, including surface and pile reinforced concrete (bored, including with and without broadening) foundations should be used as foundations for portals.

2.1.1.17. In new construction, integrated R&D T/AT at substations with stationary devices for repairing transformers (towers) and rolling rails, as well as at substations with transformers located in closed rooms, should be installed on carriages (rollers).

Earthquake-resistant transformers should be installed directly on the foundation with their fastening to the embedded elements of the foundation to prevent their displacement in the horizontal and vertical directions. Places for the installation of jacks must be provided on the foundations of the transformers.

In other cases, it is possible to use a railless (brushless) installation with the use of special stands to provide access to the bottom of the T/AT tank.

2.1.1.18. To minimize the production of earthworks, various types of prefabricated reinforced concrete and pile foundations should be used (prismatic reinforced concrete piles, screw piles, open profile piles, shell piles, bored and bored piles), shallow and surface foundations, thermal piles and screw piles in permafrost fillings in rocky soils, as well as highly efficient working drilling bodies for drilling holes in hard rocks and rocky soils.

2.1.1.19. In the construction of substation buildings (indoor switchgear, storage facilities, fire-extinguishing tank buildings, and others), it is preferable to use frame or modular structures of buildings with lining with sandwich panels. The use of bricks in the construction of large buildings is allowed with special justification, including safety requirements.

2.1.1.20. During the construction of SPZ or PSU buildings, along with the use of bricks, foam concrete and slag concrete blocks with external finishing of buildings with facing bricks, porcelain stoneware or a ventilated facade, hinged facing panels with corporate colors, it is allowed to use frame or modular structures of buildings with facing with sandwich panels, in particular in areas of permafrost.

2.1.1.21. It is recommended to use new high-performance materials for corrosion protection of building structures, corrosion-resistant steels of increased strength for the manufacture of metal structures of portals and support structures for equipment.

2.1.1.22. For wiring the cables of secondary systems in the premises of the control room and distribution center, it is preferable to use cable shafts and raised floors, cable floors are allowed during feasibility studies.

2.1.1.23. Production and utility tanks should be made of monolithic reinforced concrete with a waterproofing grade of at least W8 or from prefabricated concrete blocks with waterproofing by means of a steel jacket, use penetrating materials as external and internal waterproofing of tanks, overlap the tanks with prefabricated reinforced concrete with glued surface waterproofing.

2.1.1.24. Wastewater treatment plants can be built in a metal frame lined with sandwich panels. Treatment facilities in areas with an absolute minimum of temperatures below minus 45 ºC are recommended to be carried out in metal tanks with insulation made of sprayed polyurethane foam, waterproofing by means of a steel jacket, using electric heating of outdoor treatment facilities, drain pipes with automatic temperature control.

2.1.1.25. Water fire extinguishing tanks can be performed:

- buried to a depth below the level of soil freezing. Recessed tanks are made of monolithic reinforced concrete;
- ground, in tanks made of steel, composite or polymer materials.

2.1.1.26. Tanks in cisterns can be placed together with a fire extinguishing pumping station in a light frame building with heating and lining with sandwich panels or open. For open placement in areas with an absolute minimum of temperatures below minus 45 ºC, it is recommended to use a built-in electric heating system for fire-fighting water supply tanks with water level and temperature control, as well as transmitting information to the control station on duty.

2.1.1.27. At substations 110 kV and above, as a rule, a water supply and sewerage system should be provided.

2.1.1.28. Substation buildings must be equipped with heating, ventilation, fire alarms in accordance with the established requirements. The entrance external doors of all premises of the substation should be made of metal with internal locks. Glazing of buildings on the territory of the substation should be reduced to a minimum. If natural light is required, the windows on the first floor are equipped with grilles, which should be easily removed or opened from inside the room without the use of tools.

2.1.1.29. External networks of low-pressure drinking water supply systems should be provided with socket-type pressure pipes made of polyvinyl chloride (PVC) of the "T" type, complete with rubber rings. For areas with a cold climate, it is recommended to use a system of flexible polyethylene pipelines with polyurethane foam with a built-in electric heating system.

2.1.1.30. External networks of domestic sewerage should be provided from non-pressure PVC pipes, complete with sealing rings. For areas with a cold climate, it is recommended that external domestic sewage networks be made of pipes made of low-pressure polyethylene with a built-in electric heating system.

2.1.1.31. When installing oil receivers for oil-filled equipment, the method of pouring reinforced concrete with the use of polymer additives to improve the characteristics of concrete should be used.

The oil outlets must be closed. It is allowed to construct open oil outlets in highly heaving soils, at high levels of groundwater in accordance with the feasibility study.

2.1.1.32. At the substation with ASK, two separate stationary reservoirs for storing turbine oil should be provided, while the systems of turbine and transformer oil should be independent. The volume of each reservoir of turbine oil must be at least 110% of the volume of the oil system of the largest ASK installed at the substation.

2.1.1.33. Concrete surfaces should be painted with oil resistant paint to protect the surface from transformer oil.

2.1.1.34. It is recommended to consider the use of new effective materials for enclosing and roofing structures, floors and finishing of buildings.

2.1.1.35. The choice of a constructive floor solution must be carried out taking into account the provision of:

- reliability and durability of the adopted design;
- economical use of building materials;
- the fullest use of the physical and mechanical properties of the materials used;
- optimal sanitary and hygienic conditions;
- fire and explosion safety.

2.1.1.36. In office and industrial premises, depending on the functional purpose, floor coverings such as commercial linoleum, ceramic tiles, porcelain stoneware tiles should be used, as well as for premises with special requirements for dust formation (switchgear, halls of converting and microprocessor technology, protection and automation, etc. others) - self-leveling floors based on polyurethane or epoxy resins as the most durable and wear-resistant.

2.1.1.37. Self-leveling floors must meet the following requirements:

- insignificant abrasion;
- dust formation;
- chemical resistance;

- high speed of installation work (floors can be laid at positive and negative temperatures);

- ease of renovation and repair.

The basis for the self-leveling floor should be a concrete floor (concrete grade 200-300), made of acid-resistant and ceramic tiles, there should be no cracks and chips on the surface, the moisture content of the base is not more than 4-5%.

2.1.1.38. When repairing or reconstructing facades of substation buildings, in addition to the traditional use of facade paints, it is allowed to use the "ventilated facade" technology. Work is allowed to be carried out only after a comprehensive examination of the technical condition of building structures of buildings and structures by a specialized organization.

2.1.1.39. When designing a substation, it is necessary to carry out environmental measures in accordance with the current environmental legislation.

2.1.1.40. When designing a substation, it is necessary to combine design solutions into a single architectural and industrial complex, apply a single corporate style for decorating the facades of buildings of structures using elements of the approved corporate style (colors, emblems, etc.).

2.1.1.41. The master plan and layout solutions of the substation, as well as space-planning solutions of buildings and structures located on its territory, must provide:

- ease of use;

- the ability to carry out routine maintenance and repair work, including those related to the replacement of large-sized equipment;

- conditions for prompt elimination of accidents and emergencies.

2.1.1.42. For timely detection of faults in the building structures of KRU, ZRU, ZTP, facades are allowed to be repaired or reconstructed without covering the walls with frame facade materials.

2.1.1.43. To create favorable conditions for the operation of buildings and structures of the substation, it is necessary to control that, during the construction of new and reconstruction of old buildings, the planning and improvement of the territory, drainage systems for precipitation and groundwater are carried out in accordance with the project documentation and are subsequently maintained in good condition in accordance with the established requirements.

2.1.1.44. Facade parts of buildings and structures of closed substations, transformer substations, transformer substations and RTPs located in the residential area must fit into the surrounding architectural landscape.

2.1.1.45. When designing substations, buildings and structures, it is necessary to provide technical solutions that ensure the safety of their operation, including safe work at height by arranging stationary ladders using slider-type protective equipment as a safety system when climbing equipment, stationary anchor points (anchor pillars), either with the pre-installation of the anchor line and the use of retracting-type protective equipment, or with the use of telescopic anchor poles for work at substations of 35 kV and higher, where there is a risk of falling from a height of more than 1.8 m.

2.1.1.46. When designing closed substations, it is recommended to use technologies of three-dimensional models of equipment and laid engineering systems to exclude unacceptable approaches and intersections of technological equipment of the substation and laid cables with engineering systems in closed substations (ventilation, water supply, fire extinguishing, sewerage and others).

2.1.1.47. During the construction of buildings and structures of the substation, the roof structure must be pitched. During the construction of a substation within the boundaries of urban development, a flat roof is allowed.

2.1.1.48. When designing substations of 35 kV and higher, calculations should be carried out on the basis of the results of mathematical modeling of power systems operation modes using calculation models that ensure the required accuracy of the results of mathematical modeling of power systems modes developed in accordance with the Methodological Guidelines for the Design of Power Systems Development (Order of the Ministry of Energy of Russia dated June 30, 2003 city No. 281). Mathematical modeling of the power system operating modes for the development of design solutions should be carried out in accordance with the design conditions established by the Methodological Guidelines for the Stability of Power Systems (Order of the Ministry of Energy of Russia dated August 3, 2018 No. 630).

For the purposes of forming the specified calculation models, the design organization forms an information model of the power system in the amount necessary for the design of the substation, in compliance with the requirements approved by the Ministry of Energy of Russia in accordance with the Decree of the Government of the Russian Federation of March 2, 2017 No. 244 "On improving the requirements for ensuring the reliability and safety of electric power systems and electric power facilities and amendments to some acts of the Government of the Russian Federation ”.

Based on the results of the development of design solutions, the design organization transmits information about changes in the information model of the power system associated with the commissioning (decommissioning) of the substation, taken into account in the design, to the customer, and in relation to substations, the equipment or devices of which or outgoing from which power lines will belong (refer) to dispatching objects, - also to the subject of operational dispatch control in the electric power industry in accordance with the information exchange profile agreed with him.

2.1.2. Electrical schematic diagrams of switchgear substations

2.1.2.1. When designing a substation, it is necessary to individually approach the choice of the RP scheme, the composition of the components of the combined switch in order to ensure ease of operation, maintainability of the scheme, exclude the possibility of erroneous actions during operation, fit into the designated construction site and at the same time incur minimal costs in comparison with other possible options construction (reconstruction) of substations by conducting their technical and economic comparison.

When designing a substation, it is necessary to generally be guided by the requirements of the technological design standards for alternating current substations with a higher voltage of 35-750 kV.

2.1.2.2. Electrical schematic diagrams of the RU Substation must provide:

- reliability of functioning in the normal and repair scheme of a specific substation and the adjacent electrical network, taking into account redundancy from other CPUs;
- Convenience in carrying out operational switching, which consists in the simplicity and clarity of the diagrams that reduce the likelihood of erroneous actions of the operating personnel, minimizing the number of switchings in the primary and secondary circuits when changing the operating mode of the electrical installation;
- compactness;
- technically sound efficiency.

2.1.2.3. The electrical schematic diagrams of the substation switchgear should be typical, while, as a rule:

- for 0.4 kV switchgear transformer substations 6-20 / 0.4 kV and 35 / 0.4 kV substations, one working bus system is accepted, with or without automatic transfer switch, depending on the category of connected consumers;
- for switchgear 6-20 kV, depending on the reliability and redundancy of the network, diagrams and circuit solutions should be used:
  • one bus system sectioned by a circuit breaker;
  • two busbar systems sectioned by switches;
  • on the side of low voltage 6-20 kV transformer windings, their separate operation should be provided for different sections of busbars of switchgear 6-20 kV;
  • the choice of the number of outgoing line cells for new construction of 10-20 kV switchgear and reconstruction of 6-20 kV switchgear should be carried out in accordance with the current applications and contracts for grid connection of power receivers of consumers of electrical energy, facilities for the production of electrical energy, as well as facilities farms belonging to grid organizations and other persons for the billing period (the year of commissioning), taking into account the prospects for its development (5 years after commissioning);
- electrical circuits of RU 35, 110 (150) kV should be selected in accordance with the requirements of the standard “Circuit diagrams of electrical switchgears of 35-750 kV substations. Typical solutions "(STO 56947007-29.240.30.010-2008), while:
  • deviations from standard schemes are allowed in the feasibility study;
  • as a rule, schemes with one switch per connection should be used (if there are appropriate justifications, it is allowed to provide for the presence of two bus systems or a bypass bus system with the possibility of transferring the most critical or all connections to it by making operational switching);
  • it is allowed to use bypass bus systems in outdoor switchgear of 35-110 kV,

from which ice melting on wires and lightning protection cables of outgoing overhead lines is carried out;

• when constructing a switchgear in a GIS design, it is recommended to use simpler schemes that provide, among other things, optimization of the arrangement of the switchgear busbars;

• in the schemes for connecting overhead lines through two switches, it is allowed to install TT in the overhead line circuit for the purposes of commercial metering of electricity;

• the number of transformers installed at substations 35, 110 (150) kV is assumed to be two. Installation of more than two transformers is allowed on the basis of a feasibility study;

• commissioning and operation of a substation with one transformer is allowed if there is a construction stage in the design documentation - the start-up phase;

• it is allowed to use one transformer at dead-end substations while ensuring the required reliability of power supply to consumers;

- electrical circuits of switchgear 220 kV and above should be selected in accordance with the requirements of the standard “Schemes of electrical distribution devices for substations with a voltage of 35-750 kV. Typical solutions "(STO 56947007-29.240.30.010-2008), while:

• deviations from standard schemes are allowed in the feasibility study;

• when constructing a switchgear in a GIS design, as a rule, the same schemes are used as for an open switchgear;

• for switchgear 330-750 kV, as a rule, circuits with power line switching by two switches or with switching connections through one and a half chains should be used;

• for switchgear 220 kV, as a rule, schemes with one switch per connection should be used. It is allowed, in the presence of appropriate justifications, to provide for the presence of two bus systems or a bypass bus system with the possibility of transferring the most critical or all connections to it by making operational switching and the use of circuits with power transmission lines switching through one and a half chains;

• it is allowed to use bypass bus systems in 220 kV outdoor switchgear, from which ice melting is carried out on wires and lightning protection cables of outgoing overhead lines;

• the choice of the number and capacity of T / AT 220 kV and below, as well as transformers for auxiliary needs, must be carried out taking into account their overload capacity;

• at the UNEG substation (voltage 220-1150 kV), it is recommended to supply power to third-party 6-35 kV consumers from separate 110 or 220 kV transformers;

• Tertiary windings T / AT 220-500 kV should be made for a rated voltage of 20-35 kV in order to minimize the volume of the main equipment, reduce the values of short-circuit currents and increase the reliability of power supply for the substation's auxiliary needs, provided that it is possible to connect to electric networks of this voltage class.

2.1.2.4. If it is necessary to compensate for capacitive currents on the 6-35 kV side at the substation, the electrical circuits should provide for the installation of arc suppression grounding reactors, while:

- in 35 kV networks, the DGR should be connected to the zero terminals of the corresponding transformer windings through a fork from the disconnectors, which allows them to be connected to any of the transformers;
- in 6-20 kV networks, DGR, as a rule, must be connected through disconnectors to the neutral terminals of individual transformers connected to the busbars through switches. It is allowed to use grounding filters instead of separate transformers. It is also allowed to use combined arc suppression devices such as ADSK, RDSK and others;
- the number, power and range of regulation of the GDR are determined by the design documentation based on the results of technical and economic calculations performed on the basis of the data provided by the customer
- the degree of detuning of the compensation of the capacitive current of a single-phase earth fault should not exceed 1% in accordance with the standard "Reactors grounding arc suppression 6-35 kV. General technical requirements "(STO 34.01-3.2-008-2017).

2.1.2.5. In electrical circuits, the choice of the neutral grounding mode for electrical networks with a voltage of 6-35 kV should be determined by the design solution, based on ensuring reliable and safe operation of electrical equipment and power lines in modes associated with the closure of one of the phases of the electrical network to ground, while:

- in urban distribution networks of 6-20 kV, as well as within residential areas of 35 kV electrical networks, it is possible to use a low-resistance resistive neutral grounding with automatic disconnection of earth faults and 100% redundancy of consumers in the presence of a feasibility study;
- when introducing resistive grounding during the reconstruction of existing electrical networks with a voltage of 6-35 kV, it is necessary to coordinate with existing consumers;
- in electrical networks with an isolated neutral, depending on the length and design of the transmission line, conditions for ensuring electrical safety and reliability of power supply, the need to install arc suppression devices or the use of high-resistance resistive or combined neutral grounding should be considered;
- in order to limit the capacitive current of the OZZ, it is necessary to provide galvanic isolation of the sections of the distribution network based on the maximum permissible currents of the OZZ, determined taking into account the neutral grounding mode used on the section of the electrical network.

2.1.3. Power transformers, autotransformers and reactors

2.1.3.1. Power transformers, autotransformers (AT), transformers (T) and reactors (CSR, SHR) must meet the following general requirements:

- the construction should use transposed wire windings with gluing and a pressing system made of electric cardboard with the possible use of appropriate wood-laminated plastics that are not subject to shrinkage, allowing not to pre-press the windings throughout their entire service life;
- in the manufacture of power T/AT and reactors, the original winding paper of windings with a degree of polymerization of at least 1250 units should be used;
- the design should use magnetic cores with reduced losses due to: the use of high-quality electrical steel with a specific loss level of 1.0 W / kg at an induction of 1.5 T, the use of steel 0.23-0.3 mm thick, assembly of magnetic cores using technology with oblique joint "Step Lap";
- the structure must have at least two built-in CTs, in addition, one CT is recommended for monitoring purposes. The number of built-in current transformers and the power of their secondary windings is determined during design;
- oil pumps of direct flow type should be used;
- the necessary electrodynamic resistance of the windings to short-circuit currents must be ensured;
- the following control modes for combined cooling systems M / D and M / D / DC should be applied: manual, automatic;
- the functions of the cooling control system should include:
  • control of the cooling system in terms of load capacity and monitoring the state of each electric motor of the cooling system separately;
  • possibility of smooth start-up and reduction of starting currents;
  • protection of electric motors against overload and short circuit;
  • protection of electric motors of coolers against phase loss and phase asymmetry;
  • indication of the load of electric motors;
  • detection of an unloaded motor or operating with an increased load torque;
- the design of cooling devices (radiators) must be plate (flat-stamped radiators, hot-dip galvanized);
- AT should preferably be used with a rated voltage of the LV winding, usually 20-38.5 kV, in order to reduce the values of short-circuit currents;
- AT with reduced power of the LV winding should preferably be used (except for the cases when reactive power compensation devices are connected to it);
- tertiary windings T/AT, from which the power supply of 6-35 kV consumers is carried out, must have a circuit and a connection group corresponding to those adopted in supplied distribution networks;
- a reduced level of noise and vibration must be ensured:
  • noise level - no more than 75 dB (for CSR - no more than 90 dB);
  • vibration level for SR - no more than 60 microns;
- the level of radio interference should be no more than 2500 μV;
- explosion safety must be ensured due to the design of the transformer tanks, the use of systems for preventing depressurization of the case in case of internal

damage (valves, and, if justified, systems for preventing explosions and fires).

2.1.3.2. In oil-filled T/AT voltage classes 110 and 150 kV with a capacity of 25 MBA and more and all transformers of voltage classes 220 kV and above, the oil must be completely protected from contact with the ambient air by means of a film protection.

For transformers with a voltage of 110 kV with a capacity of less than 25 MVA and transformers with a voltage of less than 110 kV, the expander must be equipped with an air dryer with an oil seal or other device to protect the oil in the expander from direct contact with the ambient air.

2.1.3.3. Oil transformers with an oil mass of over 1000 kg should be equipped with filters: thermosyphon - for types of cooling systems M and D, adsorption - for other types of cooling systems and filters for cleaning oil from mechanical impurities - for types of cooling systems DC, NDC, Ts, NTs.

2.1.3.4. 110 kV high-voltage bushings installed on transformers must be with solid (RIP or RIN) insulation, 220-750 kV high-voltage bushings - hermetically sealed capacitor without overpressure and without an expansion tank or with solid insulation (RIP or RIN insulation for voltage class up to 500 kV inclusive), with the obligatory presence of a measuring output at the inputs of 110 kV and above.

High-voltage bushings with RIP and RIN insulation from 110 kV and above must be equipped with sensors for safe connection of bushing insulation monitoring systems.

2.1.3.5. Power T/AT 110 kV and above must be equipped with:

- on-load tap-changers complete with a voltage regulator with the ability to operate in automatic and manual remote mode from a remote control point;
- sensors and state control (monitoring) devices in accordance with the requirements of subsection 3.7.2 of the Technical Policy, as well as the output of relay signals for technological protections of cooling systems, on-load tap-changers, relay signals for power supply of transformer protections, etc.

2.1.3.6. Power transformers 35 kV and below should generally be equipped with a no-load voltage regulator (off-load voltage regulator). The number of steps and the adjustment range are determined during design.

2.1.3.7. Automatic control cabinets for transformer cooling must be galvanized or made of stainless materials (the degree of protection is not lower than IP55 in accordance with GOST 14254-15), to ensure automatic maintenance of the temperature inside the cabinet; access control to the cabinet with alarm, manual control of each of the installed oil pumps and blower fans, smooth start-up and current protection of electric motors of oil pumps and fans, monitoring of the state (serviceability) of the switch that control the motors, the presence of a remote control panel (installed in the control room) should be provided for operational control and visualization of the state of the cooling system.

2.1.3.8. Reliability requirements:

- service life - at least 30 years;
- warranty period of operation - at least 5 years from the date of

commissioning;

- no need for major repairs during the service life;
- no need for pre-pressing the windings during the service life;
- resistance to railway transportation (mandatory presence of an acceleration sensor).

2.1.3.9. At distribution transformer substations 6-35 / 0.4 kV, power transformers should be used:

- oil-filled, sealed oil-filled, dry with reduced losses (including due to the use of amorphous steel magnetic circuits in transformers) and weight and size parameters, as well as special designs of transformers with a capacity of up to 100 kVA, intended for installation on overhead transmission line supports;
- with balancing devices;
- with a connection diagram of windings Δ / Yn or Y / Zn (it is allowed to use a connection diagram of windings of power transformers Y / Yn if there is an appropriate justification, for example, replacing a failed transformer with a two-transformer TP).

2.1.3.10. In TP, RTP, RP built into buildings, as well as constructed in dense urban areas or in cramped conditions, as a rule, small dry transformers with a reduced noise and vibration level should be used:

- with a system of automatic control of the temperature of the transformer;
- with temperature sensors inside the transformer chamber.

2.1.3.11. To increase explosion and fire safety, power transformers can be filled with non-combustible insulating liquids in accordance with the requirements of IEC 61099 "Specifications for unusual synthetic organic essential oils for electrical purposes".

The use of gas-insulated power T/AT must have a feasibility study.

2.1.3.12. Regulating transformers are allowed to be installed:

- if there is an appropriate justification - for AT 500-750 kV to regulate active power flows;
- at substations 35-220 kV with transformer equipment equipped with off-circuit tap-changers, where voltage regulation does not meet the initial requirements when using off-circuit tap-changers in accordance with the Standards for technological design of 35-750 kV substations.

2.1.3.13. Linear VDTs may be used to adapt distribution electrical networks with a voltage of 0.4-20 kV to a change (increase) in electrical loads and to ensure the required quality of electrical energy, based on a feasibility study in comparison with other options for ensuring the quality of electrical energy.

The place of installation of RCCB can be points of critical voltage drop (more than 10% of the nominal voltage value) of power lines or directly the consumer bus.

2.1.3.14. RCCB voltage regulation should be carried out in automatic mode.

2.1.3.15. When changing the direction of power (when switching to a backup power source), the RCCB should not change the operating mode in relation to the direction of the power flow.

2.1.3.16. The voltage regulation level when using RCCB should be:

- on 6-20 kV power transmission lines, which do not provide the quality of electrical energy at consumers, with voltage regulation ± 10%;

- on 6-20 kV power transmission lines in order to increase the transmission capacity of the lines, with voltage regulation + 10%;

- at substations 35-110 kV, equipped with off-circuit breakers, where voltage regulation does not meet regulatory requirements, with voltage regulation ± 15%;

- at distribution substations and substations with a voltage of 6-20 kV, with voltage regulation ± 15%.

2.1.3.17. In electrical networks of 6-35 kV, dry current-limiting reactors with low power losses and sufficient electrodynamic resistance to short-circuit currents should be used. Reactors of a similar type should be used for installation at 6-20 kV bushings of power transformers or at outgoing line connections.

2.1.3.18 To compensate for capacitive ground fault currents and reduce overvoltages in case of single-phase arc faults to ground in 6-35 kV networks, it is recommended to use continuously adjustable GDRs with an automatic tuning regulator. In the cramped conditions of a closed-type substation, arc suppression units (DGR and transformers for their connection in one case, made on a single magnetic circuit) should be used, including dry versions.

2.1.4. Switching devices

2.1.4.1. In electrical networks of 110 kV and above, the following should be used as a switch:

- gas-insulated core and tank circuit breakers explosion-proof with pressure relief valves, mainly with spring drives;

- with the development of technologies, it is also allowed to use vacuum circuit breakers, as well as circuit breakers - disconnectors (combined modular devices) in 110-220 kV networks;

- in the circuit (U) of SHR and capacitor banks - switches intended for switching the current of the reactor and capacitor banks, respectively;

- SF6 circuit breakers, when the pressure of SF6 gas in the casing drops, does not require automatic shutdown. In this case, a two-stage warning / alarm signaling of a decrease in the pressure (density) of SF6 gas in high-voltage SF6 circuit breakers should be performed (when the second stage of this alarm is triggered, an automatic electrical blocking of the circuit breaker control is performed, which prohibits the opening and closing of the circuit breaker);

- disconnectors 110 kV and higher of pantograph, semi-pantograph and horizontal - rotary type equipped with electric motor drives, including for grounding knives, high-strength porcelain or polymer support insulators, switching devices for the implementation of electromagnetic blocking schemes.

2.1.4.2. Technical measures should be developed to eliminate the risks of damage to SF6 circuit breakers with unacceptable values of the aperiodic component during switching of power lines equipped with inductive means of lateral compensation.

2.1.4.3. In the circuit (U) SHR, with an appropriate justification, switches with UPNKP (device for deliberate non-simultaneous pole switching) are used.

2.1.4.4. It is recommended to use column-type SF6 circuit breakers 110-750 kV with longitudinal insulation corresponding to at least II * degree of pollution (2.25 cm / kV).

2.1.4.5. In electrical networks with a voltage of 6-35 kV, the following should be used:

- SF6 circuit breakers on connections with high currents or in confined conditions, as well as, if necessary, to ensure the permissible level of switching overvoltages with appropriate justification;
- indoor vacuum switches;
- outdoor vacuum switches, including reclosers, on overhead lines;
- vacuum load break switches for outdoor installation on overhead lines;
- indoor vacuum load break switches;
- fuses - disconnectors up to 20 kV.

2.1.4.6. In distribution networks with a voltage of 6-20 kV, it is additionally recommended to use fuses - disconnectors and disconnectors that meet modern operating requirements, if necessary, with the possibility of remote control.

2.1.4.7. The choice of switch types should be determined taking into account the following:

- switches must ensure operability in the entire required range of ambient temperatures;
- in the circuit of ShR, CSR and BSK, switches designed for switching the current of ShR and BSK, respectively, must be used;
- the breaking capacity of the circuit breakers must be performed on the basis of the calculations of the short-circuit currents for the billing period, in accordance with subsection 3.1.3 of the Technical Policy;
- circuit breakers must ensure disconnection of power lines equipped with inductive means of lateral compensation. In this case, measures must be provided to exclude the occurrence of an unacceptable value of the aperiodic component when the short-circuit currents arising in the electrical network are disconnected.

When choosing a switch, a reasonable minimization of the volume of their maintenance should also be presented.

2.1.4.8. Switches 330 kV and above must have phase-wise drives. On circuit breakers 110-220 kV, the need to install a phase-by-phase drive must be technically and economically justified.

2.1.4.9. Reliability requirements:

- service life - at least 30 years;
- warranty period of operation - at least 5 years from the date of commissioning;
- The switch should not require major repairs during the service life or until the exhaustion of the switching resource;

- mechanical life for spring drives - at least 10,000 off / on cycles, and at least 30,000 off / on cycles - for electromagnetic drives.

2.1.5. Complete switchgears

2.1.5.1. Requirements for GIS:

- all GIS modules must be low-maintenance;
- GIS must be completed with continuous monitoring automated control systems in accordance with subsection 3.7.2 of the Technical Policy;
- the design of the switchgear should provide for the withdrawal of any gas volume for repair without a complete shutdown of the switchgear, except for single-transformer substations, organized according to the 3H scheme;
- the design of the switchgear should ensure the possibility of joining the cells (perspective expansion of the switchgear circuit) with a minimum repayment of the existing connections;
- to connect connections to 110-500 kV switchgear cubicles, cables of the appropriate voltage class with XLPE insulation or, with appropriate justification, gas-insulated conductors must be used;
- GIS must provide nominal parameters at a lower ambient air temperature of minus 5 ºC, SF6 conductors for outdoor installation at a lower ambient air temperature of minus 45 ºC for substations located in a temperate climate zone, and minus 60 ºC for substations located in cold climate zone, taking into account the cooling effect of the wind;
- in the design of gas-insulated conductors, compensating devices must be provided within the boundaries of the temperature difference and in the boundary between the foundations of the GIS building and the outer supports of the conductors with expansion joints;
- the design of the switchgear should provide for the ability of service personnel to access each switch.

2.1.5.2. When assembling the GIS in the indoor switchgear, maintenance sites should be provided at different levels, while for the safe maintenance of gas-insulated equipment, 110 kV switchgears should be completed with mobile service platforms for factory production, 220 kV and higher GIS with stationary service platforms.

2.1.5.3. In the GIS room, cable rooms under the GIS rooms, rooms for storing SF6 gas cylinders, forced supply and exhaust ventilation must be performed. Ventilation must ensure air exchange in the GIS room, rooms for storing SF6 gas cylinders and air intake from cable rooms and cable ducts.

2.1.5.4. In the halls of the switchgear, a system should be provided to prevent the ingress of SF6 gas (gaseous and solid products of SF6 decomposition) into the atmosphere, above the permissible limits in case of emergency emissions with depressurization of the switchgear volumes.

2.1.5.5. Cable glands in switchgear / switchgear must exclude flooding of the cable room with groundwater.

2.1.5.6. Requirements for combined switch combining the functions of a switch, disconnector (s), earthing switches (GIS) must be similar to the requirements for GIS. KRUEN must provide nominal parameters at a lower ambient temperature value of up to minus 45 ºC for substations located in a temperate climate zone, and minus 60 ºC for substations located in a cold climate zone, taking into account the cooling effect of the wind.

2.1.5.7. Requirements for switchgear (E) 6-35 kV:

- to use 6-35 kV switchgear with air, including combined, insulation, with an appropriate feasibility study - with SF6 insulation, as well as KSO (E) with vacuum switches or load break switches, including in the "monoblock" version;
- to use metal protective shutters of the cells;
- use in switchgear TT with cast insulation, VT of antiresonant design in electrical networks, where the occurrence of the phenomenon of ferroresonance is possible;
- must be equipped with high-speed protection against arc faults;
- use cells with insulated compartments;
- it is recommended to use 6-20 kV switchgear (E) with the upper arrangement of the busbars, with two-way service;
- it is recommended to use KRU (E) cells with a motor drive with the possibility of remote disconnection of the circuit breaker;
- for the organization of energy metering, it is recommended to install TT in each phase.

2.1.5.8. In urban electrical networks with a voltage of 10-20 kV, it is recommended to use switchgear (E) with modular cells in a metal case (cells should be low-maintenance or, if possible, do not require maintenance during their service life).

2.1.5.9. The use of KRUV must have a feasibility study and meet the requirements for GIS.

2.1.5.10. Reliability requirements:

- service life - at least 30 years;
- warranty period - at least 5 years from the date of commissioning;
- KRU (E) should not require major repairs during the service life or until the exhaustion of the switching resource;
- climatic modification and category of placement according to GOST 15150.

2.1.5.11. Transformer substation and distribution substation 6-35 kV must comply with the following requirement:

2.1.5.12. complete block or modular TP, RP, RTP, factory equipped with the necessary digital interfaces for integration into the network infrastructure, should be used.

2.1.5.13. Requirements for the organization of the work of operational and field and repair teams: the activities of operational and field and repair teams should be organized using software and hardware systems that provide automation and digitalization of planning, execution and control of work at power grid facilities

(PTC).

2.1.5.14. The software and hardware complex must ensure the implementation of the following functions:

- monitoring and regulation of work in the required locations (both outside and inside the premises) by employees with appropriate permissions;
- monitoring the use of protective equipment, devices, tools, protective signs, etc. when performing work;
- preventing workers from entering the territory where there is a threat to life, leaving workers outside the territory of the designated work area;
- monitoring, warning, blocking of cases of work in an unidentified place, on equipment without removing the voltage;
- informing the superior operational and operational-repair personnel (including the foremen of the brigades) about any deviations from the regulated rules;
- video-audio recording of work.

2.1.6. Outdoor switchgears

2.1.6.1. General requirements:

- open switchgears (OSG), as a rule, can be used for voltage class from 35 kV and above;
- as a rule, flexible busbars should be used at the outdoor switchgear;
- switchgear and measuring transformers that do not contain transformer oil should be mainly used at the outdoor switchgear;
- the switchyard must be provided with a passage for mobile mechanisms and devices, as well as for trucks and mobile laboratories.

Protection against direct lightning strikes is not required for 35 kV substations with transformers with a unit capacity of 1.6 MVA or less, regardless of the number of such transformers and the number of thunderstorm hours per year, as well as for all 35 kV outdoor switchgears in areas with the number of thunderstorm hours per year no more than 20, at 220 kV outdoor switchgear and below on sites with an equivalent earth resistivity in a thunderstorm season no more than 2000 Ohm with no more than 20 thunderstorm hours per year;

- the territory of the SS switchyard must be fenced off. The fence should be solid or with a visible height of at least 2.5 m. The territory of outdoor switchgear and substation in urban electrical networks should, as a rule, be continuous.

Requirements for the execution of solid and visible fences must comply with the requirements of the standards "Distribution electrical networks with a voltage of 0.4-110 kV. Requirements for technological design "(STO 34.01-21.1-001-2017)," Typical technical solutions for 6-110 kV substations "(STO 34.01-3.1-002-2016)," Standards for technological design of alternating current substations with higher voltage 35-750 kV (STO 56947007-29.240.10.248-2017):

- the location and power of the outdoor lighting installations of the outdoor switchgear should provide a standardized level of illumination at night and in conditions of poor visibility in open areas of the outdoor switchgear area where traffic and people are moving, and on the working surfaces of electrical equipment. Lighting installations must be made using energy-saving lamps;

- on the territory of the outdoor switchgear, it is necessary to provide for measures to prevent the germination of tree and shrub vegetation (asphalting, laying geotextiles, needle-punched cloths or materials similar in properties) with further laying on top of crushed stone, etc.);
- on the territory of the outdoor switchgear, provide for the protection of the metal portal structures of the outdoor switchgear from bird nesting;
- connections of flexible wires in spans should be performed by crimping using connecting clamps, and connections in loops at supports, connecting branches in a span and connecting to hardware clamps - by crimping or welding. The connection of branches in the span should be carried out without cutting the wires;
- branches from the OSG busbars, as a rule, should be located below the busbars;
- the pulling of descents to the switchgear devices should not cause unacceptable mechanical stresses and unacceptable convergence of wires;
- the suspension of HF traps and stubs should be carried out using technical solutions that exclude their clashing.

2.1.6.2. It is allowed not to fence transformers and devices in which the lower edge of the porcelain (polymer material) of the insulators is located above the level of the planning or ground communication facilities at a height of at least 2.5 m. regulated by safety standards. Instead of permanent fences, it is allowed to install visors to prevent maintenance personnel from touching insulation and live equipment elements.

2.1.6.3. Suspension of a busbar with one span over two or more T/AT cells is not allowed.

The layout of the equipment and the location of the outdoor switchgear 330 kV and above must ensure the least influence of electromagnetic fields on the personnel servicing the equipment of the substation, taking into account the requirements of SanPiN 2.2.4.3359-16.

2.1.6.4. In order to reduce the occupied space and optimize the layout solutions, it is allowed to use rigid busbars on the outdoor switchgear, both non-insulated and protected.

2.1.6.5. At 110-500 kV outdoor switchgear, it is allowed to use gas-insulated conductors with an insulating medium based on SF6 gas with an appropriate feasibility study.

2.1.6.6. When reconstructing or expanding existing power grid facilities, it is allowed to use hollow wires to perform busbar.

2.1.6.7. When constructing outdoor switchgear in areas with an aggressive environment, a flexible or rigid busbar with an anti-corrosion coating must be used.

2.1.7. Transformer and distribution substations 6-35 kV

2.1.7.1. For power supply to consumers in distribution electrical networks, small-sized complete transformer substations of full factory readiness should be used.

2.1.7.2. Structurally, transformer substations 6 - 35 / 0.4 kV are performed:

- freestanding;
- built into buildings.

2.1.7.3. Built-in TP should be located on the first or basement floor of the building and have exits directly to the street. If such an arrangement of the transformer substation is impossible, it should be possible to install the heaviest equipment, primarily power transformers.

2.1.7.4. For consumers who do not allow interruptions in the power supply for more than one hour, two-transformer substations should be used.

2.1.7.5. Power transformers with oil and dry insulation can be used in 6-20 kV transformer substations, while in built-in transformer substations - only with dry insulation.

2.1.7.6. The TS equipment (including bushings) must be protected against overvoltage both on the HV side and on the LV side. The neutral of the transformer must be grounded on the LV side.

2.1.7.7. In urban cable networks for the power supply of a special group of the first category of consumers, such as residential neighborhoods, shopping centers, industrial complexes and others, it is recommended to install equipment equipped with a switch with motor drives and an ATS circuit on the high side in TP and RP.

2.1.7.8. In order to reduce the building area of TP and RP in urban electrical networks, as a rule, protection and automation cabinets built into the cells should be used.

2.1.7.9. Switchgear 6-35 kV with air, including combined insulation (air with insulated busbars) should be used as a switchgear in a transformer substation and distribution substation.

It is allowed, in justified cases, to use prefabricated chambers of one-sided service, gas-insulated switchgear and vacuum switches or load break switches, including in the "monoblock" version.

2.1.7.10. In block-complete transformer substations with a voltage of 6-20 / 0.4 kV with transformers with a capacity of up to 630 kVA, it is recommended to use an insulated rigid or insulated flexible busbar.

2.1.7.11. In distribution networks with a transformer capacity of 1000 kVA or more, closed or insulated (three-phase and single-phase) current conductors should be used on the 0.4 kV side. It is allowed to use flexible busbars for justification.

2.1.7.12. It is recommended to use 0.4-20 kV switchgears with built-in systems for automated control of heating of contact connections, taking into account the following conditions:

- no need for maintenance of the system during the entire service life;
- wireless transmission of the heating signal from the measurement object

(contact connection) to the analyzing device (sensor);

- absence of galvanic batteries for sensors or signal readers;
- the absence of system elements that have risks of influencing the reliability of the protected electrical equipment;
- the minimum cost of the system, insignificantly affecting the final total cost of the 0.4-20 kV switchgear as a whole (positive feasibility study).

2.1.8. Mobile and modular substations

2.1.8.1. Modular substations with a voltage of 6-220 kV are designed to solve the following tasks:

- during the construction of a new substation until commissioning;
- for electricity consumers located in densely built-up areas, remote areas, aggressive external environment;
- for electricity consumers located in places where the construction of stationary substations is economically ineffective.

2.1.8.2. Mobile substations with a voltage of 6-220 kV are designed to solve the following tasks:

- during the repair and reconstruction of the existing substation;
- during the construction of a new substation until commissioning;
- to unload networks during peak loads;
- if necessary, prompt provision of power supply to new facilities;
- for electricity consumers located in places where the construction of stationary substations is economically ineffective;
- when carrying out emergency recovery work in electrical networks.

2.1.8.3. A mobile or modular substation must have the basic parameters (weight, size) that allow the delivery of an assembled substation or its modules by all modes of transport, as well as quick installation and commissioning of the substation at the facility.

2.1.8.4. The combination of various PS modules makes it possible to create maintenance-free substations with the provision of remote control of the substation, including monitoring the visible ruptures of the disconnector blades and the position of the earthing switches.

2.1.8.5. Modular substations have the following advantages:

- mobility, ease of transportation;
- ease of installation, operation;
- efficiency (installation up to two months for 110 kV substation);
- the possibility of increasing the cells of the substation according to the block principle;
- remote monitoring and remote control in the dispatching system;
- lack of open live parts;
- detachable cable connection;
- the ability to connect to both cable lines and overhead lines.

2.1.8.6. Mobile PS have the following advantages:

- mobility;

- efficiency (commissioning time after delivery to the prepared site is minimal).

2.1.8.7. To carry out emergency recovery work in 6-20 kV electrical networks for the organization of temporary power supply to consumers, autonomous backup power supply sources (DPP) with mobile step-up transformer points can be used".

2.1.9. Instrument transformers

2.1.9.1. General requirements for instrument transformers:

- measuring transformers should be used electromagnetic (TT, VT) or capacitive (VT) types;

- according to the types of insulating medium, gas (with SF6 or nitrogen filling) or oil-filled sealed CTs should be used. In the case of using oil-filled TT and HP, use TT and HP with a reduced oil volume;

- to use capacitive VTs of 110 kV and above;

- apply electromagnetic VT 6-35 kV;

- electronic (optoelectronic and other types) measuring transformers can be used with appropriate justification;

- VTs must be antiresonant;

- use CTs that ensure the correct operation of relay protection and automation devices in case of short circuits in the network, including when an aperiodic current component occurs;

- to use TT and VT, providing increased reliability, explosion and fire safety;

- use capacitive dividers with a reduced value of the temperature coefficient of capacitance;

- use TT and VT with cast corrosion-resistant housings;

- to use, when justifying, combined current and voltage transformers for installation in cells of 110-750 kV overhead lines in order to compact the switchgear;

- instrument transformers must have a separate winding for electricity metering purposes.

2.1.9.2. For networks of 110 kV and above, including in GIS, it is allowed to use electromagnetic VTs with an appropriate design justification for installation at expansion and reconstruction facilities with a significant secondary load.

2.1.9.3. Instrument transformers in electrical networks of 35 kV and above must have the following winding accuracy classes:

- not worse than 0.2S for TT and 0.2 for VT for new construction, reconstruction or modernization of metering points for connections of 110 kV and above the facilities of grid enterprises;

- TT for consumers with a connected capacity of 100 MW and above, as well as TT 220 kV and above for the purposes of electricity metering (including AIIS KUE) not worse than 0.2S, for the purposes of APCS and measurements - not worse than 0.2;

- TT for consumers with a connected capacity of less than 100 MW for the purposes of electricity metering - not worse than 0.5S, for the purposes of APCS and measurements - not worse than 0.5;

- TN 220 kV and above for the purposes of electricity metering (including AIIS KUE), APCS and measurements no worse than 0.2;
- TN 35-110 kV for the purposes of electricity metering (including AIIS KUE), APCS and measurements not worse than 0.2 (in the presence of connections with a connected capacity of 100 MW and more, taking into account the prospects of load growth), for other VTs for purposes electricity metering (including AIIS KUE), APCS and measurements - no worse than 0.5:
- CTs of the zero sequence for the functions of relay protection and transmission of the TC about the values of the current of the zero sequence must have an accuracy class of at least 1.0 when operating with a load in the secondary circuit up to 3 Ohm.

2.1.9.4. Accuracy classes of CT and VT windings for relay protection purposes must meet the following requirements:

2.1.9.4.1. TT - the limit of the permissible total error at the current of the rated limiting multiplicity should not exceed 10%.

2.1.9.4.2. VT - the accuracy class and the scheme for connecting its circuits to the relay protection and automation devices is determined according to the conditions for ensuring the correct operation of the relay protection and automation devices.

2.1.9.4.3. Measuring sensors of pre-emergency information for APNU, as well as measuring circuits of AOPO must be connected to CTs with an accuracy class of at least 0.5; for the purposes of AOPO, the use of TT windings with a limit of permissible total error at a current of nominal limiting multiplicity of no more than 10% is allowed if there are design justifications.

2.1.9.4.4. The measuring circuits of the transient monitoring system must be connected to the secondary windings of the measuring CTs and VTs of the following accuracy classes:

- TT 110 kV and above - no worse than 0.2;
- other TT - not worse than 0.5;
- VT 110 kV and above - not worse than 0.2;
- other TN - not worse than 0.5.

2.1.9.5. TT 0.4 kV should be used for the purposes of AIIS KUE, APCS and measurements in cases where the measured current exceeds 60 A, and the connected power is more than 25 kW.

2.1.9.6. Actual secondary loads of measuring CTs and VTs must comply with the requirements of regulatory documents and ensure the operation of CTs and VTs in the required accuracy class.

2.1.9.7. The transformation ratio of the windings of AIIS KUE, APCS and measurements should ensure the measurement of the operating current with normalized accuracy in the range of its variation from the minimum to the maximum value determined on the basis of calculations of electric power modes.

2.1.9.8. It is necessary to use a measuring circuit with three CTs.

2.1.9.9. It is recommended to use hydrophobic coatings or external polymer insulation for TT and HT to reduce operating costs.

2.1.9.10. Measuring CTs and VTs used in electrical networks with a voltage of 0.4-20 kV, as well as in electrical networks of 35 kV at closed-type substations, must have:

- cast insulation (it is allowed to use oil heat pumps with appropriate justification);
- at least two secondary windings;
- accuracy class of windings:
  • not worse than 0.5S for TT and 0.5 for HP in case of new construction, reconstruction or modernization of metering points of grid enterprises;
  • not worse than 0.5S for TT and 0.5 for VT for 6-20 kV connections;
  • not worse than 0.5 for TT for the purposes of electricity metering, measurements and APCS on outgoing lines and 0.4 kV inputs of network enterprises;
  • for connecting consumers to networks up to 1 kV, secondary windings of TT for connecting electric energy meters must be of accuracy class no worse than 0.5.

2.1.9.11. Reliability requirements:

- service life - at least 30 years;
- warranty period of operation - at least 5 years from the date of commissioning;
- no need for repairs during the service life;
- apply TT and VT with an increased interval between checks (at least 8 years).

The choice of parameters for measuring CTs and VTs should be carried out in accordance with GOST 7746–2015, GOST 1983–2015, PNST 282–2018, PNST 283–2018 and PNST 319–2018.

2.1.9.12. Digital instrument transformers must comply with the requirements of subsection 2.2 of the Technical Policy.

2.1.9.13. Instrument transformers used must comply with the provisions of subsection 3.6 of the Technical Policy.

2.1.10. Surge arresters

2.1.10.1. During new construction, reconstruction and technical re-equipment of power grid facilities for protection against lightning and switching overvoltages, surge arresters (including those with spark gaps on overhead lines) should be installed on the basis of zinc oxide varistors for all voltage classes, explosion-proof with sufficient energy capacity and protective level.

2.1.10.2. In the cases of using the UPNKP circuit breaker designed to perform the closing operation at the moment of the maximum voltage on the contacts of the switch (for example, switching on the reactor, transformers), which corresponds to the maximum overvoltages, it is necessary to evaluate the increased loads on the surge arrester and the insulation of the main equipment of the substation, power transmission line.

2.1.10.3. The choice of parameters and determination of the installation points of the surge arrester should be carried out in accordance with GOST R 52725-2007 “Nonlinear surge arresters for alternating current electrical installations with voltages from 3 to 750 kV. General technical conditions ", STO 56947007-29.120.50.076-2011" Typical technical requirements for overvoltage arresters of voltage classes 6-750 kV ", the current requirements and norms of technological design.

2.1.10.4. When reconstructing a substation, it is necessary to simultaneously replace all arresters or surge arresters on busbar sections and connections. Simultaneous operation of surge arresters and arresters with different characteristics is not allowed due to the risk of damage to an element with worse characteristics due to its overload.

2.1.10.5. Reliability requirements:

- service life - at least 30 years;
- warranty period of operation - at least 5 years from the date of commissioning.

2.1.11. Electromagnetic compatibility and lightning protection

2.1.11.1. Secondary electrical equipment installed at the substation, secondary switching cables are exposed to electromagnetic influences arising from short circuit, switching of primary equipment, lightning strikes, high-frequency communication for various purposes and others.

2.1.11.2. At the substation, an electromagnetic environment must be provided, in which the levels of electromagnetic influences of all types do not exceed the permissible values for each specific device. At the same time, any electromagnetic influences should not lead to damage and disruptions in the operation of secondary equipment, protection, control and communication systems.

2.1.11.3. Devices exposed to electromagnetic influences: protection and automation devices, APCS, TM, AIIS KUE, ASTU, information collection and transmission systems, fire-prevention systems, video surveillance systems, burglar alarms, communication systems, operational current systems.

2.1.11.4. The technical policy in the field of creating the required electromagnetic environment at the substation is ensured by the implementation of a set of organizational and technical measures in accordance with the current regulatory documents:

- implementation of ZU, providing equalization of potential on the territory of the substation and grounded equipment;
- the use, as a rule, of corrosion-resistant materials with a reduced specific resistance for the charger;
- implementation of lightning protection, excluding insulation overlap and overvoltage penetration in the secondary switching circuit;

- selection of substation layout, taking into account the electromagnetic influence of primary circuits and equipment on secondary switching circuits and individual devices;

- Carrying out surveys for electromagnetic compatibility for newly built and reconstructed substations by specialized organizations;

- selection of the method and routes for laying power cables and secondary switching cables, which guarantee the levels of pickup, interference and other influences that are permissible for the applied substation devices;

- prohibition of laying DC and AC circuits in one cable;

- adoption, if necessary, of additional measures to ensure EMC (use of shielded cables, installation of filters in power circuits, SPDs, etc.);

- taking measures to protect electrical installations from high-frequency switching overvoltages;

- taking measures to protect against static electricity;

- taking measures to protect against radio emission;

- the use of fully dielectric fiber-optic cables at the substation, which are protected from mechanical damage and rodents;

- placement of cable trays, as a rule, below the surface of the earth with the organization of drainage of ground and melt water, including at the intersections with communications and at the entrances to buildings.

2.1.11.5. Diagnostic examination of the lightning protection system of a substation should be carried out during operation in order to:

- assessing the effectiveness of the existing lightning protection system and its compliance with the requirements of technical documentation;

- ensuring the protection of electrical equipment from lightning effects;

- checking the provision of EMC of protection and automation circuits, automated control system, automated process control system, information processing system and automated information system control system;

- development of measures to ensure the required level of lightning protection and EMC.

2.1.11.6. It is recommended to carry out a comprehensive diagnostic examination of the electromagnetic environment:

- when designing the reconstruction of the substation for the electromagnetic environment of the existing substation, subject to reconstruction. The results of the report should be used in the formation of technical specifications for the design;

- after reconstruction of the substation;

- after the completion of the construction of the substation.

2.1.11.7. Lightning protection of outdoor switchgear equipment of 35 kV and above is performed by installing free-standing lightning rods and lightning rods installed on the linear portals of the outdoor switchgear.

2.1.11.8. During the construction of closed substations (switchgear, indoor switchgear 35, 110 (150) kV), lightning protection of the building is carried out along the roof of the building, from which down conductors descend and are connected to the external ground loop. If the roof of the building is made entirely of metal or the use of metal supporting structures, it is sufficient to ground the metal parts of the roof.

2.1.11.9. To protect block transformer substations from lightning strikes, the package of which does not include a lightning protection system, the design documentation should provide for the use of an air terminal grid.

2.1.11.10. During new construction and reconstruction of substations 110 kV and above, it is recommended to use catenary wire lightning rods at outdoor switchgear, which, in addition to increasing the reliability of protection against direct lightning strikes, allows simultaneously solving the problem of electromagnetic compatibility at the substation due to the possibility of installing ground wire supports outside the protected area and thereby weakening the galvanic connection between the ground electrodes of these supports and the substation grounding loop, which practically completely eliminates the penetration of lightning current into its underground utilities.

Due to the removal of the ground wire supports from the protected area of the substation, it is possible to either completely suppress the formation of sliding spark channels from the point of entry into the ground of the lightning current, or to orient them in a direction safe for the object.

2.1.11.11. For new construction and reconstruction of substations 110 kV and above, it is recommended to use a computer-aided design (CAD) system for lightning protection of substations and overhead lines.

2.1.11.12. When organizing lightning protection for 35-220 kV overhead lines, it is necessary to consider the use of combined insulators - arresters, which make it possible to abandon the use of both a lightning protection cable and a surge arrester, which leads to a decrease in the mass and cost of supports and foundations, and, accordingly, the total cost of construction of overhead lines.

The result of replacing traditional means of lightning protection of overhead lines (lightning protection cable or surge arrester) with combined insulators - arresters is a decrease in labor intensity and cost of maintenance and repairs of overhead lines.

2.1.12. Reactive power compensation devices

2.1.12.1. The following types of reactive power compensation devices (RPC) should be used:

uncontrolled static means of longitudinal and lateral compensation, including:

• shunt reactors (SR) 110-500 kV;

• shunt batteries of static capacitors (BSK) and FKU using dry capacitors or capacitors impregnated with an environmentally friendly liquid synthetic dielectric;

• longitudinal compensation devices (UPC);

controlled means of longitudinal and lateral compensation, including:

• bias-controlled shunt reactors 110-500 kV (UShRP);

• controlled by thyristor valves using transformers with short-circuit voltage equal to 100%, shunt reactors 110-500 kV (USHRT);

• static thyristor compensators (STK) and static compensators based on voltage converters (STATCOM);

• vacuum reactor (VRG) and thyristor-reactor groups (TRG), commutated by switches with increased switching resource, equipped with a synchronous switching device;

• active filter-compensating and balancing devices (AFS) based on modular multilevel voltage converters.

• controlled longitudinal compensation devices (UUPD);

• asynchronized electric machine compensators;

• asynchronized electromechanical frequency converters (ASEMPCh).

2.1.12.2. The use of a capacitor unit is allowed provided that resonance phenomena are excluded in all operating modes of the electrical network.

2.1.12.3. In distribution networks, if it is impossible to place adjustable capacitor banks and with appropriate justification, it is allowed to install separate capacitors designed only to compensate for the magnetizing current of the transformer in the base part of the reactive load graph.

2.1.12.4. When designing electrical networks of 110 kV and above, it is recommended to consider the issues of reactive power compensation together with the issue of the possibility and feasibility of building self-compensating overhead lines (USVL), as well as compact overhead lines.

2.1.12.5. Reliability requirements:

- service life - at least 30 years;

- warranty period of operation - at least 5 years from the date of commissioning.

2.2. Digital substation

2.2.1. General requirements

2.2.1.1. Distinctive characteristics of a digital substation (DSP) are: the presence of intelligent electronic devices, the use of local area networks for communications, a digital way of accessing information, its transmission and processing, automation of the substation and its control processes.

2.2.1.2. The goals of creating a digital substation:

- reduction of cable facilities;

- reduction of terms of design, installation, adjustment of substation equipment;

- ensuring the observability of the parameters of the operation of power transmission lines, equipment and substation devices;

- unification of substation configuration mechanisms;

- formation of a unified diagnostic system. Transition to remote functional diagnostics;

- transition to unattended substations.

2.2.1.3. DSP is the main element of the electrical network.

DSP is a highly automated substation, operating, as a rule, without the presence of permanent operational personnel on duty, and equipped with digital information and control systems interacting in a single time mode: automation, control, monitoring and diagnostics of the state, accounting, local and remote control of technological processes, communications providing a unified information space and based on unified data transmission protocols (SV-streams, GOOSE-messages, MMS).

2.2.1.4. When designing the construction of a central heating station, it should be provided for:

2.2.1.5. Application of digital design approaches based on digital models with the support of a unified information model of the network.

2.2.1.6. Application of the corporate profile IEC 61850 of PJSC Rosseti for the purpose of typing technical solutions using the IEC 61850 standard in terms of implementing various functions of intelligent electronic devices, exchange and transfer of information between them.

2.2.1.7. Creation of uniform solutions for the description of the electronic catalog of PS equipment, the use of functionality and communications within the framework of the IEC 61850 standard, which includes:

- principles for describing primary equipment for generating SSD files for switchgear of voltage classes 6-750 kV in accordance with IEC 61850-6;
- description of typical functions of relay protection and automation, automated process control system, PA, UPASK using logical nodes according to IEC 61850-7-4, as well as new logical nodes created according to IEC 61850-7-1;
- a description of data objects for logical nodes according to IEC 61850-7-3, as well as new data objects created according to IEC 61850-7-3 for existing and new logical nodes used to describe information not defined by the IEC 61850 standard;
- description of information transfer to the substation level using the MMS protocol in accordance with IEC 61850-8-1 and the requirements of PJSC Rosseti regarding the use of report parameters for various categories of information;
- description of signal transmission for relay protection and automation equipment and process control systems at the field level and connection level using the GOOSE protocol in accordance with IEC 61850-8-1 and the requirements of PJSC Rosseti regarding the clarification of the operating rules for the transmission mechanism;
- description of the transfer of instantaneous samples of analog values using the Sampled Values protocol in accordance with IEC 61850-9-2, profile 9-2LE and the requirements of PJSC "Rosseti" regarding the transfer of samples of analog values within the framework of IEC 61850 9-2 and IEC 61869-9 for Architecture III.
- a description of the main modes of operation of the IED using the model of the IEC 61850 standard;
- a description of the possibilities of implementing the functional hierarchy in the IED using the capabilities of the IEC 61850 standard;

- description of the mechanism of interaction of functions implemented by logical nodes.

2.2.1.8. All solutions described in the corporate profile must comply with the requirements of PJSC Rosseti for the implementation of DSP using standard cabinets of secondary equipment, with varying degrees of application of DSP technologies in accordance with Architectures I, II and III.

2.2.1.9. At the stage of development of project documentation, an electronic description file of the PS System Description Specification (SSD) is formed, which serves as the basis for the specification of functional requirements for the equipment of all DSP systems, regardless of the specific manufacturer.

2.2.1.10. Creation of SSD-files of PS specification at the stage of development of project documentation allows:

- to obtain a typed electronic description of the primary equipment of the PS in the SCL language in accordance with IEC 61850-6 to simplify the assessment and use of design results, as well as the integration of the electronic circuit into the SCADA system;
- to obtain a typed list of functions of secondary substation systems with reference to the primary equipment of connections to simplify the process of checking compliance with the requirements for secondary equipment in terms of functionality, regardless of the degree of integration of DSP technologies in accordance with Architectures I, II and III;
- to maintain a single electronic library of design solutions described in a universal format, which makes it possible to simplify the analysis and addition of current design solutions.

2.2.1.11. The design of the DSP based on the existing infrastructure should be carried out through a comprehensive modernization of secondary systems based on intelligent electronic devices and technological LANs in accordance with the requirements of the IEC 61850 series, as well as through the modernization and/or replacement of equipment and systems using specialized digital sensors and devices (including installation of field controllers), corresponding converters with integration into the overall control and monitoring system.

2.2.1.12. The DSP must meet the following criteria:

- remote observability of parameters and operating modes of equipment and systems;
- provision of remote control of equipment and systems for the operation of the substation;
- a high level of automation of control of equipment and systems using automated control systems;
- remote control of all technological processes in a single time mode;
- digital data exchange between all technological systems in a single format;
- integration into the power grid and enterprise management system, as well as ensuring digital interaction with the relevant infrastructure organizations (with

adjacent facilities);

- functional and information security in the digitalization of technological processes;
- continuous monitoring using ASMD of the main technological equipment and systems online with the transfer of the required amount of digital data, monitored parameters and signals.

2.2.1.13. The software and hardware complex of the DSP should be performed at three structural levels - the process level, the connection level, the PS level, and it should include the following functional subsystems:

- APCS;
- Relay protection and automation, including registration of emergency events and processes (RASP);
- specialized automatic control and regulation;
- monitoring of power quality parameters;
- commercial and technical metering of electricity;
- ASMD continuous control of the main technological equipment;
- monitoring and management of engineering systems;
- synchronized vector measurements;
- NTD and information support of service personnel;
- information security;
- general safety.

2.2.2. Typical Architectures

Depending on the current tasks of power grid construction, as well as the tasks to be solved for the management of power grid assets, it is currently advisable to consider three main architectures developed on the basis of the IEC 61850 standard:

2.2.1.1. Architecture I - DSP architecture, in which the exchange of all information between IEDs is carried out by discrete and analog electrical signals transmitted over a control cable; information exchange between the substation level (SCADA) and the IED is carried out using the MMS protocol according to IEC 61850-8-1. GOOSE and Sampled Values are not used.

Additional requirements in the project are imposed on the format of the presentation of tables of signals transmitted to the APCS, where the names of signals according to the IEC 61850 standard and in accordance with this standard and other regulatory documents should be used.

2.2.1.2. Architecture II is a DSP architecture in which communication between IEDs is carried out using object-oriented GOOSE messages in accordance with the IEC 61850-8-1 standard; information exchange between the substation level (SCADA) and the IED is carried out using the digital MMS protocol in accordance with IEC 61850-8-1; current and voltage measurements are transmitted as electrical analog signals using control cables.

The Sampled Values protocol is not intended to be used in this architecture.

2.2.1.3. Architecture III is a DSP architecture in which communication between IEDs is performed using object-oriented GOOSE messages according to IEC 61850-8-1; information from current and voltage measuring devices is transmitted in digital form using the instantaneous value transfer protocol using the Sampled Values protocol according to the IEC 61850-9-2 standard; information exchange between the substation level (SCADA) and the IED is carried out using the MMS protocol according to IEC 61850-8-1.

When designing objects in accordance with Architecture III, in addition to the features of the second architecture, requirements are also added in terms of data transfer using the Sampled Values protocol.

2.2.1.4. All the features of the implementation of Architectures I, II and III in terms of the applied technical means and protocols of the IEC 61850 standard are given in Table 1.

Table 1. Features of the implementation of Architectures I, II and III

Technical means	Architecture I	Architecture II	Architecture III
Using the MMS protocol	Yes	Yes	Yes
Using the GOOSE protocol	Not	Yes	Yes
Using the Sampled Values Protocol	Not	Not	Yes
Application of equipment supporting IEC 61850 at the substation level	Yes	Yes	Yes
Application of equipment supporting IEC 61850 at bay level	Yes	Yes	Yes
Field application of equipment supporting IEC 61850	Not	Yes	Yes
Using broadband	Not	Yes	Yes
Use of SHPAS	Not	Not	Yes
Using CGT and CGT with Sampled Values Protocol	Not	Not	Yes

2.2.1.5. The following solutions, equipment and materials should be applied and implemented at the DSP:

- Closed-type centralized central heating systems should be designed using switchgear;

- switching equipment 35 kV and above must be equipped with electric drives with the function of remote control, position control and accounting of the switching resource;

- equipment of switchgear 6-20 kV, MV switchboard should be equipped with specialized units and elements that provide remote control of switches and monitoring of their condition;

- The DCS should be extended and provide working and, if technically necessary, backup power for the following electrical receivers: relay protection and automation equipment, automated process control systems, automated information and control system devices, dispatch / technological control and communication facilities (SDTU), local electrical network of substations, DC drives of switching devices emergency engineering systems of the substation (fire extinguishing, smoke removal, supply and exhaust ventilation, etc.), security systems (KSOB), fire alarm, emergency lighting, if necessary, - DC / AC or DC / DC inverters;

- fiber optic conductors embedded in cables or separately laid with redundancy, or fiber optic cables must comply with the requirements of IEC 60794;
- a system of centralized monitoring and control of the state of local automation of engineering systems (heating, ventilation, air conditioning, water supply, sewerage, storm drains, fire extinguishing and fire alarm systems) should be used with the implementation of the following functions:
- control, registration and analysis of the main parameters (temperature, humidity, dustiness, pressure drop, pressure of the extinguishing agent at the inlet of the system and in the directions of fire extinguishing, consumption, equipment operating time, electricity consumption, etc.) and their deviations outside the permissible limits;
- control of operation of automatic devices with registration of discrete signals of emergency events;
- electronic measuring transformers or PAS devices should be used in combination with traditional measuring transformers, providing:
- automatic detection of a malfunction of a digital measuring transformer with the formation and transmission of a signal about data unreliability on a digital channel;
- automatic detection of the failure of the data transmission system from digital measuring transformers with the formation of the corresponding signal about the failure;
- accuracy class is not worse than specified in subsection 2.1.9 of the Technical Policy;
- calibration interval - at least 8 years,
- improved weight and size characteristics and lower labor costs during their installation and operation in comparison with traditional instrument transformers;
- fire and explosion safety;
- security and work lighting should be integrated with video surveillance with sufficient illumination for security and technological video surveillance;
- technological video surveillance should provide:
- visual control of the premises of the control room, indoor switchgear and outdoor switchgear of the central heating station with the main technological equipment (transformers, switchgear, switchgear, outdoor switchgear);
- visual control over the operation and condition of individual elements, functional units and measuring instruments of the equipment;
- visual control of the premises of the control room, indoor switchgear of the central control station, equipped with security and fire alarms and a fire extinguishing system, with the analysis of video information and the formation of alarm signals;
- visual inspection of the installation zones of cabinets with microprocessor equipment and control cabinets;
- visual control of the position of remotely controlled switching devices at outdoor switchgear, indoor switchgear, switchgear of switches (according to the indicator in the drive), disconnectors (including neutrals of transformers) and earthing switches, evacuated cells;
- visual control over the safe performance of work by the personnel of repair teams in rooms with increased danger, outdoor switchgear, indoor switchgear, switchgear;
- information security must be ensured;
- AIIS KUE should be implemented using digital commercial metering devices;

- measuring instruments (digital CTs and VTs) must have at least two mutually redundant measurement channels suitable for the accuracy class both for relay protection and automation purposes and for the purposes of measuring, accounting and monitoring FE;

- an integrated security system (KSOB) should be implemented with access control, event registration and data transfer to the AWP of the corresponding users.

- to provide for the installation of a network traffic monitoring system and control of the conformity of data transmission using the GOOSE, Sampled Values and MMS protocols to the electronic project (SCD file) with monitoring of abnormal modes and event registration based on GOOSE / Sampled Values messages, including, but not limited to:

- assessment of the current workload of the LAN;

- analysis of messages of the GOOSE, Sampled Values and MMS protocols for packet loss or distortion;

- analysis of the configuration of the information network (analysis of the correspondence of the network to the SCD file);

- control of the appearance of MAC addresses in the information network to ensure information security;

- control of the appearance of unauthorized messages in the network (white noise);

- issuance of signaling about network faults and errors in the APCS;

- blocking of switch ports (blocking criteria to be determined during design).

2.2.3. Integration of DSP data based on the CIM model

2.2.2.1. In accordance with the concept of development of OTU, information interaction between systems within the NCC should be carried out by means of a single integration platform of the ASTU based on the Common Information Model (CIM-model).

2.2.2.2. All measurements in the measurement / signal information model must be associated with elements of the power system model.

2.2.2.3. An unambiguous interpretation of data by all NCC subsystems is ensured by using a common information model (CIM-model) defined in the international standard IEC 61970-30x. By means of the CIM-model, the unambiguous identification and classification of the data involved in the information interaction between subsystems should also be provided.

2.2.2.4. As a generalizing top-level data model (information model), the General Information Model (CIM-model) should be used, including the information model of the power system and the information model of measurements and signals.

2.2.2.5. The information model of the electrical network should be created on the basis of the provisions of the international standards IEC 61970 and 61968 and should be detailed down to the elements of the digital substation equipment.

2.2.2.6. The information model of measurements / signals should be created on the basis of the provisions of the international standards IEC 61970 and 61968 and should include all measurements / signals required for the operation of the NCC, processed by the PTC SSPTI of digital substations.

2.2.4. Criteria for the application of various architectures in the construction of digital substations

2.2.3.1. Architecture I is used for non-complex or partial reconstruction of a substation with a large volume of equipment that has worked for up to 15-20 years.

2.2.3.2. Architecture II is used in new construction and complex reconstruction of the substation.

2.2.3.3. Architecture III is used only for testing new technologies, confirming or revealing new technical and economic effects.

2.2.3.4. The choice of DSP architecture is determined by the condition of not increasing capital and operating costs.

2.3. Own needs

2.3.1. General provisions

2.3.1.1. When organizing a substation's own needs:

- it is necessary to power the AC power consumers of the substation from two independent sources (for substations 330 kV and above - from three, while the UPS can be considered the third independent source);

- have their own power sources at 110 kV substations and above, which ensure the autonomous operation of their own power consumers directly involved in the technological process for at least two hours with a complete loss of external power supply of the MV, and the subsequent start of the substation "from scratch" (power source type: DGS or UPS, including those based on high power AB, should be determined on the basis of a technical and economic comparison of options);

- in the presence of a feasibility study, it is allowed to supply power to the auxiliary needs of the substation, TP, RP, RTP, PP, for which ensuring compliance with the requirements of the current normative and technical documentation will entail significant investments (geographically distant objects, single-transformer substations, the initial stage of construction of the facility, etc.) from HP with increased power secondary winding;

- use cables with voltage higher than 1 kV with XLPE insulation, below 1 kV - with insulation that does not support combustion;

- to provide separate operation of 0.4 kV sections for auxiliaries with ATS, provide for separate operation without ATS of circuits powered by different 0.4 kV sections (power supply of disconnector drives, spring loading of circuit breaker drives, etc.);

- to use a protective switch with the ability to create visible ruptures;

- to use selective automatic switches as input and sectional protective devices on the 0.4 kV side;

In TP, RP and RTP with alternating and rectified operating current, the TSN should be connected through fuses, from the supply side, to the input switch, with the exception of TSN with cast (dry) insulation, which must be connected through the SC from the busbars, while transformers with cast (dry) insulation must be equipped with thermal protection acting on the shutdown of the switch;

- power supply of the operational alternating current network from auxiliary buses through stabilization devices with a voltage of 220 V at the output;

- to organize a centralized system with a switchboard and a control panel for emergency and evacuation lighting of the main control panel of the substation with the possibility of using standard lighting installations for emergency lighting and integration into the existing APCS of the substation, with autonomous testing of components and assemblies, both the system itself and the connected to her load (lighting networks), with the ability to analyze the monitoring of the state of lighting networks.

One of the main conditions for the reliable functioning of protection and automation devices, APCS, AIIS KUE, SSPI at substations is the organization of the optimal structure of their operational power supply;

- power supply of third-party consumers from the substation's own network is not allowed

2.3.1.2. Depending on the conditions, a decentralized (two or more sets) operating current system can be used. Decentralization of the operating current system is recommended if there are remote switchgears at the substation, as well as during the reconstruction of power grid facilities, based on the territorial distribution of loads on the substation or based on the nature of consumer loads.

2.3.1.3. The peculiarity of the organization of operational power supply for the SS's own needs is determined by the fact that at present, new systems and types of equipment are being introduced at the SS, requiring new approaches compared to the existing ones. The power supplies for these systems are AC and DC systems.

2.3.1.4. The design of the operating current systems should be carried out taking into account the possibility of the substation operation without permanent duty personnel.

2.3.1.5. In justified cases, with the exception of the cases specified in clause 2.3.1.1 of the Technical Policy, when organizing operational power supply, the installation of a diesel generator set of the required power should be provided.

2.3.1.6. For power supply of SSESK, APCS, SSPI, OPS, automation of fire protection installations, information and computing infrastructure of substations and other systems, as a rule, centralized uninterruptible power supplies (UPS) should be provided, both with their own battery, and with power supply from the operational constant current that meets the following basic requirements:

- provision of power supply for SSESK, OPS, automation of fire protection installations from UPS with its own battery, as a rule, not less than 4 hours when switching off the MV substation for any reason;

- provision of power supply of the APCS, SSPI systems from the UPS (possibly without its own AB with power supply from the operating direct current), as a rule, not less than 2 hours when the MV substation is disconnected;

- providing power to other systems from the UPS, as a rule, without its own AB with power supply from the auxiliary direct current when the MV substation is disconnected in accordance with the relevant NTD;

- ensuring the requirements for electromagnetic compatibility.

2.3.2. DC operating current

It must meet the requirements of the technological design standards for alternating current substations with a higher voltage of 35-750 kV.

2.3.2.1. OOPT PS must meet the following basic requirements:

- stationary AB should be used with a service life of at least 20 years (for SHUOT - at least 15 years) and a capacity capable of providing the maximum rated shock currents after a guaranteed, not less than two-hour, discharge with a load current in an autonomous mode (in case of loss of auxiliary needs) during the entire service life;

- electromagnetic compatibility must be ensured;

- an automated search for "ground" in the direct current network must be applied without disconnecting the connections outgoing from the DC voltage;

- automatic detection of a decrease in the insulation of each pole and a simultaneous decrease in insulation at both poles of the OSS should be applied;

- OOPTS of the substation must have a three- or two-level protection system:

• lower level: protection of power supply circuits for direct consumers (protection and automation devices, circuit breakers control circuits, etc.);

• middle level: protection of SHROT circuits and other consumers of DC power supply;

• upper level: protection of DCB busbars at the AB input;

- the implementation of the protection of the direct current network at the upper and middle levels should be carried out using switching protection devices with fuses of electrical safety design, at the lower level it is recommended to use automatic switches;

- the design of protective devices must ensure their safe maintenance.

2.3.2.2. At distribution substations with a voltage of 35 kV and above, it is recommended to use a 220 V OSS.

2.3.2.3. At 35-110 (150) kV substations, the use of a direct operating current system is justified by the need to install switch and modern protection and automation systems, process control systems, automated control systems and the organization of digital communication channels.

2.3.2.4. During the reconstruction of 35-220 kV distribution substations, associated with the installation of microprocessor protections, it is allowed to install a new (duplicate) OOPT in addition to the existing OOPT, to supply only the reconstructed part of the substation.

2.3.2.5. The AB connection to the protective devices of the first level and between the elements should be carried out with copper flexible (multi-wire) cables with acid-resistant insulation.

2.3.2.6. It is also recommended when organizing a direct operating current:

- availability of a device for monitoring the current parameters of the DCS;

- the presence of a device for monitoring the insulation of the poles of the network relative to the ground;

- availability of a system for automated search for damage sites;

- measurement of the insulation of the poles of the network relative to the ground without disconnecting the connections (search for "ground");

- availability of a device for recording emergency processes and events in the OOPT with the organization of data transfer to the automated process control system or telemechanics (if justified);

- availability of a means for issuing a generalized malfunction signal in the APCS and telemechanics.

2.3.2.7. Existing decisions on the organization of OOPT should be focused on:

- development of standard schemes for organizing operational power supply (SOPT, TSN, UPS, DGU) and standard design solutions, taking into account the decisions of various manufacturers;

- the use of modern methods for calculating short-circuit currents and the choice of types of protective devices and parameters of their operation;

- study of the issues of using new alternative sources of direct current instead of AB.

2.3.2.8. To organize the rectified operating current, stabilized voltage blocks connected to the VT on the HV side of the substation and current power supplies connected to the CT on the HV side of the substation must be used.

2.3.2.9. To find a ground fault without disconnecting connections in rectified operating current systems, automatic devices or manual search means must be provided.

2.3.2.10. The operational blocking circuits must be powered from the ISS with galvanic isolation.

2.3.3. AC operating current

2.3.3.1. Alternating operating current and rectified alternating operating current, as a rule, are recommended for use at substations 35 kV, TP, RP and RTP 6-20 kV.

2.3.3.2. The use of alternating operating current at substations with 110 kV HV is allowed only if there are additional justifications.

2.3.3.3. Schematic solutions for the organization of the AC power supply system should provide for:

2.3.3.4. On the busbars of the operating alternating current, insulation monitoring devices must be provided.

2.3.3.5. Separate CTs, to which power supplies and pre-charged capacitors are connected, should be used as sources of alternating operational current to power the protection and control circuits.

2.3.4. Charging devices

2.3.4.1. Chargers (charger) must provide:

- the possibility of an automatic three-stage charging mode (stage for limiting the initial charge current, stage for voltage limiting, stage for temperature-compensated voltage stabilization);

- in the float charge mode, the voltage quality (level, ripple, stability and temperature compensation) to the technical specifications for batteries of a particular type;

- voltage quality according to the technical conditions of direct current electric receivers (for example, protection and automation devices) in the modes of both holding charge and equalizing charge;

- power supply of devices that are constantly energized (in particular, protection and automation devices), corresponding to their technical conditions in case of communication failure with the battery for any reason;

- automatic full charge of the battery in the shortest possible time, taking into account the limitations determined by the technical conditions for the battery;

- power supply of DC electrical receivers, including when the battery is turned off for any reason;

- recharging the battery at a constant stabilized voltage of the float charge recommended by the battery manufacturer.

2.3.4.2. The power of two chargers operating in parallel on one AB must provide power to all PS electrical receivers connected to the OSS set, taking into account the simultaneous accelerated charging of the AB up to 90% of the nominal capacity for no more than 8 hours.

2.3.4.3. The charger should be powered from 0.4 kV auxiliary sections. Power supply of mutually redundant chargers must be carried out from different sections of the 0.4 kV APS.

2.3.4.4. The charger must ensure the accuracy of stabilization of the output voltage in the float charge mode not worse than ± 1% and temperature compensation of the float charge voltage.

2.3.4.5. The level of current ripple in the battery with a maintenance charge should not exceed 5 A per 100 Ah of its capacity, and the voltage ripple when the charger is operating at full load of the OSS set with the battery disconnected should not exceed ± 5% Un.

2.3.4.6. The charger must have a lock for enabling the equalizing and accelerated charging of the AB when the supply and exhaust ventilation of the AB room is inoperative.

2.3.4.7. The charger should automatically turn on after power interruptions from the AC side and operate in a charge mode corresponding to the state of the AB.

2.3.4.8. The possibility of simultaneous parallel operation on the side of the rectified voltage of two storage devices with a symmetrical division of the total load current between them or the operation of one of the storage devices in the "hot" standby mode (when using three storage devices for two AB) should be provided.

2.3.4.9. Chargers should not be placed in the same cabinet, in adjacent cabinets.

2.3.4.10. Requirements for memory reliability:

- service life - at least 30 years;

- warranty period of operation - at least 5 years from the date of commissioning.

2.3.5. Engineering infrastructure

2.3.5.1. A prerequisite for the operation of power grid facilities of equipment is the provision of their engineering infrastructure, as well as ensuring its reliable and efficient operation.

2.3.5.2. The technical policy in the field of engineering infrastructure of power grid facilities should be aimed at:

- the use of equipment, hardware and automation with characteristics and functionality that meet the current level of development of engineering infrastructure;
- organizational and technical transformation associated with the digitalization of ESCs;
- the use of modern effective technologies in the construction and operation of engineering infrastructure.

2.3.5.3. The basic principles of building an engineering infrastructure for substations 110 kV and above are:

- the use of controllers for local automation of field-level engineering systems based on freely programmable controllers with a Russian-language interface;
- the use of engineering systems, taking into account the possibility of heat recovery from technological equipment and energy saving requirements;
- interrelated analysis and control of the operation of engineering equipment affecting the same control parameter;
- observability of all parameters and operating modes of engineering equipment;
- self-diagnostics and remote diagnostics of engineering equipment;
- exchange of information on the state of equipment, on the parameters of the air environment, on events in the subsystems of the engineering infrastructure through digital communication systems and equipment that provides support for protocols approved by IEC standards;
- autonomous automatic control and centralized remote control of engineering infrastructure equipment.

2.3.5.4. The subsystems of the engineering infrastructure that provide technological equipment with the necessary climatic mode of operation during its operation, shutdown, storage and conservation, as well as the necessary required parameters, are the following subsystems:

- general ventilation;
- air conditioning;
- heating (electric, air, water);
- technological video surveillance;
- power supply;
- water supply;
- drainage and sewerage.

2.3.5.5. Requirements for the construction of technical means of fire protection:

- construction (reconstruction) of fire protection means must be carried out on the basis of addressable devices with control of the state of communication lines and ring topology;

- power supply must be performed according to the first category of reliability from two independent power supply sources and with the use of UPS, which ensure autonomous operation of the means in standby mode when the main and backup power is lost for 4 hours;

- it is necessary to provide remote control of all required parameters of the CPM (position, pressure, temperature, level, voltage, etc.) of the state, operating modes of devices, equipment power supplies via the interface or through dry contacts;

- it is necessary to ensure reliable detection of signs of fire, control of the level of "dustiness" of each detector in order to prevent false alarms and emergencies;

- in order to verify fire alarm triggers without the arrival of the OVB at the power facility, it is necessary to provide remote video monitoring of the premises of the indoor switchgear and control room, other rooms with the main technological equipment with fire extinguishing and fire alarm systems, the main technological equipment located at the outdoor switchgear;

- it is necessary to ensure the integration of fire protection and engineering equipment into the ASTU subsystem - a complex for managing fire protection systems and engineering equipment for the purpose of round-the-clock monitoring of the operability of fire protection systems and engineering equipment and, if possible, managing the state of engineering infrastructure facilities, conducting remote diagnostics, control repairs, forecasting and prevention of failures.

2.4. Relay protection and automation

2.4.1. General provisions

2.4.1.1. Basically, the requirements for relay protection and automation must comply with the technological design standards for alternating current substations with a higher voltage of 35-750 kV.

2.4.1.2. Reliable operation of the relay protection and automation system ensures the maintenance of the stable operation of the UES of Russia, reduction of damage from damage to electrical equipment and undersupply (reduction of transmission volume) of electricity in the event of technological disturbances in the electric power complex.

2.4.1.3. Reliability of relay protection is determined by:

- the ideology of construction;

- quality of calculation and selection of response parameters;

- ensuring a working condition, through timely and high-quality maintenance and repair of the URZA;

- ensuring information security.

2.4.1.4. The ideology of building relay protection and automation should be based on:

- the use of modern, technologically compatible intelligent microprocessor devices with an extended time interval between service maintenance;

- construction of relay protection and automation complexes, in which a malfunction of an individual element or device does not lead to failure or malfunction of all relay protection and automation functions of the protected power transmission line or equipment;

- implementation of technical solutions in terms of control of relay protection and automation devices - remote change of the operational state of relay protection and automation devices or individual functions (switching groups of settings, input / output of individual protection stages and the device as a whole);

- the use of standard technical solutions (typical architectures for building digital substations) and albums of typical secondary switching schemes, the use of standard cabinets (panels) of a high degree of factory readiness;

- implementation of built-in information protection means as part of relay protection and automation complexes that meet the requirements of the Company for built-in information protection means of the automated control system;

- providing short-range and long-range protection of relay protection and automation;

- the principle of ensuring the "survivability" of relay protection and automation (autonomous performance of the main functions of relay protection and automation), regardless of the performance of other automated systems;

- using replacement microprocessor relay protection and automation devices that are in hot standby with the ability to remotely enter the parameters of the terminal being replaced.

2.4.1.5. In order to reduce operating costs for staff training, reduce the time spent on maintenance, and reduce the risks of incorrect operation of relay protection and automation through the fault of personnel, it is recommended to use standard cabinets within one subsidiary and dependent company.

2.4.1.6. When choosing relay protection equipment, priority should be given to devices manufactured in the territory of the Russian Federation.

2.4.1.7. The selected relay protection and automation equipment, including its software, must support the profile of the IEC 61850 standard and must undergo a quality control procedure for use at ESC facilities, with the exception of those used in pilot operation.

2.4.1.8. The implemented relay protection and automation devices should provide:

- selectivity of detecting damage to network elements through the use of modern algorithms and principles;

- the required performance;

- reliability of functioning, including due to high-quality self-diagnostics of devices;

- correct functioning, taking into account the operation of electromagnetic CTs in a transient short-circuit mode;

- improving the efficiency of the relay protection and automation system as a whole through the use of adaptive properties based on intelligent algorithms, including those using power system models with automatically refined parameters of the current mode.

2.4.1.9. The quality of calculations and selection of parameters for the operation of relay protection and automation devices must be ensured:

- the application of the current guidelines for the calculation and selection of parameters for the operation of relay protection and automation devices, taking into account the recommendations of equipment manufacturers;

- the use of a software and hardware complex in the relay protection and automation services for maintaining the power system model, calculating the parameters of the equivalent circuit of the power system elements, calculating the emergency mode parameters, calculating and selecting the parameters of the relay protection devices triggering.

- the ability to simulate existing and prospective network elements, intelligent elements of active-adaptive action: FACTS, STK, CSR devices, longitudinal compensation devices for power lines, HVDC, TOP, energy storage devices, etc.

- support of a high level of qualification of the personnel of departments of relay protection and automation services involved in the calculation, selection of settings (settings) and algorithms for the functioning of complexes and relay protection devices; increasing control over the preparation and implementation of tasks for setting up relay protection and automation devices (complexes).

2.4.1.10. The operational state of the relay protection and automation devices (complexes) must be ensured:

- maintaining a high level of operational state of the complexes and timely modernization of the relay protection and automation equipment fleet;

- creation of software and hardware complexes for automated testing and assessment of the state of relay protection and automation devices;

- organization and performance of routine technical and operational maintenance;

- availability of highly qualified specialists in relay protection and automation services.

2.4.1.11. The organization of technical and operational maintenance of relay protection and automation devices must be carried out in accordance with the current Rules for the maintenance of relay protection and automation devices (complexes) and provide for:

- the use of effective methods for checking relay protection devices for the timely identification and replacement of units, elements susceptible to malfunction during the life cycle of a relay protection device, as well as during the period of extending the service life;

- use of remote control of functions and control (monitoring) of the state and correct operation of relay protection and automation devices;

- the use of automated systems for checking and assessing the state of relay protection and automation devices.

2.4.1.12. The recruiting of relay protection services by highly qualified specialists who have undergone specialized training and have the right to independently carry out maintenance of the corresponding relay protection and automation devices should be one of the priority tasks of the Company in the field of ensuring the reliable operation of ESCs as a whole.

2.4.1.13. In order to ensure information security, special measures should be taken to prevent the implementation of destructive effects on equipment.

2.4.1.14. The number of CTs, CT secondary windings and their accuracy classes should provide separate connection of relay protection and automation devices, AIIS KUE, measurements.

2.4.1.15. The technical characteristics of the current transformers and the relay protection devices connected to them in aggregate must ensure the correct operation of the relay protection devices in case of short circuits, including when an aperiodic current component occurs.

2.4.1.16. Hardware and functionally redundant relay protection devices, including the main and backup protection of power transmission lines (equipment), must be connected to different secondary windings of TT, powered by different circuit breakers of operational direct current and have independent output circuits.

When developing a system of relay protection and automation of the backbone network, the issues of integration of protection and automation systems with the APCS of power facilities at the information level should be taken into account. In this case, the functioning of relay protection and automation devices should be autonomous and not depend on the state of the APCS.

2.4.1.17. Automatic reclosing should be used at KVL with a voltage of 35 kV and above, if the cable sections are used only for entering the switchgear. In other cases, use automatic reclosure KVL with a voltage of 35 kV and above in the absence of cable sections on them with direct contact of cables of different phases. The presence of transposition sleeves on the cable section does not affect the use of automatic reclosing.

2.4.1.18. For KVL, it is not recommended to use separate relay protection devices to detect short circuits only on cable sections.

2.4.1.19. Relay protection devices that perform the function of the main protection of power lines and (or) automatic reclosing, installed on power lines from all sides, must meet the requirement of interoperability.

2.4.1.20. Structurally, each RPA cabinet should provide for the possibility of complete removal of protection from operation with the output of all external circuits, through which erroneous disconnection of switches or erroneous start-up of breaker failure protection is possible when operating in the RPA cabinet.

2.4.1.21. For the cable network of 20 kV megacities, relay protection and automation devices should be used, which allow selectively disconnecting the damaged section of the cable network without disconnecting other sections of the network or with automatic self-healing of intact sections.

2.4.1.22. Technical accounting and analysis of the functioning of relay protection and automation should be carried out in accordance with the "Rules for technical accounting and analysis of the functioning of relay protection and automation", approved by order of the Ministry of Energy of Russia dated February 8, 2019 No. 80.

2.4.1.23. The interaction of subjects of the electric power industry, consumers of electrical energy in the preparation, issuance and execution of tasks for setting up relay protection and automation devices is determined by Order of the Ministry of Energy of Russia dated February 13, 2019 No. 100.

2.4.2. Features of the construction of relay protection and automation devices in electrical distribution networks

2.4.2.1 Requirements for relay protection and automation of 35 kV transformers

2.4.2.1.1. On 35 kV transformers, it is necessary to provide protection against the following types of damage:

- multiphase short circuits in the windings and at the terminals (busbars);
- turn short circuits in the windings;
- currents in the windings due to external short circuits;
- currents in the windings due to overload;
- incomplete phase mode;
- protection against overload of power transformer windings;
- lowering the oil level;
- protection against single-phase earth faults (OZZ).

2.4.2.1.2. It is recommended to install differential protection on 35 kV transformers with a capacity of 2.5 MVA and above.

2.4.2.1.3. The gas protection must have a device for monitoring the insulation of the operating current circuits coming to the gas relay, and acting in the event of a circuit failure with a time delay to take the gas protection out of operation and to the signal.

2.4.2.1.4. To ensure sensitivity in the zone of long-range redundancy and speed in the zone of short-range redundancy, the backup protection of a 35 kV transformer must have at least two stages.

2.4.2.1.5. Protection against overload, low oil level, open-phase operation must act, as a rule, on the signal.

2.4.2.1.6. Input switches for LV transformers of 35 kV, as a rule, must be equipped with automatic reclosing.

2.4.2.2 Requirements for relay protection and automation of 35 kV transmission lines

2.4.2.2.1. On 35 kV transmission lines, it is necessary to provide protection against the following types of damage:

- phase-to-phase short circuits;

- single-phase earth faults.

2.4.2.2.2. On single lines with one-way power supply from multiphase faults, predominantly step current protection or step current and voltage protection should be used, and if such protections do not meet the requirements of sensitivity or speed of fault tripping, distance step protection, mainly with current start. In the latter case, instantaneous overcurrent should be used as additional protection. All overcurrent protection stages must have a protection acceleration function when the circuit breaker is closed for a short circuit.

2.4.2.2.3. On single lines with power from two or more sides, both with and without bypass connections, as well as on lines entering a ring distribution network with a single feed point, the same protections should be applied as on single lines with single-sided power supply, made directional if necessary, and distance protection must be performed with a start from a resistance relay.

2.4.2.2.4. Protection against single-phase earth faults should be performed, as a rule, with an effect on the signal. An insulation monitoring device may be used for protection purposes.

2.4.2.2.5. Protection against single-phase earth faults should be carried out selectively, with the possibility of detecting a damaged feeder, excluding the method of alternate disconnection of the lines.

2.4.2.2.6. For 35 kV overhead lines, it is allowed to use a "blind" automatic reclosure in the case of one-way power supply of overhead lines or in cases where asynchronous switching is unlikely and does not pose a danger to equipment and the power system.

2.4.2.3 Requirements for relay protection and automation of 6-20 kV transmission lines

2.4.2.3.1. On 6-20 kV transmission lines, it is necessary to provide protection against the following types of damage:

- phase-to-phase short circuits;
- single-phase earth faults.

2.4.2.3.2. On single lines with one-way power supply from multiphase faults, as a rule, two-stage overcurrent protection should be installed, the first stage of which is made in the form of a current cutoff, and the second in the form of overcurrent protection with an independent or dependent time delay characteristic. All overcurrent protection stages must have a protection acceleration function when the circuit breaker is closed on short circuit.

2.4.2.3.3. On single lines with bi-directional power supply with or without bypass connections, as well as on lines included in a ring distribution network with a single feed point, it is recommended to apply the same protections as on single lines with one-way power supply, performing them directionally if necessary.

2.4.2.3.4. Protection against single-phase earth faults for a distribution network with isolated neutral or neutral compensated via an arc suppression reactor should generally be performed with an effect on the signal. An insulation monitoring device may be used for protection purposes.

2.4.2.3.5. Protection against single-phase earth faults should be carried out selectively, with the possibility of detecting a damaged feeder, excluding the method of alternate disconnection of the lines.

2.4.2.3.6. For cable networks of 20 kV with a resistively grounded neutral, the damaged section must be selectively disconnected by protection, without affecting other sections of the network

2.4.2.3.7. For each connection of 6-20 kV switchgear, protection against arc faults with current control on the input and sectional switches should be provided.

2.4.2.3.8. Connections of overhead lines with a voltage of 6-35 kV must be equipped with devices for single or double automatic reclosing at the main switch of the line and at sectioning points.

2.4.3. Devices for registering emergency events and determining the location of damage to power lines

2.4.3.1. Registration systems for emergency events and processes should provide:

- registration of events and processes to the extent necessary for their full analysis;
- recording of electromagnetic transient processes (RAS system) and electromechanical (SMPR system);
- automation of collection, processing of information and provision of access to the database and oscillograms from the network control centers;
- the availability and clarity of the information received from the RAS;
- the required accuracy of automatic determination of places of damage to power lines, automatic detection of damaged connections in the event of single-phase ground faults in 6-35 kV networks;
- reducing the duration of outages and the risks of phase-to-phase short circuits due to the sufficiency of information and the promptness of its provision (reducing the time for making decisions by operating personnel in emergency situations) when single-phase ground faults appear in networks with isolated neutral.

2.4.3.2. The SMPR system should provide:

- monitoring the effectiveness of emergency management;
- checking the reliability of computational models;
- the adequacy of the reliability of the assessment of the mode;
- improvement of emergency management.

2.4.3.3. When designing, solutions should be worked out for integrating the SMPR and RAS systems with the APCS, as well as transferring information about emergency events and oscillograms to the NCC and DC in an automated mode.

2.4.3.4. Automatic transmission of RAS data to the monitoring system of the operation of relay protection and automation devices for maintenance of relay protection and automation devices should be provided.

2.4.4. The main directions of development of relay protection and automation

2.4.4.1. The modern development of information technologies and computer facilities, as well as the latest advances in the development of relay protection equipment, measuring TT and VT allow us to revise the approaches to the implementation of relay protection and automation functions.

2.4.4.2. High-voltage digital CTs and VTs, primary and secondary equipment are equipped with built-in digital communication communication ports, including optical ones.

2.4.4.3. The international standard IEC 61850 is being improved, which regulates the effective presentation and processing of data of an automation object, including information exchange between microprocessor-based intelligent electronic devices.

2.4.4.4. Digital signal transmission at all levels of automation and control has a number of advantages, including:

- increasing the noise immunity of secondary equipment due to the transition to digital optical communication channels;
- unification of device interfaces;
- reduction in the number of cases of unacceptable decrease in insulation resistance in OSSs (optimization of the OSSS architecture due to the use of digital information exchange by means of digital interfaces);
- simplification of operation and maintenance of relay protection and automation devices due to effective diagnostics in real time, no distortion of transmitted signals, collection and display of comprehensive information about the state of objects;
- unification of the processes of design and operation of the substation.

2.4.4.5. One of the main directions in terms of modernization (reconstruction) of relay protection and automation systems is the use of low-maintenance (maintenance-free) intelligent electronic devices (microprocessor devices).

2.4.4.6. The introduction of innovative solutions in the field of relay protection and automation should not lead to a decrease in the reliability of the functioning of complexes and relay protection systems, a decrease in the achieved level of information security, an unreasonable increase in operating costs.

2.4.4.7. The development of relay protection and automation complexes should be based on the use of devices and computer technology of the latest generation.

2.5. Overhead power lines

2.5.1. General provisions

2.5.1.1. The main directions of technical policy in the design, construction, technical re-equipment and operation of overhead transmission lines (OHL) are:

- ensuring the reliability and efficiency of work;

- reducing the cost of construction and operation;
- reducing the impact on the environment, including by minimizing the width of forest clearings, using high-rise supports and supports with vertical suspension of wires;
- reduction of electricity losses on overhead lines;
- the use of structures and materials that provide resistance to vandalism, theft and damage by third parties;
- the use of new standard series of supports made of weather-resistant rolled steel, as well as lattice supports from a bent profile;
- the use of steel multifaceted, narrow-base lattice, reinforced concrete sectioned and composite supports of overhead lines;
- the use of advanced, safe methods of construction, operation and repair;
- with the development of technologies for diagnostics of overhead lines, the use of systems for diagnosing the technical condition of overhead lines under operating voltage without taking out of service;
- the use of unmanned aerial vehicles and robotic systems for monitoring the technical condition of overhead lines 110 kV and above;
- equipping overhead lines of 35 kV and higher with modern means and systems for determining the location of the short circuit of overhead lines;
- equipping 6-35 kV overhead lines in electrical networks with isolated neutral with devices for determining the location of the short circuit of the overhead line of the topographic type, which make it possible to determine the direction of the short circuit current flow to the place of damage and transfer information about the damaged section of the network;
- complex provision of emergency reserve of equipment and materials, its optimal placement and development of routes for its delivery;
- use of computer-aided design systems (CAD VL);
- application of geographic information systems based on satellite positioning systems (GPS, GLONASS).

2.5.1.2. Overhead lines must meet the following basic requirements:

- for overhead lines 6 kV and above, a 3D digital model of the overhead line should be created with its imposition on the terrain plan and display (visualization) of the overhead line in real time on electronic GIS maps of the PTC NCC with the ability to change the scale to visualize the points of pickup of the measured parameters;
- on overhead lines of 110 kV and above, continuous monitoring should be carried out using ASMD of current parameters and current state (primarily parameters of the throughput of overhead lines), as well as periodic monitoring of the state using UAVs and robotic complexes that allow remotely receiving information about the state on a 3D digital overhead line models and electronic maps of GIS PTK NCC;
- devices for determining the location of the short circuit in the overhead line with the display of information in a 3-D digital model of the overhead line and

electronic circuits of the GIS PTK NCC should be used;

- reclosers with a remote control function must be used in the 6-35 kV electrical network;

- in the 6-35 kV electrical network, protection and automation devices should be used, operating according to the logical scheme of disconnecting the damaged section and the function of self-healing of undamaged sections with the display of information on electronic maps.

2.5.1.3. GIS PTK NCC should operate on the basis of a common information model (CIM-model) of the network.

2.5.2. Technical solutions for design, new construction and reconstruction of overhead lines

2.5.2.1. When designing overhead lines, the following technical solutions should be considered:

- the use of unified structures of supports and foundations, directly developed or modified and adapted in accordance with the requirements of scientific and technical documentation for overhead lines of 35 kV and above;

- taking into account the danger of atmospheric and soil corrosion to the elements of overhead lines based on the results of engineering surveys;

- the use of technical solutions that ensure increased reliability, minimization of operating costs for 35 kV and higher overhead lines that do not have year-round access for their maintenance and repair;

- at the stage of preparing the executive documentation of the overhead line and preparing the reporting documentation, it is necessary to prepare a layout in accordance with the rules for describing the objects of the information system used in the subsidiaries and dependent companies for the subsequent prompt introduction of changes in the architecture of the information system objects and the equipment database of subsidiaries and dependent companies;

- the use of wires with a protective insulating sheath for overhead lines

6-35 kV when passing the line in cramped conditions, through populated areas, through forests;

- the use of self-supporting insulated wires for 0.4 kV overhead lines;

- to protect wires, cables, insulators and fittings on overhead lines 35 kV and above from fatigue damage and dynamic loads, protection systems against wind vibrations (aeolian vibration, dance, sub-vibrations) should be used, while vibration protection by vibration dampers should be carried out according to the analytical method IEC 61897, protection against dance - by dance dampers according to the manufacturer's recommendations and protection against sub-vibrations - by spacers - dampers according to the manufacturer's recommendations;

- Overhead lines in difficult operating conditions (climatic, geological and special conditions), overhead lines of new voltage classes or new structural performance should, as a rule, be designed on the basis of the corresponding design and, if necessary, research work, taking into account the accumulated construction experience and operation of overhead lines.

2.5.2.2. For overhead lines passing in especially difficult conditions for operation (mountains, swamps, regions of the Far North, etc.), as part of the project documentation, a technology for organizing repair and maintenance of overhead lines should be developed, taking into account the use of mechanisms and vehicles that correspond to the conditions of future operation.

Decisions related to increasing the throughput of overhead lines when designing new ones, as well as during the reconstruction and repair of existing overhead lines, should be carried out on the basis of the corresponding development schemes for electrical networks approved in the prescribed manner.

2.5.2.3. When designing transmission lines of 110 kV and above, equipped with means of transverse compensation of reactive power, calculations of operating modes should be performed when the transmission line is disconnected after an unsuccessful TAPV or unsuccessful switching on of the transmission line from the control key.

The purpose of the calculations is to determine the possibility of the occurrence of an aperiodic current component in undamaged phases with asymmetric short-circuit. In the event of the occurrence of an aperiodic component in the undamaged phases of the overhead line, an assessment of its share in the total no-load current of the line after switching it on to an illiquid short-circuit and, if necessary, the development of systemic technical solutions to minimize it by the time the circuit breaker is turned off, as well as the requirements for circuit breakers for disconnecting ability to ensure successful disconnection of power lines.

2.5.2.4. In order to reduce the time and optimize costs during construction, technical re-equipment and reconstruction of overhead lines, the following should be considered:

- industrial methods of construction, the use of structures of high factory readiness in order to minimize the time and complexity of performing technological operations in the conditions of the overhead line, minimizing the volume of earthworks;
- arrangement and cleaning of the clearing using modern technical means (high-performance felling complexes, mulchers, etc.);
- the use of environmentally friendly technologies for clearing glades and technologies that prevent and reduce the growth rate of trees and shrubs
- the use of technologies for the construction of foundations of supports, which provide a reduction in the time spent on installation and minimization of the volume of earthworks (vibration immersion, indentation of shell piles, screwing of screw piles, rod terminations in rocky soils, the use of highly efficient working drilling bodies for drilling wells in hard rocks and rock soils);
- as a rule, the use of truck cranes, providing the installation of supports without the use of a falling boom;
- the use of helicopter technology or the installation of supports by the building-up method in hard-to-reach terrain or in confined conditions;

- replacement of steel-aluminum wires with wires with increased throughput, including high-temperature ones, if it is necessary to increase the throughput without building a new overhead line. During the reconstruction of overhead lines, this replacement must be provided with technical capabilities: the sufficiency of the strength of the supports, the bearing capacity of the bases and foundations, and stocks in size.

- the use, as a rule, of quick-fit fittings (pressed, spiral, wedge-jointed), as well as collet-type connectors, which are certified by PJSC Rosseti or have passed the quality control procedure with the appropriate wire;

- on the mains of electrical networks 6-20 kV and below with branches, the use, as a rule, of pin insulation, without branches - suspended insulation;

- use of 6-20 kV power transmission line supports for joint suspension of self-supporting insulated insulated wire with VLI for voltages up to 1000 V.

2.5.2.5. If necessary, the feasibility study of 6-20 kV overhead lines can be made in the dimensions of 35-110 kV.

2.5.2.6. When designing overhead lines 35 kV and above, it is necessary to provide technical solutions that ensure the safety of their operation, including safe lifting / lowering, moving and performing work at a height by installing stationary rigid anchor lines and stationary ladders for lifting and (or) stationary anchor points on reinforced concrete supports, multifaceted and other types of supports with the possibility of installing flexible anchor lines without lifting to the support using rods, lifters, with the possibility of further using slider-type protective equipment and for use as a safety system when working at height on a support.

2.5.2.7. When designing the construction of overhead lines in flat terrain on overhead lines, no more than two brands and sections of wires should be used. The use of grades and cross-sections of wires and lightning protection cables, and phase structures that are different from those used in the rest of the line, should be technically and economically justified in individual sections of overhead lines (large crossings through water bodies, mountains, floodplains, swamps, difficult climatic conditions)

2.5.2.8. When designing overhead lines up to 35 kV inclusive, as a rule, you should use the typical nodes presented in the agreed standard solutions.

2.5.2.9. 0.4 kV overhead lines should be performed only using self-supporting insulated wires that comply with GOST 31946-2012. If necessary, in terms of ensuring the required throughput of overhead lines, it is allowed to use self-supporting insulated wire with core cross-sections higher than given in GOST 31946-2012. When laying through buildings and when organizing input to buildings and structures, SIP-4 (self-supporting insulated wire without a carrier) with flame retardant insulation should be used. In this case, the cross-section of the conductors of the wire should not exceed 35 mm^2.

2.5.2.10. When installing a 0.4 kV overhead line (new construction, replacing an uninsulated wire with a self-supporting insulated wire, etc.) on the main sections, it is necessary to use only self-supporting insulated wire-2 with a zero load-bearing core. The use of SIP-4 (without a bearing core) is possible only when carrying out emergency recovery or repair work on the VLI sections, where the SIP-4 was installed earlier.

2.5.2.11. When designing the construction or reconstruction of a 0.4 kV overhead line:

- it is recommended to carry out an overhead line in a full-phase version with a wire of the same cross-section along the entire length of the line, if there is a prospect for the development of the electrical network;

- it is recommended to provide additional conductors with a cross-section of 16 mm2 for the possibility of connecting street lighting with its predicted development.

2.5.2.12. When designing overhead lines 35-750 kV, the results of mathematical modeling of the operating modes of power systems should be taken into account.

For the purposes of the formation of these calculation models, the design organization forms an information model of the power system in the amount necessary for the design of power transmission lines, in compliance with the requirements for the formation, updating of information models of the electric power industry and information exchange profiles approved by the Ministry of Energy of Russia in accordance with the Decree of the Government of the Russian Federation of March 02, 2017 No. 244 "On improving the requirements for ensuring the reliability and safety of electric power systems and electric power facilities and on introducing amendments to some acts of the Government of the Russian Federation." Based on the results of the development of design solutions, changes should be made to the information model of the power system related to the commissioning (decommissioning) of power lines taken into account in the design.

2.5.3. Supports and foundations

Basically, the requirements of the norms for the technological design of power transmission lines with a voltage class of 35-750 kV should be applied

2.5.3.1. On overhead lines of 35 kV and above, supports of the required height and strength should be used that comply with the current regulatory documents: single-circuit, double-circuit and multi-circuit steel supports of multifaceted and lattice structures from a corner and a bent profile, composite supports, as well as reinforced concrete supports from centrifuged sectioned racks.

2.5.3.2. On overhead lines of 35 kV and above, passing in cities and in areas with a high risk of vandalism, it is recommended to use free-standing supports made of polyhedral steel profiles and reinforced concrete supports made of centrifuged sectional racks as intermediate ones.

2.5.3.3. On 220-500 kV overhead lines passing through agricultural lands, steel or reinforced concrete from sectioned racks, free-standing supports (without braces) should be used. On overhead lines 35, 110 (150), 220 kV, passing through agricultural lands, it is possible to use composite supports with insulating traverses, provided that they ensure the reliability and safety of their use, ensure resistance to external influences and, if their use is technically and economically justified.

The use of supports with guys on sections of 35-500 kV overhead lines passing through agricultural lands, through the territory of settlements, as well as on overhead lines departing from nuclear power plants, is not allowed.

2.5.3.4. For anchor and anchor-angle supports of 220-750 kV overhead lines, in the absence of justification, steel free-standing supports of a rigid structure should be used.

2.5.3.5. The geometric parameters and weight of the supports, their placement should be optimized for specific overhead lines, including through the choice of the material of the support structure and the wider use of steels with increased mechanical strength and corrosion resistance with an appropriate feasibility study.

2.5.3.6. The structures of supports for overhead lines of 220 kV and above should provide: the possibility of maintenance and repair of overhead lines under voltage, the maximum efficiency of the installation of wires and cables, the absence of the need to obtain a special permit during transportation by road.

2.5.3.7. Steel supports, as well as steel parts of reinforced concrete supports and structures, metal foundations, U-bolts, fasteners not made of corrosion-resistant steel must be protected from corrosion at the manufacturing plants by hot or thermal diffusion galvanizing. In the absence of the technological possibility of applying a coating by hot-dip galvanizing (for example, on metal elements of reinforced concrete foundations to which grillages are welded during installation), it is allowed to apply zinc-filled paint coatings in the factory with restoration of areas damaged by welding after installation.

2.5.3.8. Estimated climatic loads on supports and foundations should be determined in accordance with engineering survey data, regional maps of climatic zoning, valid NTD, as well as the Code of Rules.

2.5.3.9. It is allowed to use high-rise supports, mounted by building up, ensuring the passage of overhead lines through industrial and infrastructure facilities or specially protected forest areas with the minimum possible width of a clearing with appropriate justification, taking into account the costs of the entire life cycle of overhead lines (50 years). For overhead lines of 110 kV and above, the route of which passes through an area characterized by frequent ground or peat fires, elevated supports should be used.

2.5.3.10. On overhead lines passing through the territory of settlements, tourist and recreational zones, near recreation sites, in national parks and reserves, at intersections with major transport arteries in the vicinity of cities, it is recommended to carry out decorative painting of poles with paint and varnish coatings with a long service life, as well as to use individual supports. designs designed for increased aesthetic requirements.

2.5.3.11. Vibrated reinforced concrete racks, multifaceted supports, metal supports from a bent profile, composite supports, as well as wooden antiseptic supports can be used on 0.4-20 kV overhead lines. The choice of the type of supports should be carried out taking into account the feasibility study, and when passing overhead lines in settlements - compliance with aesthetic requirements

For 0.4 kV overhead lines, the possibility of replacing three-column anchor-angle reinforced concrete supports with a single-column steel multifaceted support should also be considered.

2.5.3.12. The installation of wooden poles of 0.4-20 kV overhead lines should be carried out directly into the ground, the installation of wooden poles of 0.4-20 kV overhead lines using reinforced concrete stepchildren (attachments) during new construction, reconstruction or repair is prohibited.

In places of possible ground fires, the use of wooden supports is not recommended.

2.5.3.13. To prevent birds from landing and making nests on supports of 110 kV and higher overhead lines in places of stay, congregations of birds, the supports should be equipped with non-traumatic bird protection devices of an anti-attachment type that prevent the landing and nesting of birds, as well as a barrier type that protect garlands of insulators from contamination by the waste products of birds. It is allowed to use such devices for 6-35 kV overhead lines when justified.

2.5.3.14. On the supports of overhead lines with a height of 100 m and more, regardless of their location, day marking (painting) and light shielding should be provided in accordance with the current rules "Requirements for aerodromes intended for takeoff, landing, taxiing, parking of civilian military ships" approved by the order of the Ministry of Transport of Russia dated August 25, 2015 No. 262.

Low, medium and high intensity obstruction lights should be used to illuminate the poles, which are installed at the very top, at the ends of the longest traverses.

It is recommended to power the obstruction lights from renewable sources of electricity (solar battery) or by taking power from the overhead line.

On poles with a height of 50 meters and higher in the vicinity of airports, spherical signal radio-noticeable markers should be installed on lightning protection cables. Supports of overhead lines with a height of more than 150 m must have day marking (coloring) and high-intensity light shielding in accordance with the requirements of STO 34.01-2.2-016-2016 "Markers for overhead power lines. Marking of supports and spans of overhead lines ".

2.5.3.15. Supports of overhead lines installed on cramped approaches to substations, as a rule, should provide the ability to suspend from two overhead lines and more with a voltage of 220 kV and up to four circuits for voltages up to 110 kV.

2.5.3.16. The service life of metal, reinforced concrete and composite poles of overhead lines should be at least 50 years. The service life of wooden poles must be at least 40 years.

2.5.3.17. To carry out emergency recovery work on overhead lines up to 220 kV inclusive, it is necessary to provide for the use of special pre-fabricated supports, including reusable ones, a mobile set of pre-fabricated supports complete with a foundation and an insulating suspension, including multifaceted and composite supports that do not require lengthy assembly and easy to install, with a high mobilization readiness factor, in order to minimize the time for eliminating the emergency mode.

2.5.3.18. The conditions for the use of foundations on overhead lines are determined by the design documentation, taking into account the requirements of the current scientific and technical documentation, depending on the results of soil studies (engineering-geological, hydrogeological and other surveys) in the places of their installation.

2.5.3.19. When choosing the type of support foundations, preference should be given to foundations that have the least destructive effect on the soil structure.

2.5.3.20. When designing new construction and reconstruction of overhead lines, the following should be applied:

- unified prefabricated reinforced concrete foundations (buried, shallow, surface);
- monolithic reinforced concrete foundations;
- pile foundations with metal grillages (from reinforced concrete piles, tubular piles, open profile piles, screw piles);
- piles - shells (reinforced concrete centrifuged and metal).

2.5.3.21. The feasibility of introducing on overhead lines should be considered:

- industrial methods of performing work in the field;
- modern corrosion-resistant materials, weather-resistant steels and coatings to protect reinforced concrete and metal structures from corrosion;
- foundations for braces of supports with the removal of attachment points for U - shaped bolts above the ground;
- foundation structures that do not destroy soil structures in particularly difficult geocryological conditions;
- use as guy wires compacted steel ropes or similar lightning protection cables with low operating draft and aerodynamic resistance, which have the ability to self-damp vibrations.

2.5.3.22. To fix the supports in permafrost soils, one should, as a rule, use foundations that ensure the preservation of the frozen state of soils during the construction process and throughout the entire period of operation of the overhead line. It is recommended to use steel (driven and screw) piles, the internal cavity of which is filled with light (foam) material at the factory.

2.5.3.23. To fix the supports of overhead lines in rocky soils, anchor rock fillings and foundations from bored injection piles should be used.

2.5.3.24. When the overhead line passes through the dune sands, the supports should be installed between the dunes with the implementation of sand fixing measures.

2.5.3.25. The method of fixing the supports of 0.4-20 kV overhead lines in the ground should be unified.

2.5.3.26. In reinforced concrete structures of supports and foundations, in accordance with SP 28.13330 "Protection of building structures from corrosion", concretes must be used, water resistance, frost resistance and other characteristics of which will ensure reliable operation throughout the entire service life, but not less than 50 years, without the use of surface waterproofing.

2.5.3.27. In aggressive environments, use foundations made of sulfate-resistant cement, covered with specialized protective compounds.

2.5.3.28. Concrete foundations must have waterproofing to prevent the destruction of reinforced concrete from the effects of aggressive water and soil, a stable surface waterproofing that does not collapse from exposure to ultraviolet radiation, temperature changes and environmental influences.

2.5.3.29. Metal heads of reinforced concrete foundations, metal grillages must be protected from corrosion in accordance with applicable regulations.

2.5.3.30. Prototypes of the first used types of supports and foundations of overhead lines are subject to mechanical tests. When assessing the possibility of using structures of supports and foundations in conditions that differ from those for which they are designed, it is necessary to perform verification calculations of structures for specific conditions of their installation. Structural calculations should be contained in the design documentation of the overhead line.

2.5.4. Wires and lightning protection cables

2.5.4.1. On overhead lines of 35 kV and above, as a rule, steel-aluminum wires should be used.

2.5.4.2. With an appropriate feasibility study for 110 kV overhead lines and above, new wire designs can be used, which can significantly increase the throughput without increasing the load on the supports and surpassing standard wires in terms of technical characteristics:

- in new construction - wires with a core of steel and aluminum alloys or composite non-magnetic materials:

• with increased throughput;

• with a cylindrical surface made of trapezoidal or z-shaped wires or any other figured shape with a lower coefficient of aerodynamic resistance;

• possessing increased corrosion resistance;

• with increased resistance to ice and wind effects;

• possessing better deformation capacity and higher torsional rigidity;

- during reconstruction in order to increase the throughput while maintaining (or reducing) the load on the supports, as well as during the construction of large crossings, wires should be used:

• with long-term permissible temperatures up to 240 ºC with conductive layers of heat-resistant and super-heat-resistant aluminum alloys;

• with a corrosion-resistant core, including one made of steel, aluminum alloys, or with a composite core, in order to reduce the load on supports and foundations;

• with an appropriate feasibility study - wires with a built-in optical cable (OKFP).

2.5.4.3. As lightning protection cables on overhead lines 35 kV and above, the following should be used:

- ropes and wires made of steel galvanized according to the coolant group or clad with aluminum wires, lightning protection cables made of low-alloy steel with high lightning resistance, mechanical strength, corrosion resistance, resistant to wind and vibration loads;

- lightning protection cables with built-in fiber-optic cable (hereinafter OPGT), including heat-resistant optical fiber, complying with the norms and requirements of the current standards of PJSC Rosseti.

When planning the replacement of a lightning protection cable with an overhead line according to the approved target programs of subsidiaries and dependent companies and, if necessary, organizing a fiber-optic communication line for this overhead line, determined according to the approved development scheme for fiber-optic communication lines, it is necessary, if there is a technical and economic feasibility, to plan an OPGT suspension.

2.5.4.4. In areas with intense wind and ice loads, as well as at large crossings, it is recommended to use new wire designs on overhead lines of 35 kV and higher, which can significantly increase the throughput and exceed the standard ones in terms of technical characteristics in order to:

- reduction of loads on supports and foundations;
- increasing the length of the spans;
- reducing the coefficient of aerodynamic drag;
- reducing the likelihood of dancing wires;
- reducing the likelihood of wire breakage when exposed to external mechanical loads (counteracting the adhesion of snow and ice formation).

2.5.4.5. In the presence of a feasibility study at large crossings through water and other natural barriers, it is allowed to use steel ropes from galvanized wires and steel ropes from aluminum-clad wires as wires.

2.5.4.6. The service life of wires and lightning protection cables on overhead lines with a voltage of 35 kV and above must be at least 50 years.

2.5.4.7. On the highways of 6-20 kV overhead lines, an uninsulated steel-aluminum wire or a protected wire with a cross section of at least 70 mm2 should be used. On linear branches (taps) from highways, it is recommended to use steel-aluminum wires or protected wires with a cross section of at least 35 mm2.

2.5.4.8. Protected wires are recommended to be used on 6-35 kV overhead lines in the first place:

- when passing the overhead line route through a populated area;
- when passing overhead lines through forests;
- when crossing overhead lines of water barriers;
- in the absence of the possibility of observing the overall distances when passing overhead lines in cramped conditions;
- with joint suspension with 0.4 kV VLI.

With the appropriate feasibility study, it is allowed to use a self-supporting cable on 6-35 kV overhead lines.

2.5.4.9. For new construction and reconstruction of 0.4 kV overhead lines on trunk sections, it is necessary to predominantly use a certified SIP-2 brand with an insulated zero load-bearing core. The use of the SIP-4 brand on the main sections is allowed only when carrying out emergency recovery or repair work on the VLI sections where the SIP-4 was installed earlier.

2.5.4.10. The installation of 0.4 kV VLI wires with an insulated zero core can be carried out both on supports and along the walls of buildings and structures, taking into account clause 3.1.15.

2.5.4.11. VLI 0.4 kV with a distributed load along the length of the line must be performed using a self-supporting insulated wire with a cross section of at least 50 mm2. In this case, the length of the VLI 0.4 kV must ensure a stable voltage at the consumer at the end of the line in accordance with the requirements of NTD. To connect individual consumers, as well as perform a branch from the line, a self-supporting insulated wire of a smaller section, but not less than 16 mm2, can be used.

2.5.4.12. For air inputs on the sections of lines from the bushings of the switchgear cells to the first supports of 6 (10) kV overhead lines, as a rule, it is necessary to use a protected wire with flame retardant insulation. Fire hazard class of the wire - not lower than O1.8.2.5.4 in accordance with GOST 31565-2012 “Cable products. Fire safety requirements ".

2.5.4.13. The service life of the self-supporting insulated wire should be at least 40 years (the standard service life of the designed VLI).

2.5.5. Insulators and line fittings

2.5.5.1. The number and type of insulators in garlands for different purposes, coupling, supporting, tension, protective, connecting and branch (contact) fittings on overhead lines should be selected in accordance with current standards, as well as taking into account local conditions, including the availability of updated maps of insulation pollution and requirements of project documentation.

2.5.5.2. When designing new construction and reconstruction of overhead lines, you should:

- use solid-cast polymer insulators with a silicon protective shell, all year round accessible for maintenance, passing in areas with NW I-III (with the exception of overhead lines passing in areas III and higher in wind / ice), if justified;
- use strings of insulators equipped with protective fittings for overhead lines 220 kV and above;
- to use long-rod porcelain insulators for overhead lines 110 kV and above, if justified;
- to use polymer cantilever insulating traverses for overhead lines up to 220 kV inclusive, passing in cramped conditions, having the ability to approach the aerial platform to the supports for carrying out maintenance and repair of fittings and insulators;
- use glass insulators at large crossings of 35 kV overhead lines and above, on overhead lines passing in difficult conditions for operation (mountains, swamps, regions of the Far North), on overhead lines built on double-circuit and multi-circuit supports, on overhead lines supplying traction substations of electrified railways ;
- use coupling, supporting, tension, protective and connecting fittings that do not require maintenance, repair and replacement during the service life of supports and wires;

- to use for steel-aluminum wires in accordance with GOST 839 as tension compressed, wedge-jointed, spiral and, with appropriate justification, bolted fittings;
- use multi-frequency, as well as broadband (pneumatic), vibration dampers (at least 3 resonant frequencies);
- apply ice formation limiters in areas III and higher on ice;
- use dance dampers in areas with frequent and intense dance of wires;
- use phase-to-phase spacers in areas with frequent and intense dancing of wires;
- use deaf suspensions on transitional intermediate supports of large transitions;
- use linear fittings that do not cause local heating of the wire at the place of its installation;
- to use suspended glass insulators with a polymer hydrophobic coating for justification in areas with SZ IV and higher, on sections of routes with increased contamination of insulation;
- to apply on overhead lines 330-750 kV - damping distance intraphase struts in areas with frequent and intensive dancing of wires, as well as in conjunction with wires of new designs, characterized by increased rigidity;
- to recommend for use on overhead lines of 220 kV and above as a measure of strengthening the welded seam in the stubs of anchor-angle supports, the use of a spiral loop clamp;
- use anchor and branch fittings to connect to the VLI SIP branch to the entrance to the building (connection of the subscriber) from materials that do not spread combustion.

2.5.5.3. On 35-110 kV overhead lines, glass insulators are also predominantly used, and polymer insulators, with appropriate justification and equipment with overlap indicators.

2.5.5.4. When designing overhead lines of 35 kV and above, the calculation of the protection of the wire, lightning protection cable and fittings from vibration, dance and sub-vibrations using CAD should be carried out.

2.5.5.5. To reduce bending stresses and to increase the service life of the wire and lightning protection cable, it is recommended to use supporting and connecting clamps with spiral protectors integrated into the structure, using multifrequency or broadband vibration dampers installed on the wires at design locations, depending on the span length. For additional protection against vibration in order to prevent the destruction of wires (cables) in the supporting and connecting clamps, it is recommended to use protective spiral-type protectors or spiral supporting clamps.

2.5.5.6. To reduce the cost of losses during the flow of transport current, the supporting, connecting and tension fittings installed on the wires of overhead lines must be made of non-magnetic materials, while the fittings must comply with the requirement of GOST R 51177 - 2017 - energy losses caused by magnetization reversal when installed on a wire of one object of tension, support, connecting, repair, contact and protective fittings should not exceed the loss of energy in a wire

1 m long or for a section of a wire equal to the length of the fittings by more than 1.1 times.

2.5.5.7. For overhead lines of 35 kV and higher, the strength of the termination of a specific wire in tension clamps installed on transition anchor supports of large transitions must be confirmed by mandatory control tests;

2.5.5.8. The design of tension fittings of 35 kV overhead lines and above should not contribute to an increase in the length of the insulating suspension elements required for its connection.

2.5.5.9. In areas with increased damageability of insulators against vandalism, it is recommended to use polymer long-rod insulators in conjunction with an overlap indicator. It is allowed to use polymer insulation without overlap indicators if the overhead line is equipped with technical means that ensure the location of damage on the overhead line with an accuracy of a span.

2.5.5.10. When designing a 6-20 kV overhead line, the following should be used:

- suspended polymer, glass insulators;
- polymer cantilever (cantilever with a guy) insulating cross-beams;
- support-rod porcelain and polymer insulators, including those with an eyelet for protected wires;
- pin porcelain insulators with an eyelet;
- annealed glass pin insulators
- interfacial polymer insulating spacers;
- polymer insulating traverses.

2.5.5.11. On VLI 0.4 kV and VLZ 6-20 kV, it is necessary to use linear fittings of the appropriate design.

Connections and branches on VLI 0.4 kV and VLZ 6-20 kV should be performed only with the use of special clamps corresponding to the type of self-supporting insulated wire or protected wire. Connections of branches to the inputs of overhead lines with internal wiring should be carried out using branching disposable, piercing, sealed clamps with a shear head, reuse of clamps with a shear head is not allowed.

2.5.5.12. For 6-35 kV overhead lines, fittings with structural elements made of plastic must be tracking resistant.

2.5.5.13. For VLI 0.4 kV and VLZ 6-35 kV, fittings should be used that ensure the possibility of installation at temperatures up to minus 20 ° C.

2.5.5.14. For VLI 0.4 kV and VLZ 6-35 kV when organizing a branch from the main line, as well as when connecting bare wires with insulated wires, fittings should be used that have color differentiation by voltage classes:

2.5.5.15. For 0.4 kV VLI, fittings made of combustible and non-combustible materials must have color differentiation.

2.5.5.16. Linear fittings for overhead lines must be maintenance-free and correspond to the service life of the wires, cables for which it is intended.

2.5.5.17. The service life of porcelain and glass insulators must be at least 30 years, polymer insulators - at least 40 years.

2.5.5.18. When carrying out emergency recovery work on overhead lines up to 220 kV inclusive, for connecting wires it is possible to use universal clamps (Figure 1), designed for several wire cross-sections and mounted using a hand tool without using a press or other means of mechanization, selected taking into account the climatic version, with the purpose of minimizing the time to eliminate the emergency.

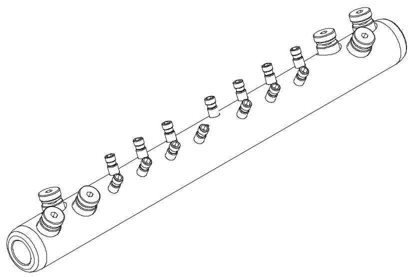

Figure 1. An example of a universal clamp for elimination of faults on overhead lines 35-220 kV

2.5.6. Lightning surge protection

2.5.6.1. The main means of protecting overhead lines from overlap due to lightning strikes into the elements of overhead lines are suspension of lightning protection cables and grounding of supports. It is allowed to use surge arresters on overhead lines of 110 kV and above in areas with icy conditions IV and above instead of installing a lightning protection cable.

2.5.6.2. Overhead lines of 110 kV and above, as a rule, must be protected along their entire length from lightning overvoltages and direct lightning strikes by lightning protection cables.

2.5.6.3. For overhead lines up to 35 kV, inclusive, the use of lightning protection cables along the overhead line route is not required, with the exception of sections of the approach to the switchgear and substation. The use of cables and/or protective devices to increase the reliability of the operation of overhead lines up to 35 kV is allowed in the presence of a feasibility study.

2.5.6.4. Protection of the approaches of the overhead line to the substation should be carried out with cables and/or protective devices.

2.5.6.5. When passing overhead lines in areas with high soil resistivity, in order to increase the lightning resistance of overhead lines, it is recommended to consider strengthening the grounding loops of supports with extended and deep grounding conductors, and if this measure is insufficient, use the combined use of lightning protection cables and overvoltage protection devices, including linear surge arresters or RMZ. In the case of using surge arresters as overvoltage protection devices on 6-35 kV overhead lines in electrical networks with insulated (compensated) neutral, preference should be given to arresters with an external spark gap, and on 110 kV overhead lines and above, surge arresters without an external spark gap.

2.5.6.6. In electrical networks with a voltage of 110 kV and above, during new construction and reconstruction, it is necessary to provide for the installation of protective devices with trip counters, and for surge arresters - with a current pulse current sensor and the ability to measure leakage currents under operating voltage.

2.5.6.7. The use of lightning overvoltage protection devices on overhead lines 6-35 kV should provide protection:

- wires from overheating and thermal destruction;
- approaches to the substation reactor plant;
- insulation of overhead lines from overlapping and damage;
- switching equipment;
- cable sleeves;
- places of intersection of overhead lines with engineering structures;
- pole and mast transformer substations.

2.5.6.8. On overhead lines with protected wires passing through a populated area and a zone with thunderstorm activity of 20 thunderstorm hours or more, it is also necessary to provide for the installation of overvoltage protection devices when designing.

2.5.6.9. The metal elements of the brackets and hooks of the 0.4 kV VLI should provide the possibility of bolting the re-grounding conductors.

2.5.6.10. It is recommended to connect the neutral conductor to the grounding descent of the 0.4 kV VLI support when performing re-grounding using special flexible conductors.

2.5.7. Linear switching equipment 6-35 kV

2.5.7.1. To optimize operating modes, increase the reliability of power supply to consumers, reduce operating costs and repair and restoration work, it is necessary to automate 6-35 kV networks when designing by:

- the use of automatic input of the reserve;
- the use of outdoor vacuum switches (reclosers), with microprocessor control units that allow programming the operation of the switches for the required operating modes for sectioning overhead lines;
- organization of the automatic reclosing system both at the linear switches of the central processing unit and at the sectioning points of the overhead line;
- the use of a switch for disconnecting branches of overhead lines;
- equipping with devices for determining the locations of damage to overhead lines;
- organization of continuous monitoring using ASMD overhead lines in accordance with subsection 3.7.3 of the Technical Policy.

2.5.7.2. Sectioning points with vacuum switches and points for automatic switching on of the reserve must be installed on the main lines of 6-35 kV, as well as on extended branches of overhead lines in the presence of a feasibility study.

2.5.7.3. ATS points and sectioning points must be equipped with vacuum switches and microprocessor-based protection and automation devices.

2.5.7.4. To disconnect branches from the trunk, the length of which is more than 1.5 km, it is recommended to install a switch at the beginning of these branches.

2.5.7.5. In order to increase the controllability and controllability of the electrical network, all automation systems should operate with the ability to transmit information to the NCC about the current state of the equipment, as well as provide the ability to remotely control this equipment.

2.5.8. Requirements for overhead lines passing in difficult climatic, geological and special conditions

2.5.8.1. Areas with difficult climatic, geological and special conditions include:

- ice region IV and higher (ice wall thickness 25 mm and more with a repeatability of 1 time in 25 years);
- wind region V and higher (standard wind pressure 1000 Pa and more at a height of 10 m above the earth's surface with a repeatability of 1 time in 25 years);
- areas where the wind pressure during ice with a repeatability of 1 time in 25 years exceeds 280 Pa, regardless of the area on ice;
- Areas with frequent and intense dance of wires;
- Areas with permafrost, waterlogged, swampy, heaving soils;
- Areas with frequent ground or peat fires;
- Areas with a high risk of vandalism;
- areas where the accident rate of overhead lines of this voltage class due to the impact of ice and wind loads exceeds the average for the region, regardless of the area by wind or ice, according to climatic zoning maps or regional maps.

2.5.8.2. When designing overhead lines in difficult climatic and geological conditions, it is necessary to take into account the problems arising during the operation of overhead lines in the regions under consideration, such as:

- increased vibration of wires and cables;
- clashing of wires and cables when dancing, dumping ice and under wind influences;
- low lightning-proof overhead lines;
- insulation overlapping in case of grassland and peat fires;
- cryogenic destruction of reinforced concrete piles;
- frost heaving of piles of foundations of supports, etc.

2.5.8.3. In areas with frequent formation of ice and in special icy areas, as well as in areas with high wind loads, it is necessary to consider the possibility of building cable lines instead of overhead lines.

2.5.8.4. In order to ensure reliable operation of overhead lines in areas with difficult climatic conditions, measures and options for the construction of overhead lines should be considered:

a) in icy areas, as well as in areas with high wind loads:

- construction of overhead lines in "ice-resistant" design, i.e. designed for the maximum observed ice-wind loads (the use of supports, wires and linear fittings with increased mechanical strength, the use of special types of wires with high antiicing characteristics, the use of reduced lengths of anchor spans), without the use of ice melting;

- construction of overhead lines with the organization of ice melting on wires and lightning protection cables;
- the use of phase-to-phase insulating spacers, limiters of ice formation and adhesion of wet snow on the wires, the use of supports with increased distances between the phase wires and between wires and cables, dance dampers to prevent wires from entangling when dropping ice;
- for overhead lines 35 kV and above - the use of double-circuit supporting and tension strings with separate attachment of chains to the support;
- the use of glass insulators or, if justified, polymeric;
- horizontal arrangement of the OHL phases;
- application of AISKGN;

b) in areas with intense dancing wires:

- for overhead lines 6-35 kV - the use of phase-to-phase insulating spacers;
- for overhead lines 110 kV and above - the use of dance dampers;
- the use of supports with increased distances between phase wires and between wires and cables, taking into account the possible trajectories of wires when dancing;
- for 110 kV overhead lines and above - the use of single-circuit overhead lines with horizontal phases and surge arresters instead of a ground wire (with the number of lightning outages not exceeding three per year for 110-330 kV overhead lines and one for 500 kV overhead lines), reduced (up to 25% of breaking force) tension of wires and cables, with a simultaneous decrease in the length of the overhead line spans;
- for overhead lines 6-110 kV inclusive - the use of reduced lengths of anchor spans and the use of support structures, including those made of composite materials;

c) in areas with a high risk of vandalism:

- the use of free-standing supports, including multifaceted, reinforced concrete sectioned and composite, the use of support structures characterized by increased protection from the influence of third parties;
- the use of polymer insulation;

d) in areas with frequent ground and peat fires:

- the use of supports with an increased height of the wire suspension, with an appropriate economic justification. The material of the supports of 0.4-35 kV overhead lines (wooden, reinforced concrete, metal, composite) should be selected depending on the terrain, conditions and installation method on the basis of a feasibility study, taking into account the minimization of the effects of fires in the protected area of overhead lines;
- the use of glass insulators;

e) in areas with permafrost, watered, waterlogged, heaving soils:

- to use, as a rule, supports and foundations of an individual design (both newly developed and manufactured according to re-use drawings);

- the use of monolithic concrete foundations is allowed;
- to fix supports in permafrost soils, as a rule, you should use foundations that ensure the preservation of the frozen state of soils during construction and throughout the entire period of operation of the overhead line. It is recommended to use steel (driven and screw) piles, the inner cavity of which is filled with light (foam) material at the factory.

2.6. Cable lines

2.6.1. General provisions

2.6.1.1. The main directions of technical policy in the design, construction, technical re-equipment and operation of cable lines and cable jumpers 110 kV and above (CL) are:
- ensuring the reliability and efficiency of the cable line;
- use of cables with XLPE insulation;
- application of stationary continuous monitoring systems using ASMD CL 110 kV and above;
- reduction in the cost of construction and operation of cable lines;
- reducing the impact on the environment due to the optimal use of land, the use of structures and design solutions that, other things being equal, require the least alienation of land for permanent and temporary use;
- reduction of electricity losses in cable lines;
- the use of structures and materials that provide resistance to vandalism, theft and damage by third parties;
- the use of advanced, safe methods of construction, operation and repair;
- with the development of technologies for diagnostics of cable lines, the use of systems for diagnosing the technical condition of cable lines under operating voltage without taking out of service
- equipment of CL 35 kV and higher with means of determining the location of the short circuit of the CL;
- equipping 6-20 kV cable lines in electrical networks with isolated neutral with devices for determining the location of the short circuit of the cable line of the topographic type, which make it possible to determine the direction of the short circuit current flow to the place of damage and transfer information about the damaged section of the electrical network.

2.6.1.2. CL must meet the following basic requirements:
- CL 6 kV and above must be plotted on the electronic GIS maps of the PTK NCC with overlay on the terrain plan with a geo-base, indicating engineering communications near the cable line, places of installation of couplings and applying fiducial marks;
- in 110 kV cable lines and above, continuous monitoring should be carried out using ASMD of the current parameters and current state (primarily the parameters of the cable line capacity) based on the use of fiber-optic digital technologies, which make it possible to remotely receive information about the

corresponding monitored parameters on electronic GIS PTC maps NCC;

- in the 6-35 kV electrical network, protection and automation devices should be used, operating according to the logical scheme of disconnecting the damaged section and the function of self-healing of undamaged sections with the display of information on the electronic GIS maps of the PTK NCC.

2.6.1.3. GIS PTK NCC should operate on the basis of a common information model (CIM-model) of the network.

2.6.2. Technical solutions for design, new construction and reconstruction of cable lines

2.6.2.1. A prerequisite for the design of cable lines is the availability of permission from land users / rightholders for its placement, the conditions for occupying land plots, as well as coordination with the owner of engineering communications for the intersection, convergence with the designed cable lines, and when crossing the cable lines with navigable rivers and other water spaces - owners of engineering structures and organizations engaged in the economic use of the water body.

2.6.2.2. When designing cable lines, it is recommended to use standardized or standard designs of cable manholes, cable structures and other elements that comply with the current regulatory legal acts and LNA.

2.6.2.3. At the stage of preparing the executive documentation for the CL and preparing the reporting documentation, it is necessary to prepare a layout in accordance with the rules for describing the objects of the information system used in the subsidiaries and dependent companies for the subsequent prompt introduction of changes in the architecture of the information system objects and the equipment database of subsidiaries and dependent companies.

2.6.2.4. When developing design documentation for cable lines, technologies should be used aimed at reducing the production of earthworks, including through the use of trenchless methods for laying cable lines (horizontal directional drilling) or collectors in order to protect environmental zones and landscaped areas of cities and places saturated with engineering communications and infrastructure facilities;

2.6.2.5. The design of cable lines should be carried out on the principle of minimizing the number of couplings, unifying the equipment used.

2.6.2.6. Design of cable lines in special conditions (underwater laying, laying of cable lines along bridge structures), cable lines of new voltage classes or new structural design, construction of transition points on special supports should be carried out on the basis of appropriate design and, if necessary, research and development work, special technical conditions.

2.6.2.7. When designing an underwater cable line, it is necessary to provide for:

- cable exit to coastal cameras;

- reserve, for underwater laying of single-phase cables 110 kV and above: for one cable line - one phase, for two cable lines - two phases, for three or more the number is determined by the design documentation, but not less than two phases. Standby phases must be routed so that they can be used to replace any of the active operating phases.

2.6.2.8. When designing cable lines, the following should be taken into account:

- rated mains voltage and neutral grounding mode;
- frequency and duration of overload;
- current and shutdown time of short circuit and short circuit;
- the required load capacity of the cable line;
- climatic conditions;
- special requirements for the cable design (optical fiber embedded in the cable), as well as sealing (longitudinal or transverse) of the cable insulation;
- the condition for ensuring the safety of CL from the actions of unauthorized persons;
- heating of CL from closely located heat sources, soil temperature, exposure to solar radiation;
- geometric arrangement of single-phase cables;
- method and conditions of laying, the state of the natural environment (aggressiveness of soil, groundwater, and others);
- the way of arranging screens, the presence and location of transposition points for screens of single-phase cables;
- construction length and number of couplings and end couplings, their location;
- fire safety requirements;
- compensation for thermal elongation;
- maintainability and arrangement of a technological reserve in case of replacement of couplings;
- provision and ease of maintenance.

2.6.2.9. The design and construction of a new cable line should be carried out on the basis of an approved scheme for the development of electrical networks. When laying cable lines in a populated area, the route must be selected in accordance with the Instructions for the design of urban electrical networks, approved by urban planning documentation (master plans of cities and other settlements, schemes and projects of planning and development of territorial entities, etc.).

2.6.2.10. In cities, single cable lines should, as a rule, be laid in the ground (trenches) along impassable parts of streets, under sidewalks, in courtyards and technical lanes in the form of lawns.

2.6.2.11. Technical solutions during the construction (laying) of cable lines (KVL) should exclude the possibility of damage to adjacent phases of the cable in the event of damage in one of the phases.

2.6.2.12. It is recommended to lay cable lines in the amount of 10 or more in a stream in collectors, cable ducts and cable tunnels. When crossing streets and squares with improved coatings and with heavy traffic, cable lines must be laid in specialized heat-resistant pipes to protect power cables, including with the ability to determine the location of cable damage in a pipe made of non-magnetic materials.

2.6.2.13. In confined or filled with underground communications sections of the route, at the intersection of highways, railways, rivers, canals and other bodies of water, wide streets and streets with heavy traffic and others, it is recommended to lay cable lines in a closed way.

2.6.2.14. It is recommended to provide redundant cables or redundant pipes at intersections.

2.6.2.15. Pipes for cable laying must be specialized heat-resistant to protect power cables, including with the ability to determine the location of damage to the cable in the pipe, made of non-magnetic materials. It is allowed to lay three-core cables or single-phase cables fastened in a triangle in pipes made of magnetic material. In this case, the calculation of the permissible current load must be carried out taking into account additional losses in the pipe.

2.6.2.16. Cable entries into buildings, cable structures and other premises must be made in asbestos-cement, concrete, ceramic or polymer pipes.

2.6.2.17. The need to lay reserve pipes should be determined by a feasibility study, while for 110 kV cable lines and above with a pipe section length of more than 100 m, as well as in other cases, if justified, for the fastest possible repair work, reserve pipes with a reserve cable should be provided (for CL of single-phase cables - one cable for each circuit). When using pipe sections with a length of more than 500 meters, as a rule, a reserve must be provided - at least two pipes for each chain. When laying cable lines in pipes, specialized heat-resistant pipes should be used to protect power cables, including with the ability to determine the location of cable damage in the pipe.

2.6.2.18. If it is necessary to lay cable lines in aggressive soils, measures should be taken to replace the soil, while the need for laying cable lines in sealed pipes should be additionally considered.

2.6.2.19. The cable line, including on the sections of the KVL, must be protected from overvoltages (lightning and switching) with the installation of a surge arrester. At the same time, protection against lightning overvoltages is not required for cable inserts 35-220 kV with a length of 1.5 km or more at high-voltage lines, protected by cables.

2.6.2.20. For CL 35 kV and above, after preliminary selection of the cable cross-section and design, a clarifying thermal calculation of the cable must be performed in accordance with GOST R IEC 60287, taking into account all factors that determine the temperature regime of the cable.

2.6.2.21. Cable entries into the substation building and other cable structures (chambers, collectors, microtunnels, etc.), places of branches, passages through each floor and building structures must be sealed with modern fireproof materials (products) with a fire resistance limit of at least EI 45, reusable providing reliable waterproofing from the ingress of groundwater.

The design of the cable sealing units in the GIS ceilings must be demountable and reusable.

2.6.2.22. Transition points (BCPs) at KVL located in the residential area should be of a closed type or with placement on special transitional supports (portals); on the territory of the OSG substation, the transition points should be of an open type, ground-based design.

2.6.2.23. When placing the PCB on special transitional supports (portals), it is necessary to provide for the following solutions:

- the design of the supports should take into account the additional load;
- cable sleeves, surge arresters, support insulators and other equipment should be placed on special structures that allow performing equipment maintenance work without assembling scaffolding and using lifting mechanisms;
- access of third parties must be excluded;
- the cable must be protected from mechanical damage from ground level to the base plate of the termination;
- along the cable line route, in front of the end couplings, a supply of cable must be provided for rewiring the end coupling.

2.6.3. Cables

2.6.3.1. When constructing cable lines, it is necessary to be guided by the following requirements:

- use cables that have passed prequalification tests for reliability in accordance with GOST R IEC 60840 (IEC 60840), GOST R IEC 62067-2017 (IEC 62067);
- for cable lines with voltage classes of 110 kV and above, cables with XLPE insulation and conductor cross-sections up to 3000 mm2, with longitudinal sealing along the core, transverse and longitudinal sealing along the screen against moisture penetration, including new generation completely made of sealed structures, should be used , with built-in optical fiber for cable temperature monitoring;
- for underwater laying, armored cables of a single construction length with XLPE insulation should be used, ensuring operation during the assigned service life under conditions of hydrostatic pressure;
- for cable lines with a voltage of 20, 35 kV, cables with XLPE insulation should be used; the need to use a cable with built-in optical fiber for monitoring the cable temperature should be determined during design;
- for cable lines of all voltage classes, it is recommended to use cables with a reinforced outer polyethylene sheath for laying in the ground, preferably having the ability to lay at temperatures up to minus 20 ° C without preheating, with an outer semiconductive layer, including as part of a fire retardant coating applied during laying cable on its sheath made of materials of low flammability, with low smoke and gas emission, or from halogen-free compositions with a high oxygen index for laying in engineering structures;
- when designing the transition of cable lines from the coast to the sea in the presence of a strong sea surf, laying a cable in sections of rivers with strong currents and eroded banks, as well as at great depths (from 40 to 60 m), it is necessary to

choose a cable with double metal armor;

- for laying in mountainous areas, use armored cables and lay them in special engineering structures;
- use armored cables for laying in zones of seismic activity. The method of laying should be determined by the design documentation with the use of special protection measures;
- for laying cable lines in cable structures, fireproof power cables with a flame-retardant sheath with low emission of toxic gases and smoke should be used;
- for laying cables in fire protection systems, as well as in other systems that must maintain the system operability in a fire, use a fire-resistant cable that does not spread combustion when laying in a group, with a reduced smoke and gas emission, version "ng";
- for laying cables in soils containing substances that have a destructive effect on cable sheaths (salt marshes, swamps, bulk soil with slag and building material), as well as in areas hazardous due to the effects of electrocorrosion, use cables with lead sheaths and reinforced protective covers or cables with aluminum sheaths and reinforced protective sheaths;
- for laying cables in soils subject to displacement, cables with wire armor should be used, or technical solutions should be taken to eliminate the forces acting on the cable when the soil is displaced;
- for laying and fixing cables in cable structures, metal structures with bolted joints of structural elements, with an anti-corrosion coating, made at the factory by hot or thermal diffusion galvanizing should be used. Fixation of cables to metal structures should be carried out mainly with cable clamps made of polymer materials.

2.6.3.2. The choice of the cable core cross-section should be based on the calculation of the required throughput and thermal resistance to short-circuit current, installation depth, ambient temperature, soil thermal resistance, cable placement method (in a plane or triangle), the presence of long pipe transitions, the type of grounding and the design cross-section cable shields, distances between circuits, cable structures, the presence of utilities (cable lines, heating network and others).

2.6.3.3. The throughput of the cable line should be determined from the calculation of electrical modes in the adjacent network for normal and repair schemes of the network, taking into account the maximum consumption of the area of the prospective development of the electrical network and the growth of loads. The choice of the cable core section should be confirmed by calculations in accordance with the requirements of GOST 22483-2012 (IEC 60228), GOST R IEC 60287-2-1-2009 (IEC 60287) and GOST R IEC 60949-2009 (IEC 60949).

2.6.3.4. In distribution networks up to 1 kV, cables with a zero core must be used. The cross-section of the neutral conductor for cable lines supplying mainly single-phase loads (more than 50% in terms of power) must be at least the cross-section of the phase conductor. The cross-section of the neutral conductor can be greater than the cross-section of the phase conductor, if this is required to ensure the permissible voltage deviations at the consumer, as well as when it is impossible to provide other means with the necessary selectivity of line protection against single-phase short circuits. In all other cases, the conductivity of the neutral wire should be taken at least 50% of the conductivity of the phase wires. The use for this purpose of the lead sheaths of three-core power cables is allowed only in the reconstructed urban electrical networks 220/127 and 380/220 V.

2.6.3.5. It is recommended to use cables and cable accessories of the same manufacturer or different manufacturers that have passed joint tests (certification) as part of the cable system.

2.6.3.6. Cables must comply with fire safety requirements in accordance with GOST 31565, as well as comply with the requirements for permissible maximum operating voltages, the magnitude and duration of the voltage rise in accordance with GOST R 57382-2017.

2.6.3.7. In accordance with the required load capacity of the cable line, the cross-section of the current-carrying conductors of the cables should be selected according to the section with the worst cooling conditions for a cable with a length of at least 10 m according to:

- GOST 31996 for cables with plastic insulation for rated voltage up to 1 kV;
- IEC 60502-2 for plastic insulated cables 6-20 kV;
- catalog (reference) data of manufacturers for cables of other designs and voltage classes.

2.6.3.8 Cables with a service life of at least 30 years should be used.

2.6.4. High voltage cable fittings

2.6.4.1. The number and types of cable fittings used should be determined by the design documentation for the cable line laying. The fittings should have the maximum degree of factory readiness, which minimizes the influence of the human factor during installation and the likelihood of damage to the structural elements of the couplings during installation and transportation.

2.6.4.2. When choosing cable fittings for cable lines 110 kV and above, one should be guided by the requirements:

- use cable accessories that have passed prequalification tests for reliability in accordance with GOST R IEC 60840 (IEC 60840), GOST R IEC 62067-2017 (IEC 62067);
- the end fittings (end couplings and gas-insulated bushings) should be collapsible, preferably have an external insulator made of polymeric materials, focused on the exclusion of the use of liquid dielectric media and make-up fittings (except for cases stipulated in the design documentation), allow removing the insulator to perform maintenance works, adapted to the installation of cables with optical fibers integrated into the cable shield. Composite insulators for outdoor terminations should be used with different creepage distances depending on the degree of atmospheric pollution at the facility;
- use dry (without filling with compound) connecting and connecting-

transposition couplings of a prefabricated structure, the structural elements of which have passed factory tests, with the possibility of placing them in the ground and in cable structures, with reliable sealing against moisture penetration, ease of installation, with the connection of optical fibers (built into the cable shield) that do not require maintenance, with the longest shelf life of the repair kit (at least three years);

- connection fittings that do not require maintenance should be used;
- fittings should be used, the design of which provides protection against mechanical damage, penetration of water and dust;
- end fittings with special adapters for periodic monitoring of PD levels using mobile measuring installations should be used, as well as have a design for the installation of stationary sensors for monitoring partial discharges and measuring currents in cable shields;
- for the installation and fastening of end couplings, metal structures with an anticorrosive coating, made in the factory by the method of hot or thermal diffusion galvanizing, should be used;
- service life of cable fittings - at least 30 years.

2.6.4.3. The following should be used as cable fittings for cable lines 1-35 kV:

- fittings based on heat-shrinkable tracking-resistant, non-combustible, flame retardant tubes and products;
- cable fittings of cold shrinkage and on the basis of pre-fabricated elastomeric elements.

2.6.5. Requirements for arrangement of cable shields

2.6.5.1. In single-phase cables with XLPE insulation (XLPE or XLPE) up to 500 kV inclusive, it is necessary to pay special attention to the selection of the cross-section, the methods of connection and grounding of the screens.

2.6.5.2. The choice of the design, cross-section of the screen and the method of its grounding should be carried out according to the conditions of permissible heating of the cable in normal operation, as well as according to the conditions of its thermal resistance, including in the mode of short-circuit currents, with ensuring the electrical safety of servicing the transposition boxes in accordance with the current requirements, taking into account their the number, locations and design of cable lines based on the principle of minimizing the number of connecting transposition couplings.

2.6.5.3. Checking the admissibility of the chosen method of grounding cable screens and calculating the transposition of screens should be carried out during design, taking into account the permissible voltages on the cable screens when the maximum operating current and short-circuit current flow through the conductor during the time due to the operating conditions of the protection and automation.

2.6.5.4. Specialized transposition wells for cable lines must be sealed, maintainable and protected from access by unauthorized persons.

2.6.5.5. Cable shields must be grounded in accordance with the selected shield arrangement by connecting the substation, transposition point or transition point to the grounding device. The cross-section of the grounding conductor should be selected according to the results of the corresponding calculations.

2.6.5.6. When grounding metal shields of cables at substations and transition points, the shields must be connected directly to the ground loop or through the grounding box. If the end sleeve is installed at an open transition point or switchgear of a substation, the design of the grounding box should provide for its external installation. The earthing box shall provide the possibility of earthing the cable screens for testing. In case of one-sided grounding of cable shields in the place of their earthing between the metal shields and the ground loop, surge arresters must be installed, located in the end box.

2.6.5.7. The connection (transposition) and grounding conductors of the shields must be accessible for measuring currents with a clamp meter on the cable line under load.

2.6.5.8. For 110 kV cable lines and above, in the case of using a grounding scheme for screens with their transposition, boxes (boxes, cabinets) should be used for the transposition of screens made of non-magnetic material, with reliable sealing against moisture penetration, ease of installation and the possibility of rewiring transposition cables without replacing structural elements. It is recommended to use the design of boxes with surge arresters, which can not be disconnected during testing of the cable sheath with a constant voltage of 10 kV, with box sizes that allow their replacement without disassembling the building structures of cable structures (wells). To place transposition (grounding) boxes, it is preferable to use cable structures (transposition wells).

2.6.6. Cable collectors and underground structures

2.6.6.1. Cable collectors and underground structures (cable tunnels, cable galleries and closed passage chambers) must meet the following requirements:

- to ensure the convenience of inspections, maintenance and repair of cable lines;
- to ensure reliable safe operation of building structures;
- to ensure the reliability of the engineering life support systems.

2.6.6.2. Technological solutions for the design of cable collectors and underground structures (cable structures) should be selected based on the conditions:

- feasibility and economic feasibility;
- implementation of environmental measures in accordance with applicable law;
- application of a unified style of design of facades of ventilation shafts and ventilation kiosks of cable collectors.

2.6.6.3. The use of cable structures (through or non-through) or closed pipe crossings by the method of horizontal directional drilling is recommended when laying cable lines in residential areas, in forest park zones, in specially protected natural areas, when crossing railways, federal and regional transport highways, engineering structures , water obstacles, with the use of casing casings or an additional reserve pipe for each cable line.

2.6.6.4. When choosing a method for laying cable structures, preference should be given to the device of cable passages using the shield penetration method, especially in areas of urban networks saturated with engineering structures and underground communications.

2.6.6.5. Constructive solutions of cable structures should provide the necessary cable bending radii, redo the SF6 glands of cable lines without destroying and damaging structural elements, have platforms for inspecting end couplings without assembling scaffolds and disconnecting the cable lines.

2.6.6.6. It is allowed, with appropriate justification and development of special technical conditions, to lay cable lines in cable structures with the organization of cable line outputs at a distance of up to 500 m.

2.6.6.7. When designing cable structures, it is necessary to provide a convenient passage to the cable structure for service personnel through entrances with stairs and free, at any time of the year, access for personnel, vehicles and mechanisms to the entrances on paved roads.

2.6.6.8. The design of the cable structure and the building materials used must ensure reliable operation in conditions of increased vibration and possible inflow of groundwater. The clear height must be at least 2.5 m.

2.6.6.9. In the design and construction of cable structures, the use of prefabricated reinforced concrete structures should be limited as much as possible.

2.6.6.10. In the chambers of cable structures, technological openings should be provided for performing repair work on cable lines without disassembling building structures (for laying a cable, lowering transposition boxes, couplings, metal structures).

2.6.6.11. The design of the cable structure must ensure the possibility of laying at least two backup cable lines in each cable structure, and also allow the location of repair couplings anywhere in the cable structure.

2.6.6.12. Cable structures of all types must be carried out taking into account the possibility of additional cable laying in the amount of 15% of the number of cables provided for by the project.

2.6.6.13. Specialized sealed wells for cable lines made of monolithic reinforced concrete or polymeric materials with the possibility of maintenance, protected from access by unauthorized persons (second anti-vandal lockable covers) should be used.

2.6.6.14. When designing cable collectors and underground structures, technological solutions for equipping them with stationary engineering systems should be considered and applied, based on economic feasibility, ensuring safety, ensuring the reliability of power supply, as well as occupational health and safety of the service personnel:

- ventilation (supply with mechanical induction);
- water removal (drainage pumps);

- working and emergency lighting;
- security and fire alarm systems;
- control of gas content and oxygen content;
- temperature control;
- personnel evacuation;
- dispatching control of technological equipment (pumps, fans, air and fire-retardant valves);
- high-frequency stem communication;
- electricity metering for operation;
- external power supply (second category);
- access control and penetration of unauthorized persons.

2.6.6.15. When designing a digital electrical network, the engineering systems of cable structures must be provided with systems of automatic control, automatic actuation, remote control and video surveillance, continuous monitoring using ASMD equipment and apparatus.

2.7. Promising technologies

2.7.1. General provisions

2.7.1.1. The use of promising technologies will make it possible to make the transition to an electric grid of a new technological structure with qualitatively new characteristics of reliability, efficiency, availability, manageability and customer focus of the electric grid complex of the Russian Federation as a whole.

2.7.1.2. The promising technologies for use in the power grid complex currently include:
- equipment based on the phenomenon of superconductivity;
- active-adaptive electrical networks;
- DC links and asynchronous electromechanical frequency converters;
- high-power storage batteries and energy storage.

2.7.1.3. Large-scale introduction of promising technologies is possible after positive testing, taking into account the prepared regulatory and technical base and confirmed technical and economic indicators.

2.7.2. Equipment based on the phenomenon of superconductivity

2.7.2.1. There are two types of superconductivity:
- low-temperature (LTSC), corresponding to the temperature of liquid helium (4.2 ° K);
- high-temperature (HTSC), corresponding to the temperature of liquid nitrogen (77 ° K).

Historically, the limiting value for attribution to HTSC is a temperature of 30 ° K. At the moment, HTSC means superconductors with a critical temperature above the boiling point of nitrogen (77 ° K or minus 196 ° C).

The phenomenon of superconductivity consists in the loss of electrical resistance by a material when cooled below the critical temperature characteristic of a given material.

2.7.2.2. HTSC cable

HTSC cables (HTSC CL) are used to transmit high power (more than 50 MW) at the middle voltage class, mainly in the following cases:

- unification of the energy "rings" of the energy systems of megalopolises;
- power supply of non-remote large consumers at the "generator" voltage;
- transmission of electric power at medium voltage, as an alternative to the transmission system of high and ultra-high voltage levels with a large number of transformation stages;
- transmission of electrical power at medium voltage, as an alternative to gas-insulated transmission lines.

According to their design, HTSC CLs are divided into three main categories:

- single-core (single-phase) cable: one phase of electric current per one cryogenic sheath;
- three-core (three-phase) cable: three cores of a single-phase cable in one cryogenic sheath;
- triaxial cable: three phases of electric current are concentrically located on a common core inside a common cryogenic sheath.

2.7.2.3. High temperature superconducting current limiting device

A high-temperature superconducting current-limiting device (HTSC TOU) is a cryogenic device consisting of a non-linear resistor in an insulating / cooling liquid nitrogen medium.

The main function of the HTSC TOU is almost instantaneous limitation of the short-circuit current.

The use of HTSC TOU is possible for:

- limitation of short-circuit currents in the electrical network;
- unification of sections of the electric network that are open according to the conditions of the short-circuit currents.

2.7.3. Active-adaptive electrical networks

2.7.3.1. The formation of the concept of an active-adaptive electric power network is due to the development of technologies such as:

- FACTS;
- Power transmission lines and DC links based on modern converting devices with microprocessor control;
- high-speed communication facilities;
- monitoring of the dynamic properties of EPS (WAMS - Wide Area Measurement Systems) based on the registration of vector parameters of the electrical mode of the network in real time using modern technical means of processing and transmitting information;
- microprocessor technology for information processing and equipment control;
- introduction of digital technologies for information processing and

equipment control, including continuous monitoring using ASMD with predictive analysis of equipment condition.

2.7.4. DC links and asynchronous electromechanical frequency converters

2.7.4.1. A direct current link (DC link) is a converter PS designed to convert alternating current into direct current and then convert direct current into alternating current of the original or other frequency.

2.7.4.2. HVAC based on the use of power electronics elements make it possible to provide:

- connection of two electric power systems of the same nominal frequency, but different non-fixed phase shifts;
- connection of electric power systems with different frequencies and phases.

2.7.4.3. HVAC can be used to combine open circuit sections of the network under the conditions of limiting the short-circuit currents, providing a controlled flow of active and reactive power.

2.7.4.4. An asynchronized electromechanical frequency converter (ASEMFC) is an electric machine, on a common shaft of which two asynchronized revolving motors/ generators are installed (Figure 2), and is a functional analogue of a VCT.

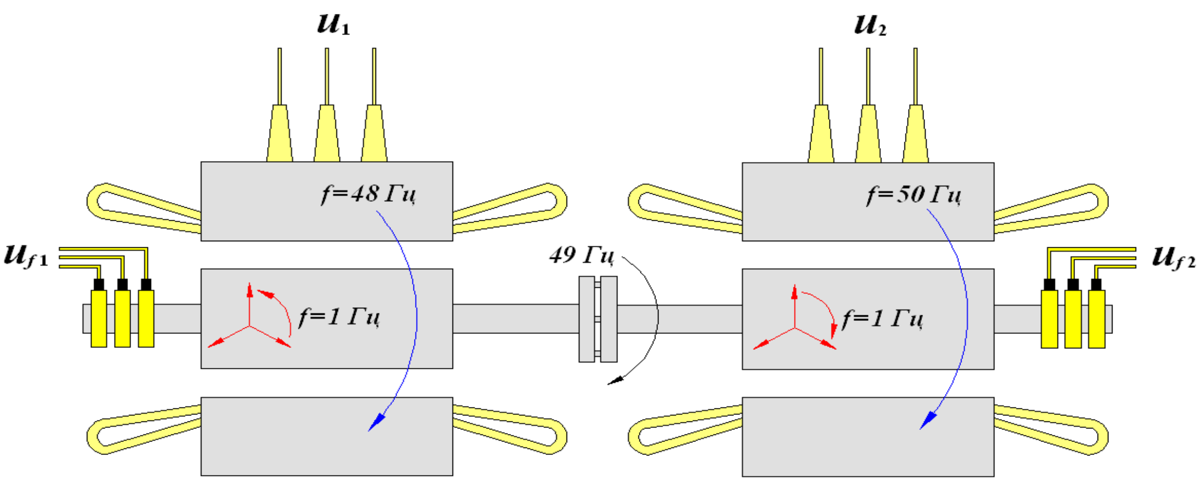

Figure 2. Asynchronized electromechanical transducer (functional connection diagram)

2.7.4.5. ASEMPCh can be used for the purpose of:

- limitation of short-circuit currents in the electrical network;
- unification of sections of the electric network that are open according to the conditions of the short-circuit currents without electrical communication;
- implementation of a controlled flow of active and reactive power

2.7.5. High power storage batteries and energy storage

2.7.5.1. An electric energy storage device (NE) is a device capable of absorbing electrical energy, storing it for a certain time and giving electrical energy back, during which energy conversion processes can occur, the basis of which are storage devices (batteries).

2.7.5.2. In the electrical network, NEs can be used:
- to reduce peak loads;
- increasing the reliability of power supply;
- frequency regulation and generally improving the reliability of the electrical network.

2.7.5.3. NE with the use of AB in the 6-35 kV distribution network can be used:
- as an emergency backup power supply;
- as a device that improves the quality of power supply, excluding voltage dips, overvoltage;
- as a device for leveling the daily load schedule.

2.7.5.4. Currently, NEs based on AB of various types of batteries are used (sodium-sulfur NaS, vanadium redox VRB, lead-acid Pb, zinc-bromide ZnBr, lithium-ion Li-ion).

2.7.5.5. The main characteristics of NE are:
- energy intensity - energy that the storage device can store and supply to the power system;
- response time - the time of the drive's transition from an inoperative state (idle, charging mode) to the state of energy supply with the declared parameters;
- discharge time - the time during which power and energy are supplied to the power system without recharging;
- the density of power and energy, determined by the quantities of power and energy per unit weight of the storage medium

2.8. Automated systems for technological control of the power grid complex

2.8.1. General provisions

2.8.1.1 To carry out the OTU functions, the NCC must be equipped with an automated process control system (APCS).

2.8.1.2. The control system is carried out from the NCC, which includes a set of software and hardware systems that provide centralized management of digital electrical network objects, including SCADA / OMS / DMS / WFM systems, a central network data warehouse and tools for working with the CIM network model, software and hardware complex AIIS KUE, software and hardware complex monitoring systems and equipment settings.

2.8.1.3. The PTC should consist of two levels and two inter-level systems:
- the level of objects of control and management (APCS);
- the level of the territorial network organization - NCC (SCADA with applications for NCC);
- information technology infrastructure management systems;
- information security management systems.

At the facility level, provision should be made for the transfer of technological information to the DC of JSC SO UES in relation to dispatch facilities.

2.8.1.4. The level of objects of control and management of the PTC should include a set of PTC devices for controlling equipment of the electric power infrastructure. This level includes PTC HV substations (110 kV and above) and nodal substations 35 kV, PTC RP and MV transformer substations (6-35 kV), measuring transducers and other equipment installed outside the substation areas directly at transition points 110-220 kV, cable and overhead lines, as well as devices for information and communication support for the activities of operational field and emergency recovery teams. In addition, this level should include hardware and software equipment installed and owned by consumers and related subjects of the electric power industry.

2.8.1.5. ASTU is a set of automation tools for industrial and technical and OTU power grid facilities, providing a solution to problems of automating processes on the basis of modern software and hardware automation, computer technology and information technology:

- collection and transmission of technological information from the object of electrical networks and its processing and storage;
- production of operational switching;
- Carrying out maintenance and repair work;
- analysis of the technical condition of the equipment;
- observability of the state of equipment and power grid facilities.

2.8.1.6. ASTU is designed to ensure and improve the efficiency of the entire production and technological ESC by ensuring the efficiency of personnel and comprehensive automation of processes

2.8.2. Requirements for building an information model of the ASTU

2.8.2.1. When creating an ASTU, the current open standards of the International Electrotechnical Commission (IEC), as well as the standards of other international organizations, methodically and technically related to them, should be taken as a basis.

2.8.2.2. The most important tool in the construction of the automated control system is the unity of information, including calculation, models of electrical networks. The standardized IEC (IEC 61968, 61970) Common Electricity Information Model (CIM) shall be used as a basis for creating these models.

2.8.2.3. The network model should include means of integration (including those implemented on platform principles) of electric network models - descriptions of adjacent power systems in order to ensure transparent exchange of information about power system models in accordance with the provisions of IEC 61970-30x series standards.

2.8.2.4. The use of ASTU on a unified information platform for the NCC allows:

- to eliminate the need to combine control and technological management systems from different manufacturers and create a corporate standard for operational information systems;
- carry out centralized support, operation of the ASTU software and hardware complex and personnel training;
- to unify the ASTU software and reduce the cost of licensing software.

2.8.2.5. Information exchange between the automated control systems installed in the NCC of the distribution grid companies of PJSC Rosseti, the automated control systems of dispatch centers of the subject of operational dispatch control must be carried out using the ICCP / TASE.2 protocol (IEC 60870-6, IEC 62351-3).

2.8.2.6. A modern approach to the construction of an automated control system should involve the use of platform technology ADMS, which will create:

- a unified system and application platform;
- unified user interface;
- a single database;
- a unified design model of the 220/110 (150) / 35/20/10/6 / 0.4 kV network;
- a unified environment for configuration and administration.

The target function of implementing ADMS platform solutions is to reduce operating costs and obtain commercial benefits.

2.8.3. Functional requirements for ASTU

2.8.3.1. ACS, built on the ADMS technology, must perform all the functions provided for individual systems SCADA, DMS, OMS, EMS and others.

2.8.3.2. SCADA system functions should include:

- visual control in real time over the state of equipment and the course of the technological process, as well as forecasting and retrospective of the operating mode of the electrical network (topological coloring of the network, organizing event logging, event archives, and others);
- the possibility of geo-presentation of the electrical network in a dynamic and easy-to-work form;
- remote control of power grid facilities (control of switching equipment) with blocking of invalid commands;
- prevention and localization of technological disturbances in electrical networks by signaling about unacceptable (or close to unacceptable) modes of operation of equipment and power lines, signaling and blocking incorrect actions of personnel;
- monitoring and maintaining an electronic log of the state of the network, equipment and power lines;
- archiving, backup copying and restoration of information;
- maintenance of databases of technological, regulatory, reference information;
- operational, technological and analytical reporting.

2.8.3.3. The graphical interface of the SCADA system must be visual, scalable and easy to use by users, as well as provide support and linkage with the CIM model when displaying graphical information (network equivalent circuits, equipment, measurements, etc.), in accordance with IEC 61970-453.

2.8.3.4. The APCS platform with the DMS, OMS, EMS subsystems located on it should be able to integrate and unify, on the basis of a single CIM-model, various modules of computational and analytical tasks unified by PJSC Rosseti that ensure the performance of the following functions:

- calculations of flow distribution;
- calculations of losses in the electrical network;
- switching control with the installation of safety posters;
- assessment of the reliability of power supply to consumers in the event of a failure of one of the elements of the electrical network, based on the criterion N-1, and identification of unreliable elements of the electrical network;
- calculations of indicators SAIDI, SAIFI, undersupply of electricity;
- determination of the type and location of damage according to the indications of the installed OMP systems, telemetry measurements, oscillograms, according to subscribers' requests, events about the absence of voltage from the AIIS KUE and the calculated model of the electrical network;
- automatic generation of a switching sequence to isolate the damaged area and restore power supply to the maximum number of consumers (automated FLISR) for the NCC of distribution grid companies;
- assessment of the state of the electrical network;
- planning the development of the electrical network, including the calculation of the possibility of grid connection of consumers to the electrical network;
- calculation and optimization of the electrical network mode;
- calculation of short-circuit currents;
- control of the level of short-circuit currents, including single-phase earth faults;
- optimization of the topology of the electrical network;
- voltage regulation;
- load control;
- planning of repairs of substation electrical equipment;
- training and education of personnel (availability of a dispatcher simulator).

2.8.3.5. The target tasks in the implementation of computational and analytical tasks using ADMS technology are:

- improving the safety and reliability of the ESC;
- reduction of consumption peaks and power losses;
- reducing the time of interruption of power supply to consumers;
- improving the quality of electricity;
- improving performance indicators (KPI);
- increasing the efficiency of using network assets.

2.8.3.6. When organizing remote control of dispatching facilities in relation to the ASTU, the following approved by PJSC Rosseti, PJSC FGC UES and JSC SO UES must be ensured:

2.8.3.6.1. Typical principles of switching in electrical installations when remote control of equipment and relay protection and automation devices of substations;

2.8.3.6.2. Typical order of switching in electrical installations when remote control of equipment and relay protection and automation devices of substations;

2.8.3.6.3. Typical technical requirements for PTC ACS TP of substations, microprocessor relay protection and automation devices and for the exchange of technological information for remote control of equipment and relay protection and automation devices of substations from DC of JSC "SO UES", NCC of network organizations and the procedure for implementing remote control.

2.8.4. Requirements for information exchange for the purposes of operational and technological management

2.8.4.1. For operational control and management of ESC facilities, the ASTU should provide for:

- switch remote control;
- telesignalization of switch position;
- telemetry of operating parameters (current, voltage, power, frequency);
- emergency warning signaling of inadmissible deviations from the set values of parameters, modes of the electrical network and the state of equipment of substations and power lines, signals for starting and operating protection and automation devices, PA (including emergency shutdown of circuit breakers);
- fire and security telesignalization;
- continuous monitoring using ASMD equipment of substations and power lines;
- control of the reliability of the input information.

2.8.4.2. Sources of information for the automated control system, first of all, should be the systems of the automated process control system, SSPI, AIIS UE, TM devices at the electrical network facilities.

2.8.5. Architectural solutions for the construction of ASTU

2.8.5.1. Technical solutions for the creation of ASTU should provide for the construction of complex architectures using the following principles:

- modular principle, providing flexibility of the system - the ability to change functionality by adjusting the composition of modules;
- the principle of clustering and segmentation, which ensures the distribution of load and tasks between software and hardware, increasing the reliability of the complex as a whole, as well as the level of information security;
- the principle of replication, ensuring the fault tolerance of the hardware and software complex.

2.8.6. Requirements for the reliability of the ACS and the integrity of information

2.8.6.1. The following requirements for the reliability of the automated control system must be observed:

- the availability factor must be at least 99.98% (for NCC);
- the availability factor must be at least 99.95% (for the automated process control system);

- the time to restore full working capacity should not be more than four hours;

- ensuring the ability to gradual degradation (maintaining the functionality of the complex with a decrease in quality in the event of failure of individual elements of hardware or software);

- the system should be implemented according to the redundancy scheme with automatic switching of all functions and components to the backup system in case of failure of the main one;

- in normal mode, round-the-clock and continuous operation should be ensured during the established service life, subject to the required technical measures for maintenance and repair;

- software and hardware for monitoring the performance and diagnosing system malfunctions should ensure the solution of the following tasks:

• performance check and detection of equipment and component failures;

• finding faults with an accuracy of an individual element or a group of replacement elements;

• signaling about the occurrence of a failure and the results of performance tests;

- during the performance of scheduled (preventive) work on the equipment of the system, the reliability should not decrease;

- all equipment of the system must have a power supply circuit that ensures the preservation of operability (to ensure the transmission of an alarm and the preservation of the received information) during short-term power outages and voltage deviations from the nominal no more than ± 20%.

2.8.6.2. The integrity and correctness of information in the system must be maintained when the power supply is disconnected. After the restoration of the power supply, a procedure for automatically restoring the required amount of information must be provided.

2.8.7. Ensuring information security of ASTU

2.8.7.1. As part of the creation, modernization, operation of information infrastructure facilities of the ASTU, an assessment of the scale of possible consequences for the Company, social, political, economic, environmental consequences, as well as consequences for ensuring the country's defense, state security and law and order in the event of computer incidents at information infrastructure facilities should be carried out ASTU, assignment of the information infrastructure facilities of ASTU to one of the categories of significance in accordance with the Decree of the Government of the Russian Federation dated February 8, 2018 No. 127.

2.8.7.2. All information objects in the automated control system must be protected using unified security tools and systems.

2.8.7.3. Access to obtaining information, changing information, entering control commands and others should be implemented by system means of delimiting user powers.

2.8.7.4. Changes to the level of access and user authority should be performed by the system administrators at the direction of the relevant supervisors. Actions to edit access must be confirmed by personal electronic signatures of the participants in the process.

2.8.7.5. Changes to the settings and parameters of the operation of the APCS subsystems must be confirmed by the electronic signature of the user making the changes.

2.8.7.6. The security system should record the actions of administrators and users of the APCS subsystems.

2.8.7.7. Control of software integrity should be ensured.

2.8.7.8. Safety requirements should be established by a special section of job descriptions and (or) operating instructions for the ASTU TsS and have links to instructions for operating technical means of information protection.

2.9. Automated control systems for power grid facilities

2.9.1. General provisions

2.9.1.1. ESC facilities (PS, TP, RP, RTP, power transmission lines) should be equipped with automated control systems, monitoring, continuous monitoring using ASMD elements of these objects.

2.9.1.2. When formulating requirements for automated systems, the following classification of ESC objects is used:

- Substation 35-750 kV;
- RP, RTP, SP, TP 6-20 kV (TP - with remotely controlled switch);
- TP without remotely controlled switch (including the pole version);
- CL (KVL) 110 kV and above;
- CL 6-35 kV;
- overhead lines 110 kV and above;
- overhead lines 6-35 kV;
- sectioning point (recloser).

2.9.1.3. During the design and new construction of 35-750 kV substations, RP, RTP, SP, 6-20 kV transformer substations (except for dead-end ones) and sectioning points (reclosers) must be equipped with a switch with the function of remote control of drives.

2.9.1.4. The following types of automated systems should be implemented:

1) control of technological processes (APCS) of the substation for:

- Substation 35-750 kV;
- telemechanics (TM) for:
- RP, RTP, SP, TP 6-20 kV;
- TP without remotely controlled switch (including the pole version);
- sectioning points (reclosers);

2) continuous monitoring using AFMD for:

- equipment for substations 35-750 kV;
- KL, VL, KVL 110 kV and above.

2.9.1.5. Metrological support of APCS must comply with the provisions of subsection 3.6 of the Technical Policy "Metrological support".

2.9.2. Functions of automated systems

2.9.2.1. Functions of the automated process control system for substations 35-750 kV.

2.9.2.1.1. Technological functions:

- measurement, conversion, collection of analog and discrete information about current technological modes and equipment condition;
- technological warning and emergency alarms: control and registration of warning and alarm signals, their output to the AWP, filtration, processing;
- presentation of current and archived information to operational personnel and other users at the substation (control and visualization of the state of the substation equipment);
- displaying on the mnemonic diagrams of the object (with a dynamic change in state) of the values of analog technological parameters that are essential for maintaining modes and displaying the state of the equipment with indication of deviations from the norm;
- automated control of substation equipment, including switch substation (circuit breakers, disconnectors, grounding knives, on-load tap-changer drive, withdrawable elements and ZN of 6, 10, 20 kV connections, reactor disconnectors and their ZN, ZN neutral of transformers, technological equipment: pumps, gate valves other);
- remote change of the state of software operating elements of relay protection and automation systems, automated process control systems: switching groups of settings of relay protection and automation terminals, operational input - output from operation, shutdown - activation of individual functions through the implementation of software operating keys in microprocessor terminals. Resetting and testing the alarm. Remote configuration of MP relay protection and automation;
- monitoring of the state of the battery chargers AB PS (VAZP);
- programmed switch control locks (operational logical switch locking);
- registration of events by own means or by means of information exchange with secondary systems of the substation, as well as fixation and display of the results of the work of weapons of mass destruction;
- information interaction with the autonomous digital systems available at the substation (relay protection and automation equipment, automated information and information technology system for energy consumption, etc.) according to standard protocols;
- exchange of operational information with the subject of operational dispatch control and the ASTU NCC;
- exchange of non-operational technological information with the NCC;
- control of voltage levels of 0.4-750 kV on substation buses;
- integrated accounting of cases of exceeding long-term permissible voltage levels;
- continuous monitoring using ASMD equipment;
- automatic control of operational switching based on program logic, similar

to standard switching forms;

- remote control of voltage in 6-750 kV lines;
- analysis of outages using software tools;
- use of the dispatcher's advisor in the work of the system on circuit and regime issues.

The organization of control of the substation switch is presented in Table 2.

Table 2. Organization of control of the substation switch

<table>
<tr><th>Item No.</th><th>Switching device type</th><th>Main place of management</th><th>Reserve control place in case of failure of the upper level of the APCS</th><th>Controls in case of impossibility of remote control or during commissioning</th></tr>
<tr><td>1</td><td>Switches, disconnectors and earthing knives with motorized connections</td><td rowspan="4">AWS of operational personnel at the substation, AWS of operating and dispatch personnel at NCC (with the priority of control by the personnel on duty or the ATS personnel while they are at the facility) DC JSC "SO UES" (for remote control of the power transmission line switch and equipment in dispatch control</td><td>From the mnemonic diagram on the bay controller screen (control commands are recorded in the bay controller event log).</td><td>Local control cabinets, controls at the control automation installation site</td></tr>
<tr><td>2</td><td>35 kV and above</td><td>From buttons (keys) in cubicle cabinets RU 20 kV and below</td><td>controls at the control automation installation site</td></tr>
<tr><td>3</td><td>Switches, disconnectors and grounding knives with electric drives RU 20 kV and below</td><td>From buttons (keys) in on-load tap-changers cabinets</td><td>controls at the control automation installation site</td></tr>
<tr><td>4</td><td>RPN</td><td>From buttons (keys) in SHSN cabinets</td><td>-</td></tr>
</table>

2.9.2.1.2. When organizing remote control of dispatch facilities in relation to the process control system, the following approved by PJSC Rosseti, PJSC FGC UES and JSC SO UES must be ensured:

2.9.2.1.2.1. Typical principles of switching in electrical installations when remote control of equipment and relay protection and automation devices of substations;

2.9.2.1.2.2. Typical order of switching in electrical installations when remote control of equipment and relay protection and automation devices of substations;

2.9.2.1.2.3. Typical technical requirements for PTC ACS TP of substations, microprocessor relay protection and automation devices and for the exchange of technological information for remote control of equipment and relay protection and automation devices of substations from DC JSC "SO UES", NCC network organizations and the procedure for implementing remote control

2.9.2.1.3. System-wide functions:

- organization of intrasystem and intersystem communications;
- processing and transmission of information to adjacent and higher levels;
- testing and self-diagnostics of the software, hardware and channel (network) part of the hardware and software complex components, including input-output and information transfer channels;
- synchronization of the components of the software and hardware complex and the autonomous digital systems integrated into the automated process control system according to the signals of the uniform time system;
- archiving and storing information in specified formats and for specified time intervals;
- protection against unauthorized access, information security and differentiation of rights (levels) of access to the system and functions;
- documenting, generating and printing reports, reports and protocols in a given form, maintaining an operational database, daily list and operational log;
- computer-aided design, programming and configuration.

2.9.2.2. Functions of telemechanics systems RP, RTP, TP, SP, TP (TP - with remotely controlled switch):

- short circuit detection on 6-20 kV cable lines;
- selective directional detection of single-phase earth faults in cable lines 6-10 kV;
- ATS to restore power to consumers by automatically connecting a backup power source when the working power source is disconnected, the IFC should be implemented in the form of a software algorithm with the possibility of remote input / output from the automated control system;
- collection and transmission of telemetric information to the ASTU;
- reception and execution of commands for remote control of the switch from the ASTU
- collection of oscillograms of emergency events.

2.9.2.3. The functions of TP telemechanics systems without remotely controlled switch (including the pole version) are the collection and transmission of telesignalization to the automated control system in a minimum volume: actuation of the automatic transfer switch, the presence of voltage on 0.4 kV busbar assemblies (on the slopes of 0.4 kV transformers), other parameters.

2.9.2.4. Functions of telemechanics systems of sectioning points (reclosers):

- collection and transmission of telemetric information to the ASTU;
- receiving commands for remote control of the switch from the ASTU.

2.9.2.5. Continuous monitoring functions using ASMD equipment must be performed to the extent and meet the requirements set out in subsection 3.7 of the Technical Policy.

2.9.3. Technical requirements for automated systems

2.9.3.1. ACS TP SS 35-750 kV:

- the construction of an automated process control system should be based on modern information technology principles with the use of modern software and hardware, made on a microprocessor element base;

- when designing an automated process control system, the possibility of hardware and software expansion should be provided;

- APCS should be built as a multi-level distributed human-machine system operating in real time, and include the following levels (Figure 3):

• the level of networks - equipment and software for processing and storing data, for organizing an automated workstation and managing networks;

• substation level of APCS - equipment and software for processing and storing data, as well as for organizing an automated workstation;

• level of APCS connection - equipment and software for concentration and unification of heterogeneous information flows from the level of APCS process and separate automation systems;

• the level of the process control system - equipment for transformation, direct measurement of physical quantities, as well as for interfacing with control and automation objects;

- the main protocol for the exchange of information between devices included in the APCS and MP RPA, and other autonomous PS systems should be IEC 61850-8.1 GOOSE, MMS. If these systems do not support IEC 61850-8.1 GOOSE, MMS information exchange can be performed using standard protocols.

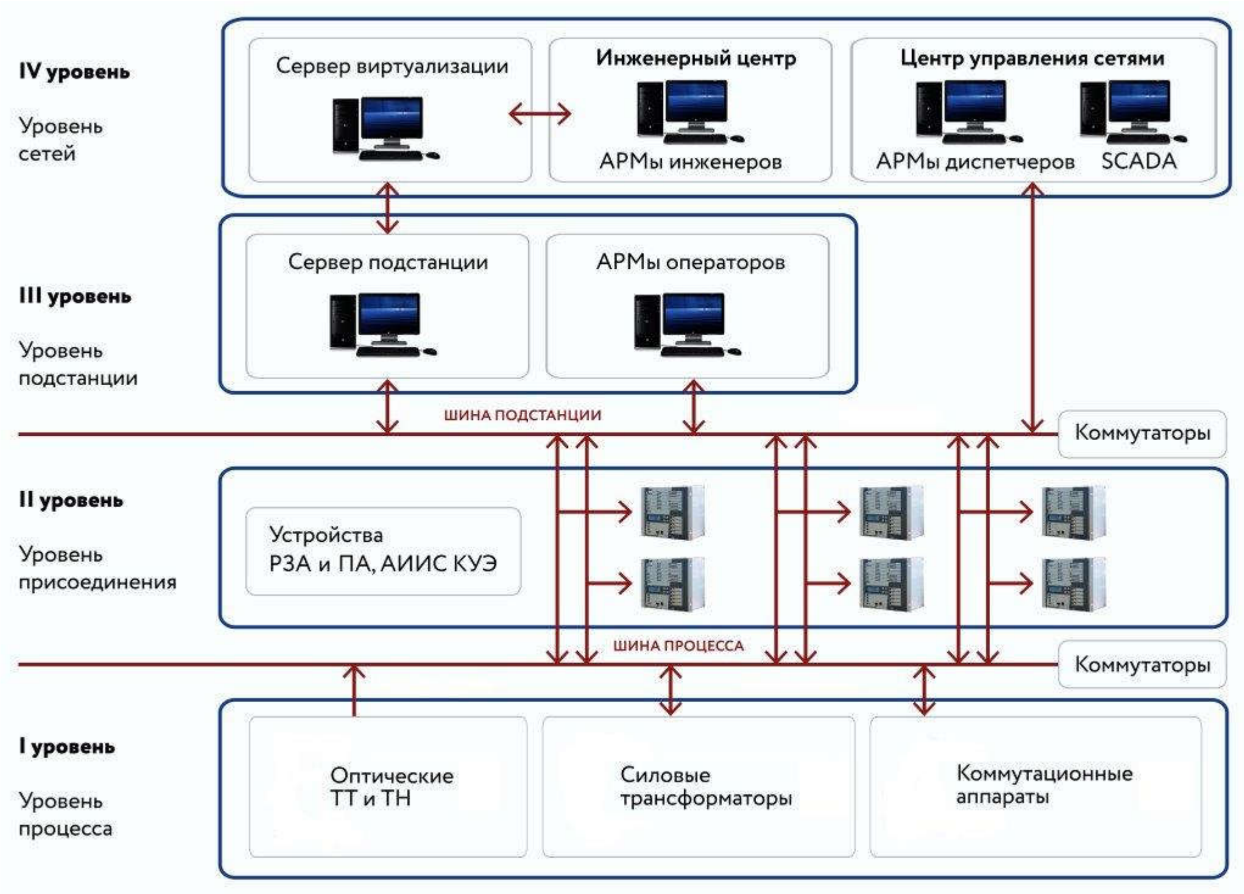

Figure 3. Multilevel structure of the APCS

2.9.3.2. Process level controllers should do:

measurement, conversion, collection and processing of analog and discrete information on connection from secondary windings of CT and VT, block contacts of primary equipment, relay contacts, sensors, converters;

formation of control commands for switch, on-load tap-changers and other devices;

software operational blocking of the control switch of attachment (with the provision of information exchange between peer-to-peer devices using the GOOSE protocol of the IEC 61850-8.1 standard);

information exchange with other bay controllers with medium-level PTC APCS devices using IEC 61850-8.1 GOOSE protocols;

backup control of the switch in case of malfunction of the upper or middle level facilities.

2.9.3.3. At the level of the bay controller and its constituent USOs, primary processing of input signals should be carried out: filtering, linearization, verification, processing by aperture, conversion of a binary code into a physical quantity, etc. At the same time, access from the automated workstation of the ACS engineer should be provided for parameterizing the primary processing of the USO modules.

2.9.3.4. Bay level controllers must have duplicated Industrial Ethernet digital exchange modules in accordance with the requirements of the ISO Ethernet IEEE 802/3 standard. In the event of a loss of communication with the upper control level, the controllers must go into autonomous mode with the registration of events in an internal buffer of sufficient capacity. Controllers must support hot-swap modes of components (except for the central processor module) and have the ability to back up the main modules (processor, power supply, communication). Immunity to electromagnetic radiation in accordance with the requirements of IEC 61850-3.

2.9.3.5. Bay controllers for equipment of 110 kV and above must be equipped with a graphical control panel with a Russified display that provides local visualization of the connection equipment operation state, control of the switch to provide backup control, input/output and visualization of blocking operation, viewing events, identification and authentication of subjects and objects of access , functions of registration of security events with transmission to a specially dedicated server for collecting information of the security monitoring subsystem.

2.9.3.6. APCS bay controllers should be modular devices that support a flexible configuration of input/output modules. Controllers must have serial interface ports to provide the function of integrating information subsystem equipment using protocols other than those of the IEC 61850 standard. Controllers must support freely programmable logic in accordance with the IEC 61131 standard.

2.9.3.7. The LAN of the APCS should be built taking into account the redundancy requirements and provide sufficient performance for information exchange between APCS devices, as well as relay protection and automation devices according to IEC 61850 protocols.

LAN redundancy according to IEC 62439-3 PRP / HSR is preferred.

OSI Layer 2 and Layer 3 redundancy protocols must provide protection against single failure of switches/ routers and LAN cabling.

2.9.3.8. When building a LAN network, Industrial Ethernet switches must be used in accordance with the requirements of the IEC 61850-3 standard. Switches must have two power supplies and a built-in diagnostic system that monitors the status of the switch ports, the operating mode of the switch, the temperature, the health of the power supplies with information being sent to the SCADA system using the SNMP v3 + protocol. The switches must comply with the requirements of STO 34.01-6-005-2019 “Switches for power facilities. General technical requirements ". Organization standard.

2.9.3.9. When devices are connected to the LAN of the APCS, redundancy of communication channels between these devices and the LAN equipment must be provided.

2.9.3.10. A single-mode or multi-mode optical fiber is provided as the main medium for transmitting information in a LAN.

2.9.3.11. The substation level of the APCS includes:

- devices for collecting, processing and archiving data (SCADA server);
- devices for presenting information to users (AWP, printers, screens for shared use, etc.);
- servers for remote access and acquisition of oscillograms;
- routers organizing a demilitarized zone;
- equipment of the uniform time system;
- telemechanics servers / controllers;
- server for collecting information of the security monitoring subsystem.

2.9.3.12. The servers of the PTC APCS must be redundant, with two hot-swappable power supplies each connected to different power supplies. Use a hot-swappable RAID array as an information storage array. Servers should be equipped with a duplicated Ethernet interface connected to different LAN switches.

2.9.3.13. As part of the PTC ACS TP should be provided for the minimum:

- 2 AWPs for operating personnel (stationary, redundant) with two monitors each;
- AWP of relay protection and automation;
- AWP ACS (stationary and portable).

2.9.3.14. Operator stations must be equipped with SATA drives combined into a RAID array of level 1 or higher. The stations must be equipped with a duplicated Ethernet interface connected to various LAN switches. Monitors (displays) of operator and engineering stations, as a rule, are the main means of displaying operational information to users. Workstations must use high-resolution color graphic liquid crystal displays with a diagonal of at least 24 ".

2.9.3.15. The workstation of operational personnel should be created on the basis of an industrial personal computer, the MTBF of which should be at least 20,000 hours.

2.9.3.16. Diagnostic tools for the workstation of operating personnel should ensure monitoring of the health of HDD (SSD) drives, monitoring of the temperature regime with the transfer of information to the SCADA system.

2.9.3.17. Autonomous digital systems with which the APCS must support information exchange (if available on the substation) are as follows:

- relay protection and automation;
- automated systems of engineering and auxiliary systems;
- continuous monitoring of ASMD equipment;
- other autonomous microprocessor systems or devices installed on the substation, if necessary, providing information about the operation of the systems to the operating personnel.

2.9.3.18. The integration of autonomous systems into the APCS should be carried out when it is necessary to provide information from it to the end users of the APCS: operational personnel at the substation, operational and non-operational personnel at the NCC.

2.9.3.19. When implementing data exchange between the APCS and integrated subsystems and devices, including for the purpose of monitoring the status of devices, the use of intermediate OPC servers and clients is undesirable. The use of OPC servers and clients is allowed if a feasibility study is available.

2.9.3.20. Power supply for automated systems should be provided from the APS and UPS (it is allowed without its own AB with power supply from the auxiliary direct current) and ensure functioning in the event of a power failure from the auxiliary needs of the substation (ShchSN) during the operating time of the auxiliary current system of the substation.

2.9.3.21. The power supply for all devices of the PTC ACS TP of the substation level, including all stationary workstations, must also be organized from the APS and UPS (it is allowed without its own AB with power supply from the operating direct current).

2.9.3.22. To build a UPS, 220 V inverters with static bypass must be used. It is allowed to use UPS with an input voltage of 220 V, using AB, as well as power supplies with DC input and output. To increase the reliability and maintainability of the power supply of the APCS devices, when building the UPS, ATS, manual and automatic bypass modules should be used. In the power supply circuits of APCS devices, it is necessary to provide for line filters and voltage stabilizers to protect the APCS equipment from supply voltage surges.

2.9.3.23. Devices of guaranteed power supply must be of a modular design principle with N -1 redundancy and parallel operation. The use of single-module devices is allowed, provided they are duplicated.

2.9.3.24. Switching devices used in the UPS must be fast, with a switching time of no more than 20 ms.

2.9.3.25. The UPS must provide for the autonomous operation time of the APCS (when the MV substation is disconnected) determined in accordance with subsection 2.3.2 of the Technical Policy (2 hours).

2.9.3.26. The software and hardware complex of the APCS should include a single precise time subsystem designed to synchronize the system time of all devices of the APCS complex and the equipment of integrated autonomous digital systems (relay protection and automation, PA and others) of the SS.

The synchronization accuracy of the single time must be no worse than 1 ms.

2.9.3.27. The subsystem of uniform time should include software and hardware that ensure the reception of accurate time signals from an external GPS / GLONASS source.

2.9.3.28. The subsystem of uniform time must support the PTPv2 protocol (including PowerProfile), taking into account the requirements of the standard STO 56947007-29.240.10.261-2018 “Digital substation. Accurate time synchronization protocol for measuring and control systems (based on IEC 61588) "(or NTP (SNTP v3 +), taking into account the fulfillment of the requirements of clause 2.11.3.27 of the Technical Policy).

2.9.3.29. In the case of building an ACS TP system using the IEC61850-9.2 SV protocol, the synchronization accuracy of the single time should be no worse than ±1 μs.

If a network organization has a separate system for ensuring uniform accurate time, synchronization from it is the preferred method.

2.9.3.30. The following processing and analysis of information should be carried out in the APCS:

- control and analysis of the state of the switch;
- algorithms for analyzing emergency shutdown of the line and transformer equipment;
- work of algorithms of operational locks;
- control of the execution of control commands of the switch (control with feedback);
- identification and registration of emergency events;

- transcoding of oscillograms into COMTRADE format;
- formation of a time stamp for discrete signals;
- calculation of operating parameters;
- in circuits with two busbar systems, the possibility of transferring VT circuits from one busbar system to another must be taken into account;
- determination of sections of the circuit that are energized;
- processing of information about the normal mode: additional calculation of unmeasured parameters;
- combining oscillograms into a single emergency process in time;
- analysis of information reliability.

2.9.3.31. The speed of the APCS should be no worse than the values indicated in Table 3.

Table 3. Speed of ACS TP

Parameter	**Value**
The frequency of signal polling by process level devices, which ensures the requirements for the accuracy of recording events and values of analog signals in relation to the system time of the PTC (depending on the dynamic properties of the parameter): - discrete - analog - analog technological parameters	 1.0 ms 0.5-1.0 ms 0.1-1 s
Delay from the operator giving the command to call information to the start of the output: - on the monitor screen	 1.0 s
Frequency of information update: - on the monitor screen	 1.0-2.0 s
Delay in displaying spontaneously occurring alarms and alarms on operator station monitors	0.5-2.0 s
Time of command passage from the moment the operator presses the button of the virtual control unit until the signal appears on the output circuits of the PTC, no more	1.0 s
Delay from the moment the operator issues a remote control command until the results of the command execution are displayed on the monitor without taking into account the time the command was processed by the control object	1.5-2.0 s
Impulses applied to the actuator (configurable parameter): - minimum duration - change step, no more	 0.1 s 0.05 s
Delay from the moment of receiving a request (command) from a higher-level automated control system to the start of its processing, no more	0.25 s

2.9.3.32. The process control system should provide for the implementation of software operational blocking.

For busbar disconnectors and busbar earthing blades, a complete operational interlock must be performed, prohibiting the switching on of the busbar earthing knife when (at least one) busbar disconnector is on and any busbar disconnector turning on when the busbar earthing knife is on.

In complete switchgears, an operational blocking is performed, which prohibits the switching on of the earthing knife of the switchgear busbars when the switch trolleys of any of the connections of these busbars are in the working position, as well as rolling in these trolleys into the working positions when the earthing knife of the switchgear busbars is on.

The lock in the closed switchgear prevents the circuit breaker trolley from rolling in the on position.

Bay controllers for actuators must issue separate commands:

- command "Allow operation" - to energize the block - the electromagnetic blocking lock or to the blocking relay coil, if any. Formation of commands "Allow operation" is performed in the controller for each switch, while the command is formed by means of logic algorithms programmed in the controllers in accordance with the logic of traditional relay-contact circuits;

- command "Execute control" - to disconnect - enable from the APCS in the control circuit of the switch drive. Remote commands "Execute control" for devices with motor drives are generated by the bay controller, are activated from the operator's workstation or from the interface controller of the bay and enter the drive control circuit, while the logical admissibility of the operation is checked at the controller level.

2.9.3.33. As an additional blocking condition, in the presence of appropriate signals in the controllers of the lower level of the APCS, control of the absence of voltage on buses, overhead lines, transformer inputs, synchronization of voltage vectors and control of the absence of current can be used.

2.9.3.34. Software interlocking by means of APCS with the use of interlocking elements in the drive, if any, should be used for all types of disconnectors, including for switch with a manual drive of the main and grounding knives.

2.9.4. Requirements for the organization of information exchange between the substation and dispatch control centers

2.9.4.1. SSPI PS is a subsystem of the APCS, which should provide:

- measurement and collection of primary information about the parameters of the mode and condition of the equipment in accordance with the established requirements;

- transfer of the collected information to the NCC and dispatch centers of the subject of operational dispatch control;

- processing, storage and presentation of the collected information to the relevant personnel of the NCC, the personnel of the substation and the personnel of the operational services.

2.9.4.2. Newly created SSPI PS 6-20 kV or telemechanics systems, in addition to the listed requirements, should also provide the ability to remotely control connections and exchange information with adjacent automation systems using standard protocols (if the adjacent subsystems are technically possible).

2.9.4.3. SSPI PS should be built taking into account the following requirements:

- use of modern microprocessor (MP) telemechanics systems with direct connection to secondary circuits of TT and VT or to multifunctional measuring transducers;
- increasing the volume and expanding the range of transmitted technological information;
- modular principle of construction of hardware and software;
- support for international data transfer protocols IEC 60870-5-104, IEC 61850-8.1 GOOSE, MMS, IEC 61850-9.2 SV for data transfer to NCC and DC;
- the possibility of scaling and integrating the MP of telemechanics systems into the APCS of the substation.

2.9.4.4. Preparation of teleinformation for transmission to the dispatch center of the subject of operational dispatch control, carried out by means of the APCS of the substation, must meet the technical requirements established by JSC SO UES.

During the primary processing of discrete signals, the following should be performed:

- elimination of the influence of "bounce" arising from the closing / opening of contacts;
- detuning from interference (signals with a duration of less than 5-7 ms);
- assignment of timestamps to any discrete signal with an accuracy that ensures unambiguous recognition of technological situations in the analysis, in particular, two sequential switching of the switch of the highest speed, the accuracy of recording the time of events should be no more than 1 ms.

Discrete signals about the switch position are checked for plausibility by introducing two signals from one switch: “on” and “off”, obtained using a normally closed and normally open contact, referred to the same state of the switch.

The transfer of operational and non-operational information to the NCC of the network organization should be carried out in accordance with the requirements separately developed by the network organization.

2.9.4.5. Information transmission to the NCC should be carried out using the IEC 60870-5-104 (or IEC 61850-8.1) protocol to the main and backup digital communication channels in each direction directly without intermediate processing (retransmission). The transfer of information to the dispatch center of the subject of operational dispatch control should be carried out using the IEC 60870-5-104 protocol via the main and backup communication channels in each direction directly without intermediate processing (retransmission). The total time for measuring and transmitting telemetric information (except for teleinformation used for the operation of emergency and regime automation) to the dispatch center of JSC SO UES should be no more than 2 s.

Television information from the PS should be transmitted to the NCC and the dispatch center of the subject of operational dispatch control directly without intermediate processing via two independent (main and backup) digital communication channels in each direction in duplicate mode.

When transmitting tele-information, the bandwidth of digital communication channels should be selected in such a way as to ensure the transmission of the entire volume of the necessary telemetric information about the technological modes of equipment operation.

PTC SSPI should be created during the design and new construction of substations of 10 kV and above, as well as during partial reconstruction of substations of 110 kV and above, when the volume of reconstruction of primary and secondary equipment is up to 30% of the total. PTK SSPI can be created with a smaller amount of reconstruction of the substation if it is impossible to expand the existing telemechanics and the existing need to enter and transfer additional data. Newly created PTC SSPI should be built as a part (separate fragments) as part of a promising project of a fully functional APCS. With an increase in the volume of reconstruction of primary equipment, the elements of the PTC SSPI should be fully integrated into the APCS.

2.9.5. Requirements for the software of the automated process control system

2.9.5.1. The APCS software as a whole and in terms of individual subsystems and applied tasks must satisfy the modular principle of construction and openness of the architecture and provide:

- reliable performance of technological control tasks;
- the possibility of developing and modifying the tasks of technological management;
- continuous monitoring of the reliability of the received data;
- creation and maintenance of databases both for local use and for the needs of higher levels of operational and technological management and the purposes of operational and dispatch management in the electric power industry;
- ensuring document flow and providing operational information to personnel;
- implementation of the protocols for the functioning of technological and computer networks of the system and communication with the upper levels of operational and technological control and dispatch centers of the subject of operational and dispatch control in the electric power industry;
- self-diagnostics, as well as diagnostics of technical components of the APCS;
- remote diagnostics from the upper levels of operational and technological management;
- functioning of information and general security means;

- the ability to manually enter data transmitted as part of teleinformation;
- the ability to automatically execute commands of group remote control;
- possibility of automated drawing up of switching forms.

2.9.6. Requirements for the reliability and survivability of the APCS

2.9.6.1. The APCS must operate in a continuous mode around the clock during the established service life, which (subject to the required technical maintenance measures) must be at least:

- 20 years - for field level devices of the system;
- 15 years - for devices of the system connection level;
- 10 years - for substation level devices of the system.

2.9.6.2. In general, the reliability of the control system should be ensured based on the requirements of GOST IEC 60870-4-2011, GOST 27.003, GOST 24.701-86 and should be achieved:

- the choice of a set of technical means with appropriate indicators of reliability, duplication, redundancy;
- structural methods (use of distributed control, autonomy of individual components of the system, etc.);
- the required regulations for the maintenance of technical equipment.

2.9.6.3. Reliability quantitative indicators should be:

- mean time between failures of each channel of the APCS for information functions and control functions - at least 40,000 hours;
- the average recovery time of the APCS for any of the functions performed - no more than 8 hours.

2.9.7. Requirements for telemechanics systems RP, RTP, SP and TP with remotely controlled switching devices

2.9.7.1. In order to ensure the observability of power facilities, the organization of automated dispatch control of power grids, and the elimination of duplication of technical means of automation, it is necessary to equip ESC facilities with systems that perform the functions of protection and automation and telemechanics, remote control of switch, determining the location of damage, collecting and transmitting information.

All newly installed electrical equipment requiring the organization of remote control must be equipped with electric drives and interlocking devices controlled from the automated control system.

2.9.7.2. Relay protection and automation devices (complexes) must carry out information exchange with the server for collecting, processing and transmitting data using the IEC 61850-9.2 SV standard data transfer protocol.

The server for collecting, processing and transmitting data must carry out constant information exchange with the main and backup system of the upper level APCS through the main and/or backup connection in the IEC 61850-8.1 GOOSE, MMS or IEC 60870-5-104 protocol.

Time synchronization on the server for collecting, processing and transmitting data must be carried out from the GLONASS / GPS upper-level control system using the SNTP v3 + (NTP) protocol.

2.9.7.3. Television information generated in relay protection devices (complexes) must contain timestamps of events of the primary digital source. The synchronization accuracy must be at least 10 ms.

It is not allowed to use data transfer formats without timestamps in communication protocols.

2.9.7.4. For teleinformation, transmitted continuously or by deviation of measured values, the transmission cycle should not exceed 5 seconds.

The signal generation time for the remote signaling transmission to the upper level should not exceed 1 sec.

2.9.7.5. The probability of a teleinformation error must correspond to the first category of telemechanics systems GOST 26.205-88.

2.9.7.6. The server for collecting, processing and transmitting data must provide an automated representation of a formalized description of the current configuration of the substation automation system in accordance with GOST R IEC 61850-2009 (Substation Configuration description Language), as well as in the CIM RDF format (IEC 61968-13: 2008).

The server for collecting, processing and transmitting data should provide remote monitoring of the status through configurable web access.

2.9.7.7. The security system of the automation and protection system of the power facility should be created in accordance with the requirements and provisions of the Federal Law of July 26, 2017 No. 187-FZ "On the security of the critical information infrastructure of the Russian Federation" and the Federal Law of July 27, 2006 No. 152-FZ " On personal data ", as well as by the relevant by-laws, depending on the established category of importance. Ensuring the safety of the automation system and protection of a power facility without an established category of significance is carried out in accordance with the order of PJSC Rosseti dated April 1, 2016 No. 140r (as amended by the order of PJSC Rosseti dated April 27, 2016 No. 178r) and the requirements of this Technical Policy. To ensure the safety of the automation and protection system of the power facility operated at critical facilities, potentially hazardous facilities, facilities posing an increased danger to human life and health and the environment, the security system is created taking into account the Requirements for information protection approved by the order of the FSTEC of Russia from March 14, 2014 No. 31.

2.9.7.8. The transfer of technological information should be organized in accordance with the project. The choice of the type of communication channel, the number of communication channels, the need for redundancy, transmission speed, requirements for transmission quality and availability is made by the designer together with the customer from several options based on technical and economic feasibility.

2.9.7.9. The composition of technological information during the creation of DSP and electrical networks must correspond to the composition of information flows in the OIC in accordance with the requirements of the current standards.

2.9.8. Requirements for telemechanics systems TP, RP 6-20 / 0.4 kV (including with remotely controlled switching devices) and pole transformer substation 6-20 kV

2.9.8.1. For transformer substations, distribution substations 6-20 kV (including those with remotely controlled switch) and pole transformer substations 6-10 kV, a telemechanics system with a minimum set of teleinformation and remote control should be provided.

The system should consist of a controller (device) for collecting and transmitting information (IVKE level) and modules (nodes) for collecting and controlling.

2.9.8.2. The system should be able to:

- expansion of plug-in modules and sensors via standard interfaces Ethernet, RS-485, RS-232 or others equivalent in performance and functionality; and sensors with different types of interfaces (dry contact, current loop, etc.);
- local data processing with the transmission of information on settings to the upper level via the main and backup radio communication channels (LPWAN, cellular networks of various generations, etc.) to the upper level;
- time synchronization using one of the standard protocols (NTP, etc.);
- self-diagnostics of the controller or device performing its functions, analog information input modules, monitoring the status of communication and power channels.

2.9.8.3. Tools should be provided for secure remote and local configuration, monitoring and control of the controller (device) for collecting, processing and transmitting data (IVKE level).

2.9.8.4. When power is restored after a spontaneous loss, the controller (device) for collecting, processing and transmitting data and other elements must continue to work correctly while maintaining data integrity.

2.9.8.5. Telemechanics system modules or devices performing their functions must have an MTBF of at least 120 thousand hours.

2.9.8.6. The discrete and analog information input modules must have discrete inputs with filtering, which does not allow false alarms, and speed, which does not allow missing useful signals.

2.9.8.7. The signal generation time for the remote signaling transmission to the upper level should not exceed 5 seconds.

2.9.8.8. The delay time for the transmission of tele-information from one power facility to the upper level is no more than 30 seconds, provided that there are no corresponding delays in the information transmission channels.

2.9.8.9. In case of failure of communication channels, the system must function in an autonomous mode. After the restoration of the operability of the communication channels, the exchange of information with the upper control level with the transfer of all information accumulated in the autonomous mode should be automatically restored. The shelf life of teleinformation accumulated in offline mode is at least 24 hours.

2.9.8.10. Minimum requirements for the volume of collected and transmitted TV information and remote control.

a) for remote signaling:

- collection of information on transport and electricity consumption at 0.4 kV supply inputs in accordance with Section 13 of these Regulations;
- collection of information on the quality of electricity at 0.4 kV feed inputs in accordance with Section 14 of this Regulation on the Unified Technical Policy;
- phase-by-phase control of the presence of voltage at the LV inputs of 0.4 kV sections;
- access control to the facility (motion detectors, photographic recording, if necessary - video surveillance, protection during switching) with a signal from the door closing control sensor;
- control of the presence of flooding in cable pits (if there are pits);
- control of operation of fire alarm detectors - generalized signal section by section (if any);
- collection of data from subscriber metering devices in accordance with subsection 2.12 of the Technical Policy;
- control of ATS actuation (if any);
- control over temperature rise of the power transformer case (if necessary);

b) for remote control (for objects with switch):

- network controllability by means of switch control (if there is an appropriate technical capability in switch)

c) for telemetry information of the internal self-diagnosis of the system:

- diagnostics of communication with modules (nodes) of collection and control;
- diagnostics of malfunctions or critical modes of operation of the computing module of the system;
- monitoring the health of the system's own backup power source.

2.9.8.11. The power supply of the system equipment at the ESC facility should be provided from two 0.4 kV auxiliary sections (if any).

Controllers (devices) for collecting and transmitting information (IVKE level) and modules (nodes) for collecting and controlling must have their own power source (based on supercapacitors), which ensures the functioning of the system for transferring the last collected information and correct completion of work. The main operational characteristics of your own backup power supply must match the parameters of the system.

In the event of a power failure, the system must send a signal to the upper-level system about the absence of external power and/or loss of voltage at the 0.4 kV inputs and shut down normally.

2.9.9. Requirements for telemechanics systems of sectioning points

2.9.9.1. Requirements for this type of telemechanics systems are similar to the requirements for telemechanics systems TP (pole version), taking into account the requirements below.

2.9.9.2. Remote control modules must have the function of receiving and transmitting remote control commands.

2.9.9.3. Minimum requirements for the amount of collected and transmitted TV information:

a) TV signaling:

- phase-by-phase voltage control;

b) remote control:

- switching devices.

2.9.10. Requirements for an automated system for monitoring the operation of automated systems

2.9.12.1. The automated systems should include an automated system for monitoring the operation of existing automated systems and their subsystems.

2.9.12.2. An automated system for monitoring the operation of systems and subsystems should be built on the basis of a hardware and software complex, which allows:

- to interact with all automated systems and subsystems of the PS using open communication protocols:

• IEC 60870-5-104;
• IEC 61850-8.1, MMS;
• ICCP 870-6-503;
• SFTP (SSH File Transfer Protocol);
• HTTPS (HyperText Transfer Protocol Secure);
• SNMP;

- to carry out continuous monitoring of the correct operation and serviceability of the substation microprocessor equipment;

- to analyze the collected information on the basis of the constructed mathematical models of systems and equipment;

- to make forecasts of the technical condition of the monitoring objects;

- receive signals of self-diagnostics of controllers, USO, protection and automation, LAN equipment, servers, etc.;

- to carry out automatic collection and control of changes in settings, configurations, firmware versions and installed software;

- carry out automatic collection and analysis of data from automated systems and subsystems:

• analysis of serviceability of analog channels of controllers of docking, relay protection and automation, RAS, monitoring of FE, AIIS KUE by comparing readings in the volume of one connection;

• analysis of the health of discrete channels of controllers of connections, relay protection and automation, RAS, monitoring of FE, AIIS KUE by comparing readings in the volume of one connection of the same type of signals, as well as by predicting the sequence of incoming signals to an automated system based on the construction of predictive models;

- to carry out an automatic analysis of the correct operation of the functions of relay protection and automation, including software operational blocking, switching forms, etc.

- carry out adaptive adjustment of the parameters of relay protection and automation devices (selectivity, speed, sensitivity) in comparison with the configuration with the current (operating) settings.

2.10. Electricity metering system

2.10.1. The purpose of the technical policy in the field of electricity (power) metering is to form unified approaches to the creation of automated metering systems for electrical energy (metering system) at the Company's grid facilities.

2.10.2. The objectives of the Accounting Systems are:

- determination of the reliable volume of services rendered by the Company;

- determination and monitoring of the amount of electrical energy losses in electrical networks;

- provision to the structural divisions of the Company, subjects of the electric power industry and consumers, in the prescribed manner, information on the accounting indicators of electric energy (capacity) at the electric grid facilities of the Company.

2.10.3. Electricity metering systems should be created as geographically distributed multi-level information systems with centralized control and a single center for collecting, processing, storing and transmitting measurement data in a branch (SDC) of the Company.

2.10.4. Electricity metering systems should cover all points of commercial and technical metering of active and reactive electrical energy and power in order to obtain a complete balance of electrical energy at the facility, including balances by voltage levels, bus sections and own needs.

2.10.5. The electrical energy metering system should include electrical energy metering systems, consisting of electrical energy metering devices, current and voltage metering transformers, as well as secondary metering circuits. When creating an accounting system at network facilities, it is allowed to use USPD or industrial controllers, technical means of receiving and transmitting data (channel-forming equipment). In this case, the collection and processing of information should be carried out in a software and hardware complex equipped with a system for ensuring a uniform time (SOEB). USPD in electric energy metering systems should be used with an appropriate feasibility study.

2.10.6. The metering systems must comply with the requirements of the RLA, including at connections that are part of the supply cross-sections to the Wholesale

Electric Energy (Power) Market - the requirements for the AIMS KUE, imposed by the regulations of the wholesale electricity and capacity market, and in DGC (in the retail electricity market) - the requirements of the Basic Regulations of Operation retail electricity markets and the requirements of the Rules for providing access to the minimum set of functions of intelligent electricity (power) metering systems.

2.10.7. Metrological support of measuring instruments that are part of electricity metering systems must comply with the provisions of the subsection of the Technical Policy "Metrological support" and be carried out in accordance with the requirements of the legislation of the Russian Federation.

2.10.8. Depending on the topology of the network, in order to balance the sections of the distribution network, it is recommended to organize accounting at the network facilities along the boundaries of the balance sheet of the Company.

2.10.9. Substation 35 kV and above must be equipped with measuring systems and DCTD using data transmission facilities to the center for data collection and processing (DSPC). Metering devices must be installed at all connections.

2.10.10. To protect metering devices and (or) measuring complex for commercial and technical metering of electrical energy from unauthorized access, sealing of terminal covers of metering devices and test boxes, as well as test and intermediate terminal blocks of current and voltage circuits, identification and authentication of subjects and objects of access, functions registration of security events with transmission to a dedicated information collection server of the security monitoring subsystem, control of the integrity of the embedded software, ensuring the integrity of transmitted information, the use of a dedicated APN (VPN) of the data transmission network operator and the topology of the "Star" network (Hub and Spoke).

2.10.11. On critical connections of substations of 35 kV and above, in the presence of technical and economic feasibility, it is allowed to install metering devices that perform the functions of an oscillographic recorder of parameters of normal and emergency modes, transients and non-compliance of the PKE with the standards of GOST 32144-2013.

2.10.12. Transformer substations, RP, RTP 6-20 kV should be equipped with 0.4-20 kV measuring complexes using data transmission facilities.

2.10.13. Ensuring synchronization of the Accounting and Telemechanics System in terms of transferring technological information to the NCC for the purpose of operational and technological control (currents, voltages, power, etc.).

2.10.13.1. For the effective use of resources in the design of new construction and (or) reconstruction of objects of the 0.4-20 kV distribution network, it is recommended to provide for the use of unified devices that support the ability to collect and transmit telemechanics signals and data from the Accounting System (with an appropriate economic and/or technical justification).

2.10.13.2. Design common communication channels for the Accounting and Telemechanics System.

2.10.13.3. Provide the possibility of using telemetric information received and transmitted through the Accounting System for organizing remote monitoring and control in relation to objects of the 0.4-20 kV distribution network:

a) at the level of measuring complexes:

- network controllability by means of switch control (if there is an appropriate technical capability in switch)

b) at the level of USPD (controller, metering device (external module) with remote control functions):

- the volume of tele-information in accordance with clause 2.11.8.10 a) of the Technical Policy;

- network controllability by means of switch control (if there is an appropriate technical capability in switch)

- volume of telemetric information of internal self-diagnosis in accordance with clause 2.11.8.10 of the Technical Policy.

2.10.13.4. Use common primary converting devices (sensors, transformers) of current and voltage for connecting measuring devices of accounting and telemechanics systems.

2.10.13.5. The possibility of separate execution of the Accounting and Telemechanics System is allowed solely by agreement of the blocks for the implementation of services and technical policy in the presence of an appropriate justification (according to the criteria of economic feasibility or ensuring the required level of reliability of power supply to consumers in the projected network section).

2.10.14. Organization of electricity metering at 6-10 kV overhead lines

2.10.14.1. To organize the metering of electrical energy, including in the case of passing the balance sheet at the facilities of the consumer's grid, metering of electrical energy should be organized using remote (including high-voltage) commercial metering points.

2.10.14.2. Electricity metering points should be equipped with measuring complexes using data transmission facilities.

The priority of the choice of communication channels is shown in Table 4.

Table 4. Choice of communication channel from IIC, if available

Metering facility	Transfer protocols		Communication channels IIK-IVKE (IVK)				
	RS-485	Ethernet	PLC and HF	Ethernet - VPN on third-party networks	RF*	GPRS	WCGB
Substation 35 kV and above	2	1	4	5	2	3	1
Transformer substation 6.10 kV	2	1	2	4	3	5	1
Apartment building	2	1	1	3	2	4	-
Private households	-	-	1	4	2	3	-

** RF includes channels implemented in various radio frequency ranges, including ZigBee,* *LPWAN, BlueTooth, etc.*

2.10.14.3. To protect classical metering devices from mechanical stress and unauthorized access, their placement should be carried out in cabinets equipped with burglar alarms.

2.10.14.4. In the absence of technical feasibility and (or) economic feasibility of installing measuring instruments directly on the border of the balance sheet, it is allowed to install them in other points of the network, provided that they are as close as possible to the border of the balance sheet.

2.10.15. Organization of electricity metering at 0.4 (0.23) kV ASU for consumers of private households and legal entities

2.10.15.1. Metering points for legal entities and private households connected to a 0.4 (0.23) kV network should be equipped with measuring systems using data transmission facilities (via mobile networks, radio channels, PLC technologies, as well as interfaces for accessing remote reading information). It is allowed to use metering devices equipped with a remote (portable) display for displaying information.

2.10.15.2. For citizens - consumers of electrical energy living in private households, measuring instruments should be installed at the border of the balance sheet outside the territory of the dwelling at the entrance to the house (on the support of the overhead line, the wall of the house) or on the support of the overhead line using metering devices with split architecture or remote points commercial accounting.

2.10.15.3. For legal entities - consumers of electrical energy, measuring instruments should be installed at the border of the balance sheet using metering devices with a split architecture or remote points of commercial metering.

2.10.16. Requirements for accounting system components

2.10.16.1. Requirements for measuring CT and VT for the purposes of electricity metering:

- for new construction and reconstruction of a 110 kV and higher central processing unit, preference should be given to the installation of digital measuring CT and VT;

- measuring CTs and VTs must comply with the requirements set forth in subsection 2.1.9 "Measuring transformers" of this Regulation on the Unified Technical Policy.

2.10.16.2. Requirements for electricity metering devices installed at connections of grid facilities and in distribution networks:

- metering devices should ensure the accumulation of statistics on random events (voltage dips and interruptions, overvoltage);

- newly installed electricity metering devices must have at least two digital interfaces or an interface with multi-access to work in the Company's accounting system. At the DSP, metering devices must have a digital Ethernet interface (an external converter is allowed) for operation in the Accounting System and a second digital interface for local verification and adjustment;

- accuracy classes of electric energy metering devices for various metering objects should be as follows:

• at connections with a voltage of 110 kV and above - not less than 0.2S;

• on connections with a voltage of 0.4-35 kV - not less than 0.5S.

The accuracy class of reactive electrical energy metering devices can be selected one step lower than the corresponding accuracy class of active electrical energy metering devices.

- metering devices must comply with the requirements of the Rules for providing access to the minimum set of functions of intelligent Electricity (power) metering systems;

- digital metering devices must comply with the requirements of GOST 22261-94, GOST 31819.22-2012, GOST 31819.23-2012, IEC 61850-8.1 GOOSE, MMS, IEC 61850-9.2 SV or have the technical ability to quickly switch to information interaction in accordance with IEC 61850, if ready higher level of control (NCC) without additional costs and without the need to replace (dismantle) the metering device, USPD.

2.10.17. Requirements for communication channels

2.10.17.1. When determining the types of communication channels in each specific case, one should proceed from the territorial location of the accounting objects and the maximum use of their own telecommunication links.

2.10.17.2. Communication channels intended for the transmission of information must ensure stable connections between devices of different levels of the Electricity Metering System. The use of cellular communication is allowed as the main communication channel (for example, for the USPD (IVKE) - IVK VU) channel only in cases where there are no other communication channels that provide a stable connection.

When using cellular communication, it is imperative to ensure the integrity of the transmitted information, the use of a dedicated APN (VPN) of the data transmission network operator and the topology of the Star network (Hub and Spoke).

The types of communication channels should be determined by economic feasibility.

2.11. Communication network of the power grid complex

2.11.1. General provisions

2.11.1.1. The main tasks to be solved by the technical policy in the field of communication network development:

- coordination by the Company of the development of the telecommunications infrastructure of subsidiaries and dependent companies and their interaction with each other;

- accelerated rearmament and modernization;

- introduction of modern telecommunication and information technologies and expansion of the range of new services;

- building a unified network resource management system;
- introduction of advanced operating technologies using modern diagnostic and monitoring tools;
- improvement of the regulatory and technical base and methodological support.

2.11.1.2. The communication network of the electric grid complex (SSESK) is a complex of interacting communication networks of the Company's subsidiaries and dependent companies, which includes communication facilities and communication lines and is intended to ensure control of technological processes in the transmission and distribution of electricity, dispatch control and production activities of the electric grid complex.

2.11.1.3. The EGC communication network includes the communication network of the backbone EGC with access to the UNEG facilities and the communication networks of distribution grid companies. The key principle of planning communication networks of enterprises of the electric grid complex is to ensure the interconnection and synchronization of development plans, as well as the mutual use of network resources to ensure a single technological process and increase the reliability of communication networks.

2.11.1.4. The communication network is intended for the transmission of all types of information (voice, data, video) in order to ensure the control of technological processes in the transmission and distribution of electricity, operational and technological management, production and administrative activities of the Company and subsidiaries and dependent companies, operational dispatch management in the electric power industry.

2.11.1.5. The purpose of creating a communication network for PSC is to meet the needs of users of technological and corporate management systems of PJSC Rosseti and subsidiaries and dependent companies with a modern set of communication services with specified service quality indicators at optimal costs for the development and operation of the communication network to achieve the required level of reliability and the pace of development of a single PSC.

2.11.1.6. The ESC communications network must provide:

- information exchange between power facilities, DC and NCC for the implementation of operational dispatch and operational technological management;
- functioning of relay protection and automation systems;
- information exchange between power grid companies for the implementation of technological and corporate governance;
- information security of transmitted data;
- the possibility of integration with fuel and energy companies, as well as with departments and telecom operators interested in creating communication networks based on the infrastructure of the electric power industry;
- integration of IT systems of power industry enterprises into a single infocommunication space;
- non-discriminatory access of subjects of the electric power industry to the

resources of the technological communication network.

2.11.1.7. The solution of the above tasks will allow:

- to increase the survivability and reliability of the functioning of electrical networks by ensuring the management of power supply companies' facilities in normal and emergency modes;

- to increase the scalability of technical solutions and the efficiency of the integration of new construction projects or reconstructed ESC facilities;

- to increase the observability and controllability of ESC facilities by providing operational units, emergency teams, managers of all ranks with operational and reliable information and by promptly communicating the decisions and tasks assigned to each enterprise or official;

- to ensure the possibility of implementation and operation of automatic and automated systems of dispatch, technological management and corporate information management system at all levels of the management hierarchy;

- to ensure the possibility of digital transformation of ESCs, construction of a new generation electrical network, implementation of the "Digital Substation".

2.11.2. Principles of creation and development of the ESC communication network

2.11.2.1. When building and developing a communication network, it is necessary to follow the following basic principles:

- digitalization of the network and the introduction of equipment for packet switching technology, subject to meeting the technical requirements for organizing the exchange of technological information between the facilities of the Company's power grid. Decommissioning of analogue communication systems;

- broadband - the ability to selectively change the speed of information transmission according to a simplified procedure for a specific subsystem or service, depending on current needs;

- scalability of the network - the possibility of expanding the network without changing the fundamental technical principles of its construction and complete replacement of channel-forming equipment;

- separation of technological and corporate segments of the communication network at the physical or logical levels; The technological segment should be created and developed with the condition of ensuring the principles of organizing communication channels "Target model of command passage and organization of communication channels and transmission of telemetric information between dispatch centers and control centers of networks of network organizations, substations", approved by a joint decision of JSC SO UES and PJSC FGC UES "dated January 29, 2007;

- ensuring the prioritization of delay-critical data types through the implementation of mechanisms to ensure quality of service (QoS);

- ensuring information security in order to exclude unauthorized access to the resources of the communication network;

- invariance of access - providing users with access to automated and information systems, regardless of the technology used;
- multiservice - simultaneous transmission over the network of all types of traffic (voice, data, video);
- modernization of the network in the presence of technical and economic feasibility;
- reduction of capital and operating costs due to the use of unified standard solutions and automation of diagnostic and management processes;
- organization of interaction with existing and emerging communication networks of electric power industry entities, as well as with networks of communication operators;
- use of open and standardized protocols and interfaces;
- taking into account forecasts of potential needs for telecommunication and information services for 5-10 years;
- deployment of communication networks without disrupting the functioning of the existing telecommunication infrastructure, i.e. building new user networks in parallel with the existing ones;
- priority - when building SSESK, the use of the unconditional priority of technological traffic, taking into account the guaranteed reliability and safety of delivery;
- hybridity - the implementation of requirements for transport networks in the interaction of various types of technological systems, such as relay protection and automation, telemechanics, voice communication and others, in terms of such parameters as delay time, delay asymmetry, delay unevenness (jitter);
- ensuring control over the state of critical elements of the communication network using monitoring systems.

2.11.2.2. The technological segment of the SSESK should be created and developed in accordance with the condition of ensuring the principles of organizing communication channels in accordance with the "Regulations on technological interaction between JSC SO UES and PJSC FGC UES" dated May 17, 2019, the Concept of building a communication network of the electric grid complex, other NTD of PJSC Rosseti governing the creation and development of communication networks.

2.11.2.3. As border routers with access to the information and telecommunications network "Internet", routers certified for compliance with information security requirements (in terms of the security functions implemented in them) are selected.

2.11.2.4. The development of information and communication infrastructure involves the use of services and cloud solutions from leading telecom operators. Creation and modernization of our own communication networks, as well as storage and data processing systems is carried out taking into account the assessment of efficiency and economic feasibility.

2.11.3. Basic requirements for ESC communication network services

2.11.3.1. The ESC communications network at all management levels must ensure the exchange of all types of information (sound, video, data) with guaranteed quality in accordance with federal and corporate standards for communication channels, including in accordance with RD 45.046-99, ITU-T G.823 , ITU-T G.825, ITU-T Y.1540, ITU-T Y.1541.

Information transmission services are characterized by the following quality parameters:

- availability;
- availability factor and recovery time;
- the quality of information transfer;
- throughput;
- delay time;
- delay asymmetry;
- delay unevenness (jitter);
- functioning of the telecommunications infrastructure in a round-the-clock mode with redundancy of its elements, ensuring the continuity of operational dispatch control in the electric power industry and operational technological control.

2.11.3.2. Availability is determined by the compliance of the telecommunication signal transmission parameters with the requirements of the standards for the electrical parameters of the main digital channels and paths of the backbone and intra-zone primary networks of interconnected communication networks of the Russian Federation.

2.11.3.3. The availability factor of each direction of information exchange for the technological and corporate segments of the communication network must meet the requirements for the reliability of operating control subsystems.

2.11.3.4. The bandwidth of digital channels should be selected so that the transmission of all traffic of control tasks with the specified quality parameters is ensured, including the operation of telephone communication for operational negotiations, industrial and technological telephone communication, transmission of telemetric information about technological modes of operation of equipment, tasks of operational dispatch control in the electric power industry, performed by the subject of operational dispatch control in the electric power industry, etc.

2.11.3.5. Organization of information exchange between electric power facilities of grid organizations and DC of JSC SO UES, including the requirements for telephone communication for operational negotiations, must comply with the technical requirements specified in the existing agreements on technological interaction between JSC SO UES and grid organizations in order to ensure reliability functioning of the UES of Russia.

2.11.3.6. Communication centers NCC, substation, communication centers of electric grid companies and other subjects of the electric power industry must be connected to the EGC communication network in the network nodes of the EGC communication network at least two mutually redundant independent communication channels with the throughput determined by the project and the existing NTD. At the same time, to organize information exchange, the resources of telecommunication infrastructures of PJSC Rosseti and subsidiaries and dependent companies, and other subjects of the electric power industry should be mutually used.

2.11.3.7. The ESC communications network should ensure the provision of the following basic services for the transfer of technological and corporate information:

- telephone communication for operational negotiations;
- transmission of telemetric information (teleinformation, telesignalization and remote control);
- data transmission of technological video surveillance;
- transmission of signals and commands of relay protection and automation with the possibility of remote monitoring of relay protection and automation devices, viewing oscillograms and changing the configuration of relay protection and automation terminals;
- data transmission of AIIS KUE and SMUKE;
- data transmission of corporate IT systems;
- recording of operational negotiations;
- industrial and technological telephone communication;
- operational radio communication;
- access to services and services of the public telephone network (local, intercity and international communication);
- video conferencing;
- video conferencing recording;
- transmission of facsimile messages;
- transfer of other technological information;
- information and reference services

2.11.4. The structure and composition of ESC communication networks

2.11.4.1. The structure and composition of ESC communication networks is a complex of interacting communication networks of the Company's subsidiaries and dependent companies.

Communication networks of the Company's subsidiaries and affiliates are divided into the following components:

- primary (backbone and distribution) communication network, which is a set of networks, lines and communication channels that ensure the delivery of all types of information;
- secondary (superimposed) networks, which are a collection of means that ensure the transmission, switching, and distribution of information of a certain type.

2.11.4.2. To build a primary communication network and provide redundancy, the following types of networks, lines and communication channels can be used:

- wired:

● fiber-optic communication lines (FOCL);

● high-frequency communication network via overhead lines (HF-overhead lines);

● cable communication lines (CLS);

● communication channels using PLC technology;

● leased communication resources (channels) formed by wire means of communication operators;

- wireless:

● radio relay communication lines (RRL);

● satellite communications network;

● leased communication resources (channels) formed by wireless means of communication operators, except for the use of a mobile radiotelephone (cellular) communication network.

2.11.4.3. Secondary networks include:

data transmission network;

telephone network;

conference network (audio and video);

mobile radio network;

communication network of base stations of mobile radio communication.

2.11.4.4. The architecture of the ESC communication network is a set of communication networks of subsidiaries and dependent companies, united by at least two mutually redundant communication channels according to the radial-ring principle (Figure 4).

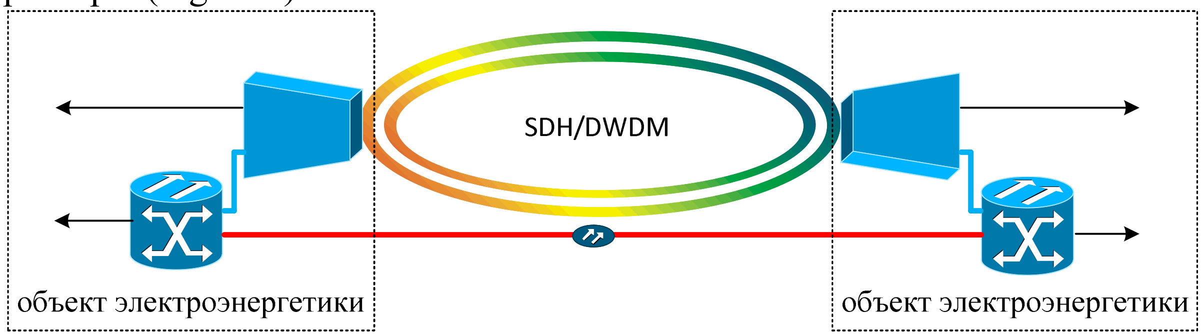

Figure 4. FOCL ring architecture

2.11.4.5. The primary communication network should be organized primarily in a ring topology. In addition, the following primary network topologies are allowed:

- cellular;
- point - point;
- point - many points;
- chain;
- multiple ring.

2.11.4.6. To ensure fault tolerance of the communication network, technologies of duplication or redundancy of equipment and channels should be used, depending on the technologies used, restrictions on information exchange or economic feasibility.

2.11.4.7. On sections of the backbone network that require high bandwidth and/or have prospects for increasing traffic, it is advisable, with an appropriate feasibility study, to use xWDM wavelength division multiplexing equipment. In addition, the use of WDM technology is one of the ways to logically separate the technological and corporate network segments, and allows you to organize the required number of SDH and/or Ethernet channels with the required bandwidth.

2.11.4.8. To ensure the subsequent transfer of the communication network to IP / Ethernet while maintaining the previously made investments, it is recommended to use communication equipment of SDH or OTN technologies that have the number of Ethernet interfaces required for a specific network topology.

2.11.4.9. Equipment and materials used in the construction of a communication network must comply with the requirements of the current normative and technical documentation. The conformity of the equipment must be confirmed by certificates of conformity, and the conformity of materials with declarations of conformity issued by the federal executive body in the field of communications".

2.11.5. Data network

2.11.5.1. The structure of the SSESC data transmission network should represent a three-level model of the communication network, shown in Figure 5.

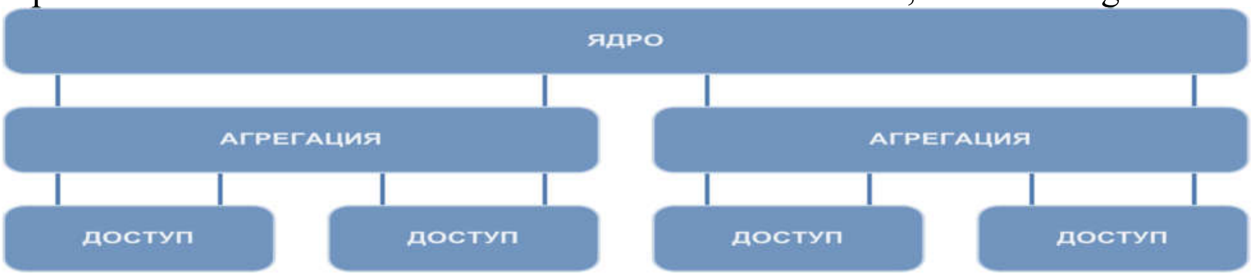

Figure 5. Three-tier SSESC model

2.11.5.2. The structure of the SSESC data transmission network (Figure 6) should include:

- basic / backbone level (core) (provides high-speed, long-distance connections between geographically remote areas, linking several sites (groups of buildings) into a distributed one, and is responsible for fast and reliable forwarding of large volumes of traffic);

- the level of distribution / aggregation (provides routing, filtering and access to the resources of the interconnected network, as well as (if necessary) in determining the rules for packet access to the base layer);

- access level (provides access for users, work groups and local technological systems when accessing the resources of the interconnected network).

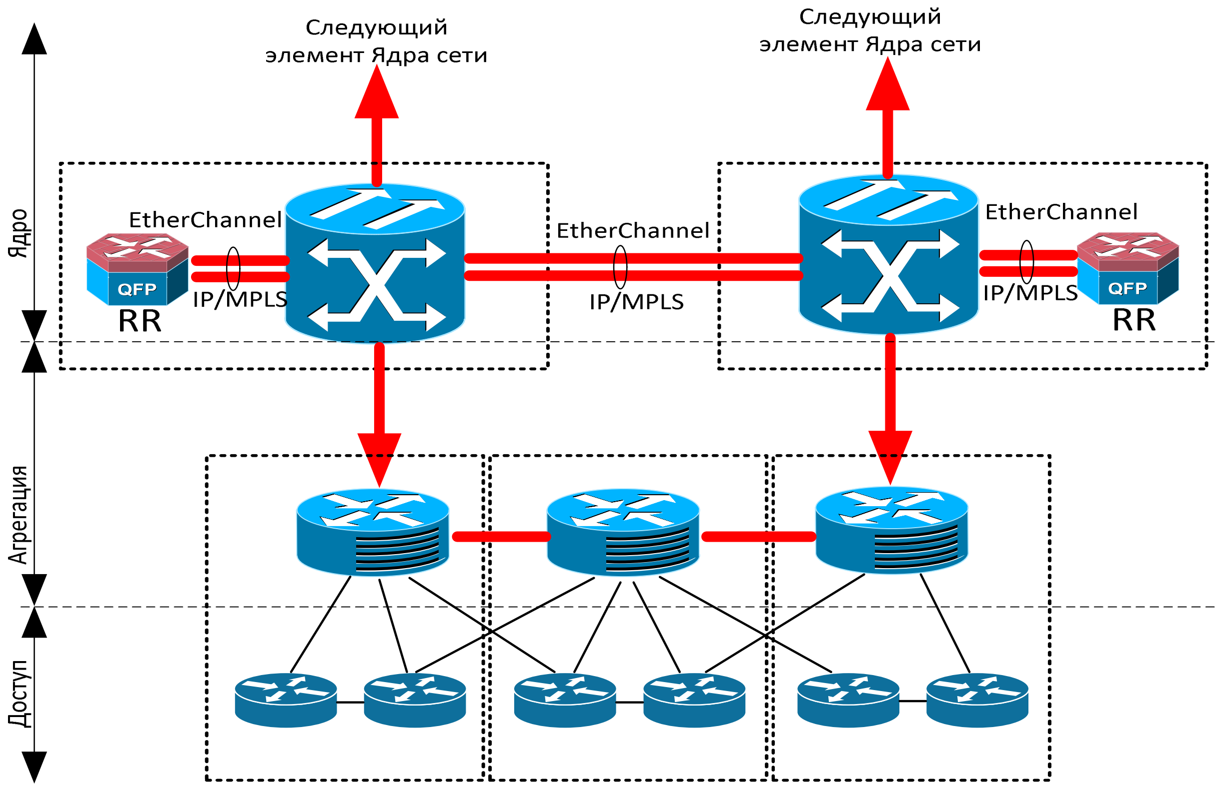

Figure 6. Structure of the SSESK data transmission network

2.11.5.3. The structure of the SSESK data transmission network should ensure the interface of communication nodes at all levels of technological and corporate management of power grid companies and JSC “SO UES”. When implementing the separation of segments of the data transmission network at the logical level, measures must be taken to ensure safe interconnection of networks, including segmentation and firewalling.

2.11.5.4. Communication centers NCC, PS, communication centers of electric grid companies and other subjects of the electric power industry must be connected to the ESC communication network at least two mutually redundant independent communication channels in the network nodes of the ESC communication network, which are SSESK access nodes.

As SSESK access nodes, PS communication nodes, regional (RUS) and district communication nodes (OUS), created on the basis of branches of electric grid companies, as well as access nodes of alternative communication operators should be used.

2.11.5.5. The basic direction of development of SSESK is the digitalization of the transport network and access network based on the widespread introduction of modern digital switching nodes through the construction of fiber-optic communication lines, radio relay links, the deployment of satellite communication systems (CCS), digital mobile radio communication (DMC), the use of wavelength division multiplexing equipment waves (WDM) and the application of packet switching technology based on the Internet Protocol (IP).

2.11.5.6. In order to improve the observability of ESCs and, as a consequence, increase the level of operational dispatch and operational technological management, a strategic priority should be given to the digitalization of access networks at the level of “object - dispatch center / network control center”.

2.11.5.7. When organizing technological communication between the NCC and ESC facilities with a voltage class below 35 kV, as well as with consumer metering devices, it is allowed to use dedicated APN technologies in GSM / GPRS / 3G / 4G networks (except for the transmission of remote control commands) and Zvezda network topology (Hub and Spoke).

An example of building a section of a network via FOCL is shown in Figure 7.

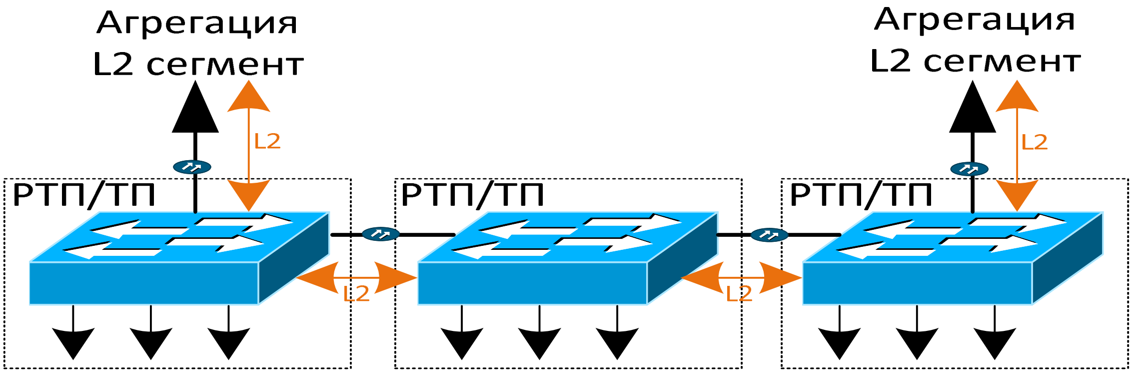

Figure 7. Section of the network via FOCL

An example of building a section of a wireless network by APN is shown in Figure 8.

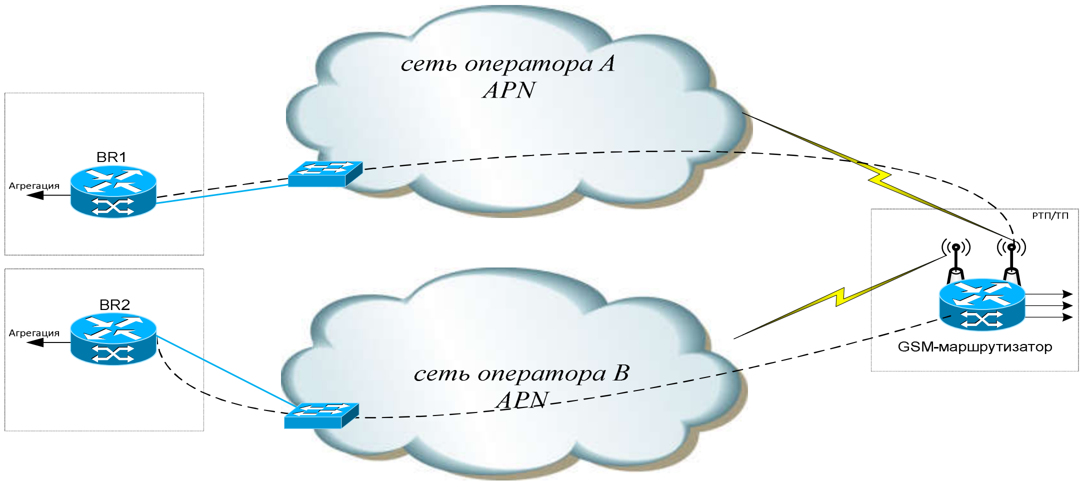

Figure 8. Section of the wireless network by APN

2.11.5.8. Wireless technologies make it possible to provide communication between the NCC and a large number of objects over a relatively large area with minimal costs for deploying and maintaining the network.

It is allowed to use PLC technology on the sections between objects with a voltage class below 35 kV, consumer metering devices with the organization of a common connection point (gateway) to the communication channel.

An example of building a network section using PLC is shown in Figure 9.

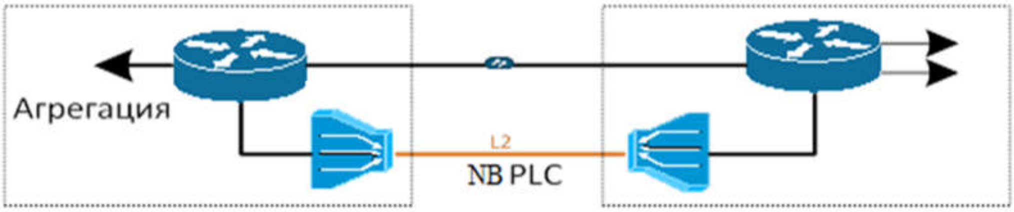

Figure 9. Network section using PLC

2.11.5.9. The materials and equipment used in the construction of the technological network, including optical cables, fittings and couplings, information transmission systems, switching and routing equipment, PTC must comply with the established requirements, be certified by the established procedure for use in the electric power industry and have a Certificate of Conformity issued by the federal authority executive power in the field of communications.

2.11.6. Fiber optic communication/transmission lines

2.11.6.1. Fiber-optic communication lines are the main method of building a backbone communication network.

2.11.6.2. The construction of fiber-optic communication lines on overhead lines of 35 kV and above is carried out mainly by the suspension of an optical cable built into the lightning protection cable (OPGT).

2.11.6.3. During the construction of fiber-optic communication lines, it is allowed to use an optical self-supporting cable (OKSN) (Figure 10), an optical cable built into the phase conductor of an overhead line (OKFP) (Figures 10 and 11), an optical cable wound on a phase wire or an overhead ground wire (OKNN).

2.11.6.4. For laying in buildings, the FOC structure is used (Figure 12), as an example, consisting of a central power element (fiberglass rod, steel cable or steel wire in a polyethylene sheath), around which optical modules are twisted, containing up to 32 optical fibers each with an armored steel corrugated tape or fiberglass rods and outer sheath made of high density polyethylene.

For laying FOCs inside buildings (objects), FOCs of a similar design are used, but the outer sheath of the cable must be made of materials that do not support combustion

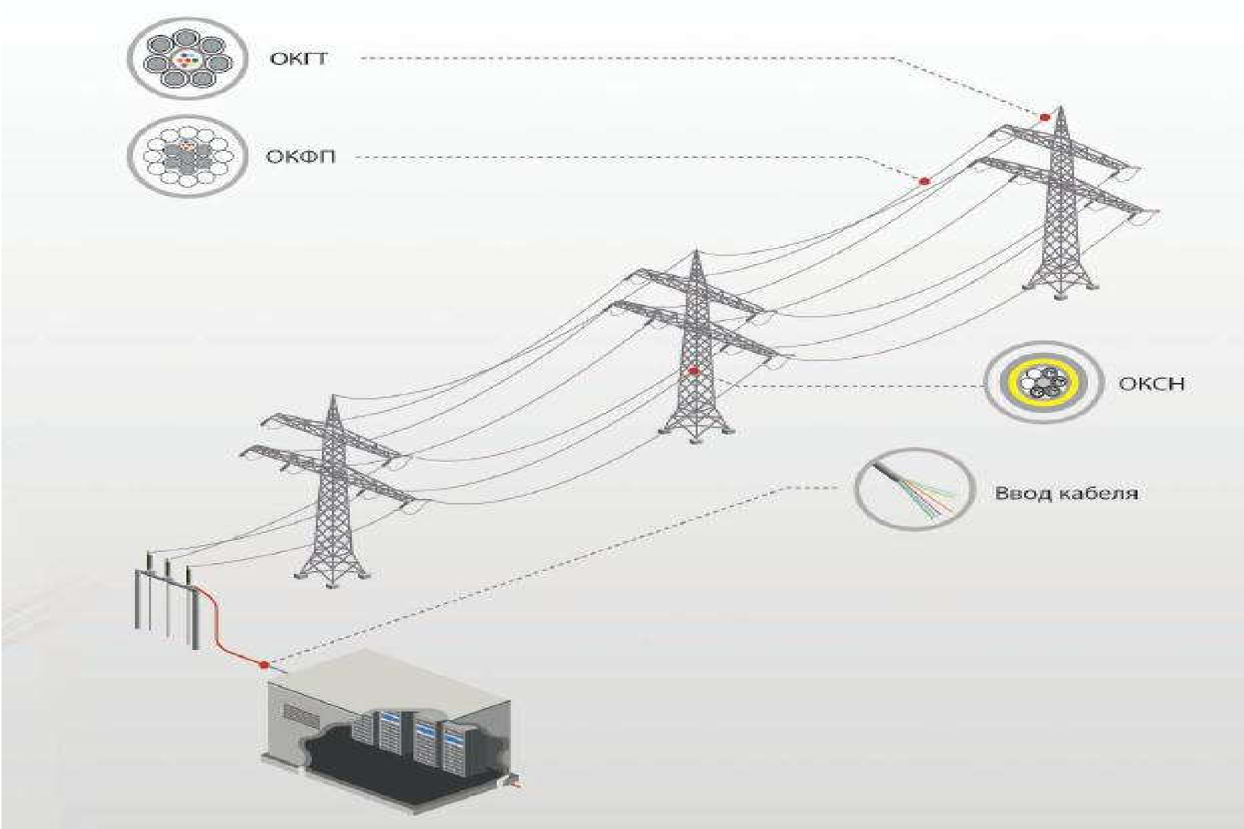

Figure 10. An example of using a self-supporting cable (OCSN) and an optical cable built into a phase wire (OFC) and a lightning protection cable (OCGT)

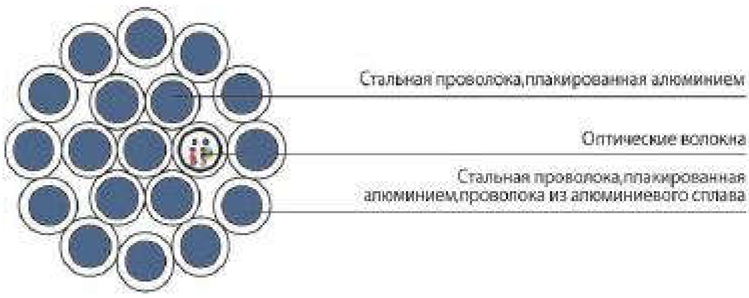

Figure 11. An example of an optical cable embedded in a phase conductor

2.11.6.5. The use of ACS is not recommended in areas with a high degree of industrial pollution, in areas up to 5 km from the sea and ocean coasts, as well as in areas in the climate zone with prolonged periods of drought and rare periods of rainfall and fog.

2.11.6.6. The technology of winding OKNN on phase wires or lightning protection cable (GT) also has a limited field of application. It is allowed to wind an optical cable onto a phase wire on an overhead line with a voltage of up to 150 kV or GT in areas with an average annual duration of thunderstorms of less than 20 hours.

Figure 12. An example of FOC construction for installation in buildings

2.11.6.7. When organizing fiber-optic communication lines on cable lines, it is allowed to use high-voltage cables of underground or underwater laying with built-in OK.

2.11.6.8. The choice of the type of cable used should be determined by economic feasibility, taking into account the condition of the overhead line and the possibility of its shutdown during the construction and possible repairs of the FOCL.

2.11.6.9. The number of optical fibers in an optical cable and the capacity of transmission systems are determined at the stage of developing a design or engineering assignment, taking into account current and future needs.

2.11.6.10. It is allowed to build fiber-optic communication lines - overhead lines with the involvement of non-tariff investments of third-party organizations (telecom operators) by providing them with temporary limited use of the power grid infrastructure in order to suspend the fiber-optic communication line.

2.11.6.11. The construction of fiber-optic communication lines should be carried out mainly according to the ring principle of combining communication nodes to ensure physical redundancy of communication channels.

2.11.6.12. For the construction of FOCL, it is allowed to use several overhead lines of different voltage classes, coinciding in direction with the FOCL route.

2.11.6.13. When placing a fiber-optic cable on the overhead line, during the design and survey work, an examination of the condition of the foundations and metal structures of the supports and their fastenings in the ground should be carried out, taking into account the additional loads arising from the installation of the fiber-optic cable.

2.11.6.14. When creating fiber-optic communication lines, the choice of technology for information transmission is carried out at the design stage, taking into account the current and future purpose of the communication line and the types of transmitted traffic.

2.11.6.15. Optical fiber parameters must comply with GOST R IEC 793 and ITU-T recommendations G.652, G.653, G.654, G.655. Individual requirements for the parameters of the optical fiber should be specified at the stage of development of design documentation for the information transmission system implemented by a specific fiber-optic communication line - overhead line.

2.11.6.16. Design, construction and operation of fiber-optic communication lines - overhead lines should be carried out in accordance with the current regulatory legal acts and

NTD.

2.11.6.17. Executive documentation must be executed in accordance with the requirements of the guidance documents STO 56947007-33.180.10.172-2014, RD 45.156-2000 and RD 45.190-2001, executive documentation of the linear part of the FOC suspension on overhead lines - in accordance with RD 34.20.504-94.

2.11.6.18. Taking into account the increased requirements for the reliability of the backbone network, it is necessary to determine the feasibility of installing automated monitoring systems for optical fibers, which allow real-time monitoring of the state of the physical parameters of optical fibers.

2.11.6.19. In order to unify technical operation and to ensure the possibility of certification, scheduled measurements and measurements in the course of emergency recovery operations, optical fibers and modules in the FOC should have the following colors: blue, orange, green, brown, gray, white, red, black, yellow, purple, pink, turquoise.

2.11.6.20. The main principles and directions for the development of fiber-optic communication lines are:

- construction of new physical high-speed communication channels for energy infrastructure facilities;
- provision and control over the quality of work at the stages of design and implementation of the construction of fiber-optic communication lines on overhead lines;
- during the construction and development of fiber-optic communication lines, it is allowed to attract non-tariff investments of telecom operators, organizations of the fuel and energy complex and others - having their own infrastructure of fiber-optic communication lines, with which a long-term mutual exchange of optical fibers and telecommunication resources is also possible on a contractual basis;
- transition from TDM equipment to packet-switched transmission systems.

2.11.6.21. The scope of FOCL is a priority type of infrastructure for building a backbone network and a communication access network to objects of all voltage classes.

2.11.7. High-frequency communication network over overhead lines

2.11.7.1. High-frequency communication systems are used to control technological processes, both under normal conditions and in emergency situations. All types of information necessary for this management are transmitted through these channels:

- speech (telephone communication);
- telemechanics signals;
- machine-to-machine data;
- data of the automated process control system;
- data of AIIS KUE.

2.11.7.2. HF communication channels use phase wires and lightning protection cables of overhead lines as a transmission medium (communication lines).

2.11.7.3. The use of digital HF communication is advisable in network sections where it is required to transmit a limited amount of information, and the use of other types of communication does not provide the necessary reliability of information transmission or is economically inexpedient. The throughput of digital HF communication paths is determined by calculation at the design stage, taking into account the characteristics of the equipment, the state of the overhead line, the presence of taps and additional attenuation caused by weather conditions and overhead line breaks. On overhead lines 35 kV and higher, the transmission rate is also limited by the availability of free frequencies in the range of 16 - 1000 kHz.

2.11.7.4. Depending on the frequency band used, the HF equipment allows the transmission of information at a rate of up to several hundred kbit / s.

2.11.7.5. HF communication channels should be organized taking into account the provision of a margin for overlapping attenuation in adverse weather conditions (fog, drizzle, ice, rain). When organizing communication channels, the conditions for ensuring electromagnetic compatibility must be met.

2.11.7.6. It is not allowed to transmit signals of HF protection of overhead lines via HF channels, organized by lightning protection cables.

2.11.7.7. The main principles and directions of development of HF communication lines is to increase the functionality, reliability and quality of HF communication, namely:

- introduction of multifunctional digital systems that meet modern increased requirements for HF communication channels (progressive types of modulation, anti-jamming coding algorithms, and others);
- introduction of specialized high-frequency communication channels for high-frequency protection and emergency control automation with digital signal processing that meet modern increased requirements for channels of this type;
- decommissioning of outdated analog HF communication equipment and phased replacement with modern HF communication systems that allow operating in both digital and analog modes;
- the use of digital signal processing in the transmission and reception paths of equipment, ensuring the effective use of the frequency resource of HF communication channels by increasing the selectivity of the equipment and more efficient use of the nominal frequency band of the channel;
- Creation of a Unified Information System for the selection of frequencies of HF communication channels.

2.11.7.8. In electrical networks of 6-10 kV, HF communication systems are used to organize communication channels with electric power facilities and with electricity metering devices.

2.11.8. Mobile radio network

2.11.8.1. The mobile radio communications network should develop by expanding the radio coverage area and replacing outdated analog radio stations with modern digital ones. When modernizing analog mobile radio communication systems, the main standard for creating a radio network of the software level (RES, PMES) should be the digital DMR standard, which allows for the gradual abandonment of the analog VHF radio communication network while maintaining the previously made investments.

2.11.8.2. A mobile radio communication system of the DMR standard should include a subsystem for determining the location of terminals (both portable radio stations and those installed in vehicles) and displaying locations on the screen of the dispatcher's workplace.

2.11.8.3. The used radio stations should be able to quickly change operating frequencies in order to use them in other radio networks when eliminating emergencies. DMR radios must have a GLONASS receiver to locate the terminal.

2.11.8.4. The resource of a charged battery of a portable radio station should provide its autonomous operation for 12 hours when operating in a 5/5/90 cycle (transmit / receive / standby).

2.11.8.5. Obtaining permits for the allocation and assignment (assignment) of radio frequencies for power grid facilities is carried out in accordance with the decisions of the State Committee for Radio Frequencies:

- Decision of the SCRF dated December 20, 2011 No. 11-13-01 (as amended on February 10, 2015) "On approval of the Procedure for considering materials and making decisions on the allocation of radio frequency bands, re-issuing decisions and making amendments to them";
- Decision of the State Committee for Radio Frequencies of November 7, 2016 No. 16-39-01 "On approval of the Procedure for the examination of the possibility of using the declared radio electronic means and their electromagnetic compatibility with existing and planned radio electronic means, consideration of materials and making decisions on the assignment (assignment) of radio frequencies or radio frequency channels within the allocated radio frequency bands ”.

2.11.8.6. Mobile radio communications, mobile radiotelephone communications (cellular) and satellite mobile radio communications (hereinafter referred to as mobile radio communications) are the main means of communication between dispatcher and operational personnel with the personnel of line and emergency recovery teams, as well as a backup means of communication for operational and technological control of the distribution electric network.

When determining the need for mobile radio communications, it is necessary to take into account the structure of overhead line services in each enterprise, the operational zones of linear sections, the quality of cellular GSM / UMTS and satellite communications in the areas of operational responsibility of each linear section.

2.11.8.7. It is allowed to use stationary radio stations and VHF radio modems for organizing main and backup data transmission channels with low and medium voltage facilities, for organizing backup communication channels with 35-110 kV facilities, if the use of other data transmission technologies is impossible or economically ineffective.

2.11.9. Satellite communication network

2.11.9.1. Channels of the fixed satellite service can be used as one of the communication channels (no more than one channel in one direction), provided that the requirements for the organization of telephone communication for operational negotiations and the transfer of information for automated and automatic control systems are met, if the use of other data transmission technologies , impossible, or economically ineffective.

2.11.9.2. In addition, the satellite communication network is an additional means of mobile communication, in the absence of a mobile radio communication network or the absence of radio coverage in the area of operation of line and emergency recovery teams, a backup means for communication of dispatcher and operational personnel with personnel of line and emergency recovery teams.

2.11.9.3. The main principles and directions of development of a satellite communication network are:

- introduction of modern systems that meet the requirements established by the Ministry of Information Technologies and Communications of the Russian Federation;
- constant monitoring of the quality indicators of channels (service level agreement, SLA);
- transfer of satellite communication channels into operational readiness mode in case of availability of fixed communication channels;
- reducing the influence of weather and climatic conditions on the functioning of the communication network;
- regional development based on one operator and a single technology.

2.11.10. Telephone network

2.11.10.1. The telephone network also consists of corporate and technology segments.

2.11.10.2. The corporate segment of the telephone network is intended to support the production (administrative and economic) activities of the electric power industry, including voice transmission. The corporate segment should develop by replacing subscriber devices with IP terminals and using switching equipment that interacts with terminals using the SIP and/or H.323 protocol.

2.11.10.3. The main objectives of the corporate telephone network development are:

- creation of a unified corporate telephone communication network based on a corporate multiservice communication network;
- introduction of a unified numbering plan;
- implementation of distributed IP-PBX, consisting of a central module of the system and media gateways. At the same time, in case of temporary unavailability of the central automatic telephone exchange, media gateways must be provided with independent IP-automatic telephone exchanges with the provision of basic voice services;
- use of SIP and H.323 protocols;
- application of normalized compression (codecs like G.726 and G.729);

- implementation and development of a unified management and monitoring system at the central automatic telephone exchange level;
- convergence with other types of communications (introduction of unified communications technologies).

2.11.10.4. The technological segment of the telephone network, including communications for operational negotiations, is designed to provide control of technological processes.

2.11.10.5. Telephone communication for operational negotiations should ensure the transfer of commands and operational interaction of the operational personnel of the NCC, operational personnel of power facilities, dispatchers of JSC SO UES. For its organization, at least two independent telephone communication channels must be provided.

2.11.10.6. Telephone communication for operational negotiations should be based on circuit switching technology (TDM - Time Division Multiplexing) with forced release of a busy channel with the possibility of a subsequent smooth and gradual transition to packet switching technology (MPLS VPN, Traffic Engineering). At the same time, strict requirements for reliability and fault tolerance are imposed on telephone communication for operational negotiations, both for individual nodes and for the entire network as a whole. Channel and technical resources allocated for these tasks must ensure guaranteed delivery and quality in normal and emergency modes of operation of electric power facilities using packet switching technology.

2.11.10.7. Switching equipment used to build telephone communications for operational conversations must have 100% redundancy in the "hot" mode of the station's processor resources, interface cards, interfaces and power supplies. It is allowed to use switching equipment for building telephone communications for operational negotiations, which does not include 100% hot reserve, but at the same time at least two sets of switching equipment that do not have a common point of failure must be installed at the workplace of operating personnel. Switching equipment used to build telephone communications for operational conversations must undergo a quality control procedure for use at ESC facilities.

Switching equipment used to build industrial and technological telephony may not have 100% redundancy in the "hot" mode of the station's processor resources, interface cards, interfaces and power supplies.

2.11.10.8. Automatic registration (recording) of all negotiations of operating personnel should be provided, with the preservation of these records in accordance with the established procedure.

2.11.10.9. To organize telephone communication for operational negotiations, a radial-nodal topology is used with the addition of a ring topology, which most fully reflects the hierarchy of dispatch and technological control of the electric power industry.

2.11.10.10. When digitalizing the technological and corporate segments of the telephone network, a transition to an open numbering system with output prefixes should be implemented: two-, three- or four-digit abbreviated numbering for intra-office communication and a single seven-digit numbering for inter-office communication. The principles of forming a unified numbering plan must comply with STO 56947007-33.040.35.203-2015 “Technological communication. Guidelines for a unified numbering system for automatic telephone exchanges of electric grid facilities”.

2.11.11. Video conferencing network

2.11.11.1. A video conferencing system (VCS) should ensure the organization of video conferencing on a hierarchical basis in accordance with the organizational structure of network companies.

2.11.11.2. To ensure optimal quality, videoconferencing equipment should implement mechanisms for automatic adaptation of coding parameters depending on the available bandwidth and the quality characteristics of the communication channel.

2.11.11.3. The videoconferencing system should provide:

- registration of software and hardware video - terminals and call control on DATS;
- connection of remote video clients from external networks, including the Internet (subject to information security requirements);
- conducting videoconferences in multicast mode;
- unified and centralized management of the bandwidth of communication channels for telephony and videoconferencing services;
- the ability for users to interactively control the screen layout, content and the list of participants from the video terminal;
- centralized planning, video conferencing session management and video conferencing equipment monitoring;
- recording on electronic media of videoconferences;
- ensuring the confidentiality of videoconferences;
- use of videoconferencing equipment for interactive training;
- support for the quality of voice and video transmission at least HD (720p) at the level of the executive office of the Company and at least 4CIF at the level of branches;
- support for collaboration with documents.

2.11.12. Monitoring and control system SSESK

2.11.12.1. Communication networks of grid companies should be managed, with an appropriate feasibility study, using centralized software-level systems (RES / MES / PMES), in which the following functions should be implemented:

- configuration, monitoring and fault management;
- inventory management (accounting of physical and logical network resources);
- performance management (monitoring of network parameters and performance analysis);

- control over the implementation of troubleshooting tasks;
- service quality management (SLA);
- security management (control of access to network resources).

2.11.12.2. The network control level should allow you to see the entire network as a whole, manage it and its individual elements, and control its state as a whole.

2.11.12.3. The level of monitoring and control of network elements should allow monitoring the parameters and control of individual network elements, including the management of events and errors, redundancy, collection, primary diagnostics and storage of events from network elements, providing support for hardware and software, as well as the state of equipment power supply systems. SSESK.

2.11.12.4. All the information necessary for network management should be located in a single database, which can be changed and supplemented with descriptions of new control objects, and the entire exchange of service data of the control system should be carried out using the existing managed network".

2.11.13. Network clock network

2.11.13.1. For the communication network of the backbone ESC, a TSS network with its own PEG and VZG should be created, while the TSS network should work with the basic TSS network of PJSC Rostelecom in a pseudo-synchronous mode and together with it constitute a system of clock network synchronization of the Company's communication network. It is impractical to install its own primary reference generators (PEG) and secondary master generators (VZG) on the communication network of the distribution grid complex. It is recommended to connect the backbone network in the branches of the Company to the TSS of PJSC Rostelecom, or to the TSS of the main power grid complex.

2.11.13.2. The TSS network should be designed for a long-term perspective, be based on the most advanced technological solutions and represent an extensive homogeneous network of generation, delivery and distribution of sync signals.

2.11.13.3. The main purpose of the TCC network is to ensure the installation and maintenance of a certain clock frequency of digital signals, which are intended for digital switching and digital transit, so that the temporal relationships between these signals do not go beyond certain limits.

2.11.13.4. The reliability and survivability of the TSS network should be guaranteed by the homogeneity of the communication network, the presence of direct and backup synchronization paths, the justified use of additional sync signals from GLONASS, PEG and VZG, the use in emergency situations of the combined operation mode of the TSS system - according to the hierarchies "master-slave" and "distributed PEG ". Synchronization should be carried out by a forced method, observing the hierarchical principle according to a tree-like (radial-nodal) scheme without closed rings.

2.11.13.5. The basic principles of building a TSS network of digital communication networks must comply with the requirements of the Guidelines for the construction of a TSS on a digital communication network of the Russian Federation, approved by the decision of the GKES of Russia dated 01.11.1995.

2.11.13.6. Synchronization signals should be assigned the quality determined by the source of these signals. The quality indicators of the TSS network must comply with the RD. 45.230-2001, ITU-T Recommendations 6.811. 6.812, 6.813 and ESE 300 462-1.23.4.5.6.

2.11.14. Power supply of communication and data transmission equipment

2.11.14.1. Power supply of SSESK equipment is carried out, as a rule, centralized by two power supply inputs:

- from uninterruptible power supplies (UPS), voltage 36-72 V DC or voltage 220 V AC;

- from a single / three-phase AC network with a rated voltage of 220/380 V and a permissible deviation of plus 10 / minus 20%, a frequency of 50 Hz and a permissible deviation of plus 2.5 / minus 2.5 Hz, performed according to the 1st category of reliability, if necessary it is necessary to provide for voltage stabilization.

2.11.14.2. The UPS power supply must be carried out according to the 1st category of reliability from a single / three-phase AC network with a rated voltage of 220/380 V and a permissible deviation of plus 10 / minus 20%, a frequency of 50 Hz and a permissible deviation of plus 2.5 / minus 2.5 Hz or from direct current networks.

2.11.14.3. The UPS must be connected to the ATS and provide guaranteed and reliable power to the load. The UPS should include groups of sealed and maintenance-free AB with a service life of at least 10 years.

2.11.14.4. The capacity of the AB UPS SSESK must provide backup power supply for communication and data transmission equipment during:

- at least 4 hours at power facilities of 110 kV and above, the transit equipment of the SSESK transport network installed at any facilities must also be provided with backup power for 4 hours;

- at least 2 hours at power facilities of 35 kV and below.

2.11.14.5. UPSs, which include AB, must be equipped with transformerless rectifier units, if necessary, off-line inverters with a switching time of less than 20 ms, with microprocessor control and automatic control and signaling devices. UPSs powered by an auxiliary DC system, as a rule, must be equipped with off-line inverters with a switching time of less than 20 ms and DC / DC converters with microprocessor control and automatic control and signaling devices.

2.11.14.6. Uninterruptible power supplies (UPS), including AB, must provide:

- simultaneous power supply of the load and charge (continuous recharge in the buffer) of the AB;

- protection of the battery against discharge below the permissible level (deep discharge);

- changing the settings of the output voltage from the charging voltage to the constant trickle charge voltage at the end of the AB charge;

- short-circuit protection of battery circuits, rectifier output circuits and load circuits;

- selective shutdown of any faulty rectifier included in the UPS;

- temperature compensation and testing of AB;

- galvanic isolation of the load from the alternating current network;

- uniform distribution of load current between UPS rectifiers;

- remote diagnostics and interaction with monitoring systems using standard SNMPv2 or SNMPv3 protocols.

- disconnection of low-priority load during battery discharge;

- local and remote signaling of the UPS.

2.11.14.7. The design of the UPS should allow increasing the output power by installing additional rectifiers and be built on a block-modular basis.

2.11.15. Organization of operation of SSESK

2.11.15.1. The operation of the ESC communications network is organized in accordance with the Rules for the technical operation of power plants and networks of the Russian Federation, the Rules for the organization of maintenance and repair of electric power facilities, the Rules for the technical operation of the primary networks of the interconnected communication network of the Russian Federation and other current regulatory legal acts and NTDs.

2.11.15.2. Operation defines a set of methods and algorithms for maintenance of SSESC facilities, a complex of technical communication facilities and software and hardware, as well as technical personnel that ensure the operation of SSESC with the required quality indicators.

2.11.15.3. The objects of operation of SSESK are linear paths of cable and overhead communication lines, network paths, communication and transmission channels, sections of communication channels, transmission and paths (multiplex and regeneration sections), equipment and equipment for communication and data transmission, line-cable facilities.

2.11.15.4. The operation of SSESK is carried out by specially created structural divisions using a centralized service method.

2.11.15.5. The main tasks of SSESK operation are:

- ensuring accurate, efficient, uninterrupted and high-quality operation of equipment and line-cable communication facilities that are part of SSESK;

- ensuring stable operation with a given quality and operational reliability;

- efficient use of resources and maintenance in accordance with technical standards and requirements;

- timely and high-quality repair and reliability improvement;

- elimination of all arising malfunctions, damages and accidents within the target period;

- maintenance of production documentation, statistical and technical accounting in accordance with the approved forms and instructions.

2.11.15.6. Operation of SSESK includes works on maintenance, elimination of accidents, current, medium and major repairs.

2.11.15.7. Maintenance of SSESK is a set of operations aimed at maintaining operability or serviceability, timely prevention of malfunctions, identifying them and eliminating emerging defects.

2.11.15.8. Correct organization of maintenance should increase the service life of SSESK facilities, maintain high quality and reliability of their operation, contribute to an increase in the overhaul period and reduce the cost of repairs.

2.11.15.9. Operation of communication equipment.

2.11.15.9.1. The process of operating the equipment and equipment of the SSESC consists of measurements of operating characteristics, monitoring of failure alarms, detection of malfunctions and damages, redundancy, restoration of operability and includes the following works:

- measurements and checks;
- repair and adjustment work;
- repair and restoration work;
- current and average repairs;
- accounting and analysis of equipment failures;
- records management;
- regular installation of firmware security updates.

2.11.15.9.2. The good condition of the equipment and equipment of the SSESK is determined by:

- compliance of the parameters of the apparatus and equipment with the technical standards of the passport;
- composition and completeness;
- operability of signaling devices and switching elements;
- lack of mechanical damage and neat appearance;
- the use of measuring instruments that meet the requirements of subsection 3.6 of the Technical Policy, as well as the timely performance of their metrological service.

2.11.15.9.3. When operating the equipment and equipment of SSESK, the following maintenance methods are performed:

- preventive maintenance performed at specified time intervals or in accordance with predetermined criteria and aimed at timely warning of the possibility of failure or deterioration in performance;
- corrective maintenance performed after the detection of the inoperability condition and aimed at restoring it to a state where the quality parameters are within established tolerances;
- Managed maintenance, performed through the systematic application of condition analysis techniques using performance controls, transmission quality controls and troubleshooting, aimed at minimizing preventive maintenance and

reducing corrective maintenance.

2.11.15.9.4. Maintenance of SSESK apparatus and equipment is carried out by replaceable and non-replaceable technical personnel:

a) shift personnel provides:

- operational and technical management;
- performance of work on operational control and routine maintenance of equipment, paths, communication channels and data transmission;
- prompt troubleshooting;
- acceptance for inspection and commissioning after inspection or restoration of paths, communication channels and data transmission;
- maintenance of operational and technical documentation.

The shift personnel is guided by algorithms, instructions and regulations of the main provisions for management, operation and operational interaction;

b) non-replaceable personnel provides:

- performance of work on operational control, maintenance, current repair, development, performance of repair and adjustment and repair and restoration work;
- acceptance, commissioning of equipment, paths, communication and transmission channels;
- preparation and maintenance of production documentation required for maintenance and operational and technical management;
- accounting and analysis of the operation of equipment, apparatus, paths, communication and transmission channels;
- development of proposals to improve the quality and reliability of work.

2.11.15.10. Operation of line-cable communication facilities.

2.11.15.10.1. Operation of line-cable structures of SSESK includes works on maintenance, elimination of accidents and accidental damages, performance of current and major repairs.

2.11.15.10.2. Maintenance of line-cable structures of SSESK is a set of operations aimed at maintaining operability and serviceability, timely prevention of malfunctions, identifying them and eliminating emerging defects.

2.11.15.10.3. Maintenance, depending on the amount of work and the frequency of their performance, is divided into routine (daily) and periodic scheduled preventive maintenance.

2.11.15.10.4. Routine maintenance is carried out systematically, is mandatory and not specifically planned.

2.11.15.10.5. Routine maintenance also includes security measures, monitoring of line-cable communication facilities and, if possible, elimination of detected faults on communication lines that may lead to disruption of the normal operation of communication.

2.11.15.10.6. Scheduled preventive maintenance is carried out periodically, mainly by conducting inspections of structures and eliminating faults detected during this, as well as by conducting electrical and optical measurements on cable and fiber-optic communication lines.

2.11.15.10.7. Scheduled preventive maintenance of line-cable facilities includes the following works:

- inspection and preventive maintenance of line-cable structures;
- conducting scheduled and control measurements of electrical and optical characteristics of communication lines;
- check of new cables, wires, terminal cable devices, equipment and fittings coming into operation;
- preparation of line-cable structures for operation in the autumn-winter period, flood and thunderstorm periods.

2.11.15.10.8. Routine repair is the minimum type of planned repair in terms of volume, in which work is carried out to systematically and timely protect line-cable structures from premature wear and damage by replacing and (or) restoring individual elements of line-cable structures.

2.11.15.10.8. Current repairs are carried out in the amount determined by the analysis of the technical condition of the line-cable structures.

2.11.15.10.9. Overhaul of line-cable structures is the largest type of scheduled repair in terms of volume, in which worn-out parts and structures of structures are replaced or replaced with more durable and economical ones that improve the operational capabilities of facilities.

2.11.15.10.10. During overhaul of line-cable structures, they should be modernized if its technical and economic feasibility is determined. Modernization is understood as a partial improvement of individual parts or details of communication facilities, usually carried out simultaneously with a major overhaul.

2.11.15.10.11. The tasks of overhaul of line-cable structures are to ensure their modernization and uninterrupted operation throughout the entire service life.

2.11.15.10.12. Overhaul of line-cable structures is carried out periodically, depending on the overhaul cycle and the technical condition of line-cable structures and is planned in each individual case on the basis of technical inspection data, electrical and optical measurement protocols, acts of inspections and inspections and lists of defects compiled on this basis.

2.11.15.10.13. Various means are used to operate the SSESK, including instrumentation, analyzers, testers and other necessary specialized equipment: gas generators, motorized pumps, cable tightening devices, etc. complexes that allow you to monitor the operation of communication facilities in real time and promptly notify shift personnel about possible malfunctions.

2.11.15.11. Emergency recovery and repair and recovery work on equipment and line-cable communication facilities.

2.11.15.11.1. Emergency recovery operations provide for a set of urgent measures and works aimed at immediate elimination of emergencies (defects, failures and damages), restoration of the required quality parameters to ensure the conditions for failure-free operation of dispatching technological control facilities.

2.11.15.11.2. Carrying out urgent repair and restoration work involves a set of urgent work aimed at prompt elimination of detected (identified) faults and damages to restore the required quality parameters and prevent (prevent) deterioration of parameters and characteristics that can lead to accidents in the SDTU.

2.11.15.11.3. Emergency recovery and repair and recovery work on equipment and line-cable communication facilities of SSESK can be performed by specialized contractors within the framework of the concluded framework contracts.

2.11.16. Protection of communication networks and transmitted information from unauthorized access

2.11.16.1. In order to protect against unauthorized access to communication networks and information transmitted through them, organizational and technical measures should be taken to prevent access to means, lines and communication facilities located both inside and outside objects, and information transmitted over communication networks.

2.11.16.2. Organizational and technical measures determine:

- organization of access control to the protected area, within which communications facilities are located (protected area) and the procedure for protecting this area;
- procedures for the use of technical means of protection, detection and signaling in the protected area;
- a list and samples of documents giving the right to be in the protected area, as well as in communication facilities and separate premises located within the protected area;
- the procedure for registration of admission to work on means and communication lines, as well as work related to the technological possibility of access to information transmitted through a communication network, establishing a list of persons entitled to carry out such work;
- the procedure for registering events related to the implementation of access to means, lines and communication facilities.
- equipping communication facilities and facilities with access control devices;
- the presence of locking devices for rooms and line-cable structures in which the means and communication lines are located.

2.11.16.3. To protect against unauthorized access to the software of nodes and communication networks, the following should be provided:

- measures to exclude the possibility of access to the means of communication of persons who do not have the right to do so;
- control of connection to communication facilities of hardware and software used during operation;
- registration and subsequent control of the actions of the service personnel during the operation of communication facilities and structures;
- differentiation of access rights, including the use of identification and authentication codes by service personnel;

- registration and subsequent control of the facts of access of individuals, including service personnel, to communication facilities and structures during operation and construction;

- Establishment of procedures for the authentication of service personnel for remote access to communication facilities and facilities.

2.11.16.4. To protect against unauthorized access to communication facilities that are not located in the protected areas, the following should be performed:

- equipping premises and buildings in which communication facilities are located, with locking devices, alarming and burglar alarms;

- installation of communication equipment in places that exclude or significantly impede unauthorized access to them;

- equipping cabinets with communication equipment with locking devices and sensors for burglar alarms about unauthorized access;

- bypasses and inspections of line-cable structures, including telephone duct wells, terminal cable devices and maintenance of an inspection log.

2.11.16.5. Events related to unauthorized access to networks and communications facilities and information transmitted through them are documented and certified by the signature of the official who registered this event.

The event log should contain:

- an indication of the means or lines of communication to which unauthorized access was made and their symbol;

- description of the event and its consequences of the event;

- date and time of the event and/or registration of the event;

- an indication of the person who identified the event.

2.11.16.6. In order to prevent the occurrence of events associated with unauthorized access to the communication network and to the information transmitted over it, during the operation of the communication network, an analysis of the identified events, causes and conditions of their occurrence is carried out.

Based on the results of such an analysis, a conclusion and a work plan are drawn up, aimed at preventing the occurrence of events in the future associated with unauthorized access to the communication network. The results of the work carried out in accordance with the plan - schedule are reflected in the operational documents

2.12.Restrictions on the use of equipment, technologies and materials

2.12.1. It is forbidden to use during the construction and reconstruction of power grid facilities 35 kV and above:

- concrete current-limiting reactors;

- rotating electrical machines for reactive power compensation, except for asynchronized compensators and ASEMFC in the presence of special feasibility studies;

- air, oil switches 110-750 kV;

- autogas switches 6-10 kV;

- low-oil switches 6-220 kV;

- switches 110 kV and above with pneumatic and electromagnetic drives;

- TT and VT with winding accuracy classes for the purposes of AIIS KUE, APCS and measurements that do not meet the established requirements of the Technical Policy;

- all types of measuring instruments (including measuring transformers, as well as built-in measuring instruments) of an unapproved type, that is, not registered in the Federal Information Fund for Ensuring the Uniformity of Measurements, and not provided with verification / calibration;

- disconnectors of vertical - chopping type with voltage of 110-750 kV;

- disconnectors with a voltage of 35 kV and above without a motor drive, except for disconnectors with a voltage of 35 kV for dead-end branch substations with a voltage of 35 / 0.4 kV;

- backfilling with gravel power oil receivers T/AT and ShR;

- oil-filled ducts for connecting T / AT to GIS;

- oil-filled cable ducts for connecting 110-500 kV cables to power T/AT;

- valve arresters;

- power supply schemes without ATS;

- cables with paper-oil insulation and oil-filled;

- power cables that do not meet current fire safety requirements and emit high concentrations of toxic products during combustion;

- AB with a fiberglass separator in the OCD;

- AB with a service life of less than 15 years;

- equipment (including BSK), in which trichlorodiphenyl (TCD) is used;

- supports with pin insulators in places of nesting of large birds;

- laying of cable lines in a trench on the territory of SS 35 kV and above;

- laying of cable lines in the areas of piers, berths, harbors, ferry crossings, as well as winter regular anchorages of ships and barges;

- joint laying in the collectors of 110 kV and higher cable lines with other cables with a voltage of 0.4-20 kV and communications (except for the cables of the collector's technological systems);

- the use of epoxy compounds as waterproofing in cable fittings;

- building materials with specific effective activity of natural radionuclides over 370 Bq / kg;

- electrical equipment containing polychlorinated biphenyls and terphenyls (sovol, sovtol, etc.) as an insulating medium;

- lighting devices requiring special measures for their disposal (containing vapors of mercury and its compounds).

2.12.2. When carrying out a comprehensive reconstruction, expansion and new construction, it is not recommended to use reinforced concrete racks of the USO type for substation equipment.

2.12.3. It is prohibited to equip facilities under construction and reconstruction:

- electrical protective equipment made with paper-bakelite insulation;

- high voltage indicators, which require grounding of the working part of the indicator;
- voltage indicators using gas-discharge lamps;
- high voltage indicators without sound signaling;
- posters and safety signs made of hygroscopic materials.

2.12.4. Prohibited for use during reconstruction, technical re-equipment and new construction of power distribution facilities:

2.12.4.1. At SS 35-220 kV:

- primary connection diagrams of 35-110 (220) kV substations with separators and short-circuits;
- diagrams of primary connections of 35-110 (220) kV substations with non-portal reception of overhead lines;
- AB of open design;
- flexible insulated conductors for connecting circuit breakers of outgoing lines to 0.4 kV buses on SN SS switchboards;
- open cabinets for auxiliaries, in which the protection of personnel from electric shock is not provided.

2.12.4.2. For transformer substations 6-20 / 0.4 kV, distribution substations 6-20 kV:

- KTP 6-20 / 0.4 kV cabinet type with vertical arrangement of equipment;
- air circuit breakers and low volume oil circuit breakers;
- leaky power transformers of TM brand;
- RP made of separate cells of KRUN;
- valve arresters of the PBO series.

2.12.4.3. On overhead lines 0.4-20 kV:

- during reconstruction and new construction, bare wires on overhead lines with a voltage of 0.4 kV;
- bare wires, twisted from aluminum wires (according to GOST 839-80);
- suspended plate-shaped insulators of the PF6-A and PF6-B types;
- polymer insulators of the LP and LPIS series with a sheath made of a polyolefin composition;
- polymer insulators made by ribbed assembly of the containment shell;
- technologies of impregnation of wooden poles that do not provide a pole service life of 40 years;
- tubular arresters, valve arresters based on silicon carbide, spark gaps (with the exception of spark gaps in the composition of lightning arresters and linear surge arresters) and arcing horns on 6-20 kV overhead lines used as lightning surge protection devices.

2.12.5. It is prohibited to use during reconstruction, technical re-equipment and new construction on overhead lines 35 kV and above:

- non-galvanized metal supports (except for those made of weather-resistant steel) and uncertified supports;
- polymer insulators of the LP and LPIS series with a sheath made of a

polyolefin composition;

- polymer insulators made by ribbed assembly of the containment shell;
- porcelain insulators, with the exception of long-rod porcelain insulators (if justified) on high-rise supports of 110 kV overhead lines and above;
- anchor clamps tensioned compressed (shortened) supporting roller hangers without the use of a protective protector, except for the cases of using wires with compacted twists and wires of a special shape, for which, as a rule, only compressed reinforcement is used;
- paint and varnish coatings and technologies for their application on metal structures of supports that have not passed certification;
- rolling of wires and lightning protection cables, including OPGT, by dragging along the ground from rolling devices;
- burning holes in the shelves of the corner supports;
- painting of metal structures with bituminous varnishes;
- steel lightning protection cables without anti-corrosion coating;
- wires and lightning protection cables of grade AZHS (aluminum-iron-steel alloy) and SB (steel-bronze);
- valve and tubular arresters;
- vibration dampers, single-frequency, type GVN;
- supporting and tension clamps installed on overhead lines, having elements made of magnetic materials (steel and cast iron) in the structure.

2.12.6. Not allowed in the field of fire safety:

- use in buildings and structures of cable products that do not meet the established requirements in terms of fire hazard indicators;
- the use of building materials (decorative, finishing and facing materials, floor coverings) in buildings and structures with a fire hazard class (CM) that does not meet the established requirements;
- the use of non-certified fire barriers;
- the use of water with the addition of foaming agents, wetting agents and salts as a fire extinguishing agent when extinguishing existing electrical installations;
- use of equipment for automatic fire protection installations without appropriate certificates;
- the use of water-based fire extinguishers in existing electrical installations;
- use of powder as a fire extinguishing agent in rooms with equipment based on microprocessor devices (server computers, APCS);
- the use of fire-retardant materials and organic-based compounds containing toxic components and organic solvents in buildings and structures with the presence of people;
- the use of smoke ionization (radioisotope) fire detectors;
- the use of self-supporting insulated wire with insulation that spreads combustion, when laying along the walls of buildings, structures, on branches to the entrance to a building, structure.

2.12.7. It is prohibited to use in the field of metrological support:

- technical means that are not SI;

- Measuring instruments of an unapproved type (not included in the information fund for ensuring the uniformity of measurements) and not approved for use in the Russian Federation;

- MI with expired period of periodic metrological control (verification / calibration).

2.12.8. During the construction of a CPF or reconstruction of a substation with its transfer to a CPF, in addition to the above, it is prohibited to use technical solutions, equipment and materials that do not meet the requirements of subsection 2.2 of the Technical Policy.

3. Technological processes in the power grid complex

3.1. Development of the power grid complex

3.1.1. General requirements for the development of schemes and programs for the development of the electric power industry and electric networks

The electrical network of the Unified Energy System of Russia, in accordance with the functions performed, is subdivided into objects of the Unified National (All-Russian) Electric Network (UNEG) and objects of the territorial distribution network.

The UNEG is a complex of power grids and other power grid facilities owned by or on another basis stipulated by federal laws to the electric power industry entities and providing a stable supply of electricity to consumers, the functioning of the wholesale market, as well as the parallel operation of the Russian power system and power systems of foreign states.

The territorial distribution network ensures the transmission of electricity from the UNEG substation, generation facilities and facilities of other owners to the central processing unit - distribution substations (RP) with bringing it to end consumers, and also ensures the transmission and distribution of electricity from power plants connected to this type of network.

3.1.2. When developing electrical networks, it is necessary to be guided by the following main criteria:

• accessibility: the electric grid should provide all subjects of the wholesale / retail electricity and capacity markets with conditions for the unhindered supply of its products (electricity and capacity) to the market on a competitive basis if there is a demand for it; provide all subjects of the wholesale / retail markets with the possibility of obtaining electricity and capacity in the required volume with the required reliability and quality that meets the regulatory requirements;

• efficiency: the development of the network should ensure maximum efficiency, provided the required level of reliability is ensured, including helping to reduce costs and losses for the transmission of electricity, as well as for the operation of equipment;

• controllability: the development of the electric network should be aimed at increasing its controllability and observability through the introduction of controllable elements and digitalization;

• efficiency: the development of the electric grid should be carried out in order to achieve the best economic indicators of the companies of the PJSC Rosseti Group and the energy system as a whole, with the maximum optimization of the use of existing production assets, regardless of the form of ownership of electric power facilities;

• innovativeness: the design of the development of the electric network should be carried out taking into account the latest achievements of science and technology;

• environmental friendliness: the development of the electric grid must comply with the requirements of environmental protection, provide for the introduction of innovative solutions that help reduce the negative impact of power facilities on the environment, as well as exclude cases of damage to the environment;

• safety: the development of the electric grid should be aimed at ensuring the energy security of the UES of Russia.

3.1.3. The task of development schemes is to develop, taking into account new technologies and digital transformation of networks, a feasibility study of solutions that determine the effective and reliable development of energy systems in order to meet the demand for electricity and capacity, create stable and favorable conditions for attracting investments in the construction of electric power facilities.

3.1.4. Planning for the development of power systems includes the development of the following documents:

- in accordance with the decree of the Government of the Russian Federation of October 17, 2009 No. 823 "On schemes and programs for the long-term development of the electric power industry":

• General layout of electric power facilities, which is formed for 15 years (with adjustments at least once every 3 years) with details for the IES;

• Scheme and program for the development of the UES of Russia, developed annually taking into account the General Scheme for the location of power facilities and determining balanced plans for the development of the grid infrastructure and generating capacities for a 7-year period;

• Schemes and programs for the development of the electric power industry of the constituent entities of the Russian Federation, developed annually for a 5-year period, taking into account the scheme and program for the development of the UES of Russia;

- in accordance with the order of PJSC "Rosseti" dated January 10, 2019 No. 4 "On improving the quality of planning the development of electrical networks":

• A comprehensive program for the development of electric grids on the territory of the constituent entities of the Russian Federation, developed annually for a 5-year period, taking into account the Scheme and program for the development of the UES of Russia;

- in accordance with the current regulatory documents, the following are developed:

• Programs for the integrated development of communal infrastructure systems in settlements and urban districts, Schemes for the power distribution of power plants, Schemes for external power supply of industrial enterprises, pumping stations for oil, gas and product pipelines, canals, amelioration systems, electrified sections of railways, as well as energy sections of district planning schemes and general plans of cities. These schemes are developed taking into account the Schemes for the development of the electric power industry of the constituent entities of the Russian Federation.

3.1.5. When developing schemes and programs for long-term development, schemes for the development of the electric network for the output of power from power plants, schemes for the development of the electric network for external power supply to consumers, it is necessary to be guided by:

- Rules for the technological functioning of electric power systems, approved by the Decree of the Government of the Russian Federation dated August 13, 2018 No. 937;
- Guidelines for the sustainability of power systems, approved by order of the Ministry of Energy of Russia dated August 3, 2018 No. 630.
- Methodological recommendations for the design of the development of power systems, approved by order of the Ministry of Energy of Russia dated June 30, 2003 No. 281;
- Guidelines for the technological design of power transmission lines with a voltage class of 35-750 kV, which must be approved by the Order of the Ministry of Energy of Russia;
- Methodological guidelines for the technological design of alternating current substations with a higher voltage of 35-750 kV, which must be approved by the Order of the Ministry of Energy of Russia;
- Rules for the development and approval of power distribution schemes for facilities for the production of electrical energy and external power supply schemes for power receivers of consumers of electrical energy.

3.1.2. Requirements for the use of autonomous power supplies for the redundancy of distribution network consumers

3.1.2.1. For a special group of the first category of consumers who do not allow a power outage, together with network redundancy in accordance with the current regulations and LNA, redundancy from an autonomous (backup or emergency) power source should be used, which can be used as mobile or stationary diesel, gas piston, gas turbine power plants or power plants of a different type, energy storage devices (EE) based on batteries. For special categories of consumers that do not allow a short interruption of power supply, it is recommended to use uninterruptible power supplies in the presence of a feasibility study.

The assignment of consumers to a special group of the first category is determined at the stage of issuing and agreeing on technical conditions for the grid connection of electrical installations of consumers to electrical networks, on the basis of the corresponding application of the consumer.

3.1.2.2. The conditions for the reservation of power supply for a special group of the first category of consumers are determined in accordance with the requirements of the NLA.

3.1.2.3. Autonomous (standby or emergency) power supply sources must be connected to dedicated buses of guaranteed power supply.

3.1.2.4. The need for autonomous power supplies and the possibility of their parallel operation with distribution networks, as well as network redundancy must be determined when issuing technical conditions for grid connection.

3.1.3. Coordination of levels of short-circuit currents

3.1.3.1. In order to ensure that the switching capacity of the devices corresponds to the actual levels of short-circuit currents (SC) and the reduction of the levels of short-circuit currents in the networks, the calculation of the short-circuit currents and the selection of measures to limit them should be carried out, taking into account the development of networks and generating sources. Under operating conditions, it is necessary to verify the compliance of the equipment with the prospective levels of short-circuit currents, ensure the thermal and electrodynamic resistance of the equipment and the breaking capacity of the circuit breakers. Calculations of short-circuit currents should be carried out when changing the network diagram and the composition of the power grid and generating equipment.

3.1.3.2. To ensure normal operating conditions for equipment and elements of electrical networks, when developing schemes for the development of electrical networks, the following methods and measures for limiting short-circuit currents should be implemented, including:

- the use of a higher voltage class, including through the construction of a “deep input” substation, transferring some of the electrical installations of the electrical network to a higher voltage class;
- optimization of the grounding mode of neutrals in electrical networks, including the use of reactor-resistor installations in neutrals T / AT;
- sectioning of elements of electrical networks using ATS;
- installation of current-limiting devices;
- installation of ultra-high-speed circuit breakers using thyristor switching or special devices for fast arc extinguishing;
- use of transformers with split windings of low voltage;
- use of transformers with increased reactances;
- use of AC and DC inserts based on fully controlled valves.

3.1.3.3. The level of short-circuit currents, which increases in the course of the development of the electrical network, must have in its growth limitations determined by the parameters of the installed equipment (rated breaking currents of switches, thermal resistance, electrodynamic resistance).

The flow of short-circuit currents should not lead to unacceptable heating of conductors and devices and subject them to electrodynamic forces above the permissible values determined by the manufacturers of this equipment and materials.

The maximum level of short-circuit currents for electrical networks of 35 kV and above should be limited by the parameters of switches, transformers, conductive materials and other equipment.

In distribution networks of 6-20 kV, the maximum level of short-circuit currents should be limited by the parameters of electrical switch, current conductors, thermal resistance of cables, insulated and protected wires.

3.1.3.4. Resistant at short-circuit currents are those devices and conductors that, under design conditions, withstand the effects of these currents, without being subjected to electrical, mechanical and other damage or deformation that impedes their further normal operation.

3.1.3.5. If it is necessary to limit short-circuit currents on the 6-20 kV side, the use of:

- three-winding transformers with maximum resistance between HV and LV windings and two-winding transformers with increased resistance;
- transformers with split windings 6 - 20 kV;
- current-limiting reactors in the input circuits from transformers, and the outgoing lines should be performed, as a rule, unreacted.

The choice of the option for limiting short-circuit currents should be justified by a technical and economic comparison

3.1.4. Features of the development of electric networks in megacities

3.1.4.1. In megalopolises, cable lines of various voltage classes should be predominantly used, and overhead lines passing through the residential area of megalopolises should be gradually replaced by cable lines.

3.1.4.2. When building the main electrical network of megalopolises, it is necessary to consider the creation of deep bushings at a rated voltage of up to 500 kV inclusive.

3.1.4.3. When designing new and reconstructing existing power grid facilities for megalopolises, primarily for Moscow and St. Petersburg, it is necessary to take into account more severe design perturbations in relation to the stability requirements:

• disconnection at substation switchgear of any voltage class;
• disconnection at power plants of RU of any voltage class;
• simultaneous disconnection of cable lines located in one collector.

3.1.4.4. When reconstructing existing 110 kV facilities, it is recommended to consider the transition to a higher voltage class of 220 kV.

3.1.4.5. With the development of distribution electrical networks of a megalopolis, it is necessary to consider the possibility and feasibility of using and developing electrical networks with a voltage of 20 kV.

3.1.4.6. An electrical network with a voltage of 20 kV in a megalopolis, as a rule, should be designed using a low-resistance resistive neutral grounding with automatic disconnection of earth faults.

3.1.4.7. During the reconstruction of the existing facilities of the 35-220 kV electrical network and the 6-10 kV distribution network, it is necessary to provide for the replacement of cables with paper-oil insulation, oil-filled cables with CL made of cross-linked polyethylene.

3.1.4.8. In the distribution network of megalopolises, it is necessary not to provide for the development of electrical networks with a voltage of 6 kV, but during reconstruction to ensure the transition to a higher voltage class.

3.1.4.9. For cable lines laid along routes passing in various soils and conditions, the choice of structures and cable cross-sections should be made in the area with the most severe conditions. With a considerable length of individual sections of the route with different laying conditions for each of them, it is possible to select the appropriate designs and cable cross-sections. For cable lines laid along routes with different cooling conditions, cable cross-sections should be selected along a section of the route with worse cooling conditions, if its length is more than 10 m. two, provided that the length of the smallest segment is not less than the building length.

3.1.4.10. For new construction and reconstruction of substations with a voltage of 10-220 kV, a closed (including, if necessary, modular underground and buried) type of performance should be performed using:

- 6-35 kV switchgear with air, including combined insulation, with a corresponding feasibility study with gas insulated;
- GIS 110-220 kV gas-insulated;
- oil-free switch (vacuum for a voltage of 10-35 kV, SF6 for a voltage of 110-220 kV);
- 6-20 kV oil-free measuring current and voltage transformers with cast resin (it is allowed to use 6-20 kV oil VTs with appropriate justification);
- measuring transformers 35-220 kV with SF6 insulation;
- in justified cases, electronic current transformers of the optical type for a voltage of 110-220 kV.

Substation must have a minimum size, while ensuring an appropriate level of safety, including environmental, and ease of use, as well as fit into the architectural appearance of the megalopolis landscape.

3.1.4.11. For new construction of 20 kV distribution networks and reconstruction of existing 6-10 kV distribution networks, power transformers should be placed in closed chambers.

During the new construction of the SS 110-220 kV and the reconstruction of the SS 35-220 kV, the power T/AT 35-220 kV should be located in the closed chambers of the SS buildings.

3.1.4.12. When constructing underground substations and built-in or adjacent to administrative buildings, use equipment, including power transformers with non-combustible insulation and without the presence of mineral transformer oil.

3.1.4.13. Overhead lines intended for outdoor street lighting should be carried out using insulated or insulated self-supporting wires.

3.1.4.14. Newly constructed substations of 110 kV and above should be carried out with the use of GIS located in the building of the substation.

3.1.4.15. To service the oil-filled equipment of substations 330-500 kV located on the territory of megalopolises, it is allowed, with appropriate justification, to organize centralized oil farms equipped with reservoirs for storing oil, pumps, equipment for cleaning, drying and regenerating oils, mobile oil-cleaning and degassing installations, containers for transportation of oil.

3.1.4.16. During new construction and reconstruction of substations 110 kV and above, it is necessary to consider the feasibility of using dielectric fluids with increased fire safety characteristics as the main insulation in power T/ATs and meeting the requirements of IEC 61099 "Technical conditions for unusual synthetic organic essential oils for electrical purposes".

3.1.4.17. For newly constructed substations 110-220 kV in residential areas of megalopolises, it is advisable to use dielectric fluids with increased fire safety characteristics as the main insulation for power T/ATs and meet the requirements of IEC 61099 "Technical conditions for unusual synthetic organic essential oils for electrical purposes."

3.1.4.18. Substation of deep input of high voltage (220 kV and above), newly constructed in megalopolises, should be located in the centers of electrical loads (in the nodes of consumption).

3.1.4.19. To locate the power grid, the underground space of megalopolises should be actively developed, deep high-voltage cable bushings should be built, territory reservation for the construction of cable structures should be envisaged, associated with projects for the development of territories, reconstruction and new construction of infrastructure facilities.

3.1.4.20. The power supply scheme in megalopolises should ensure the minimum recovery time of power supply to consumers in the event of emergency modes through the use of network redundancy, network sectioning, the use of high-speed switches in conjunction with ATS devices with the function of reverse (after ATS) restoration of the normal power supply scheme, the use of automatic reclosing, including at KL , application of technical solutions for the automated control system and remote control of the switch.

3.1.4.21. In the post-emergency mode, the restoration of power supply to consumers should be carried out in a sequence depending on the importance of the facility in the system of functioning and life support of the city (heat supply, water supply and sewerage systems, metro, high-rise buildings, hospitals, children's institutions, train stations, railways and road control devices, communications , television, radio, etc.). Such consumers must additionally have their own life support system equipped with an autonomous power supply.

3.1.4.22. The life support system of the consumer in the absence of power supply from the general-purpose electrical network must ensure the safe continuation of the production process until its end (for a full or reduced cycle) or the implementation of all technical and organizational measures for the safe and trouble-free termination of the production process.

3.1.4.23. Consumers must independently determine the requirements for the reliability of their own power supply system and, accordingly, for the parameters of the life support system.

3.1.4.24. The life support system should function both with a complete cessation of power supply from the general-purpose electrical network, and with changes in the electrical parameters of the network, including short-term ones, in which the continuation of normal work is impossible or is associated with a risk of danger. Consumers must ensure that the life support system is always operational and ready for launch at any time.

3.1.4.25. In the 6-35 kV electrical distribution network of megalopolises, in order to ensure reliable power supply for special categories of consumers, it is advisable to consider and use two-way power supply of the TS from different CPUs that do not allow short-term power outages, while the length of the cable line from the CPU, as a rule, should not exceed 20 km, and the number of connected intermediate transformer substations should not, as a rule, be more than eight. A special category of consumers is determined at the stage of issuing technical specifications for the grid connection of the consumer to the electrical network.

3.1.4.26. Technological connection of a special group of the first category of consumers to a general-purpose electrical network should include the requirement, if necessary, to organize its own life support system, as well as constant monitoring of its condition. To regulate these requirements, the necessary regulatory framework can be developed.

3.1.4.27. In the power supply systems of megalopolises, it is required to take measures aimed at limiting the growth of short-circuit currents and exceeding their level in excess of the permissible capabilities of the switch, while it is necessary to gradually abandon traditional measures, such as: unbundling of TP, sectioning and dividing electrical networks, using various current limiters to connect sections tires RU and RP, leading ultimately to a decrease in the reliability of the network, and to consider the introduction and application of TOU and ASEMPCh; HVAC, equipping the electrical network with controlled reactive power compensation means.

3.2. Operational-technological and situational management

3.2.1. In accordance with Federal Law of March 26, 2003 No. 35-FZ "On the Electric Power Industry", operational and technological management is included in a complex of organizationally and technologically related actions that ensure the transmission of electrical energy through technical devices of electrical networks in accordance with mandatory requirements - transmission services electrical energy.

3.2.2. Operational and technological management of the power grid complex

(OTU EGC) is understood as a set of measures to manage technological modes of operation and the operational state of power grid facilities in accordance with the requirements of the subject of operational dispatch control in the electric power industry in relation to power lines, equipment and substation devices related to dispatch facilities, and independently or in coordination with other subjects of the electric power industry, consumers of electrical energy in relation to power transmission lines, equipment and substation devices that are not related to dispatch facilities.

3.2.3. Situational management (SMS) is understood as activities aimed at preventing the occurrence and elimination of the consequences of accidents and other emergency situations at power grid facilities, through the analysis, adoption and implementation of appropriate management decisions, taking into account the current operational situation, available resources and forecasts of the consequences of management decisions.

3.2.4. Structure, goals, principles of construction and functioning. the main functions of the OTU system and situational management (CS) in the power grid complex are determined taking into account the provisions of the Concept for the development of the system of operational and technological management and situational management in the power grid complex of PJSC Rosseti.

3.2.5. To perform the functions of OTU and CS, structural subdivisions of the OTU and CS system in the electric grid complex must be equipped at all management levels with information technology systems to perform the corresponding functions of OTU and CS, including information collection and transmission systems, redundant communication channels for operational negotiations and transfer of technological information and hardware.

3.3. Acceptance of completed construction of power grid facilities

3.2.1. The acceptance into operation of completed construction of electrical network facilities must be carried out in accordance with the requirements of the legislation of the Russian Federation.

3.2.2. The work on the acceptance into operation of completed construction facilities is carried out in accordance with the "Standard Procedure for the Acceptance of Construction Completed Facilities of Subsidiaries and Affiliates of PJSC Rosseti" approved by Order No. 87r dated February 20, 2015 and approved by the Board of Directors of PJSC Rosseti (Minutes dated June 5, 2015 No. 191).

3.2.3. Acceptance of completed construction objects for operation can be carried out for the entire title as a whole, construction stages - start-up queues, title temporary buildings and structures, individual buildings and structures, individual units or equipment systems (in the amount provided for by the project documentation approved in accordance with the current legislation).

3.2.4. Acceptance for operation of individual stages of construction - start-up phases that are not provided for by the project documentation approved in accordance with the current legislation is not allowed.

3.2.5. Acceptance of individual pieces of equipment in the absence or malfunction of auxiliary systems that ensure the safe operation of the equipment is not allowed.

3.2.6. Before the commissioning of power grid facilities, in accordance with the Rules for the Technical Operation of Power Plants and Networks of the Russian Federation, individual equipment tests and comprehensive testing of equipment must be carried out. Prior to the comprehensive testing, Rostechnadzor permits must be obtained for admission to the operation of the power plant, if such is required in accordance with the "Rules for Technological Connection of Power Receiving Devices for Electricity Consumers, Electricity Generation Facilities, as well as Electricity Grid Facilities Owned by Grid Organizations or Other Persons. electric networks "approved by the RF Government Decree of December 27, 2004 No. 861).

3.2.7. In accordance with the order of the Ministry of Energy of the Russian Federation of June 19, 2003 No. 229 "On approval of the Rules for the technical operation of power plants and networks of the Russian Federation", working and acceptance commissions must be formed for the acceptance of facilities.

3.2.8. Before the appointment of the acceptance committee, training and education of the personnel operating the power grid facility is organized, aimed at ensuring their readiness to perform professional functions and maintaining their qualifications. The necessary requirements for operating personnel are regulated by SO 153-34.20.501-2003.

3.2.9. Acceptance of power grid facilities into operation without permits for permanent operation of power plants issued by Rostekhnadzor and conclusions on the compliance of the constructed, reconstructed, repaired capital construction facility with the requirements of technical regulations and design documentation issued by the state construction supervision is not allowed, if these documents are provided for registration for these facilities in in accordance with applicable law.

3.2.10. Commissioning of information infrastructure facilities is allowed only if there is a protocol (act) of acceptance tests with a positive conclusion on the compliance and effectiveness of the security subsystem with the established security requirements.

3.2.11. After the commissioning of completed construction projects, it is necessary to issue a permit for commissioning in accordance with the Urban Planning Code of the Russian Federation, if this document is provided for registration for these objects in accordance with the current legislation.

3.4. Maintenance and repair

3.4.1. General provisions

3.4.1.1. In order to ensure the reliable, safe and economical functioning of power grid facilities for equipment, power transmission lines, buildings, structures, technical and technological systems, maintenance and repairs should be carried out.

3.4.1.2. High-quality planning, timely and high-quality maintenance and repairs (technical impacts) of equipment, power lines, buildings, structures, technical and technological systems is one of the most important factors in ensuring the operability of power grid facilities to ensure the required level of reliability, safety and quality of power supply to consumers.

3.4.1.3. The organization of the system of maintenance and repairs must comply with the established requirements of the legislation of the Russian Federation, the current regulatory legal acts, the relevant documents in the field of technical regulation, including in accordance with the urban planning legislation of the Russian Federation, the legislation on industrial safety, safety of buildings and structures, PTE, the Rules for organizing maintenance and repair of electric power facilities, in force with regulations that establish requirements for ensuring the reliability of electric power systems, reliability and safety of electric power facilities and power receiving installations.

3.4.1.4. Ensuring and increasing the efficiency of maintenance and repairs should be ensured through the introduction and implementation of uniform principles and approaches to the planning, organization and performance of repairs and maintenance, to the processes of monitoring and evaluating the effectiveness of maintenance and repairs while ensuring that the established requirements are met.

3.4.1.5. Planning for the repair of equipment at substations and power transmission lines, which are dispatched objects, should be carried out in accordance with the current requirements of the RF Government Decree of July 26, 2007 No. 484 "On the decommissioning of electric power facilities for repair and out of service."

3.4.1.6. For HIF facilities, the requirements of the Federal Law of July 21, 1997 No. 116-FZ "On Industrial Safety of Hazardous Production Facilities" and the current regulatory legal acts in the field of industrial safety must be met.

3.4.1.7. For equipment that has exhausted its operational life, as well as equipment that is in an unsatisfactory condition (ITS $\leq$ 50), provided that it is operated without deviating from the nominal parameters, restrictions on further operation can be removed provided:

- timely performance of technical examination in accordance with the current regulatory and technical documents;
- installation of ASMD on the most critical and expensive equipment, which will make it possible to make a timely decision on the impact on the equipment;
- the use of modern methods and means of technical diagnostics, mainly under operating voltage (vibroacoustic control, measurement of partial discharges), including when conducting frequent monitoring of the technical condition.

In accordance with the Strategy for the Development of the Power Grid Complex of the Russian Federation for the equipment of power grid facilities, power transmission lines and structures, the transition from a system of planned preventive type of organization of repairs at power grid facilities to the organization of repairs based on the actual technical condition, taking into account the consequences of failure of the main technological equipment (risks).

3.4.1.8. The system for planning and organizing maintenance and repairs is an integral and integral part of the production assets management system (IMS) and must comply with the goals, principles and objectives of managing production assets of the Company's Technical Policy.

3.4.1.9. Performing maintenance and repair work should be carried out with mandatory and appropriate organizational and technical training, provision of materials and equipment and repair personnel with qualifications corresponding to the content of work in accordance with the established requirements.

3.4.2. Basic provisions for planning and organizing repairs and maintenance

3.4.2.1. Repair of equipment at substations, power transmission lines, buildings and structures, technical and technological systems is carried out in two types of organization of repair:

- scheduled preventive maintenance;
- repair according to technical condition.

3.4.2.2. Scheduled preventive repairs should be carried out at the intervals established by the repair documentation in accordance with the requirements of regulatory documents, instructions of manufacturers and LNA.

3.4.2.3. To plan the organization and conduct of scheduled preventive maintenance, the following should be carried out:

- development of long-term repair plans, developed for 5 years;
- development of annual and monthly repair schedules.

3.4.2.4. The long-term repair plan must be approved and adjusted annually, taking into account the assessment of the technical condition and changes in operating conditions.

3.4.2.5. Long-term plans and repair schedules should be developed in accordance with the requirements of the "Rules for organizing maintenance and repair of electric power facilities", approved by order of the Ministry of Energy of Russia dated October 25, 2017 No. 1013, and LNA.

3.4.2.6. The scope of scheduled preventive repairs should be determined according to the standard list of works, taking into account the actual technical condition and include the implementation of additional over-standard repair work to eliminate defects identified during operation, based on the results of the previous repair (if any), and include the performance of work established by the instructions of the state control bodies and supervision (if any).

3.4.2.7. When organizing scheduled preventive and technical repairs, depending on the volume of work performed, repairs are divided into:

- current;
- medium;
- capital.

3.4.2.8. Current repair should ensure restoration of serviceable condition with replacement or restoration of elements or components to the extent provided for by the relevant repair documentation.

3.4.2.9. Medium repairs should ensure the restoration of serviceability with the replacement or restoration of individual elements and components, provided for by the relevant repair documentation.

3.4.2.10. Overhaul should ensure the restoration of serviceable condition with ensuring the functional purpose, while the purpose of overhaul of equipment is to restore the serviceable state of equipment with the provision of technical and economic characteristics to values close to the design values.

3.4.2.11. Depending on the typical volumes and the list of work performed, repairs can be subdivided into standard and over-standard.

3.4.2.12. Maintenance repair is a repair, the scope of which is determined based on the results of control and assessment of the technical condition based on measurements, tests and inspections performed in accordance with the established requirements.

3.4.2.13. Repair planning based on technical condition should include:

- development of long-term repair plans, developed for 5 years;
- development of annual and monthly plans for repairs and maintenance;
- The long-term plan of repairs is annually re-approved and revised taking into account the assessment of the technical condition and changes in operating conditions.

3.4.2.14. Diagnostics of the technical condition of power transmission lines and substation equipment when planning repairs based on technical condition should be carried out during the current repair of substation equipment and during maintenance of power transmission lines and substation equipment.

3.4.2.15. Long-term plans and schedules for monitoring the technical condition should be developed in accordance with the requirements of the "Rules for organizing maintenance and repair of electric power facilities" and LNA.

3.4.2.16. When organizing repairs according to the technical condition, the list and scope of repair work is determined based on the results of measurements, tests, inspections, technical diagnostics and assessment of the technical condition in accordance with the established requirements and include the performance of work established by the instructions of the state control and supervision bodies (if any).

3.4.2.17. For the equipment of substations, power lines and structures for which the transition from scheduled preventive maintenance to the planning of repairs according to the technical condition in accordance with the current regulatory legal acts ("Methodology for assessing the technical condition of the main technological equipment and power lines of power plants and electrical networks", approved by order of the Ministry of Energy Russia dated July 26, 2017 No. 676 and "Rules for the organization of maintenance and repair of electric power facilities", approved by order of the Ministry of Energy of Russia dated October 25, 2017 No. 1013), LNA (organization standards) should be developed, establishing the frequency, methods, volumes and technical means of control, a system of indicators of technical condition and their permissible limit values in accordance with the requirements of the current regulatory legal acts, including the requirements of the PTE, "Requirements for the scope and standards of testing of electrical equipment", instructions of manufacturers and accumulated operating experience, allowing to determine the actual technical condition (serviceable, faulty, efficient, inoperative, limiting).

3.4.2.18. For equipment of substations, power transmission lines and structures for which repairs (technical impacts) are planned based on the results of assessing the technical condition in accordance with the current NLA "Methodology for assessing the technical condition of the main technological equipment and power lines of power plants and electrical networks" annually for each piece of equipment, Power transmission lines, structures, maps of possible scenarios for choosing the type of technical impacts should be formed based on the calculation of the technical condition index and the assessment of the risk of damage (failure), on the basis of which annual and further monthly repair programs (technical impacts) are formed, while, in accordance with the established requirements "Methods for assessing the technical condition of the main technological equipment and power transmission lines of power plants and electrical networks", approved by order of the Ministry of Energy of Russia dated July 26, 2017 No. 676, it is necessary:

- to carry out an annual calculation of the technical condition index (ITS) to determine the planned type of technical impact in accordance with the current requirements and standards;

- to recalculate the technical condition index after the implementation of the technical impact in accordance with the established terms;

- to assess the risk of failure of each piece of equipment with an assessment of the consequences of equipment failure in accordance with the requirements of the current NLA "Methodological guidelines for calculating the probability of failure of a functional unit and a unit of the main technological equipment and assessing the consequences of such a failure";

- to assess the dynamics of changes in the values of the parameters of the technical condition of the equipment and to forecast changes in the ITS and the level of technical risk for 1 year.

3.4.2.19. The list of equipment for substations, power transmission lines and structures, according to which repair planning is carried out according to the technical condition based on the calculation of the ITS and the formation of maps of possible scenarios for choosing the type of technical impacts must comply with the requirements of the current regulations, including the "Methodology for assessing the technical condition of the main technological equipment and electrical power lines stations and electrical networks ", approved by order of the Ministry of Energy of Russia dated July 26, 2017 No. 676.

3.4.2.20. Work on the repair of equipment for substations, power lines and structures should be carried out according to flow charts with the development of projects for the production of work.

3.4.2.21. Technological maps for the repair of equipment at substations, power lines and structures must contain:

- composition and sequence of operations when performing work;
- working conditions and safety measures;
- a list of monitored indicators (parameters);
- requirements for the composition and qualifications of personnel (performers of work);
- norms of labor costs when performing work;
- the nomenclature of tools, devices, devices, mechanisms, test installations, collective and individual protective equipment.

3.4.2.22. The project for the production of work must determine the technology for the production of work, the organization of work, the procedure and volume of provision of resources, safety measures when performing work in accordance with the current requirements of the NLA and LNA and the instructions of the manufacturers.

3.4.2.23. Acceptance of equipment for substations, power transmission lines and structures from repair and assessment of the quality of the work performed must be carried out in accordance with the requirements of the current regulatory legal acts, PTE, "Rules for organizing maintenance and repair of electric power facilities" and LNA.

3.4.2.24. The organization of planning, preparation, production of repair and acceptance from repair of the subsystems of the APCS and the means of TAI should be provided in accordance with the boundaries of the areas of responsibility (service).

3.4.2.25. Maintenance of the subsystems of the APCS and the means of TAI, depending on the scope of work, is divided into the following types:

- maintenance with continuous monitoring;
- maintenance with periodic monitoring.

3.4.2.26. Maintenance with continuous monitoring of APCS subsystems and TAI facilities should be carried out based on the results of continuous monitoring of the technical condition during their operation together with the main and auxiliary equipment.

3.4.2.27. Maintenance with periodic monitoring of the APCS subsystems and TAI facilities should ensure the maintenance of the serviceable and efficient technical state of the APCS subsystems and TAI facilities in order to ensure during operation the possibility of control, technological control and protection of the main and auxiliary equipment to ensure the reliability of its operation.

3.4.2.28. Maintenance with periodic monitoring of APCS subsystems and TAI facilities should be carried out according to an annual schedule in accordance with the requirements of the "Rules for organizing maintenance and repair of electric power facilities" and instructions of manufacturers.

3.4.2.29. Maintenance of relay protection and automation devices, protection and automation should be carried out in accordance with annual and monthly maintenance schedules developed on the basis of long-term maintenance plans in accordance with the requirements of the NLA "Rules for the organization of maintenance and repair of electric power facilities" and other current NLA that establish requirements for ensuring the reliability of electric power systems, reliability and safety of electric power facilities and power receiving installations.

3.4.2.30. Maintenance and repair of SDTU, alarm devices, MI should be carried out on the basis of annual and monthly schedules of planned maintenance, agreed with the relevant subject of operational dispatch control, in the introduction of which the SDTU equipment is located.

3.4.2.31. For the maintenance of the SDTU, the following types of maintenance should be applied:

- scheduled maintenance, performed at time intervals in accordance with the approved schedules, aimed at preventing the possibility of a failure or deterioration in the functioning of the SDTU;

- operational maintenance performed after the detection of systems inoperability and aimed at eliminating malfunctions in order to fully restore the functioning of the SDTU.

3.4.2.32. Scheduled repair of SDTU should be carried out in accordance with the annual schedule of repair of SDTU.

3.4.2.33. The planning of repairs of buildings and structures that are not subject to prohibitions by the current requirements of the legislation of the Russian Federation and the LNA should be carried out on the basis of an assessment of the technical condition in accordance with the established requirements.

3.4.2.34. Maintenance of buildings and structures includes a set of measures for the supervision and control of the good condition of buildings and structures and their engineering systems and the timely elimination of defects. The frequency and scope of maintenance work should be determined in accordance with the repair documentation. In this case, responsible persons should be appointed and the procedure for monitoring the technical condition of each building and structure should be determined, as well as the scope of maintenance and repair work should be established.

3.4.2.35. Repairs of buildings and structures by type are subdivided into current and major repairs.

Overhaul volumes are formed on the basis of project documentation for repairs or on the basis of a bill of quantities.

The volumes of current repairs are formed on the basis of the list of volumes of work, drawn up on the basis of acts of inspections of buildings and structures, records of the technical journal for the operation of buildings and structures.

3.4.2.36. Planning for the repairs of buildings and structures includes the development of annual and prospective repair schedules. When developing schedules, one should take into account the results of surveys, including complex ones, the results of technical examination, as well as the frequency of major repairs of buildings and structures and their structural elements.

3.4.2.37. The type of organization of repairs based on technical condition cannot be applied to the following objects:

- for facilities for which, in accordance with the requirements of the legislation of the Russian Federation, there is a ban on the organization and conduct of repairs according to the technical condition;
- newly commissioned equipment and structures in trial operation;
- objects for which there is no repair documentation in accordance with the requirements of the "Rules for the organization of maintenance and repair of electric power facilities" approved by order of the Ministry of Energy of Russia dated October 25, 2017 No. 1013, or for which the established methods and volumes of technical condition monitoring do not allow to reliably determine the actual technical state and predict its operable state until the next inspection.

3.4.2.38. Repairs, depending on the planning, are subdivided into:

- planned;
- unplanned;
- emergency.

3.4.2.39. Scheduled repairs are carried out in accordance with the approved schedules.

3.4.2.40. Unscheduled repairs are carried out in order to eliminate malfunctions and defects affecting the operability and safe operation, as well as based on the results of monitoring the current technical condition, while if unscheduled repairs require the decommissioning of the dispatched object, then this repair must be agreed with the relevant entity promptly -dispatching management.

3.4.2.41. Emergency repairs are carried out to eliminate the consequences of accidents and damage to restore operability, while for the dispatch facility, interaction with the relevant subject of operational dispatch control is carried out in accordance with the established requirements.

3.4.2.42. The list of repair documentation must comply with the requirements of the "Rules for organizing maintenance and repair of electric power facilities", approved by order of the Ministry of Energy of Russia dated October 25, 2017 No. 1013, and LNA.

3.4.2.43. The qualifications of the repair personnel performing work on the repair of objects must comply with the requirements of the current regulatory legal acts in terms of fulfilling the relevant established safety requirements, federal standards and safety rules for hazardous production facilities (which are subject to the established requirements) and labor protection.

3.4.2.44. When organizing repairs, before the start of work, the serviceable technical condition of the technological equipment, diagnostics, control must be ensured and the requirements for metrological support must be met in accordance with the requirements of the legislation of the Russian Federation.

3.4.2.45. Measuring instruments used for repair and maintenance must comply with the requirements of GOST R 8.674-2009 “State system for ensuring the uniformity of measurements. General requirements for measuring instruments and technical measuring instruments and technical systems and devices with measuring functions”.

3.4.2.46. The tools used must ensure the accuracy of measurements established in the documentation and technical conditions for repairs, technological documentation and measurement procedures;

3.4.2.47. The planning of the nomenclature and volumes of the emergency stock should be carried out, ensuring storage conditions and timely replenishment and updating of the emergency stock in accordance with the current requirements of the NLA and LNA.

3.4.3. Principles of technical policy in the implementation of maintenance and repairs at electrical network facilities

3.4.3.1. The main principles of technical policy in the implementation of maintenance and repairs at electrical network facilities are:

- ensuring compliance with the provisions and requirements of the legislation of the Russian Federation and the provisions for planning and organizing repairs and maintenance of this Technical Policy;
- ensuring the planning, implementation and control of maintenance and repairs by qualified personnel;
- providing SDCs with developed and approved multi-year schedules, annual and monthly plans for repairs and maintenance of production assets, as well as investment programs for the period of tariff regulation, taking into account the technical condition of assets, with the fulfillment of requirements for the frequency of maintenance and repairs in accordance with the established requirements.

3.4.3.2. When planning maintenance and repairs, the following should be carried out:

- assessment and analysis of parameters and indicators of the technical condition of equipment, buildings, structures, technical and technological systems based on the results of measurements, tests and inspections prior to the provision of technical impacts;
- assessment and analysis of the consequences and risks of equipment failures;
- Compliance with budgetary constraints;
- accounting for targeted programs to improve reliability;
- ensuring the optimization of maintenance and repair costs through the optimal combination of outsourcing and business methods;
- availability and effective functioning of the system for monitoring, planning and evaluating the results of maintenance and repairs;
- development and improvement of the LNA of the Company to meet the established requirements and increase the efficiency of the functioning of the AMS;
- ensuring the safe production of maintenance and repair work;
- Carrying out technical examination of equipment, power lines, buildings, structures in accordance with the requirements of the current regulatory legal acts and LNA of the Company;
- carrying out comprehensive surveys of equipment, buildings and structures

at power grid facilities in accordance with the requirements of the current regulatory legal acts and LNA of the Company;

- the use of modern, high-tech and safe technologies, tools, devices and equipment for work;
- ensuring the safe production of work on the repair of electrical networks under voltage;
- ensuring the availability in full of the necessary technological equipment, tools and devices, materials and spare parts for performing maintenance and repairs of equipment, power lines, buildings, structures, technical and technological systems;
- ensuring the availability of regulatory, technical and organizational and administrative documentation for maintenance and repairs in accordance with the established requirements;
- study, development and implementation of modern methods and technologies for maintenance and repair of equipment, power transmission lines, buildings, structures, technical and technological systems and control of their technical condition;
- the development and improvement of methods for organizing and managing the processes of performing maintenance and repairs should be carried out in accordance with the established principles of the AMS.

3.4.3.3. The main directions of development and improvement of the AMS in terms of automation of planning, management and control of maintenance and repair are:

- improving and increasing the efficiency of the process of material and technical support of production activities in terms of maintenance and repair in accordance with the principles of the AMS;
- increasing labor productivity and economic efficiency;
- development of information systems and databases, through which the automation of planning and control of maintenance and repair processes is carried out;
- automation of planning of physical volumes, costs and resources for the organization, implementation and control of the implementation of maintenance and repairs;
- digitalization of technical documentation to ensure planning, execution and control of maintenance and repairs;
- automation and digitalization of information collection processes for planning works and resources for maintenance and repairs, collecting data on the fact of work performed, resources used;
- automation and digitalization of the processes of formation and approval of acts of completed work, accompanying documents, primary accounting documents using automated document management systems;
- building and ensuring the functioning of an effective analytical reporting system for maintenance and repair.

3.5. Production asset management

3.5.1. General provisions

3.5.1.1. The management of the production assets of the Company and its subsidiaries and affiliates is understood as a systematic and coordinated activity to find the optimal balance between the costs of maintaining the technical condition of equipment in accordance with regulatory requirements, the prospects for the development of the network and risks associated with failure to achieve the established level of reliability of the services provided and the quality of electrical energy, as well as requirements of regulatory bodies to achieve the strategic goals of the Company.

3.5.1.2. The production asset management system of the Company and its subsidiaries and affiliates must comply with the goals, principles and ensure the fulfillment of the objectives of the Strategy for the Development of the Electric Grid Complex of the Russian Federation, taking into account the Concept "Digital Transformation 2030".

3.5.1.3. The main functional areas of the production asset management system:

- management of operating activities in terms of maintenance, repair and equipment, technological and engineering systems, buildings and structures;
- management of investment activities in terms of modernization, technical re-equipment and reconstruction of power grid facilities;
- asset management at all stages of the life cycle, taking into account the current and projected technical condition, risks, consequences of failures, cost of ownership and network development prospects
- management of normative-methodological and regulatory support of production assets management processes;
- management of databases and reference data of automated production assets management systems;
- management of technological solutions and IT - infrastructure to ensure effective management of production assets;
- personnel management, organizational and resource support of production assets management processes.

3.5.2. Production asset management objectives

The objectives of managing production assets are:

- increasing the efficiency of operating and investment costs while ensuring the required level of reliability of power supply to consumers.

3.5.3. Production asset management principles

The main principles of managing the production assets of the Company are:

- focus on achieving the strategic goals of the Company and SDCs;
- consistency of decision-making, application of uniform criteria, principles, rules, methods for planning, implementation, control and evaluation of the

effectiveness of work on operating and investment activities;

- focus on improving the efficiency of production assets management throughout the entire life cycle of assets by obtaining positive effects in the short, medium and long term;
- ensuring the functioning of the production assets management system in all SDCs of the Company, which are an integral and integral part of the overall asset management system of the Company;
- reducing the share of equipment, power lines and structures with high and medium levels of technical risk, taking into account the consequences of their failure

3.5.4. Development tasks of the production assets management system

The tasks of the development of the production asset management system include:

- transition from the production asset management system according to the planned preventive type of organization of repairs to the organization of repairs according to the actual technical condition, taking into account the consequences of the failure of the main technological equipment (risks);
- introduction and development of modern technologies and digitalization of business processes for managing production assets;
- development of a system of indicators for assessing the activity of managing production assets at the corporate, functional and operational organizational levels, which makes it possible to assess individual processes for the timely adoption of appropriate management decisions;
- building and functioning of a system for assessing key performance indicators (KPIs) of processes at all levels of management of production assets of the Company and SDCs;
- development and unification of the organizational and regulatory - methodological base of production assets management;
- effective allocation of funds for all types of impact, including repair, modernization or technical re-equipment of substation and power transmission line equipment, depending on the technical condition (critical, unsatisfactory, satisfactory, good, very good);
- ensuring the functioning and development of a monitoring system and a comprehensive calculation of indicators of the state of power grid facilities, including indicators of physical wear and tear and energy efficiency in accordance with the requirements of the current regulatory legal acts;
- provision of calculations and monitoring of the indices of the technical condition of the equipment of substations, power transmission lines and structures with an assessment of the probability of failure, an assessment of the risk due to failure and an assessment of the cost of ownership for planning the type and amount of technical impact in accordance with the requirements of the current regulatory legal acts;
- optimization of costs for repair activities, modernization, technical re-equipment of equipment, technological and engineering systems, buildings and structures with the provision of the required level of safety, operational reliability and ensuring the required level of quality of power supply to consumers.
- synchronization of the development of the production assets management system of the company and subsidiaries and affiliates with the departmental programs of the specialized and

related departments.

3.6. Information security

3.6.1. Goals and objectives of information security

Goals: Ensuring the stable functioning of the information infrastructure of the subjects of the energy complex of the Rosseti group of companies (hereinafter referred to as the Subjects) when carrying out computer attacks against it, preventing unauthorized access to processed information, destruction of such information, its modification, blocking and distribution, as well as other illegal actions in relation to such information.

Objectives: Creation of a security system for information infrastructure facilities and ensuring its functioning, in particular:

• as part of the certification of new equipment and systems in the power grid complex, conducting independent testing of the security functions of information infrastructure facilities for compliance with no higher than level 4 of confidence in the software (in terms of the security functions implemented in them), conducting a statistical analysis of the code for the absence of not declared capabilities in software;

• as part of the creation, modernization, operation of information infrastructure facilities, conducting a regular assessment of the scale of possible consequences for the Company, social, political, economic, environmental consequences, as well as consequences for ensuring the country's defense, state security and law and order in the event of computer incidents at information infrastructure facilities Societies, assignment of information infrastructure objects to one of the categories of significance;

• ensuring technological safety and independence from imported equipment, technical devices, components, services (works) of foreign companies and the use of foreign software at the facilities of the power grid complex by replacing software, microcontrollers and integrated circuits, as well as using, in a priority order, only such software software, information about which is included in the unified register of Russian programs for electronic computers and databases;

• development of industry standards for information security;

• ensuring the security of information infrastructure objects during operation:

o prevention of illegal access to information processed by information infrastructure objects, destruction of such information, its modification, blocking, copying, provision and distribution, as well as other illegal actions in relation to such information;

o prevention of impact on technical means of information processing, as a result of which the functioning of information infrastructure objects and processes supporting (controlled, controlled) by it may be disrupted and (or) terminated;

o automation of the processes of detecting and preventing computer attacks on the information infrastructure of the energy complex of the Rosseti group of companies using machine learning algorithms and heuristic analysis;

o ensuring the functioning of information security tools in accordance with the instructions of the developers;

o Conducting a regular instrumental assessment of the effectiveness of the security system of information infrastructure facilities of the energy complex of the Rosseti group of companies

o ensuring the fastest possible recovery (self-recovery) of information infrastructure objects;

o interaction with the state system for detecting, preventing and eliminating the consequences of computer attacks on the information resources of the Russian Federation;

o application of risk-based management of information infrastructure assets, organization within the operational process of checking and installing critical software updates for network elements;

• ensuring the security of information infrastructure facilities during decommissioning;

• Conducting internal control in the field of ensuring the security of information infrastructure facilities by carrying out scheduled or unscheduled inspections;

• staffing of units for ensuring the security of energy complex facilities with specialists in the field of protection of information systems, automated control systems, information and telecommunication networks;

• raising the level of knowledge of employees on information security issues, organizing (re) training of engineers, technicians, administrators and operators on information security issues.

3.6.2. Basic principles of development

To ensure a reliable supply of electricity to consumers, it is necessary to apply an integrated approach to protecting the information infrastructure of the electric grid, including the creation of a Cybersecurity Monitoring Center of the Rosseti Group of Companies.

The security system of information infrastructure facilities should be created in accordance with the requirements and provisions of the Federal Law of July 26, 2017 No. 187-FZ "On the security of the critical information infrastructure of the Russian Federation" and the Federal Law of July 27, 2006 No. 152-FZ "On personal data ", as well as the corresponding by-laws and regulations as a typical geographically distributed complex, including forces and means designed to detect, prevent computer attacks and eliminate the consequences of computer incidents.

In order to improve the efficiency of planning and development of organizational and technical measures to ensure the security of information infrastructure facilities, to ensure the security of confidential information when using information and communication technologies (hereinafter referred to as information security measures) and to ensure their functioning on the principles of the unity of approaches, requirements, efficiency and reliability, the Rosseti Group of

Companies has established an Information Security Competence Center.

The measures taken to ensure the security of information infrastructure facilities should not adversely affect the functioning of the automated control system, the exchange of technological information, the functions of remote control of power grid equipment and intelligent devices from remote control centers of the PJSC Rosseti group of companies (NCC) and from the dispatch centers of JSC SO UES.

The result of ensuring the security of the information infrastructure should be the preservation of the achieved effects in terms of ensuring the reliability, technological and economic efficiency of power supply and other strategic goals of the digital transformation of the electric power industry in Russia.

3.6.3. Basic requirements

3.6.3.1. The objects of protection in the context of ensuring the security of information infrastructure are:

• corporate information systems (including machine data carriers, workstations, servers, means of processing alphanumeric, graphic, video and speech information, microprogram, system-wide, application software), ensuring the sustainability of financial and economic activities;

• automated control systems (including automated workstations, industrial servers, programmable logic controllers, production, technological equipment (actuators) with functions of both local and remote control, or having functioning interfaces for network interaction, microprogram, general system, application software provision), ensuring a reliable supply of electricity to consumers;

• corporate and technological information and telecommunication networks (including telecommunication equipment, software, control system, communication lines), forming a single information space and digital interaction environment;

• telecommunication networks used to organize the interaction of objects;

• architecture and configuration of information systems, information and telecommunication networks, automated control systems, information (data) on the parameters (state) of a controlled (monitored) object or process (including input (output) information, control (command) information, control measuring information, other critical (technological) information of commercial value due to unknown third parties.

3.6.3.2. Ensuring the security of significant objects of information infrastructure is carried out depending on the established category of significance of objects in accordance with the requirements established by the federal executive body authorized in the field of ensuring the security of the critical information infrastructure of the Russian Federation.

3.6.3.3. Ensuring the security of information infrastructure facilities of the ASTU without an established category of significance is carried out in accordance with the order of PJSC Rosseti dated April 1, 2016 No. 140r (as amended by the order of PJSC Rosseti dated April 27, 2016 No. 178r) and the requirements of this

Technical Policy.

3.6.3.4. To ensure the safety of information infrastructure facilities of the ASTU without an established category of significance, operated at critical facilities, potentially hazardous facilities, facilities posing an increased danger to human life and health and to the environment, these Requirements are applied taking into account the Requirements for information protection approved by the FSTEC order Russia dated March 14, 2014 No. 31.

3.6.3.5. To ensure the security of information infrastructure objects that are personal data information systems, these Requirements are applied taking into account the Requirements for the protection of personal data when processing them in personal data information systems, approved by the Government of the Russian Federation of November 1, 2012 No. 1119.

3.6.3.6. Depending on the category of significance and current threats to information security, the following organizational and technical measures should be implemented in the security system of information infrastructure facilities:

• identification and authentication (IAF);
• access control (UPD);
• restriction of the software environment (OPS);
• protection of machine data carriers (ZNI);
• security audit (SAA);
• anti-virus protection (AVZ);
• prevention of intrusions (computer attacks) (IDS);
• ensuring integrity (OTsL);
• ensuring accessibility (CCT);
• protection of technical means and systems (ZTS);
• protection of the information (automated) system and its components (VMS);
• planning of measures to ensure safety (OSP);
• configuration management (UKF);
• management of software updates (OPO);
• Information Security Incident Response (ITC);
• provision of actions in emergency situations (CSN);
• information and training of personnel (IPO).

Technical measures to ensure information security are implemented through the use of operating systems from the register of Russian software, software and hardware and software - information security tools (including those built into the system-wide application software):

• means of protecting information from unauthorized access (including built-in node-level firewalls in the system-wide application software);
• firewalls of the network level, the level of logical network boundaries;
• firewalls of the industrial network level;
• means of detection (prevention) of intrusions (computer attacks) of the network level;

• firewalls of the web server level;
• means of unidirectional data transmission (data-diode);
• means of detection (prevention) of intrusions (computer attacks) at the node level;
• general purpose anti-virus protection means;
• means of anti-virus protection of automated workstations of production personnel, industrial servers;
• means of anti-virus protection of the network level;
• means (systems) of control (analysis) of security;
• security event management tools;
• means of protection of data transmission channels;
• means of preventing computer attacks;
• secure remote LAN access systems, including terminal access facilities;
• backup systems, including tools for creating and storing backups;
• key information management systems.

3.6.3.7. To ensure the security of information and telecommunication networks, these Requirements are applied along with the regulatory legal acts of the federal executive body responsible for the development and implementation of state policy and regulatory legal regulation in the field of communications, as well as GOST R 62443 “Industrial communication networks. Security (cybersecurity) of networks and systems ", GOST R 56498-2015 IEC 62443-3: 2008 Industrial communication networks. Security (cybersecurity) of the network and system. Part 3. Security (cybersecurity) of industrial measurement and control process.

3.6.3.8. As border routers with access to the information and telecommunication network "Internet", routers certified for compliance with information security requirements (in terms of security functions implemented in them) are selected.

In the absence of technical feasibility of using border routers certified for compliance with information security requirements, the security functions of the border routers are subject to security assessment as part of the acceptance or testing of significant

The justification for the lack of technical feasibility is given in the design documentation for objects (security subsystems of objects), developed in accordance with the terms of reference for the creation of objects and (or) terms of reference (private terms of reference) for the creation of a security subsystem for objects.

3.6.3.9. As a means of protecting information, information security means built into software and (or) software and hardware (if any) are to be used as a matter of priority.

3.6.3.10. Built-in information protection tools for automated process control systems must meet the information security objectives set forth in the order of PJSC Rosseti dated May 30, 2017 No. 282r "Requirements for built-in information protection tools for automated process control systems of the Rosseti Group of Companies".

3.6.3.11. If it is impossible to achieve the stated goals with built-in information security tools, the corresponding functionality should be provided with the imposed information security means.

3.6.3.12. Information protection means must be used in accordance with the operating instructions (rules) developed by the developers (manufacturers) of these means, and other operational documentation for information security means.

3.6.3.13. The applied means of information protection must be provided with warranty and technical support.

3.6.3.14. The procedure for creating information systems, automated control systems, management systems for information and telecommunication networks, stages of work, as well as the development of technical and working documentation must comply with GOST R 51583-2014 “Information Security. The procedure for creating automated systems in a protected design. General provisions ", the Provisions of the Federal Law of July 26, 2017 No. 187-FZ" On the security of the critical information infrastructure of the Russian Federation "and by-laws.

At the stages (stages) of the life cycle during the creation (modernization) of information infrastructure facilities, the following are carried out:

• analysis of threats to information security and development of a model of threats to information security or its refinement (if any), determination of the category of significance, the required level of protection of information infrastructure objects;

• design of organizational and technical measures to ensure information security, development of working (operational) documentation;

• implementation of organizational and technical measures to ensure information security and putting them into effect, conformity assessment in the form of tests or acceptance, which are carried out by the subjects of information infrastructure independently or with the involvement of organizations that have licenses for activities in the field of information protection in accordance with the legislation of the Russian Federation;

• regulation of information security processes during operation.

3.6.3.15. The results of the design of the security system of information infrastructure facilities are reflected in the design documentation (draft (technical) design and (or) in the working documentation), developed taking into account GOST 34.201 “Information technology. Set of standards for automated systems. Types, completeness and designation of documents when creating automated systems "(hereinafter - GOST 34.201) and organization standards, in accordance with the established category of importance.

3.6.3.16. Information protection when using virtualization technologies is carried out in accordance with GOST R 56938-2016 "Information protection when using virtualization technology".

3.6.3.17. Requirements for the functional safety of automated enterprise management systems, operational and technological management, technological management must comply with GOST R IEC 61508-1-2012, 61508-2-2012, 61508-

3-2012.

3.6.3.18. Commissioning of information infrastructure facilities is allowed only if there is a protocol (act) of acceptance tests with a positive conclusion on the compliance and effectiveness of the security subsystem with the established security requirements.

3.6.4. Information security compliance assessment

3.6.4.1. An assessment is understood as a document confirming the effectiveness of organizational and technical protection measures taken by the Subject.

3.6.4.2. To ensure the security of information infrastructure objects without an established category of significance, information protection means should be used that have passed the assessment of compliance with the mandatory requirements for information security established by regulatory legal acts or the requirements specified in the technical specifications (security tasks) not less than 4 assessed confidence level (GOST R ISO / IEC 15408) within the framework of tests or acceptance, which are carried out by the Subjects independently or with the involvement of organizations that have licenses for activities in the field of information protection in accordance with the legislation of the Russian Federation.

Tests (acceptance) of information security tools are carried out separately or as part of a significant object of information infrastructure in accordance with the program and test (acceptance) methods approved by the Subject.

3.6.4.3. To ensure the security of significant objects of the information infrastructure, information protection means should be used that have been assessed for compliance with security requirements in the form of mandatory certification established by the legislation of the Russian Federation.

In the absence of the technical feasibility of using certified information security tools for compliance with information security requirements in significant facilities, the security functions of information security means are subject to assessment for compliance with security requirements within the framework of testing or acceptance.

The justification for the lack of technical capability is given in the design documentation for significant objects (security subsystems of significant objects).

3.6.4.4. The assessment of compliance of information infrastructure facilities with technical requirements, including information security requirements, can be carried out as part of certification (quality control) in the power grid complex (subsection 5.2 of the Technical Policy) with the development and approval of the Security Task (GOST 15408), taking into account the analysis of threats security of information relevant to the environment of use of equipment, materials and systems in the power grid complex.

3.6.4.5. Certification of information infrastructure objects processing publicly available data is not required.

3.6.4.6. Certification of information infrastructure objects that process personal data is carried out by the decision of the Subject to assess the effectiveness of measures taken to ensure the security of personal data with the involvement of an organization that, in accordance with the legislation of the Russian Federation, has a license to operate in the field of information protection.

3.6.4.7. Certification of information infrastructure objects that process state secrets or interact with state information systems is carried out without fail in order to assess the effectiveness of measures taken to ensure information security with the involvement of organizations that, in accordance with the legislation of the Russian Federation, have licenses for activities in the field of information protection.

3.6.5. Restrictions on the use of technologies/equipment

3.6.5.1. When choosing information protection tools, including accompanying embedded software, the possible existence of restrictions on the part of developers (manufacturers) or other persons on the use of these tools throughout the territory of the Russian Federation should be taken into account.

3.6.5.2. Certified information security tools are used in cases established by the legislation of the Russian Federation, as well as in case of a decision by the Subject.

3.6.5.3. When implementing technical measures to protect information, it is not allowed to use the SHA-1 cryptographic hashing algorithm, SNMP v1, v2 protocols.

3.6.5.4. Information infrastructure facilities are not allowed:

• availability of remote access directly (directly) to software and software and hardware, including information protection means, for updating or control by persons who are not employees of the Subject;

• availability of local access to software and hardware and software tools, including information protection tools, for updating or managing by persons who are not employees of the Subject without control by the Subject;

• transfer of information, including technological information, to the developer (manufacturer) of software and software and hardware, including information security tools, or to other persons without control from the Subject.

3.6.5.5. The software and software and hardware tools that are part of a significant object of information infrastructure that store and process information must be located on the territory of the Russian Federation (except for cases when the placement of these funds is carried out in foreign separate subdivisions of the Subject (branches, representative offices), as well as cases established by the legislation of the Russian Federation and (or) international treaties of the Russian Federation).

3.6.5.6. Russian-made operating systems should be used as mobile operating systems

3.7. Metrological support

3.7.1. General provisions

3.7.1.1. The purpose of metrological assurance is to ensure the uniformity and required accuracy of measurements in all technological processes in the implementation of activities for the reception, transformation, transmission and distribution of electrical energy (control of modes and parameters of the network, quality of electrical energy, energy accounting, continuous monitoring using ASMD equipment, and others) in accordance with the requirements of the legislation of the Russian Federation in the field of metrological support.

3.7.1.2. Metrological support is carried out at all stages of the life cycle of power grid facilities (design, commissioning, continuous operation).

3.7.1.3. The priority directions of the technical policy in the field of metrological assurance are:

- ensuring compliance with the requirements of the current legislation of the Russian Federation in the field of metrological support;
- introduction of modern measurement methods, automated control and measuring equipment, equipping metrological laboratories with modern installations for calibration / verification and reference means, necessary computers, vehicles;
- introduction of modern and efficient measuring instruments that ensure the required measurement accuracy in the required range of parameters, the stability of metrological characteristics throughout the entire service life, an increased interval of periodic metrological control;
- introduction of automated accounting systems for measuring instruments, planning and control of their metrological service, transition to electronic passports for measuring instruments in the power grid complex;
- confirmation of the technical competence of metrological departments of all levels of subordination, performing work on the calibration of measuring instruments in the calibration system of the Company, as well as, in case of establishing economic feasibility, their accreditation in the field of ensuring the uniformity of measurements for the right to perform work on verification (calibration) of measuring instruments

3.7.2. Measurement requirements

3.7.2.1. Measurements must be carried out in accordance with the standards for the accuracy of the measurement of the specific measured parameter in accordance with the current requirements.

3.7.2.2. Measurements (with the exception of direct measurements) must be performed according to duly certified measurement procedures (methods).

3.7.3. Requirements for units of quantities

3.7.3.1. Units of quantities must be used in accordance with GOST 8.417-2002 and "Regulations on the units of quantities allowed for use in the Russian Federation", approved by the Government of the Russian Federation dated October 31, 2009 No. 879.

3.7.4. Requirements for measurement procedures (methods)

3.7.4.1. MI used in the field of state regulation of ensuring the uniformity of measurements must meet the following requirements:

- developed in accordance with GOST R 8.563-2009;
- certified in accordance with the procedure established in the field of ensuring the uniformity of measurements, and registered in the Federal Register of Measurement Techniques

(Federal Information Fund for Ensuring the Uniformity of Measurements).

3.7.5. Requirements for measuring instruments

3.7.5.1. The measuring instruments must be verified (calibrated) in the prescribed manner and have a valid certificate (certificate) and/or a verification/calibration mark, an entry in the operating documents for the measuring instruments, for the measuring instruments used to monitor technological parameters, the accuracy of which is not standardized, must be health check was carried out.

3.7.6. Requirements for information and measurement systems

3.7.6.1. Information and measuring systems (including components) must be metrologically provided at all stages of the life cycle in accordance with the requirements of GOST R 8.596-2002, the current standards and the operational documentation of the Company;

3.7.6.2. Standard software and hardware complexes used to create information and measurement systems used in the field of state regulation of ensuring the uniformity of measurements must be of an approved type (registered with the Federal Information Fund for ensuring the uniformity of measurements).

3.7.6.3. Design documentation for IMS (in terms of measurements related to the field of state regulation in accordance with Federal Law No. 102-FZ dated June 26, 2008 "On ensuring the uniformity of measurements") at the development stage is subject to metrological examination in accordance with the current requirements.

3.7.7. Requirements for reference materials

Standard samples used in measurements should:

- have a certificate of approval of the type of a standard sample;
- be fit for use (have not expired);
- to be applied in accordance with the requirements of the measurement methodology and regulatory documents for the conditions of its operation.

3.8. Technical diagnostics and monitoring of the condition of substation and power transmission line equipment

3.8.1. General provisions

3.8.1.1. Diagnostic control of the technical condition of the equipment of substations and power transmission lines must, in terms of composition, volume and frequency, comply with the current requirements "Scope and norms of testing of electrical equipment", NLA and LNA of the Company, instructions of manufacturers.

3.8.1.2. Continuous monitoring of the technical condition of power grid equipment is carried out using automated tools, monitoring systems and technical diagnostics.

Automated monitoring and technical diagnostics systems are aimed at:

prevention of emergency processes due to internal equipment defects and timely prevention of uncontrolled development of defects;

determination of load capacity;

increasing the electrical safety of operating personnel, reducing the influence of the human factor in the process of collecting, processing and generating the results of technical diagnostics;

integration of the results of monitoring and technical diagnostics into process control systems and corporate information systems;

application of the results of ASMD work to assess the technical condition and plan a strategy for servicing production assets

3.8.1.3. The introduction of automated monitoring and technical diagnostics systems should be carried out on the basis of an appropriate feasibility study.

3.8.1.4. Newly constructed and reconstructed substations should use electrical equipment in a design that makes it possible to install and use ASMD to assess the technical condition under operating voltage.

3.8.1.5. Automated diagnostic tools and ASMD should be equipped with the function of remote access to operational information about the current technical condition of the equipment.

3.8.1.6. The introduction into the practice of operation of new methods and indicators for monitoring the technical condition of equipment should be accompanied by:

- assessment of the diagnostic value (information content) of the applied method (indicator);
- the presence of a feasibility study of the applied method (indicator);
- development of the maximum permissible value of the monitored indicator and/or the value limiting the area of normal operation, and/or the boundary value;
- the availability of guidelines for the application of the method (indicator) with recommendations for decision-making when using.

3.8.1.7. Metrological support of measuring instruments used for Continuous control with the use of ASMD equipment of substations must comply with the provisions of Section 3.6 of the Technical Policy.

3.8.1.8. Measurement of the insulating characteristics of electrical equipment under operating voltage is allowed to be carried out provided that devices are used that ensure the safety of work and protection of a normally grounded low-potential terminal of the controlled object from the appearance of dangerous voltage on it when communication with the ground is disrupted.

3.8.2. Requirements for technical diagnostics and monitoring of the condition of substation equipment

3.8.2.1. Technical diagnostics and assessment of the technical condition of the substation equipment should be carried out according to the results of tests and measurements in the volume and in accordance with the NLA "Requirements for the scope and standards of testing of electrical equipment", Order of the Ministry of Energy of Russia dated July 26, 2017 No. 676 and LNA of the Company.

3.8.2.2. Automated systems for monitoring and diagnostics of continuous control should carry out prompt diagnostics of the current technical condition of the equipment, timely detection of the occurrence and development of defects.

3.8.2.3. It is recommended to use automated systems for monitoring and diagnostics of continuous control:

a) power T/AT 220 kV and above (for UNEG - T/AT 330 kV and above), power transformers 110 kV with a capacity of 63 MVA and above in the amount of:

- control of the content of hydrocarbon gases dissolved in the oil of the transformer tank (ethane, methane, ethylene, acetylene);
- control of the content of hydrogen dissolved in the oil of the transformer tank;
- temperature control of the upper layers of oil in the transformer tank;
- control of the moisture content of oil in the transformer tank;
- PD control by indicators: PD regularity, dangerous apparent charge of PD, duration of one PD registration cycle;
- control of the dielectric loss tangent and insulation capacity of 110 kV and higher high-voltage bushings (for UNEG - 330 kV and above, as well as 110 kV and above bushings installed on T/AT 330 kV and above);

b) 110 kV power transformers with a capacity of less than 63 MVA, CPU and 35 kV power transformers with a capacity of 16 MVA and above nodal substations in the amount of:

- control of the content of hydrogen dissolved in the oil of the transformer tank;
- temperature control of the upper layers of oil in the transformer tank;
- control of the moisture content of oil in the transformer tank;

c) GIS 110 kV and above in the amount of:

- control of the PD level by indicators: PD regularity, dangerous apparent charge of PD, duration of one PD registration cycle;
- control of the SF6 gas pressure in the gas compartments;

d) switches 220 kV and above (for UNEG - 330 kV and above), switches 110 kV, operated on a central processing unit with power transformers 63 MVA and above in the amount of:

- control of the mechanical resource of the circuit breaker drive by the number of on / off operations;
- control of the switching resource by the number of outages of operating currents and short-circuit currents and their value using automatic calculation of the residual life before maintenance, repair, decommissioning;
- for circuit breakers 500 kV and above - recording of oscillograms of turn-on and turn-off currents.

3.8.2.4. To assess the technical condition of the substation equipment, the following types of diagnostic control can be additionally used in the presence of measurement techniques and specified maximum permissible values of the measured parameters:

- infrared control for the entire range of equipment;
- optical control of porcelain and polymer support-rod insulation (UV diagnostics);
- sound and ultrasonic testing of microcracks in porcelain support-rod insulation and porcelain insulation of measuring transformers and switches;
- acoustic control of closed air bus ducts and bus ducts;
- PD control in bus ducts and cast resin bus ducts;
- X-ray inspection of equipment - for the entire range of equipment, in particular - SF6 switching.

3.8.3. Technical diagnostics and monitoring of the state of overhead lines

3.8.3.1. Technical diagnostics and assessment of the technical condition of the cable line should be carried out based on the results of tests and measurements in the volume and in accordance with the current NLA "Requirements for the volumes and standards of testing of electrical equipment", order of the Ministry of Energy of Russia dated July 26, 2017 No. 676 and the LNA of the Company.

3.8.3.2. To assess the technical state of overhead lines, the following types of diagnostic monitoring of the technical state of functional units and elements of overhead lines can be additionally used in the presence of measurement techniques and specified maximum permissible values of the measured parameters:

- infrared control for live and insulating elements of overhead lines;
- magnetometric non-destructive testing of the state of metal structures of supports;
- ultrasonic testing of foundation anchors;
- seismic acoustic and ultrasonic monitoring of the state of foundations and reinforced concrete structures;
- defectoscopy of cable braces of supports, wires and lightning protection cables;
- measurement of the amplitude-frequency characteristics of wires and cables;
- an acoustic method for assessing the physical and mechanical properties of reinforced concrete and wooden supports, based on comparing the natural mechanical vibrations of a support arising from impact with the vibrations of an "ideal" support of the same height, firmly embedded in the ground;
- magnetic method for assessing the corrosion state of steel cores of current-carrying wires and lightning protection cables;
- seismoacoustic and ultrasonic methods for assessing the length of immersion in the soil of reinforced concrete and metal piles of foundations of supports;
- ultrasonic and differential - optical method for assessing the strength of the material and the state of welded joints of metal elements of supports and foundations;
- vibration method for assessing the accumulated embrittlement fatigue of metal supports, wire materials and lightning protection cables;
- UFK of the state of pollution of insulation of overhead lines.

3.8.3.3. It is recommended to use wire temperature monitoring systems for overhead lines equipped with ice melting installations in the presence of special justifications for overhead lines that systematically operate with a load close to long-term permissible.

3.8.3.4. With the development of technologies, a promising direction in monitoring the condition of overhead lines is monitoring overhead lines under operating voltage.

3.8.3.5. To monitor the condition of overhead lines in order to prevent emergency shutdowns, refusal from expensive overflights and inspections of overhead lines by helicopters, horse inspections, and reduce pedestrian inspections, it is recommended to use:

a) unmanned aerial vehicles (UAVs) equipped with video cameras, thermal imagers, laser scanners, appropriate software and other devices that allow you to measure and transmit information to the AWP of the relevant users, allowing you to determine:

- the position and condition of the elements of the overhead line supports (deflection of the support from the axis, deflection of the traverse, protective coating, condition of the guy wires, etc.);
- condition and dimensions of wires, lightning protection cables (sag arrow, dimensions, condition of glades, broken wires, lightning protection cables, loops);
- the presence of vibration dampers;
- the presence of "zero" insulators and the condition of the strings of insulators;
- the presence and degree of ice formation and adhesion of snow;
- the presence of foreign objects in the security zone of the overhead line;
- breakage of wires and lightning protection cables;

b) the use of special robotic systems with the ability to move along wires and lightning protection cables of overhead lines, equipped with a video camera, thermal imager, contact devices and sensors, appropriate software and other devices that allow you to measure and transmit information to the AWP of the corresponding users, allowing you to determine:

- heating of wires;
- damage to wires, lightning protection cables, contact connections, including control of the loss of the ground wire cross-section and wire breaks in the steel core of the wire;
- malfunctions in suspensions and fittings, including malfunctions in fasteners and connections of wires and cables, deviation of insulating supporting suspensions from the design position in excess of an additional value;
- mechanical damage to porcelain or glass insulators, traces of overlapping garlands and individual insulators;
- malfunctions of grounding devices, including the identification of unsatisfactory contacts in the bolted connections of the ground wire with grounding slopes or the support body;
- the presence of foreign objects in the security zone of the overhead line;
- threatening trees;
- the dimensions of the overhead line route, including the sag arrows and the distances from the overhead line wires to the ground, to the intersected objects, between the phases to the values;
- defects in the installation of spark gaps on supports and inconsistency in the value of the

external spark gap;

- the inclination of the supports along or across the line in excess of the permissible norms;
- deformation of individual parts of the support;
- lack of alignment of racks and footrests at supports with braces, absence of bolts and nuts, absence of dowels and wedges, loosening of bolted connections, poor-quality fastening of brackets, burning and splitting of support parts;
- the presence of bursts, broken (burst) or burnt wires, traces of overlap, melting or swelling of the upper layer ("lights").

3.8.3.6. UAVs must be made in a noise-immune design against interference introduced into the UAV navigation signal by the field of the line itself.

3.8.3.7. It is recommended, with appropriate justification, to use stationary monitoring systems in critical sections of overhead lines using various control devices (optical fiber built into a ground wire or phase wire, sensors, video cameras, current and voltage transformers, etc.), as a rule, for:

- control of the heating temperature of the wire in the places where the sensors are mounted
- control of the presence and degree of ice formation and adhesion of snow;
- control of the dimensions of wires, lightning protection cables (sag arrow, dimensions) at the intersection with utilities, highways;
- control and monitoring of weather conditions (data received from autonomous weather stations).

3.8.4. Requirements for technical diagnostics and monitoring of the cable line condition

3.8.4.1. Technical diagnostics and assessment of the technical condition of the cable lines must, in terms of composition, volume and frequency, comply with the current requirements "Scope and standards for testing electrical equipment", NLA and LNA of the Company, instructions of manufacturing plants.

3.8.4.2. For CL 110 kV and above, continuous monitoring must be carried out using ASMD under operating voltage in the following volume:

- control of the PD level of end couplings according to the following indicators: PD regularity, dangerous apparent PD charge, duration of one PD registration cycle in couplings;
- thermal control of cable lines using built-in optical fiber.

3.8.4.3. To assess the technical condition of the cable line, the following types of diagnostic monitoring of the technical condition can be additionally used in the presence of measurement techniques and specified maximum permissible values of the measured parameters:

- acoustic control of cable end sleeves;
- radio frequency control of cable end sleeves.

3.8.4.4. With the development of technologies, a promising direction in monitoring the condition of cable lines is monitoring of cable lines under operating voltage.

3.9. Regulation of voltage and power quality

3.9.1. As measures to ensure that deviations from the permissible indicators of the quality of electricity in the 6-750 kV electric network do not exceed:

- rational construction of power supply schemes for consumers of electrical energy (transition to the use of a higher voltage, increase in the cross-section of current-carrying conductors of power lines, replacement of transformers with more powerful ones, construction of additional transformer substations, construction of additional power lines, uniform distribution of single-phase and two-phase loads over all three phases of the electrical network);
- the use of SRN and UKRM;
- application of means of compensation of inductive resistance of power lines;
- the use of unregulated balancing devices that convert static single-phase or two-phase loads of significant power into three-phase loads.

3.9.2. The following should be considered as SRN and UKRM in 35-750 kV electrical networks:

- automatically or manually switched BSK, ShR and VRG;
- devices on-load tap-changer, automatic tap-changer and off-load tap-changer for transformers;
- uncontrolled and controlled longitudinal compensation devices (UPK and UUPK) of various designs;
- automatically controlled UKRM based on power electronics (CSR with magnetization, CSR of transformer type, installations formed by parallel connection: STK, CSR with magnetization and BSK, STATKOM);
- PKU and FSU.

3.9.3. The choice of the type, capacity, location and connection point of the UKRM in electrical networks of 110 kV and above should be carried out on the basis of calculations in accordance with the Methodological Guidelines for the Design of Power Systems.

3.9.4. In distribution networks up to 20 kV inclusively, the following should be considered as RNS and UKRM:

- RP, RTP 10 (20) kV;
- sources of distributed generation;
- synchronous motors 6, 10 kV;
- devices on-load tap-changer and ARPN, off-load tap-changer for transformers;
- complete automatically or manually switched BSK, FKU and FSU;
- STK and STATCOM for substations supplying an abruptly variable or asymmetrical load;
- VDT and linear regulating autotransformers;
- voltage converters switched to the specified distribution network, energy

storage units and UPS based on high-power AB.

The above activities and technical means are intended for:

- maintaining the reactive power factor (tgφ) on the CPU buses in accordance with regulatory requirements;
- ensuring, in accordance with GOST 32144, GOST R 55195 and GOST 29322, voltage and power quality levels in normal and steady-state post-emergency modes, subject to the regulatory requirements for the power factor on the CPU buses and the requirements for the operation of the SNR installed at the substation;
- ensuring the permissible conditions for switching on power lines;
- reduction of resonant and switching overvoltages;
- filtering current harmonics and balancing voltages;
- increasing the throughput of the electrical network;
- reduction of losses, electricity and power.

3.9.5. When designing new construction, expansion, reconstruction, modernization and technical re-equipment of the existing 6-110 kV distribution networks to normalize the power factors in the central processing unit, ensure the normalized voltage level and ensure the quality of electricity at the points of transmission of electrical energy, it is necessary to provide:

- automatically or manually switched BC and ShR in general-purpose distribution networks 35, 110 (150) kV;
- switched BC, linear control AT in 10 kV power lines, RCC in 0.4 kV power lines in distribution networks (20) 10 (6) -0.4 (0.66) kV.

3.9.6. To reduce the asymmetrical load in general-purpose networks of 0.4 kV, it is recommended to use three-phase transformers with a connection of windings Δ / Yn-11 (for transformers with installed power from 100 to 1000 kVA) and Y / Zn-11 (for transformers with installed power up to 100 kVA).

3.9.7. Linear regulating ATs should be provided at the beginning of 10 kV power transmission lines for agricultural purposes when connected to a central processing unit, the load graphs of which differ from the graphs of agricultural loads, for example, when connecting to traction substations and substations of industrial enterprises.

The use of linear regulating ATs should also be considered to reduce voltage losses in existing main transmission lines of 10 kV, if voltage regulation in the CPU is not enough for this purpose, as well as when powering consumers from the LV winding of three-winding transformers with on-load tap changers to ensure independent voltage regulation in the presence of a feasibility study.

3.9.8. The expediency of installing RCCBs in the gap of 0.4 kV power lines should be considered in accordance with the Methodological Instruction for the installation of RCCBs in 0.4 kV distribution networks (MI BP 10 / 01-01 / 2012):

- in case of power supply to consumers with a low level of consumption;
- in power lines that have not completed their service life, when the standard voltage levels of remote consumers are not provided (as a rule, with a feeder length of more than 1.0 km);

- in exceptional cases - as a solution to the problem of low voltage on a 0.4 kV overhead line of a large length (more than 1.0 km) in the absence of the possibility of reconstruction of a central processing unit 10-35, 110 (150) kV;

- in cramped conditions where it is not possible to install an additional transformer substation or the costs of supplying a new 0.4 kV overhead line are several times higher than the cost of the RCCB and its installation;

- near a 35 kV substation with transformers with switching of winding taps without excitation, where voltage regulation does not meet the initial requirements;

- if the power transformer at the substation is not overloaded even during peak load hours, the electrical network is long and has no prospects for further development;

- with a pronounced seasonal load in extended networks that have no prospects for further development.

3.9.9. The use of STK, CSR, STATCOM should be envisaged if the switched BC and SHR do not meet local technical or operational requirements, or the reduced costs for their installation and operation are greater than the same costs for the listed funds.

3.9.10. When choosing RCRMs containing BSCs, in network sections where regular distortions of the shape of the current and voltage curves are observed, this RCRM, and in particular BSC, should be checked for possible overload by currents of higher harmonics. The choice of the circuit for connecting the UKRM at the 35-750 kV substation should be determined in accordance with the Technological Design Standards for AC substations with a higher voltage of 35-750 kV.

3.9.11. To compensate for harmonic distortions, voltage fluctuations and voltage balancing in electrical networks supplying rapidly alternating, nonlinear, asymmetric loads, preference should be given to FKU, FSU and automatically regulated high-speed CCRM with phase-by-phase control.

3.9.12. Long-term or short-term asymmetrical modes of currents and voltages can be reduced by uniform distribution of single-phase and two-phase loads in all three phases.

If these measures are insufficient, it is recommended to use baluns. For static single-phase or two-phase loads of significant power, unregulated baluns should be used, converting these loads into three-phase.

3.9.13. When designing a power supply system for electrical receivers, the load of which has a sharply variable nature, active filter-compensating and balancing devices (AFS) based on modular multi-level voltage converters can be recommended, providing voltage stabilization, filtering of harmonics and voltage balancing in real time.

3.9.14. For a number of electrical receivers of industries with a continuous technological process, computer equipment, communication facilities for consumers of a special category of megalopolises, etc., the use of UPS with AB or the use of supercapacitors should be considered. The expediency of using these devices must be justified.

3.9.15. When designing electrical networks, voltage regulation means, places of installation of appropriate voltage regulation devices and regulation systems (manual or automatic) should be selected.

3.9.16. KB and VDT should be referred to the control devices of the electrical distribution network up to 1 kV.

3.9.17. The permissible minimum and maximum voltage values at the points of common connection of power consumers must comply with GOST 32144.

3.9.18. When designing, the expediency and location of the RCCB should be considered:

- in the case of power supply to consumers with a low level of consumption, when the installation of an additional TP is not justified due to the small number of consumers located in hard-to-reach areas and the inexpediency of upgrading the network;
- on overhead lines that have not completed their service life, when the standard voltage levels of remote consumers are not provided (as a rule, with a feeder length of more than 1.0 km);
- in exceptional cases - as a final solution to the problem of low voltage on a 0.4 kV overhead line of a large length (more than 1.0 km) in the absence of the possibility of reconstruction of a central processing unit 10-35, 110 (150) kV;
- in cramped conditions, when it is not possible to install an additional transformer substation, or the costs of supplying a new 0.4 kV overhead line are several times higher than the cost of the RCCB and its installation;
- if the power transformer at the substation is not overloaded, including during peak load hours, the electrical network is long and has no prospects for further development.

4. Instruments for the implementation of the Technical Policy

4.1. Normative and technical regulation

4.1.1. The system of regulatory and technical support of the Company and its subsidiaries and affiliates - the LNA system, including organizational and administrative documents, organization standards, instructions, regulations, guidelines and others.

4.1.2. LNA are developed to ensure compliance with:

- the requirements of the legislation of the Russian Federation;
- documents in the field of technical regulation, including the regulations of the Eurasian Economic Union (technical regulations of the Customs Union);
- functions and tasks of the Company;
- the technical policy of the Company.

4.1.3. The regulatory and technical support management system should provide:

- timely development of LNA in accordance with the current and relevant requirements of regulatory bodies; timely revision and updating of the existing LNA in accordance with new and relevant requirements of regulatory bodies; timely development and updating of the existing LNA in accordance with the functions and tasks of the Company for the implementation of the Technical Policy of the Company;

- availability and timely updating of the list of regulatory legal acts, documents in the field of technical regulation and LNA of the Company regulating and ensuring the fulfillment of the requirements and provisions of the Technical Policy of the Company with posting on the official website of the Company;
- the required level of unification and typification of the LNA;
- fulfillment of the requirements and procedures established in the Company for the development, consideration of projects of the corresponding LNA and their approval;
- ensure the participation of the Company in the development of regulatory legal acts and documents in the field of technical regulation in accordance with the functions and tasks of the Company.

4.2. Quality control (hereinafter - Certification) of equipment, materials and systems

4.2.1. The quality control system (hereinafter - Attestation) in PJSC Rosseti is an internal quality control system aimed at meeting the needs of the Company in modern, reliable, safe and efficient equipment, materials and systems to ensure the operational, repair and investment activities of the Company, to ensure reliable and trouble-free operation of the UES of Russia.

4.2.2. Quality control of equipment, materials and systems is aimed at achieving the following goals:

- ensuring the reliability and safety of the operation of equipment, materials and systems by preventing the supply of equipment, materials and systems to the facilities of the Company and subsidiaries and dependent companies that do not correspond in their characteristics to the established technical requirements, safety requirements, goals and conditions of use;
- exclusion of the possibility of supplying equipment, materials and systems to the facilities of the Company and subsidiaries and dependent companies that do not meet the requirements of the RLA, current NTD, LNA and the requirements of the Company;
- ensuring compliance with the requirements of the technical policy of the Company.

4.2.3. Quality control of equipment, materials and systems supplied to power grid facilities is carried out in accordance with the internal documents of the Company (LNA of the Company).

During the quality control procedure, the equipment, materials and systems are checked for compliance with the requirements of PJSC Rosseti standards developed to ensure product quality, perform work and provide services under Article 3 and Article 21 of Federal Law No. 162-FZ dated June 29, 2015 "On standardization in the Russian Federation".

4.2.4. The result of the certification is the conclusion of the certification commission, approved in accordance with the established procedure, which applies to equipment, materials and systems supplied and operated at the facilities of the Company and subsidiaries and affiliates.

The results of a positive quality check are drawn up in the form of a "List of equipment, materials and systems recommended for use at the facilities of the Company and subsidiaries and dependent companies" and posted on the website of the Company.

4.2.5. If a decision is made to purchase equipment, materials and systems that are not included in the list of approved for use at the facilities of the PJSC Rosseti group of companies, the quality control procedure is carried out in accordance with the established procedure.

The supplier / contractor is responsible for passing the quality check and obtaining a document confirming the possibility of using tested equipment, materials and systems at the customer's facilities and determining the scope of its application.

The information base for checking the quality of the products proposed for delivery is a package of technical documentation (test reports, certificates, etc.) for these products, provided by the supplier / contractor, taking into account the requirements of industry regulatory and technical documentation, standards and regulatory technical documentation of the Company.

4.2.6. During the construction and reconstruction of power grid facilities, equipment, materials and systems that have passed the quality control procedure in accordance with the established procedure must be used.

4.3. Innovative development

4.3.1. One of the key tools for the implementation of a unified technical policy in terms of the application and development of new technical solutions is the Innovative Development Program (hereinafter referred to as the Program).

The Program is obligatory for execution by structural divisions of the Executive Office of PJSC Rosseti and SDCs, provided it is recognized as applicable (in whole or in part) by the management body of SDCs.

The program contains the most progressive technical solutions, which in the near future should replace traditional technical solutions; it also defines general approaches, goals, objectives, priorities, indicators and control points for the implementation of innovative activities, indicators of efficiency and effectiveness of innovative projects and activities.

Development, implementation and replication of new technical solutions can be carried out in several stages:

- carrying out research work;
- conducting research and development;
- conducting pilot implementations;
- carrying out experimental-industrial operation;
- correction of normative and technical documents;

- Formation of proposals for large-scale replication of innovative solutions in the development of standard projects or re-use projects.

- formation of a register of innovative products.

4.3.2. The organization of innovative activities within the framework of the Program is aimed at implementing an algorithm for the development, testing and further widespread use of innovative solutions, namely:

- identifying the need for certain solutions and technologies, in accordance with the directions of innovative development, determined by the Program;

- conducting benchmarking on the domestic and foreign market;

- in case of availability of proposals on the market - organization of pilot implementation and pilot operation, in case of absence - organization of R&D and also pilot implementation and pilot operation.

The most effective technologies or solutions can be included in the Unified Technical Policy of PJSC Rosseti as a basic technical solution for use as part of a new construction project or complex reconstruction after certification by PJSC Rosseti.

4.4. Environmental policy

The environmental policy in the power grid complex is approved by the Board of Directors of the Company and is based on federal laws and other regulatory legal acts of the Russian Federation, international obligations of the Russian Federation in the field of environmental protection. The Rosseti group of companies in its activities ensures the application of the most promising requirements aimed at reducing the impact on the environment, demonstrates and owns all the necessary mechanisms aimed at preventing environmental risks.

4.4.1. The main objectives of the technical policy in the field of environmental policy are:

- compliance with the requirements and norms in the field of environmental protection and ensuring environmental safety established by the environmental legislation of the Russian Federation and international legal acts;

- protection, reproduction and rational use of natural resources in the design, construction, reconstruction, operation and liquidation of power grid facilities;

- limitation of production and construction activities in specially protected natural areas;

- making management and investment decisions, taking into account the analysis and assessment of environmental consequences, the development of measures to reduce and prevent environmental impact;

- application in the production process of the best available technologies and technical solutions, including innovative ones, aimed at minimizing the impact of production activities on the environment;

- handling production and consumption waste and dismantled equipment in accordance with the current legislation of the Russian Federation.

4.4.2. Technologies and measures aimed at ensuring the requirements in the field of environmental protection and ensuring environmental safety are:

- phased decommissioning of equipment containing polychlorinated biphenyls, with replacement for an environmentally safe one by 2025, with its subsequent transfer for destruction to specialized organizations that have an appropriate license;
- ensuring the conservation of biodiversity, including the implementation of measures in the field of ornithological safety of power grid facilities, including the use of self-supporting insulated wires, which also significantly reduce the volume of cutting down of green spaces, and elevated supports with wires located above the crowns of forests with valuable trees;
- arrangement of a system of oil receivers at the PS using modern technologies (including polymer coatings for oil receivers);
- reclamation of lands disturbed in the course of construction, reconstruction, technical re-equipment and operation of power grid facilities;
- construction and reconstruction of local treatment facilities in order to minimize the impact on surface water bodies.

4.4.3. To achieve environmental safety, it is necessary to carry out the following measures:

- to comply with the requirements of the legislation of the Russian Federation and current regulatory legal acts, current regulatory documents, contractual obligations in the field of environmental protection;
- ensure the functioning and continuous improvement of the environmental management system that meets the requirements of GOST R ISO 14001:2015;
- to ensure that the negative impact on the environment is taken into account, the system of industrial environmental control is improved and preventive measures are taken to reduce the negative impact;
- systematic training of personnel and increasing their competence in matters of environmental protection;
- to provide free access to information related to the activities of power grid companies in the field of environmental protection.

4.4.4. During the design, construction and reconstruction of power grid facilities, it is necessary to ensure compliance with the requirements and norms established by the environmental legislation of the Russian Federation and international legal acts in the field of environmental protection in the field of environmental protection.

4.4.5. The construction and reconstruction of power grid facilities must be carried out according to the approved project documentation, which has a positive conclusion of the state expertise, as well as in cases established by the current legislation, a positive conclusion of the state environmental review of the regional or federal level, in compliance with the requirements in the field of environmental protection, sanitary and construction requirements, rules and regulations.

4.5. Energy saving and energy efficiency improvement

4.5.1. Energy saving in an electric grid company is a complex of organizational, legal, technical, technological, economic and other measures aimed at reducing the volume of energy resources used while maintaining the corresponding beneficial effect from their use (including the volume of products manufactured, work performed, services rendered).

Energy saving in power grid companies should be ensured by the implementation of a set of these measures that have a synergistic effect

Increasing energy efficiency in a power grid company is an improvement in characteristics reflecting the ratio of the beneficial effect from the use of energy resources to the costs of energy resources produced in order to obtain such an effect, in relation to products, technological process.

Power grid companies must ensure the achievement of economically justified efficiency in the use of energy resources at the current level of development of technology and technology in compliance with the requirements for environmental protection.

4.5.2. The technical policy in the field of energy conservation and energy efficiency should be aimed at implementing the requirements of the legislation of the Russian Federation in the field of energy conservation and energy efficiency, comprehensive technical support for achieving the strategic goals and objectives of the Company in the field of energy conservation and energy efficiency, rational use of natural and fuel and energy resources (FER) in the implementation of production and economic activities.

4.5.3. The objectives of the Technical Policy of the Company in the field of energy conservation and energy efficiency are:

- reduction of consumption of all types of fuel and energy resources, including reduction of losses of electrical energy during its transmission through electric grids;
- achievement of target indicators and indicators of energy efficiency in the areas of fuel and energy resources saving.

4.5.4. Achievement of the Company's goals in the field of energy saving and increasing energy efficiency is ensured by the development of measures aimed at solving the following tasks:

- reduction of electricity losses during its transmission through trunk and distribution networks;
- reducing the consumption of energy resources in industrial and administrative buildings, structures and structures, including by equipping with automated systems for monitoring and managing the consumption of fuel and energy resources;
- reducing the consumption of fuel and lubricants by vehicles and special equipment used in the production and economic activities of the Company;
- equipping facilities with energy metering devices, organizing the process of collecting information based on data from energy metering devices;
- creation and implementation of innovative demonstration projects that

ensure an increase in the energy efficiency of power grid facilities and industrial and economic facilities;

- conducting energy audits with the development of measures aimed at the efficient use of energy resources;
- development and improvement of the LNA of the Company for the implementation of energy saving and increasing energy efficiency;
- formation of an energy saving management system in a power grid company based on the implementation (development) of energy management in accordance with the best world practices; analysis and implementation of best practices and technologies;
- training on an ongoing basis for the personnel of power grid companies in energy conservation and energy efficiency improvement;
- formation of a culture of energy consumption among consumers;
- analysis and implementation of best practices and best available technologies;
- the use of modern energy efficient electrical equipment with standardized energy efficiency indicators.

4.5.5. Within the framework of energy saving and maintaining high energy efficiency indicators, it is necessary to create conditions for saving not only electric energy, but also water resources, thermal energy, and motor fuel.

4.5.6. In order to improve the efficiency of energy consumption management, the implementation of energy management should be carried out.

4.5.7. Energy management in power grid companies should be continuous, constantly declared in quarterly and annual reports and an obligatory production element.

4.5.8. As part of energy management, power grid companies should:

- to form a team (working group) for energy management from among experienced specialists and managers;
- establish the scope and boundaries of the energy management system;
- to develop and approve the energy policy of the electric grid company, aimed at observing on an ongoing basis the principles of energy saving and increasing energy efficiency for reliable and high-quality energy supply to consumers;
- develop energy goals, objectives and action plans in accordance with the development strategy of the power grid company;
- create a register of technological and energy-consuming equipment;
- to form the basic values of target efficiency indicators (energy characteristics) based on the target indicators of the energy saving program and increasing the energy efficiency of the power grid company;
- to compare the actual technical indicators of power equipment with the passport values of the manufacturers and the requirements of the technological regime;
- update and expand the register of energy-consuming equipment (towards accounting for smaller - previously unaccounted for items) every 1-2 years;

- to tighten requirements for energy efficiency and accuracy of electrical equipment, performance of technological and production work every 2-3 years.

4.5.9. Electricity grid companies should constantly increase the share of using intelligent metering systems that meet the Rules for Providing Access to the Minimum Set of Functions of Intelligent Electric Energy (Power) Metering Systems with Electronic Data Collection and Data Processing, by replacing existing metering devices (primarily integrated devices) and creating new points equipped with intelligent accounting systems. It is necessary to ensure the use of digital data analysis capabilities with intelligent accounting systems, to constantly increase the proportion of work performed by software using artificial intelligence technology.

4.5.10. Typical energy saving measures for a power grid company:

- identification of unaccounted electricity consumption and analysis of electricity balances;
- ensuring the formation of the correct effective supply of electrical energy;
- optimal loading of transformers;
- regulation of the power factor of electrical energy;
- the use of LED lamps;
- application of local lighting schemes;
- installation of automation for switching on / off the lighting of the RU Substation, the territory of the Substation;
- installation of devices for automatic switching on / off of heating systems for equipment of substations, RU substations, premises of service and production buildings;
- use of windows and enclosing structures with high thermal resistance (wall insulation, replacement of doors and windows);
- optimization of transport routes and loading of vehicles and special equipment;
- use of natural lighting;
- use of infrared heaters at the substation;
- use of sensors to control power-consuming devices;
- use of cables and wires of the section specified in the design documentation;
- uniform distribution of loads across phases;
- minimization of connections;
- the use of self-supporting insulated wire and protected wires;
- the use of modern means of protection of lines from short circuit;
- implementation of periodic monitoring of the insulation resistance of the network, checking the contacts of the electrical network;
- use of a variable frequency drive;
- the use of current-limiting reactors of a new generation.

4.5.11. When designing new construction and reconstruction of existing facilities as part of the sections of the project documentation, it is necessary to develop a list of energy saving measures in accordance with the requirements of the Decree of the Government of the Russian Federation dated February 16, 2008 No.

87 "On the composition of sections of project documentation and requirements for their content" Section 10 "Measures for ensuring compliance with energy efficiency requirements".

4.6. Import substitution in the power grid complex

4.6.1. Import substitution as a type of economic strategy and industrial policy of the state is aimed at replacing imports of industrial goods that are in demand in the domestic market with goods of national production.

4.6.2. Import substitution serves as a mechanism for the innovative development of energy and related industries and as a mechanism for the development of the domestic power engineering, electrical industry and industrial and fundamental science to ensure the technological security of the Russian Federation.

4.6.3. As part of the implementation of import substitution, Decree of the Government of the Russian Federation No. 719 dated July 17, 2015 defines the requirements for industrial products for the purpose of classifying them as products manufactured in the Russian Federation, the Government of the Russian Federation of September 16, 2016 No. of Russian origin in relation to goods produced on the territory of a foreign state.

4.6.4. By order of the Ministry of Industry and Trade of Russia dated April 16, 2019 No. 1327, the "Action Plan for Import Substitution in the Power Engineering Industry, Electrical and Cable Industry of the Russian Federation" was approved, which sets priority groups of equipment and a target for the share of imports in purchases by 2024.

4.6.5. The implementation of import substitution in the power grid complex based on the development of the competencies of domestic manufacturers and technology transfer is carried out by:

- creating conditions for providing ESCs with modern domestic equipment;
- identification of modern and innovative technologies necessary for the implementation of the Regulation, their transfer to ensure the required level of localization of production and R&D.

4.6.6. The priority directions of the technical policy in the field of import substitution are:

- minimization of the use of imported equipment and materials in the formation of design solutions and technical specifications. The use of imported products must have a feasibility study and is allowed in the absence of analogues of domestic production;
- typification of the equipment used in the power grid complex through the development and implementation of organizational standards for electrical products, in order to take into account the production capabilities of domestic manufacturers and eliminate excessive requirements for equipment, leading to the need to purchase imported equipment;
- development of localization of production of high-tech equipment and

components on the territory of the Russian Federation.

5. List of accepted abbreviations

AB	-	accumulator battery
ABP	-	uninterruptible power supply unit
ABP	-	automatic input of a reserve (reserve power supply)
ADSC	-	dry arc extinguishing unit with smooth condenser control
AIIS UE	-	automated information and measurement system for electricity metering
AIIS KUE	-	automated information and measuring system for commercial metering of electrical energy
AIIS TUE	-	automated information and measuring system for technical metering of electrical energy
AISKGN	-	automated information system for early detection of ice formation
ALAR	-	automatic elimination of asynchronous mode
APV	-	automatic reclosing
APS	-	automatic fire alarm
AWP	-	workstation
ARPN	-	on-load voltage automatic control devices
ASDU	-	automated dispatch control system
ASK	-	asynchronous compensator
ASMD	-	automated monitoring and diagnostic systems
ASTU	-	automated process control systems
ACS	-	automated control system
APCS	-	automated process control system
ASEMPCH	-	asynchronous electromechanical frequency converter
BC	-	capacitor bank
BSK	-	static capacitor bank
UAV	-	unmanned aerial vehicles
VDT	-	booster transformer
VZG	-	secondary master oscillators
Videoconferencing	-	video conferencing system
Overhead lines	-	overhead power line
VLZ	-	overhead line with protected wires
VLI	-	overhead line with self-supporting insulated wires
VN	-	higher voltage
FOCL	-	fiber optic communication line
VPT	-	DC link
AWG	-	vacuum reactor group
VRU	-	input switchgear
HTSC	-	high temperature superconductivity

HTSC TOU	-	current-limiting device based on high-temperature superconductivity
HF	-	high frequency
GIS	-	geographic information system
GOTV	-	gas extinguishing agents
GT	-	lightning protection wire
DGR	-	arc suppression reactor
DGU	-	diesel generator set
Subsidiaries and affiliates	-	subsidiary and dependent company carrying out activities for the transmission and distribution of electrical energy, the shares of which are owned by PJSC Rosseti
DC	-	dispatch center
UNEG	-	unified national (all-Russian) electric grid
EEC	-	Unified energy system
ZRU	-	closed switchgear
ZTP	-	indoor transformer station
Memory	-	grounding device
UPS	-	uninterruptible power supply
IIC	-	measuring and information complex measuring point
IP	-	measuring system (information and measuring system)
ITS	-	technical condition index
CA	-	switching device
KB	-	capacitor bank
KVL	-	cable-overhead line
KZ	-	short circuit
KL	-	cable power line
KRU	-	complete switchgear
KRUV	-	complete air-insulated switchgear (mixture of nitrogen (N2) and oxygen (O2))
GIS	-	gas insulated switchgear
CSR	-	complete stationary single-sided switchgears
KTP	-	complete transformer substation
CE	-	power quality
LAN	-	local area network
LNA	-	local regulations of PJSC Rosseti
Power lines	-	power line
M/D	-	natural oil cooling system / oil cooling with blowing and natural oil circulation
M/D/DC	-	natural oil cooling system / oil cooling with blowing and natural oil circulation / oil cooling with blowing and forced oil circulation through air coolers
MTP	-	material and technical resources

IFC	-	multifunctional microprocessor controllers
IEC	-	International Electrotechnical Commission
R&D	-	research and development work
NN	-	lower voltage
NPA	-	regulations
NTD	-	Normative and technical documentation
NTSP	-	low temperature superconductivity
NE	-	energy storage
OZZ	-	single phase earth fault
OIC	-	operational information complex
OCGT	-	optical cable built into the lightning protection cable
Surge arrester	-	non-linear surge suppressor
OBO	-	hazardous production facility
GTC	-	general substation control room
ORD	-	organizational and administrative document of PJSC Rosseti
OSU	-	open switchgear
Wholesale electricity market	-	wholesale electricity and capacity market
OTU	-	operational and technological management
OTU ESK	-	operational and technological management of the power grid complex
ECO	-	interconnected energy system
PA	-	emergency automation
PB	-	Industrial Safety
PBV	-	tap switching without excitation
Pvc	-	polyvinyl chloride
PQE	-	power quality indicators
PP	-	transition point
PPU	-	polyurethane foam
PS	-	substation
PTK	-	software and hardware complex
PTE	-	rules for the technical operation of power plants and networks
RAS	-	alarm recorders
RASP	-	registration of emergency events and processes
RD	-	guidance document
RDSK	-	dry arc suppression reactors with condenser regulation
RZA	-	relay protection and automation
RMZ	-	lightning arrester
RP	-	distribution point
RPN	-	voltage regulation under load

RRL	-	radio relay line
RSK	-	distribution grid company (subsidiaries and dependent companies of PJSC Rosseti)
RTP	-	distribution transformer substation
RU	-	Switchgear
PB	-	relay board
RES	-	electrical grid area
CAC	-	situational analysis center
SBP	-	uninterruptible power supply system
SZ	-	degree of air pollution
SI	-	measuring instrument
SIP	-	self-supporting insulated wire
SCRM	-	reactive power compensation equipment
CH	-	medium voltage
Soyev	-	system of ensuring uniform time
SOPT	-	operational direct current system
SOUE	-	fire warning and evacuation control system
SDR	-	combined production building
EIT	-	cross-linked polyethylene
NRC	-	voltage regulator
SSPI	-	information collection and transmission system
SSESK	-	power grid complex communication network
CCC	-	satellite communications network
STATCOM	-	static compensator based on voltage converters
STK	-	static thyristor compensator
ONE HUNDRED	-	organization standard
OSHMS	-	health and safety management system
SOUP	-	production asset management system
SU (ESC)	-	situational management in the power grid complex
TAI	-	thermal automation and measurements
TAPV	-	three-phase automatic reclosing
T/AT	-	transformer / autotransformer
TN	-	voltage transformer
MRO	-	maintenance and repair
TP	-	transformer substation
TP&R	-	technical re-equipment and reconstruction
TRG	-	thyristor-reactor group
TSN	-	auxiliary transformer
TT	-	current transformer
Feasibility study	-	feasibility study
Fuel and energy resources	-	fuel and energy resources

UBP	-	uninterruptible power supply
UD	-	access nodes
SPD	-	surge protection device
VHF	-	ultrashort waves (radio waves)
UKRM	-	reactive power compensation unit
CPC	-	device for longitudinal compensation of inductive resistance of power lines
OECP	-	intentional non-simultaneous pole switching device
UROV	-	circuit breaker failure backup
USO	-	object interface device
USPD	-	data collection and transmission devices
UCPK	-	controlled device for longitudinal compensation of power line resistance
UFK	-	ultraviolet control
CSR	-	controlled shunt reactor
PKU	-	filter compensating devices
FSU	-	filter balancing device
CP	-	power center (step-down substation) with voltage 35-110 (220) / 6-20 kV
CSOI	-	information collection and processing center
CTN	-	branch of PJSC "Rosseti" - Center for Technical Supervision
NCC	-	network control center
CR	-	partial discharge
SHR	-	shunt reactor
SHROT	-	operating DC switchgear cabinet
SHPT	-	dc panel
ShchSN	-	local distribution panel
EMC	-	electromagnetic compatibility
ESC	-	power grid complex
OIC (SCADA)	-	operational information complex, dispatch control and data collection subsystem
ADMS (Advanced Distribution Management System)	-	advanced distribution network management system
DMS (Distribution Management System)	-	distribution network management system
OMS (Outage Management System)	-	disaster recovery management system

CIM (Common Information Model)	-	general information model

Appendix 1

The list of normative documents containing basic terms and definitions in the field of electric power industry

- Federal Law of March 26, 2003 No. 35-FZ "On the Electric Power Industry"
- Federal Law of December 27, 2018 No. 522-FZ "On Amendments to Certain Legislative Acts of the Russian Federation in Connection with the Development of Electric Energy (Power) Metering Systems in the Russian Federation"
- Federal Law of July 22, 2008 No. 123-FZ "Technical Regulations on Fire Safety Requirements"
- Decree of the Government of the Russian Federation of August 13, 2018 No. 937 "On Approval of the Rules for the Technological Functioning of Electric Power Systems and on Amendments to Certain Acts of the Government of the Russian Federation"
- Decree of the Government of the Russian Federation of December 19, 2016 No. 1401 "On the comprehensive determination of indicators of the technical and economic condition of electric power facilities, including indicators of physical depreciation and energy efficiency of power grid facilities, and on monitoring such indicators"
- Decree of the Government of the Russian Federation of October 28, 2009 No. 846 "On Approval of the Rules for Investigating the Causes of Accidents in the Electric Power Industry"
- Resolution of the Government of the Russian Federation of March 02, 2017 No. 244 "On improving the requirements for ensuring the reliability and safety of electric power systems and electric power facilities and amending some acts of the Government of the Russian Federation"
- Order of the Ministry of Energy of the Russian Federation of June 19, 2003 No. 229 "On approval of the Rules for the technical operation of power plants and networks of the Russian Federation"
- Order of the Ministry of Energy of Russia dated July 26, 2017 No. 676 "On approval of the methodology for assessing the technical condition of the main technological equipment and power lines of power plants and electrical networks"
- Order of the Ministry of Energy of Russia dated October 25, 2017 No. 1013 "On approval of requirements for ensuring the reliability of electric power systems, reliability and safety of electric power facilities and power receiving installations" Rules for organizing maintenance and repair of electric power facilities "
- Order of the Ministry of Energy of Russia dated February 13, 2019 No. 97 "On approval of requirements for communication channels for the functioning of relay protection and automation"
- Order of the Ministry of Energy of Russia dated February 13, 2019 No. 100 "On approval of the Rules for interaction of subjects of the electric power industry, consumers of electrical energy in the preparation, issuance and execution of tasks for setting up relay protection and automation devices"
- Order of the Ministry of Energy of Russia dated February 13, 2019 No. 101 "On

approval of the requirements for equipping power lines and equipment for power facilities with a voltage class of 110 kV and above with devices and complexes of relay protection and automation, as well as for the principles of functioning of devices and complexes of relay protection and automation".

• Order of the Ministry of Energy of Russia dated August 3, 2018 No. 630 "On approval of requirements for ensuring the reliability of electric power systems, reliability and safety of electric power facilities and power receiving installations" Guidelines for the sustainability of power systems"

• Order of the FSTEC of Russia dated March 14, 2014 No. 31 "On approval of the Requirements for ensuring the protection of information in automated control systems for production and technological processes at critical facilities, potentially hazardous facilities, as well as facilities posing an increased danger to human life and health and to the natural environment "

• Order of the Ministry of Emergency Situations of Russia dated February 24, 2009 No. 91 "On approval of the form and procedure for registering a declaration of fire safety"

• Order of the Ministry of Transport of Russia dated August 25, 2015 No. 262 "On approval of the Federal Aviation Regulations" Requirements for aerodromes intended for takeoff, landing, taxiing and parking of civil aircraft "

• Order of the Ministry of Industry and Trade of Russia dated April 16, 2019 No. 1327 "On approval of the Action Plan for import substitution in the power engineering industry, electrical and cable industry of the Russian Federation"

• GOST R 57114-2016 Unified power system and isolated power systems. Electric power systems. Operational dispatch control in the electric power industry and operational technological management. Terms and Definitions

• GOST 19431-84 Energy and Electrification. Terms and Definitions;

• GOST R 55105-2012 Unified power system and isolated power systems. Operational dispatch control. Automatic emergency control of power systems modes. Emergency automation of power systems. Norms and requirements

• GOST R 55438-2013 Unified power system and isolated power systems. Operational dispatch control. Relay protection and automation. Interaction of subjects of the electric power industry and consumers of electrical energy during the creation {modernization} and operation. General requirements

• GOST R 55608-2013 Unified power system and isolated power systems. Operational dispatch control. Switching in electrical installations. General requirements

• GOST R 55890-2013 Unified power system and isolated power systems. Operational dispatch control. Regulation of frequency and active power flows. Norms and requirements;

• GOST R 56302-2014 Unified power system and isolated power systems. Operational dispatch control. Dispatching names of electric power facilities and equipment of electric power facilities. General requirements

• GOST R 56303-2014 Unified power system and isolated power systems.

Operational dispatch control. Normal diagrams of electrical connections of electric power facilities. General requirements for graphic design

• Order of the Ministry of Energy of Russia dated August 16, 2019 No. 856 "On approval of Methodological guidelines for the technological design of alternating current substations with a higher voltage of 35-750 kV"

• Order of the Ministry of Energy of Russia dated August 16, 2019 No. 855 "On approval of Methodological guidelines for the technological design of power transmission lines with a voltage class of 35-750 kV"