Approved
by the Board of Directors
of PJSC “Rosseti”
(Minutes No. 378 of November 8, 2019)

PJSC “Rosseti”

Regulations

On the Uniform Technical Policy in the Electric Grid Sector

(Restated version)

Introduction

These Regulations of PJSC “Rosseti” titled On the Uniform Technical Policy in the Electric Grid Sector” (hereinafter, the “Technical Policy”) are in accordance with legal regulations of the Russian Federation (hereinafter, “LR”), documents relating to technical regulation in the Russian Federation, and technical regulations of the Eurasian Economic Union and the Customs Union subject to the requirements of IEC standards and with due consideration to the current level of engineering and technological development and are a ruling document binding upon PJSC “Rosseti” (hereinafter, the “Company”) and binding upon PJSC “Rosseti” subsidiaries and dependent companies (hereinafter, “SDCs”) engaged in electricity transmission and distribution, provided that it is recognized as such (in whole or in part) by SDCs’ management bodies.

The Technical Policy is a set of goals, principles, effective technical, technological, and organizational requirements and solutions that improve the efficiency, reliability, safety, and cost effectiveness of electricity transmission and distribution pursuant to the Strategy for Development of the Electric Grid Sector of the Russian Federation.

The Technical Policy is aimed at performing the functions and tasks of the Company and achieving the objectives of the Digital Transformation 2030 Concept.

The requirements of this Technical Policy shall apply to existing and future electric grid facilities (hereinafter, “production assets”) in new construction, rehabilitation, and technical upgrading.

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

“Design”: Formulation of the detailed requirements for a production asset; technologies of creation;

“Creation”: Process of the production, supply, and installation of a production asset. The result is a production asset put into operation;

“Operation”: Process of using a production asset for its intended purpose and keeping it in working order with preset efficiency parameters through technical operation and maintenance (hereinafter, “TO&M”) and technical upgrading and rehabilitation (hereinafter, “TU&R”). The main result is a production asset used for its intended purpose with preset operation parameters;

“Liquidation”: The main result is a production asset used for its intended purpose with preset operation parameters.

Based on the provisions of this Technical Policy, domestic corporate documents are formulated and implemented, specifying the provisions, standards, requirements, and recommendations of this Technical Policy in relation to the content of a production asset and governing the procedure (rules) for organizing interactions in the area of TO&M and TU&R.

The implementation of this Technical Policy does not require additional funding, is within the framework of agreed scenarios of business plans and capex programs with due consideration to approved enlarged price standards.

As used in this Technical Policy, the terms shall have the meanings ascribed thereto in the laws of the Russian Federation, departmental regulatory documents, and technical standard documents applicable to the electric power industry as set forth in Appendix 1.

The list of abbreviations used herein is contained in Section 6 of this Technical Policy.

1. General

1.1. Goals and Principal Objectives of the Uniform Technical Policy in the Electric Grid Sector

Goals:

• define of the main technical areas and unify technical and technological solutions that increase the reliability, efficiency and reduce the resource intensity of the operation of the electric grid sector in the short and medium term while ensuring adequate safety;

• ensure the transition of PJSC “Rosseti” to risk-based management based on digital technology and big data analysis;

• organize the introduction of advanced scientific developments and innovative solutions into the electric grid sector.

Principal objectives:

• ensure and improve the readiness of electric grids for electricity transmission and distribution to ensure a reliable electricity supply, the operation of wholesale and retail electricity markets, the parallel operation of Russia’s UPS and of electric power systems of foreign countries;

• ensure the delivery of capacity from power production facilities to the grid;

• create the conditions for electricity connections in the wholesale and retail markets on the terms of nondiscriminatory access to electric grids;

• participate in improving and developing the regular and emergency management systems of Russia’s UPS;

• develop and improve the structure of operational process control for electric grid facilities;

• develop and improve information and telecommunications infrastructure, improve the observability of electric grids and the quality of information exchange with other electric power industry entities;

• optimize and reduce investment and operating costs and expenses in electric grid facilities through the optimization of technical and technological solutions in the preparation of design documents, the use of modern technology and types of equipment, construction structures and materials, and the reduction of areas occupied by electric grid facilities;

• improve the efficiency of grid asset administration;

• enhance the energy efficiency of applied technology, equipment, materials, systems and reduce electricity losses in electric grids;

• overcome the trends of aging capital assets of electric grids and electric grid equipment through their modernization, the optimization of work on their rehabilitation and technical upgrading, and the improvement of the efficiency of managing electricity grid assets;

• promote process automation for electricity transmission and distribution, introduce and develop modern systems for the monitoring of technical condition, the diagnostics and monitoring of process equipment, relay protection systems, emergency control systems, communication systems, utility systems, electricity metering, and the creation and development of digital substations and electric grids;

• improve technologies and increase the efficiency of the operation, maintenance, and repair of electric grid facilities;

• support, improve, and develop occupational training for operational and repair personnel;

• minimize the environmental impact in the new construction, rehabilitation, operation, repair, and technical maintenance of electric grid facilities;

• ensure safety in the operation of electric grid facilities;

• create incentives for the development of the Russian-based production of modern types of equipment, construction structures, materials, and promote scientific, technical and design potential;

• create the conditions for power supply without the construction/rehabilitation of electric grid assets.

The achievement of the goals and objectives of the Regulations of PJSC "Rosseti" "On the Uniform Technical Policy in the Electric Grid Sector" shall lead to an increase in capex or OPEX of the Company.

1.2. Structure and Status of the Technical Policy

Managing the uniform technical policy in the electric grid sector

1.2.1. Managing the Technical Policy of the Company is a systematic objective and function of the Company, which implements measures on an ongoing to ensure compliance with the requirements of this Technical Policy in the Company and SDCs, supervise compliance with the requirements of this Technical Policy in SDCs, and ensure the timely updating and revision of this Technical Policy.

1.2.2. The Technical Policy of the Company is subject to approval by the Board of Directors of the Company.

The approval of the Technical Policy of the Company shall be included on the agenda of a meeting of the Board of Directors of the Company after its prior approval by the Technical Council of PJSC "Rosseti".

1.3. Scope of Application of the Technical Policy

The Technical Policy is fundamental document binding upon the Company and binding upon SDCs engaged in electricity transmission and distribution, provided that it is recognized as such (in whole or in part) by SDCs' management bodies.

1.4. Formulation and Updating of the Technical Policy

1.4.1 The Technical Policy shall be revised every five years.

1.4.2. The Technical Policy shall be revised earlier, amended, or supplemented:

- if the laws of the Russian Federation are amended, directly affecting the provisions of this Technical Policy;
- if new provisions and requirements of documents relating to technical regulation, regulations Eurasian Economic Union (technical regulations of the Customs Union) become effective, directly affecting the current provisions of this Technical Policy;
- in order to ensure the achievement of the Company's goals as resolved by the Company's management bodies.

2. Requirements for Equipment, Technology, Materials, and Integrated Systems

2.1. Substations and Switchgear

2.1.1. Technical Solutions for the Design, New Construction, and Rehabilitation of Substations

2.1.1.1. The basic principles of the construction of SS (TSS, DSS, DTSS) shall be as follows:

- structures of buildings and utility structures of electric SS, indoor TSS, DSS and DTSS shall ensure the required reliability throughout their operation life defined by TSD or design documents;
- the construction of SS shall typically use standard solutions;
- at the stage of preparing as-built documents for SS and preparing reporting documents, it is necessary to prepare a model in accordance with the rules of SDCs’ information systems used for facility descriptions objects for subsequent timely changes in the architecture of objects of SDCs’ information systems and equipment databases;
- structures bearing electrical equipment shall withstand electromagnetic, thermal, and electrodynamic impacts in normal and emergency operation modes of electric grids;
- the area of SS is reduced through optimized layout solutions, subject to maintaining their reliability, maintainability and safe operation;
- the selection of equipment and busbars according to the nominal current shall take into account the normal, repair, emergency and post-accident operation modes of electric grids and overload equipment capability;
- SD and grounding SG disconnectors shall be equipped with operational blocking against incorrect actions during switching on electrical installations. Designing operational blocking for SG shall also use software-enabled (logical) blocking on controllers of connections or interlock controllers, using mechanical blocking on SG;
- with an appropriate FS, it is allowed to build modular buried or underground SS in densely built-up urban areas.

2.1.1.2. The design of indoor SS rated 35 kV shall comply with design standards for alternating-current substations with a high voltage of 35–750 kV (latest version).

2.1.1.3. Indoor switchgear (IDSG) rated 35 kV and above with equipment of factory-assembled switchgear with air, combined, or SF6 insulation (FASG/SF6/I FASG) shall be used in accordance with design standards for alternating-current substations with a high voltage of 35–750 kV.

2.1.1.4. On SS rated 110–500 kV, it is possible to use SF6-insulated conductors, with an appropriate FS.

2.1.1.5. The use of hollow wires for busbars is allowed in the rehabilitation or expansion of existing electric grid facilities.

2.1.1.6. Cables rated 110–500 kV in SS shall use flyovers, galleries, ducts, cable channels.

2.1.1.7. The new construction and rehabilitation of SS shall ensure the possibility of their expansion in the future by:

- increasing (auto)transformer capacity through the replacement of supply T/AT with supply T/AT of higher capacity (rated capacity) or installing additional supply T/AT (with sufficient justification);
- increasing the number of connections through the redundancy of places.

The necessity of any possible SS expansion shall be based on approved development schemes and programs for the electric power industry for a period of 5, 7 and 15 years.

2.1.1.8. For heating for SS buildings in the absence of heat supply systems recommended, fireproof energy-saving electric heaters with thermostats are recommended for use.

2.1.1.9. On SS rated 110–500 kV, it is possible to use heat from supply T/AT for heating for production premises.

2.1.1.10. For auxiliary supply for SS, including electric heating, it is possible to use modern solar power technology.

2.1.11. If SS are built in an urban area, equipment for ventilation, air conditioning, solar batteries, and heaters (in areas with sufficient solar activity) are better placed on flat roofs (if used).

2.1.1.12. To maintain climatic conditions for the operation of equipment in the buildings SS, MSS, and SS rated 220 kV and above, centralized climatic installations are recommended.

2.1.1.13. Locations for rehabilitated SG rated 110–750 kV SS shall be selected with an appropriate FS. In urban and industrial areas (or near them), the rehabilitation of SG rated 110–750 kV SS shall typically be located on the same site.

2.1.1.14. In the case of indoor SS, transformers (AT, Sh/R) with a nominal voltage of 110 kV and above shall be installed outdoors, if necessary, with noise barriers; the indoor installation of transformers (AT, Sh/R) is allowed with special substantiation and exhaustive fire protection measures.

2.1.1.15. Foundations for equipment shall be lightweight prestressed reinforced-concrete supports, solid blocks of heavy concrete, reinforced-concrete, solid-cast and screw piles.

2.1.1.16. Foundations for gantries shall be solid-cast and prefabricated, including reinforced-concrete surface and pile-supported (bored, including with widening and without widening) foundations.

2.1.1.17. In the new construction, major TU&R for T/AT on SS having stationary repair devices for transformers (towers) and rail rolling, and on SS with indoor transformers, carriages (rolls) shall be used.

Earthquake-resistant transformers shall be installed directly on foundations with their fastening to foundations to prevent their displacement in horizontal and vertical directions. Foundations for transformers shall have places for jacks.

In the other cases, railless (carriageless) installation is allowed, using special coasters to provide access to the tank bottom of T/AT.

2.1.1.18. To minimize earth work, various types of prefabricated reinforced concrete and pile foundations (prismatic reinforced concrete piles, screw piles, open-type piles, shell piles, bored piles), shallow and surface foundations, thermal piles and screw piles in permafrost soils, rod embeddings in rock soils, and highly efficient well-drilling equipment for strong rock and rock soils shall be used.

2.1.1.19. The construction of buildings for SS (IDSG, warehouses, tanks for fire extinguishing equipment, etc.) shall mainly use frame or modular buildings with sandwich panels. The use of bricks for the construction of large buildings is allowed with special justification, including in relation to security requirements.

2.1.1.20. The construction of CPB or buildings for SSCR may, along with the use of bricks, foam concrete and slag concrete blocks with outside coatings of brick, porcelain stoneware or ventilated facades, hinged facing panels with corporate colors, use frame or modular buildings with sandwich panels, specifically in areas of eternal permafrost.

2.1.1.21. New highly effective corrosion protection materials for structures, corrosion-resistant steels with increased strength are recommended for use to make metal structures of gantries and support structures for equipment.

2.1.1.22. Wiring cables of secondary systems in SSCR and RSB shall predominantly use cable shafts and raised floors; cable floors are allowed with an appropriate FS.

2.1.1.23. Process and service tanks shall be made of solid-cast reinforced concrete with a water resistance mark of not less than W8 or prefabricated concrete blocks with waterproofing of steel jacketing; external and internal waterproofing tanks shall use materials with penetrating action; tank roofs shall be prefabricated reinforced concrete with surface waterproofing.

2.1.1.24. Treatment facilities may be built in metal frames with sandwich panels. Treatment facilities in areas with absolute minimum temperatures of below –45 °C are better be in metal tanks with insulation from sprayed polyurethane foam, waterproofing of steel linings, using electrical heating for outdoor treatment facilities, drainage pipes with automatic temperature regulation.

2.1.1.25. Tanks for water fire-extinguishing may be:

- buried below the level of freezing soil. Buried tanks made of solid-cast reinforced concrete;

- above-ground, in barrels made of steel, composites or polymers.

2.1.1.26. Tanks in barrels may be placed together, with the firefighting pump house in a lightweight frame building with heating and sandwich panels or outdoors. When they are installed outdoors in areas with absolute minimum temperatures of below –45 °C, built-in systems electrical heating tanks for firefighting water supply are recommended for use with water level and temperature control, and with data sent to the duty officer of SS.

2.1.1.27. SS rated 110 kV and above shall typically have water supply and sewerage systems.

2.1.1.28. SS buildings shall be equipped with heating, ventilation, fire alarm in accordance with the established requirements. Outdoor entrance doors of all rooms of SS shall be metal and have internal locks. Glazing for buildings of SS shall be reduced to a minimum. If natural lighting is needed, windows on the first floor shall have gratings, which shall be easily removed or opened from within the rooms without tools.

2.1.1.29. External networks of low-pressure utility and drinking water supply shall have polyvinyl chloride (PVC) socket pressure T-pipes with rubber rings. For areas with cold climates, systems of flexible polyethylene pipelines with FR with built-in electrical heating are recommended.

2.1.1.30. External sewerage networks shall have PVC non-pressure pipes with seals rings. For areas with cold climates, it is recommended that external sewerage networks have pipes of low-pressure polyethylene with built-in electrical heating.

2.1.1.31. Oil-receiving devices of oil-filled equipment shall use cast-in-situ reinforced concrete with polymer additives to improve characteristics of concrete.

Oil drains shall be closed. Open oil drains may be used for strongly swollen soils, with high levels of ground water in accordance with a FS.

2.1.1.32. SS with ASC shall have two individual stationary storage tanks for turbine oils, while systems of turbine and transformer oils shall be independent. The volume of each tank for turbine oils shall be not less than 110% of the volume of the oil system of the largest ASC on SS.

2.1.1.33. Concrete surfaces shall be coated with oil-resistant paint to protect surfaces from transformer oils.

2.1.1.34. It is recommended that new effective materials be selected for fencing and roofing structures, floors, and surfaces of buildings.

2.1.1.35. The selected solution for floors shall ensure:

- reliability and durability of the selected design;
- efficient use of construction materials;
- fullest use of physical and mechanical properties of materials;
- optimal sanitary and hygienic conditions;
- fire and explosion safety.

2.1.1.36. Office and production rooms, depending on their functional purpose, shall use floor coatings, such as commercial linoleum, ceramic tiles, porcelain tiles, or stoneware; and rooms with special dust requirements (SF6/I

FASG, rooms of converter and microprocessor equipment, relay protection, etc.) shall use floors of cast-in-place polyurethane or epoxy pitches as the most durable and wear resistant.

2.1.1.37. Cast-in-place floors shall comply with the following requirements:

- slight abrasion;
- no dust generated;
- chemical resistance;
- high speed of installation work (floors may be laid temperatures above and below zero);
- easy replacement and repair.

The base for cast-in-place floors shall be concrete floor (concrete grade 200–300) made of acid-resistant and ceramic tiles, with no surface cracks or chips, with a humidity of not more than 4–5%.

2.1.1.38. The repair or rehabilitation of SS facades may, in addition to traditional facade paints, use ventilated facades. Work is allowed only after the comprehensive inspection of the technical condition of buildings and structures by a specialist organization.

2.1.1.39. When designing SS, it is necessary to carry out environmental activities in accordance with the current environmental legislation.

2.1.1.40. When designing an SS, it is necessary to combine design solutions into a single architectural and industrial solution, use a uniform corporate style for facades, using the elements of the approved corporate style (colors, logos, etc.).

2.1.1.41. The general layout and layout solutions for SS, and space-planning solutions for SS buildings and structures shall ensure:

- convenient operation;
- routine and repair work, including that related to the replacement of large equipment;
- prompt remedy of accidents and emergencies.

2.1.1.42. For the timely detection of faults in construction structures of FASG, IDSG, IDTSS facades, it is allowed to repair or reconstruct them without covering their walls with frame facade materials.

2.1.1.43. To create the favorable conditions for the operation of SS buildings and structures, it is necessary to ensure that, during the construction of new and rehabilitation of old buildings, the planning and landscaping of areas and the drainage systems for atmospheric precipitation and ground water are in accordance with the design documents and, thereafter, maintained in good order in accordance with the requirements.

2.1.1.44. The facade parts of buildings and structures of indoor SS, TSS, DSS and DTSS located in residential areas shall fit into the architectural landscape.

2.1.1.45. When designing SS, buildings and structures, it is necessary to select technical solutions that ensure the safety of their operation, including safe work at height by using stationary stairs with slider-type protection for lifting people on equipment, stationary anchor points (anchor pillars), or with an anchor line and the use of retractor-type protection, or using telescopic anchor pillars for work on SS rated 35 kV and above if there is risk of falling from a height of more than 1.8 m.

2.1.1.46. It is recommended that the design of indoor SS use three-dimensional models of equipment and utility systems to exclude unacceptable approaches and intersections for SS process equipment and cables with utility systems in indoor SS (ventilation, water supply, fire-extinguishing, sewage, and other systems).

2.1.1.47. The construction of SS buildings and structures shall use pitched roofs. SS in residential areas may use flat roofing.

2.1.1.48. For SS rated 35 kV and above, calculations shall be carried out on the basis of mathematical modeling for operation modes of power systems using calculated models ensuring the necessary accuracy of mathematical modeling for operation modes of power systems in accordance with the Recommended Guidelines for Designing the Development of Energy Systems (Order of the Ministry of Energy of the Russian Federation No. 281 of June 30, 2003). Mathematical modeling for operation modes of power systems in the development of design solutions shall be in accordance with the calculated conditions set by the Guidelines for Energy System Resilience (Order of the Ministry of Energy of the Russian Federation No. 630 of August 3, 2018).

For such calculated models, the design organization shall build an information model for the power system in the scope necessary for the design of SS in compliance with the requirements approved by the Ministry of Energy of the Russian Federation in accordance with Resolution of the Government of the Russian Federation No. 244 of March 2, 2017, “On the Improvement of the Reliability and Safety Requirements for Electric Power Systems and Electric Power Facilities and on Amendments to Certain Resolutions of the Government of the Russian Federation.”

Based on the results of developing the design solutions, the design organization shall send information about changes in the information model for the power system due to the commissioning (decommissioning) of SS, taken into account in the design, to the customer and, in the case of SS whose equipment or devices or whose outgoing power lines will relate (relate) to dispatching facilities, also to the entity in charge of operational dispatching control in the electric power industry in accordance with the agreed method of information exchange.

2.1.2. Schematic Electrical Diagrams of Substation Switchgear

2.1.2.1. When designing SS, it is necessary to use a case-by-case approach to selecting SG schemes, components of combined SD in order to ensure their convenient operation and maintainability, exclude errors during operation, fit into the allotted construction site and at the same time incur minimal costs compared with other possible options of SS construction (rehabilitation) by conducting their technical and economic comparisons.

When designing SS, it is generally necessary to apply design standards for alternating-current substations with a high voltage of 35–750 kV.

2.1.2.2. Schematic electrical diagrams of SS SG shall ensure as follows:

- reliable operation in normal and repair conditions for SS and adjacent electric grids with due consideration to reserved supply from other MSS;

- ease of carrying out operational switching, consisting in the simplicity and clarity of schemes that reduce the probability of errors on the part of operational staff, minimize the number of switching in primary and secondary circuits when changing the operation mode of an electrical installation;

- small sizes;

- technically justified cost effectiveness.

2.1.2.3. Schematic electrical diagrams for SS SG shall be standard, and typically:

- for SG rated 0.4 kV for TSS rated 6–20/0.4 kV and SS rated 35/0.4 kV, one working system of busbars is used, with or without ALT, depending on the category of connected customers;

- for SG rated 6–20 kV, depending on the reliability and reserve of grids, the following schemes and circuit solutions shall be used:

• one breaker-sectioned system of busbars;

• two breaker-sectioned systems of busbars;

• on the side of LV of 6–20 kV on transformer windings, they shall operate separately for different sections of busbars of SG rated 6–20 kV;

• the number of output linear cubicles in the new construction of SG rated 10–20 kV and the rehabilitation of SG rated 6–20 kV shall be selected in accordance with existing network connection requests and contracts for customers' power receivers, power generation facilities, and electric grid facilities owned by grid organizations and others persons for the calculation period (year of commissioning) with due consideration to its future development (5 years after commissioning);

- electrical schemes for SG rated 35, 110 (150) kV shall be selected in accordance with the standard "Schematic Electrical Diagrams of 35–750 kV Substation Switchgear. Model Solutions" (OS 56947007-29.240.30.010–2008), however:

• deviations from standard schemes are allowed with an appropriate FS;

• schemes shall typically be used with one connection breaker (if there is sufficient justification, it is allowed to use two busbar systems or bypass busbar systems with the possibility of using it for the most critical or all connections through operational switching);

• it is allowed to use bypass busbar systems in ODSG rated 35–110 kV, which are used to remove ice from wires and lightning protection cables of outgoing OL;

• for SG in the SF6/I FASG version, simpler schemes are recommended in order to ensure, among other things, the optimized location of SF6/I FASG current leads;

• in schemes of OL connections through two breakers, it is allowed to use CT in OL circuits for electricity billing metering;

• the number of transformers installed on SS rated 35, 110 (150) kV shall be two. Installing more than two transformers is allowed with an appropriate FS;

• the commissioning and operation of SS with one transformer are allowed if the design documents contain the start-up phase of construction;

• it is allowed to use one transformer on dead-end SS while ensuring the required reliability of electricity supply;

- electrical schemes for SG rated 220 kV and above shall be selected in accordance with the standard “Schematic Electrical Diagrams of 35–750 kV Substation Switchgear. Model Solutions” (OS 56947007-29.240.30.010–2008), however:

• deviations from standard schemes are allowed with an appropriate FS;

• for SG in the SF6/I FASG version, the same schemes are typically used as those for ODSG;

• SG rated 330-750 kV shall typically use schemes with two breakers for PL or with switching connections through one-and-a-half circuits;

• SG rated 220 kV shall typically use schemes with one connection breaker. With sufficient justification, it is allowed to use two busbar systems or a bypass busbar system with the possibility of using it for the most critical or all connections through operational switching and the use of schemes with PL switching connections through one-and-a-half circuits;

• bypass busbar systems may be used for ODSG rated 220 kV, which are used to remove ice from wires and lightning protection cables of outgoing OL;

• the number and capacity of T/AT rated 220 kV and below and auxiliary transformers shall be selected with due consideration to their overload capacity;

• on UNEG SS (rated 220–1,150 kV), power supply for external customers of 6–35 kV is recommended from separate transformers rated 110 or 220 kV;

• tertiary windings of T/AT rated 220–500 kV shall have a nominal voltage of 20–35 kV in order to minimize primary equipment, reduce S/C currents and increase the reliability of auxiliary supply for SS if it is possible to use this voltage for electric grids.

2.1.2.4. If it is necessary to compensate for capacitive currents on 6–35 kV on SS, electrical schemes shall be provided with arc-extinguishing grounding reactors, while:

- in grids rated 35 kV, A-SC shall be connected to zero-phase taps of the relevant transformer windings through a fork of disconnectors, allowing them to be connected to any of the transformers;
- in grids rated 6–20 kV, A-SC shall typically be connected through disconnectors to neutral taps of separate transformers connected to main busbars through breakers. Grounding filters may be used instead of separate transformers. It is also allowed to use combined arc-extinguishing devices (DASU CBSC, CCD A-SC, etc.);
- the number, capacity, and regulation range of A-SC are defined by design documents following technical and economic calculations using data provided by the customer;
- the value of detuning compensation for capacitive current for a one-phase ground fault shall not exceed 1% in accordance with the standard “6–35 kV Arc-Extinguishing Grounding Reactors. General Technical Requirements” (OS 34.01-3.2-008-2017).

2.1.2.5. In electrical schemes, the selection of neutral grounding for electric grids rated 6–35 kV shall be determined by the design solution to ensure the reliable and safe operation of electrical equipment and PL in the modes associated with a ground fault of one phase of the electric grid, however:

- in urban distribution grids rated 6–20 kV and within residential areas with electric grids rated 35 kV, it is possible to use low-resistance resistive neutral grounding with the automatic shutdown of ground faults and a 100% reserve for customers with an appropriate FS;
- when implementing resistive grounding during the rehabilitation of existing electric grids rated 6–35 kV, approval from current customers is required;
- in electric grids with isolated neutral, depending on the length and design of PL, conditions for ensuring electrical safety and electricity supply reliability, it is necessary to consider the need for arc-extinguishing devices or the use of high-resistance resistive or combined neutral grounding;
- to limit the capacitive current of L/GS/C, it is necessary to provide galvanic interchange for distribution grid sections based on the maximum permissible currents of L/GS/C, which are determined with due consideration to the neutral grounding used for the section of the electric grid.

2.1.3. Supply Transformers, Autotransformers, and Reactors

2.1.3.1. Supply transformers, autotransformers (AT), transformers (T), and reactors (CSR, Sh/R) shall meet the following requirements:

2.1.3.1. Supply transformers, autotransformers (AT), transformers (T), and reactors (CSR, Sh/R) shall meet the following requirements:

- the design shall use windings from the transposed wires with gluing and a pressing system of electric cardboard with the possible use of appropriate wood-layered plastics, not exposed to shrinkage, making it possible not to provide additional pressing for windings during their operation life;

- supply T/AT and reactors shall use original winding paper for windings with polymerization of at least 1,250 units;

- the design shall use magnetic cores with reduced losses due to: using high-quality electrical steel with specific losses of 1.0 W/kg with induction of 1.5 T, using 0.23–0.3 mm steel, using Step Lap magnetic cores;

- the design shall use at least two built-in CTs; additionally, one CT is recommended for monitoring. The number of built-in current transformers and the capacity of their secondary windings is determined during design;

- direct-flow oil pumps shall be used;

- the necessary electrodynamic stability shall be provided ensured for windings against S/C currents;

- the following control modes shall be used for combined cooling systems of OI/AB and OI/AB/ABOF: manual, automatic;

- the functions of a cooling control system shall include:

• control of the cooling system using the values of load ability, and control of the state of each electric motor of the cooling system;

• possibility of a smooth start and the reduction of start-up currents;

• protection for electric motors from overloads and S/C;

• protection for electric motors of coolers from any loss of a phase and from any asymmetry of phases;

• indication of loads for electric motors;

• detection of unloaded motors or motors with excessive loads;

- the design of cooling devices (radiators) shall be plates (hot-galvanized flat-forged radiators);

- preference shall be given to AT with a nominal voltage of LV windings of 20–38.5 kV in order to decrease S/C currents;

- preference shall be given to AT with a reduced capacity of LV windings (excluding the connection of reactive-power compensators);

- tertiary windings of T/AT for 6–35 kV customers shall have a scheme and connection group corresponding to those in their distribution grids;

- a reduced level noise and vibration shall be ensured:

• noise: not greater than 75 dB (for CSR, not greater than 90 dB);

• vibration for Sh/R: not greater than 60 microns;

- radio interference shall not be greater than 2,500 mkV;

- explosion safety shall be ensured by the design of transformer tanks, the use of systems preventing body depressurization caused by internal damage (valves and, with justification, systems preventing explosions and fires).

2.1.3.2. In oil-filled T/AT rated 110 and 150 kV and 25 MVA and above and all transformers rated 220 kV and above, oil shall be fully protected from contact with the air, using film.

For transformers rated 110 kV and below 25 MVA and transformers rated below 110 kV, the expander shall be equipped an air dryer with oil shutter or other devices protecting oil in the expander from direct contact with the air.

2.1.3.3. Oil transformers with oil of over 1,000 kg shall be equipped with filters: thermosiphon for types of cooling systems of M and D, adsorption for the other types of cooling systems and filters cleaning oils from mechanical impurities (for DC, NDC, C, NC cooling systems).

2.1.3.4. Mounted on transformers, high-voltage bushings rated 110 kV shall have solid insulation (RIP or RIN); high-voltage bushings rated 220–750 kV shall be sealed, capacitor-type, without excess pressure and without expansion tanks or with solid insulation (RIP or RIN for those rated up to 500 kV), with a mandatory measuring tap on bushings rated 110 kV and above.

High-voltage bushings with RIP and RIN insulation rated 110 kV and above shall have sensors for the safe connection of condition monitoring systems for bushing insulation.

2.1.3.5. Supply T/AT rated 110 kV and above shall be equipped with:

- OLVC devices complete with voltage regulator with the ability to work in automatic and manual remote mode from a remote control point;

- sensors and condition control (monitoring) devices in accordance with the requirements of subsection 3.7.2 of this Technical Policy, and output relay signals from protective systems of cooling systems, OLVC devices, relay signals from supply for transformer protection, etc.

2.1.3.6. Supply transformers 35 kV and below shall typically be equipped with devices controlling no-load voltages (O/S TCO). The number of steps and the adjusting range shall be determined during design.

2.1.3.7. Automatic cooling control cabinets for transformers shall be galvanized or made of stainless materials (protection of not below IP55 in accordance with GOST 14254-15) and shall provide automatically maintained temperature inside the cabinet; the cabinet shall have alarm-based access control, manual control for each oil pump and fans, a smooth start and current protection for electric motors of oil pumps and fans, control for the status (serviceability) of motor SD, a remote control panel (installed in SSCR) for the operational control and condition visualization of the cooling system.

2.1.3.8. Reliability requirements:

- operation life: at least 30 years;
- warranty period of operation: at least 5 years from the date of commissioning;
- no need for major repair during the operation life;
- no need for additional pressing for windings during the operation life;
- resistance to railroad transportation (acceleration sensors are required).

2.1.3.9. Distribution TSS rated 6–35/0.4 kV shall use supply transformers:

- oil-filled, sealed oil-filled, dry with reduced losses (including through the use magnetic cores made of amorphous steel in transformers) and weights and sizes, and special designs of transformers rated up to 100 kVA intended for installation on OL towers;
- with balancing devices;
- with connection diagram Δ/Yn or Y/Zn windings (Y/Yn windings of supply transformers may be used with sufficient justification, e.g. the replacement of an out-of-order transformer with a two-transformer TSS).

2.1.3.10. TSS, DTSS, DSS built into buildings and located in densely built-up urban areas or in a confined area shall typically use small-sized dry transformers with reduced noise and vibration:

- with a system of automatic temperature control for a transformer;
- with temperature sensors inside transformer chambers.

2.1.3.11. To raise explosion and fire safety, supply transformers may be filled with noncombustible insulating liquids in accordance with the requirements of IEC 61099 *Specifications for unused synthetic organic esters for electrical purposes*.

The use of SF6-insulated supply T/AT shall be substantiated by FS.

2.1.3.12. Adjusting transformers may be installed:

- with sufficient justification, on AT rated 500–750 kV to control flows of active power;
- on SS rated 35–220 kV with transformer equipment provided with O/S TCO devices if regulation voltages fail to meet the initial requirements when O/S TCO are used in accordance with the design standards for substations rated 35–750 kV.

2.1.3.13. Linear BT may be used to adapt electricity distribution grids rated 0.4–20 kV for a change (increase) in electrical loads and ensure the required electricity quality, with an appropriate FS and with a comparison with other options for ensuring electricity quality.

BT may be installed at points of a critical fall in voltage (more than 10% of the nominal values) on power lines or directly on the customer's busbars.

2.1.3.14. BT voltage shall be controlled automatically.

2.1.3.15. If the direction of capacity flow is changed (when switching over to backup power supply), BT shall not change operation mode in relation to the direction of capacity flow.

2.1.3.16. Levels of voltage control using BT shall be as follows:

- on PL rated 6–20 kV, which do not ensure electricity quality at the customer, ±10% voltage control;
- on PL rated 6–20 kV, for the purpose of increasing PL transmission capacity, +10% voltage control;
- on SS rated 35–110 kV, equipped with O/S TCO devices where voltage control fails to meet the requirements, ±15% voltage control;
- on DSS and SS rated 6–20 kV, ±15% voltage control.

2.1.3.17. Electric grids rated 6–35 kV shall use dry current-limiting reactors with small electricity losses and sufficient electrodynamic resistance to S/C currents. Reactors of a similar type shall be used for bushings rated 6–20 kV for supply transformers or for connections of outgoing lines.

2.1.3.18 For compensation for capacitive ground fault currents and the reduction of overvoltage at one-phase arc ground faults on grids rated 6–35 kV, it is recommended that continuously variable A-SC be used with automatic setting regulators. In a confined area of indoor SS, arc-extinguishing units shall be used (A-SC and transformers for their connection in one body, made on a single magnetic core), including, dry-type units.

2.1.4. Switching Devices

2.1.4.1. On electric grids rated 110 kV and above, the following shall be used as SD:

- SF6-insulated breakers, column-type and tank-type, explosion-proof, with pressure release valves, mainly with spring drives;
- as technology advances, it is also allowed to use vacuum breakers, and breaker-disconnectors (combined modular devices) for grids rated 110–220 kV;
- in (U)Sh/R circuits and capacitor batteries, circuit breakers designed for switching a current reactor and capacitor batteries may be used respectively;
- SF6-insulated breakers may be used if the lowering of SF6 pressure in their bodies does not require their automatic shutdown. However, two-step warning/emergency signals for decreased SF6 pressure (density) in SF6-insulated high-voltage circuit breakers shall be used (when the second step of the signals is actuated, this actuates the automatic electric blocking of circuit breaker control,

which prohibits the off and on operation of the breaker);

- disconnectors rated 110 kV and above (pantograph, semi-pantograph, and horizontal-swivel type, equipped with electric drives, including and for grounding blades, high-strength porcelain or polymer supporting insulators, switching devices for electromagnetic blocking).

2.1.4.2. Technical measures shall be formulated to eliminate the risks of damage to SF6-insulated breakers due to invalid values of aperiodic components in the case of PL switching equipped with inductive devices for shunt compensation.

2.1.4.3. With sufficient justification, (U)Sh/R circuits may use circuit breakers with intentional asynchronous pole-switching devices (IAPSD).

2.1.4.4. Column-type SF6-insulated circuit breakers rated 110–750 kV are recommended for use with longitudinal insulation corresponding to at least II* pollution (2.25 cm/kV).

2.1.4.5. Electric grids rated 6–35 kV shall use:

- SF6-insulated circuit breakers for connections with large currents or in a confined area, and if it is necessary to ensure acceptable switching overvoltage, with sufficient justification;
- indoor vacuum breakers;
- outdoor vacuum breakers, including reclosers, for OL;
- outdoor vacuum load breakers for OL;
- indoor vacuum load breakers;
- fuses-disconnectors rated up to 20 kV.

2.1.4.6. On distribution grids rated 6–20 kV, it is additionally recommended that fuse-disconnectors and disconnectors that meet modern operating requirements be used, if necessary, with the possibility of remote control.

2.1.4.7. The selection of types of breakers shall be with due consideration to the following:

- breakers shall provide performance in the entire required range of air temperatures;
- Sh/R circuits, CSR and SCB shall use breakers intended for switching for currents of Sh/R and SCB respectively;
- the disconnecting ability of breakers shall be based on calculations of S/C currents for the calculation period in accordance with subsection 3.1.3 of this Technical Policy;
- breakers shall provide the shutdown of PL equipped with inductive devices for shunt compensation. However, measures shall be implemented to prevent the occurrence of invalid values of aperiodic components when S/C currents in the electric grid are disconnected.

The selection of SD shall also be based on justification for the minimization of their maintenance.

2.1.4.8. Circuit breakers rated 330 kV and above shall have one-phase drives. The use of one-phase drives for circuit breakers rated 110–220 kV shall have technical and economic justification.

2.1.4.9. Reliability requirements:

- operation life: at least 30 years;
- warranty period of operation: at least 5 years from date commissioning;
- SD not shall require major repairs during the operation life or until the exhaustion of switching durability;
- 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. Factory-Assembled Switchgear

2.1.5.1. Requirements for SF6/I FASG:

2.1.5.1. Requirements for SF6/I FASG:

- all SF6/I FASG modules shall be low-maintenance equipment;
- SF6/I FASG shall be equipped with AMDS for continuous monitoring in accordance with subsection 3.7.2 of this Technical Policy;
- SF6/I FASG shall be able to transfer any volume of gas to repair without the full shutdown of SF6/I FASG except one-transformer SS implemented as 3N;
- the design of SF6/I FASG shall provide the opportunity of docking cubicles (for the potential expansion of SG) with a minimum elimination of existing connections;
- the connection of cubicles in SF6/I FASG rated 110–500 kV shall use cables with appropriate voltages and with cross-linked polyethylene insulation or, with sufficient justification, SF6-insulated current leads;
- SF6/I FASG shall provide nominal parameters at lower air temperatures of up to –5 °C, SF6-insulated outdoor current leads at lower air temperatures of up to –45 °C for SS located in a moderate climate, and –60 °C for SS located in a cold climate with due consideration to the cooling effect of wind;
- the design of SF6-insulated current leads shall include compensators within the temperature range and within the boundaries of temperature seams for the separate foundations of the SF6/I FASG building and outdoor supports of current leads;
- the design SF6/I FASG shall provide maintenance personnel with access to each SD.

2.1.5.2. The layout of SF6/I FASG in IDSG shall provide service platforms at different levels, while for the safe maintenance of SF6-insulated equipment, SF6/I FASG rated 110 kV shall be equipped with factory-made mobile service platforms, and SF6/I FASG rated 220 kV and above shall be equipped with factory-made stationary service platforms.

2.1.5.3. SF6/I FASG rooms, cable rooms under SF6/I FASG rooms, SF6 cylinder storage rooms shall be provided with forced supply and exhaust ventilation. Ventilation shall ensure air change in SF6/I FASG rooms, SF6 cylinder storage rooms and shall take air from cable rooms and cable channels.

2.1.5.4. SF6/I FASG rooms shall be provided with a system that prevents emissions of SF6 (gaseous and solid SF6 decomposition products) into the atmosphere above the permissible limits for emergency emissions with the depressurization of SF6/I FASG.

2.1.5.5. Cable bushings in FASG/SF6/I FASG shall not allow ground water to flood cable rooms.

2.1.5.6. The requirements for combined SD, which include the functions of a breaker, disconnector(s), grounding switches (SF6-insulated factory-assembled outdoor switchgear), shall be similar to those for SF6/I FASG. SF6-insulated factory-assembled outdoor switchgear shall provide nominal parameters at lower air temperatures of up to –45 °C for SS located in a moderate climate, and –60 °C for SS located in a cold climate with due consideration to the cooling effect of wind.

2.1.5.7. Requirements for FASG/SF6/I FASG 6–35 kV:

- use FASG 6–35 kV with air, including combined, insulation, with an appropriate FS, SF6-insulated, and FA FASSG(E) with vacuum breakers or load breakers, including in the single-unit version;
- use protective metal curtains for cubicles;
- use antiresonant-type VT for cast-insulated FASG CT on electric grids that may have ferroresonance;
- use fast-acting arc protection;
- use cubicles with isolated compartments;
- FASG/SF6/I FASG rated 6–20 kV are recommended with on-top main busbars, two-sided maintenance;
- FASG/SF6/I FASG cubicles are recommended with motor drive with the possible remote shutdown of breakers;
- for electricity metering, it is recommended that CT be installed on in each phase.

2.1.5.8. It is recommended that urban electric grids rated 10–20 kV use FASG/SF6/I FASG with modular cubicles in metal bodies (cubicles shall be low-maintenance equipment or, if possible, shall not require maintenance during the operation life).

2.1.5.9. The use of A/I FASG shall be substantiated by FS and shall meet the requirements for SF6/I FASG.

2.1.5.10. Reliability requirements:

- operation life: at least 30 years;
- warranty period: at least 5 years from the date of commissioning;
- FASG/SF6/I FASG shall not require major repairs during the operation life or until the exhaustion of switching durability;
- climatic version and location category in accordance with GOST 15150.

2.1.5.11. TSS and DSS rated 6–35 kV shall comply with the following requirements:

2.1.5.12. Factory-assembled packaged or modular TSS, DSS, DTSS equipped with necessary digital interfaces for integration into grid infrastructure shall be used.

2.1.5.13. Requirements for the organization of work of operational mobile crews and maintenance crews: the activities of operational mobile crews and maintenance crews shall be organized using software and hardware systems (SHS) providing automation and digitalization for processes of planning, performing, and supervising work at electric grid facilities.

2.1.5.14. SHS shall ensure the implementation of the following functions:
- monitoring and control of work in the necessary locations (both outdoors and indoors) for employees with appropriate permits;
- monitoring of using protective equipment, devices, tools, protective signs, etc. while performing work;
- measures to prevent employees from entering an area with threats to life or an area allocated for work;
- monitoring, warning, blocking of cases of work in an unauthorized place, on energized equipment;
- provision of information for superior operational and operational-repair personnel (including crew foremen) about any noncompliance with the rules;
- video and audio recordings of work.

2.1.6. Outdoor Switchgear

2.1.6.1. General requirements:
- outdoor switchgear (ODSG) may typically be used for a voltage of 35 kV and above;
- ODSG shall typically use flexible busbars;
- ODSG shall predominantly use switching equipment and metering transformers not containing transformer oils;
- ODSG shall be accessible to mobile mechanisms and devices and to cargo vehicles and mobile laboratories.

Protection from direct lightning strikes is not required for SS rated 35 kV with transformers, each rated 1.6 MVA and below, regardless of the number of such transformers, and from the number of lightning hours per year, and for all ODSG rated 35 kV in areas with more than 20 lightning hours per year, and for ODSG rated 220 kV and below at sites with the equivalent specific earth resistance of not more than 2000 Ohm in a lightning season with not more than 20 lightning hours per year;

- ODSS SG shall be fenced. Fencing shall be solid or shall have a visible height of at least 2.5 m. ODSG and SS in urban electric grids shall typically to be located in a single place.

Requirements for solid and visible fences shall be consistent with the standards “0.4–110 kV Electricity Distribution Grids. Design Requirements” (OS 34.01-21.1-001-2017), “Model Technical Solutions for 6–110 kV Substations” (OS 34.01-3.1-002-2016), “Standards for the Design of Alternating-Current Substations with a High Voltage of 35–750 kV (OS 56947007-29.240.10.248-2017):

- location and capacity of outdoor lighting installations for ODSG shall ensure a controllable level of illumination in the nighttime and with bad visibility in open areas of ODSG with the movement of vehicles and people, and on surfaces of electrical equipment. Lighting installations shall use energy-saving lamps;

- it is necessary to implement measures to prevent ODSG from being affected by vegetation (paving, geotextiles, needled fabrics or materials with similar properties over crushed stone, etc.);

- metal structures of ODSG shall be provided with protection from nesting;

- connections of flexible wires in spans shall be clamps, and connections in tower loops and connections of branches in spans and connections to equipment clamps shall be crimping or welding. Connections of branches in spans shall be without cut wires;

- branches from main busbars of ODSG shall typically be below main busbars;

- the tension of wires leading to ODSG devices shall not create any unacceptable mechanical stress or any unacceptably short distance between wires;

- HF traps and loops shall use technical solutions that prevent their whipping.

2.1.6.2. Fencing is optional for transformers and devices with the lower edge of porcelain (polymer) insulators located above the layout level or ground communication structures at a height of at least 2.5 m. With any smaller height, equipment shall have permanent fences located at a distance from transformers and devices as prescribed by safety standards. Instead of permanent fences, it is allowed to use canopies that prevent maintenance personnel from touching insulation and energized components of equipment.

2.1.6.3. Busbars shall not be suspended on one span above two and more T/AT cubicles.

The layout and location of ODSG rated 330 kV and above shall ensure the minimal impact of electromagnetic fields on SS equipment maintenance personnel, subject to Public Health Regulations (SanPiN) 2.2.4.3359-16.

2.1.6.4. In order to reduce the occupied area and optimize layout solutions, ODSG may use uninsulated or insulated rigid busbars.

2.1.6.5. ODSG rated 110–500 kV may use SF6-insulated current leads with an appropriate FS.

2.1.6.6. The rehabilitation or expansion of existing electric grid facilities may use hollow wires for busbars.

2.1.6.7. The construction of ODSG in areas with an aggressive environment shall used flexible or rigid busbars with anticorrosion coatings.

2.1.7. 6–35 kV Transformer and Distribution Substations

2.1.7.1. Electricity distribution grids shall use small-sized factory-assembled transformer SS for electricity supplied to customers.

2.1.7.2. TSS rated 6–35/0.4 kV may have the following designs:

- detached;
- built into buildings.

2.1.7.3. Built-in TSS shall be on the first or basement floor and shall have direct exits to the open air. If this location is not available to TSS, it shall be used for the heaviest equipment, primarily supply transformers.

2.1.7.4. For customers that cannot have power outages of more than one hour, two-transformer SS shall be used.

2.1.7.5. Supply transformers with oil and dry insulation may be used for TSS rated 6–20 kV, while built-in TSS shall have only dry insulation.

2.1.7.6. TSS equipment (including through-type insulators) shall be HV and LV surge protected. Transformer neutral shall have LV grounding.

2.1.7.7. It is recommended that urban cable networks supplying electricity to a special group of Category 1 customers, such as residential areas, shopping centers, production facilities, etc., use TSS and DSS with motor-driven SD and a HV ALT scheme.

2.1.7.8. In order to reduce the area occupied by TSS and DSS in urban electric grids, relay protection cabinets in cubicles shall typically be used.

2.1.7.9. SG for TSS and DSS shall be FASG rated 6–35 kV with overhead insulation, including combined insulation (overhead insulation with insulated busbars).

With sufficient justification, front-accessible assembled chambers, SF6-insulated FASG, and vacuum breakers or load breakers may be used, including in the single-unit version.

2.1.7.10. It is recommended that unit-type package TSS rated 6–20/0.4 kV with transformers rated up to 630 kVA use insulated rigid or insulated flexible busbars.

2.1.7.11. Distribution grids with transformers rated 1,000 kVA and above shall use closed or insulated (three-phase and one-phase) current leads on the 0.4 kV side. Flexible busbars may be used with sufficient justification.

2.1.7.12. SG rated 0.4–20 kV with built-in automated heating control systems for contact connections are recommended for use subject to the following conditions:

- no need for maintenance throughout the operation life;
- wireless transmission of heating signals from the measurement object (contact connection) to the analyzing device (sensor);
- no galvanic cell–based power supply for sensors or readers;
- no system elements that may impair the reliability of protected electrical equipment;
- low system costs, which insignificantly affect the ultimate total cost of SG rated 0.4–20 kV (positive FS).

2.1.8. Mobile and Modular Substations

2.1.8.1. Modular SS rated 6–220 kV are designed for the following purposes:

- construction of new SS until their commissioning;
- electricity consumers located in densely built-up areas, remote areas, aggressive environments;
- electricity consumers located where the construction of stationary SS is not cost-effective.

2.1.8.2. Mobile SS rated 6–220 kV are designed for the following purposes:

- repair and rehabilitation of existing SS;
- construction of new SS until their commissioning;
- unloading of grids during peak loads;
- urgent electricity supply for new facilities;
- electricity consumers located where the construction of stationary SS is not cost-effective;
- accident recovery work on electric grids.

2.1.8.3. Mobile or modular SS shall have main characteristics (weight, size) that allow them to ensure the delivery of assembled SS or SS modules by any means of transportation, and the fast installation and commissioning of SS.

2.1.8.4. The combination of various SS modules makes it possible to build unattended, remotely controlled SS, including controlling the visible disconnection of disconnector blades and the position of grounding blades.

2.1.8.5. Modular SS have the following advantages:

- mobility, convenient transportation;
- convenient installation, convenient operation;
- time efficiency (installation of SS rated 110 kV within two months);
- possible expansion of SS cubicles;
- remote monitoring and remote control in the dispatching system;
- no open current-carrying parts;
- detachable cables;
- possible connection to both CL and OL.

2.1.8.6. Mobile SS have the following advantages:

- mobility;
- time efficiency (minimum time from delivery to commissioning).

2.1.8.7. Temporary electricity supply for accident recovery work on electric grids rated 6–20 kV may use self-contained backup power supply sources (diesel power plants) with mobile step-up transformers.

2.1.9. Metering Transformers

2.1.9.1. General requirements for measuring transformers:

- metering transformers shall be electromagnetic (CT, VT) or capacitive (VT) types;
- insulation shall be gas (SF6 or nitrogen) or oil (sealed CT). In the case of oil-filled CT and VT, a reduced amount of oil shall be used for CT and VT;
- capacitive VT rated 110 kV and above shall be used;
- electromagnetic VT rated 6–35 kV shall be used;
- electronic (optoelectronic and other) metering transformers may be used with sufficient justification;
- VT shall be antiresonant-type;
- CT, shall ensure correct operation for relay protection from short circuits in the grid, including in the event of an aperiodic component of current;
- CT and VT shall ensure increased reliability, explosion safety, and fire safety;
- capacitive dividers shall have a reduced temperature coefficient of capacitance;
- CT and VT shall have corrosion-resistant cast bodies;
- with sufficient justification, combined current and voltage transformers may be used with cubicles of OL rated 110–750 kV in order to reduce the size of SG;
- metering transformers shall have separate windings for electricity

metering.

2.1.9.2. For grids rated 110 kV and above, including in SF6/I FASG, electromagnetic VT may be used, with sufficient design justification, for expansion and rehabilitation with significant secondary load.

2.1.9.3. Metering transformers for electric grids rated 35 kV and above shall be the following winding accuracy classes:

- not lower than 0.2S for CT and 0.2 for VT for the new construction, rehabilitation, or modernization of electricity meters for connections of 110 kV and above for grid companies;
- not lower than 0.2S for CT for network connections of 100 MW and above and for CT rated 220 kV and above for electricity metering (including AISEBM), not lower than 0.2 for APCS and measurements;
- not lower than 0.5S for CT for network connections of below 100 MW for electricity metering, not lower than 0.5 for APCS and measurements;
- not lower than 0.2 for VT rated 220 kV and above for electricity metering (including AISEBM), APCS and measurements;
- not lower than 0.2 for VT rated 35–110 kV for electricity metering (including AISEBM), APCS and measurements (if there are connections of 100 MW and above with due consideration to future load growth), not lower than 0.5 for the other VT for electricity metering (including AISEBM), APCS and measurements;
- not lower than 1.0 for residual current CT used to provide RP and remote measurements of residual current for on-load operation in secondary circuits of up to 3 ohms.

2.1.9.4. The winding accuracy classes of CT and VT for RP shall comply with the following requirements:

2.1.9.4.1. CT: maximum permissible composite error for rated accuracy limit current, 10% max.

2.1.9.4.2. VT: accuracy classes and RP connection schemes determined by the need to ensure the correct operation of RP devices.

2.1.9.4.3. Measuring sensors of stability control for pre-fault data, and measuring circuits of overcurrent protection shall be connected to CT with an accuracy class of not lower than 0.5; CT windings with maximum permissible composite error for rated accuracy limit current of not greater than 10% may be used for overcurrent protection, with sufficient design justification.

2.1.9.4.4. Measuring circuits of transient monitoring systems modes shall be connected to secondary windings of measuring CT and VT with the following accuracy classes:

- CT rated 110 kV and above: not lower than 0.2;
- other CT: not lower than 0.5;

- VT rated 110 kV and above: not lower than 0.2;
- other VT: not lower than 0.5.

2.1.9.5. CT rated 0.4 kV shall be used for AISEBM, APCS, and measurements if measured current exceeds 60 A and the connected capacity is more than 25 kW.

2.1.9.6. Actual secondary loads on measuring CT and VT shall comply with the requirements of regulatory documents and ensure the operation of CT and VT with the required accuracy class.

2.1.9.7. The transformer winding ratio for AISEBM, APCS, and measurements shall ensure the measurement of working current with standardized accuracy in the range of its changes from the minimum to maximum values determined based on calculations of electric power modes.

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

2.1.9.9. It is recommended that CT and VT use moisture-repellent coatings or external polymer insulation to reduce operational costs.

2.1.9.10. Measuring CT and VT used for electric grids rated 0.4–20 kV and for electric grids rated 35 kV on indoor SS shall have:

- cast insulation (allowed application oil VT with sufficient justification);
- at least two secondary windings;
- winding accuracy classes:
  • not lower than 0.5S for CT and 0.5 for VT for the new construction, rehabilitation, or modernization of electricity meters of grid companies;
  • not lower than 0.5S for CT and 0.5 for VT for network connections of 6–20 kV;
  • not lower than 0.5 for CT for electricity metering, measurements, and APCS on outgoing lines and bushings rated 0.4 kV for grid companies;
  • not lower than 0.5 for secondary CT windings for electricity meters of network connections or up to 1 kV.

2.1.9.11. Reliability requirements:

- operation life: at least 30 years;
- warranty period of operation: at least 5 years from the date of commissioning;
- no need for repair during the operation life;
- CT and VT with increased calibration intervals (at least 8 years).

The selection of parameters for measuring CT and VT shall be in accordance with GOST 7746-2015, GOST 1983-2015, PNST 282-2018, PNST 283-2018, and PNST 319-2018.

2.1.9.12. Digital metering transformers shall comply with the requirements of subsection 2.2 of this Technical Policy.

2.1.9.13. Metering transformers shall comply with the requirements of subsection 3.6 of this Technical Policy.

2.1.10. Overvoltage Suppressors

2.1.10.1. In the new construction, rehabilitation, and technical upgrading of electric grid facilities, protection from lightning overvoltage and switching overvoltage shall be provided by OVS (including OL spark gaps) based on zinc oxide varistors for all voltages, explosion-proof with sufficient energy capacity and protective capacity.

2.1.10.2. In the case of using IAPSD breakers designed to conduct closing operation when voltage reaches the highest level on breaker contacts (for example, when reactors or transformers are turned on), which corresponds to maximum overvoltage, it is necessary to evaluate increased loads on OVS and insulation of SS and PL primary equipment.

2.1.10.3. The selection of parameters and locations for OVS shall be in accordance with GOST R 52725-2007 *Surge arresters for A.C. electrical installations for voltage from 3 kV to 750 kV. General specifications*, OS 56947007-29.120.50.076–2011 “Standard Technical Requirements for 6–750 kV Overvoltage Suppressors,” and the applicable design requirements and standards.

2.1.10.4. The rehabilitation of SS shall include simultaneously replacing all arresters or OVS on busbars and connections. The simultaneous operation of OVS and arresters with different characteristics is not allowed due to the risk of damage to the overloaded element with the worst characteristics.

2.1.10.5. Reliability requirements:

- operation 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 on SS, cables of secondary switching are exposed to the electromagnetic impact of S/C, switched primary equipment, lightning strikes, high-frequency communications, etc.

2.1.11.2. SS shall be provided with an electromagnetic environment in which the level of electromagnetic impact of any kind does not exceed the permissible value for each device. No electromagnetic impact shall result in any damage to or malfunction in secondary equipment, protection systems, control, or communications.

2.1.11.3. Devices affected by electromagnetic impacts: relay protection, APCS, TM, AISEBM, PAS, data collection and communication, fire protection, video surveillance, security alarm, telecommunications, auxiliary current systems.

2.1.11.4. The Technical Policy in the area of creating the required electromagnetic environment for the SS is implemented by a package of organizational and technical measures in accordance with the applicable regulatory documents:

- installation of GD to align potential in SS and grounded equipment;
- selection of corrosion-resistant materials with reduced specific resistance for GD;
- lightning protection to protect insulation from flashovers and prevent overvoltage from going into secondary switching circuits;
- selection the SS layout with due consideration to the electromagnetic impact of primary circuits and equipment on secondary switching circuits and specific devices;
- involvement of specialist organizations in examinations for electromagnetic compatibility for newly constructed and rehabilitated SS;
- selection of laying methods and routes for power cables and secondary switching cables to ensure levels of interference and other impacts allowed for SS devices;
- measures to prevent one cable from containing auxiliary direct current and alternating current;
- additional measures, if necessary, to ensure EMC (shielded cables, filters for supply circuits, SPD, etc.);
- measures to protect electrical installations from high-frequency switching overvoltage;
- measures to provide static discharge protection;
- measures to provide RF radiation protection;
- completely dielectric fiber-optic cables used for SS and provided with protection from mechanical damage and rodents;
- cable trays typically located below the ground level and provided with drainage for ground water and snow water, including at intersections with utility lines and in building entrance areas.

2.1.11.5. Diagnostics for SS lightning protection shall be conducted during operation in order to:

- assess the effectiveness of an existing lightning protection system and its compliance with the requirements of TSD;
- provide lightning protection for electrical equipment;
- examine whether EMC is provided for circuits of relay protection, ADS, APCS, DCCS, and AISEBM;
- prepare measures to ensure the required level of lightning protection and EMC.

2.1.11.6. It is recommended that comprehensive diagnostics for the electromagnetic environment be conducted:

- when designing the rehabilitation of SS to assess the electromagnetic environment of an existing SS that will be rehabilitated. The examination results shall be used to prepare terms of reference for design;
- on completing the rehabilitation of SS;
- on completing the construction of SS.

2.1.11.7. Lightning protection of ODSG equipment rated 35 kV and above is provided by freestanding lightning structures and lightning rods installed on line gantries of ODSG.

2.1.11.8. In the construction of indoor SS (SF6/I FASG, IDSG rated 35, 110 (150) kV), lightning protection for a building is used for the roof with current leads connected to the outer grounding circuit. If any roof is completely or partly made of metal, it is sufficient to ground metal parts of the roof.

2.1.11.9. For protect unit-type TSS without a lightning protection system from lightning strikes, design documents shall specify the use of lightning protection grids.

2.1.11.10. It is recommended that the new construction and rehabilitation of SS rated 110 kV and above use ODSG equipped with ground wires, which in addition to increasing the reliability of protection from direct lightning strikes, makes possible to deal with the issue of electromagnetic compatibility on SS by installing lightning protection cable poles outside the protected area, thus decreasing the galvanic connection between the ground leads of the poles and the grounding circuit of SS, which almost fully prevents lighting current from going into underground systems.

Since lightning protection cable poles are located at a distance from the protected area of SS, this either completely suppresses guided sparks created by lighting current hitting the ground or sends them in a direction that is safe for the facility.

2.1.11.11. It is recommended that the new construction and rehabilitation of SS rated 110 kV and above use a computer-aided design (CAD) system to provide lightning protection for SS and OL.

2.1.11.12. In providing lightning protection for OL rated 35–220 kV, it is necessary to consider the use of combined insulator arresters, which removes the need to use lightning protection cables or OVS, thus reducing the weights and costs of supports and foundations and consequently the total cost of OL construction.

The result of replacing traditional lightning protection for OL (lightning protection cables or OVS) by combined insulator arresters is the reduction of labor intensity and expenses associated with the maintenance and repair of OL.

2.1.12. Reactive-Power Compensators

2.1.12.1. The following types of reactive-power compensators (RPC) shall be used:

- uncontrolled static devices for series and shunt compensation, including:
• shunt reactors (Sh/R) rated 110–500 kV;
• shunting static capacitor banks (SCB) and FCD using dry capacitors or capacitors impregnated with environmentally safe liquid synthetic dielectrics;
• series compensators (SC);
- controlled devices for series and shunt compensation, including:
• bias-controlled shunt reactors (BC-SR) rated 110–500 kV;
• thyristor-controlled shunt reactors (TC-SR) rated 110–500 kV, using transformers with a S/C voltage equal to 100%;
• static reactive-power compensators (SRPC) and static compensators based on voltage converters (STATCOM);
• vacuum reactor groups (VRG) and thyristor reactor groups (TRG) using breakers provided with increased switching durability and equipped with synchronous switching devices;
• active filter-compensating and filter-equalizing devices (AFED) based on modular multilevel voltage converters;
• controlled series compensators (CSC);
• asynchronous electromechanical compensators;
• asynchronous electromechanical frequency converters (ASEMFC).

2.1.12.2. Capacitor units may not be used unless the electric grid is free from any resonant phenomena in all operation modes.

2.1.12.3. If it is not possible to place capacitor banks and with appropriate justification, distribution grids may use individual capacitors designed only for compensation for the transformer’s magnetizing current in the base part of the reactive load schedule.

2.1.12.4. When designing electric grids rated 110 kV and above, it is recommended that consideration be given to reactive-power compensation along with the possibility and practicability of building self-compensating OL (CSCOL) and compact OL.

2.1.12.5. Reliability requirements:

- operation 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. The distinguishing characteristics of a digital substation (DSS) are as follows: intelligent electronic devices; LAN-based communications; digital methods of data access, communication, and processing; automated substation operation and management.

2.2.1.2. Goals creation digital substations:

- reduce cabling;
- shorten the time of the design, installation, and setup of substation equipment;
- ensure the observability of operating parameters of PL, equipment, and devices of substations;
- unify mechanisms of substation configuration;
- set up a uniform system of diagnostics, switching over to remote functional diagnostics;
- switch over to unattended substations.

2.2.1.3. DSS shall be the main element of the electric grid.

DSS is a highly automated SS usually working without the permanent presence of operational personnel on duty and equipped with digital information and management systems synchronized with each other: automation, control, status monitoring and diagnostics, metering, local and remote process control, communications, providing a single information space and made based on unified data communication protocols (SV traffic, GOOSE messages, MMS).

2.2.1.4. The design process for DSS construction shall include:

2.2.1.5. Applying digital design approaches based on digital models supporting the unified information model of the grid.

2.2.1.6. Using PJSC “Rosseti” corporate profile IEC 61850 in order to type technical solutions using IEC 61850 as related to the implementation of various functions of intelligent electronic devices and the exchange and transfer of information between them.

2.2.1.7. Creating uniform solutions relating to the description of the electronic SS equipment catalog, using functionality and communications under IEC 61850, including:

- principles of descriptions of primary equipment for generating SSD files for SG rated 6–750 kV in accordance with IEC 61850-6;
- description of typical functions of RP, APCS, AECS, and devices for the transmission of emergency and control signals, using logical nodes in accordance with IEC 61850-7-4, and new logical nodes created in accordance with IEC 61850-7-1;

- description of data objects for logical nodes in accordance with IEC 61850-7-3, and new data objects created in accordance with IEC 61850-7-3 for existing and new logical nodes used to describe information not specified in IEC 61850;

- description of data communication to the substation level, using the MMS protocol in accordance with IEC 61850-8-1 and PJSC "Rosseti" requirements applicable to the use of report parameters for various categories of information;

- description signal transmission for RP and APCS at the field level and at the level of connections using the GOOSE protocol in accordance with IEC 61850-8-1 and PJSC "Rosseti" requirements applicable to the clarification of the operating rules for the transfer mechanism;

- description of instant analog value sample transmission using the Sampled Values protocol in accordance with IEC 61850-9-2, profile 9-2LE, and PJSC "Rosseti" requirements applicable to analog value sample transmission in accordance with IEC 61850 9-2 and IEC 61869-9 for Architecture III.

- description of the main operation modes of intelligent electronic devices (IED) using the model of IEC 61850;

- description of possibilities for the implementation of functional hierarchies in IED using IEC 61850;

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

2.2.1.8. All solutions described in the corporate profile shall comply with PJSC "Rosseti" requirements for DSS implementation using typical cabinets of secondary equipment with different degrees of the application of DSS technology for Architectures I, II and, III.

2.2.1.9. In the design documentation phase, an electronic file is generated to create a System Specification Description (SSD) for a substation, which serves as the basis for the specification of functional requirements for equipment for all DSS systems, regardless of the specific manufacturer.

2.2.1.10. Creating SSD files for the SS specification in the design documentation phase makes it possible to:

- obtain an SCL-language typed electronic description of primary equipment for SS in accordance with IEC 61850-6 to simplify the evaluation and use of design results and integrate electronic diagrams into the SCADA system;

- obtain a typed list of functions of secondary systems of SS with reference to primary equipment in order to simplify the compliance verification process for secondary equipment as related to functionality, regardless of degrees of the integration of DSS technology for Architectures I, II and, III;

- implement a unified electronic library of design solutions described in a universal format to simplify the analysis and updating of current design solutions.

2.2.1.11. The design of DSS based on the existing infrastructure shall be carried out through the integrated modernization of secondary systems based on intelligent electronic devices and process LANs in accordance of the requirements of the IEC 61850 series and through the modernization and/or replacement of equipment and systems using special digital sensors and devices (including field controllers) and corresponding converters with their integration into the common management and control system.

2.2.1.12. DSS shall meet the following criteria:

- remote observability of parameters and operation modes for equipment and systems;
- remote control of equipment and systems for the operation of the SS;
- high level of control automation for equipment and systems through automated control systems;
- remote controllability of all production processes in a synchronized manner;
- digital data exchange between all process systems in a uniform format;
- integration into the grid and enterprise management system and support for digital interactions with relevant infrastructure organizations (with allied facilities);
- functional and information security in the digitalization of production processes;
- continuous online control using AMDS for primary process equipment and systems with the transfer of all necessary digital data, controlled parameters, and signals.

2.2.1.13. DSS SHS shall be implemented at three structure levels (process, connection, SS) and shall contain the following functional subsystems:

- APCS;
- relay protection, the including disturbance recording process (DRP);
- special automatic control and regulation;
- monitoring of electricity quality parameters;
- electricity metering;
- AMDS for the continuous monitoring of primary process equipment;
- monitoring and management of utility systems;
- synchronized vector measurements;
- TSD and information support for service personnel;
- information security;
- general security.

2.2.2. Base Architectures

Depending on the current objectives of electric grid construction and the objectives of enterprise asset management, it is currently practicable to consider three main architectures based on IEC 61850:

2.2.1.1. Architecture I: a DSS architecture where all communication between IED uses discrete and analog electric signals transmitted via control cables; data exchange between the substation level (SCADA) and IED uses the MMS protocol in accordance with IEC 61850-8-1. The GOOSE and Sampled Values protocols are not used.

Additional project requirements apply to the format of tables of signals transmitted to APCS, where signals shall have names in accordance with IEC 61850 and in accordance with this standard and other regulations.

2.2.1.2. Architecture II: a DSS architecture where communication between IED uses object-oriented GOOSE messages in accordance with IEC 61850-8-1; data exchange between the substation level (SCADA) and IED uses the MMS protocol in accordance with IEC 61850-8-1; current and voltage measurements are transmitted as electrical analog signals via control cables.

The Sampled Values protocol is not used.

2.2.1.3. Architecture III: a DSS architecture where communication between IED uses object-oriented GOOSE messages in accordance with IEC 61850-8-1; current and voltage measurements are transmitted digitally as instant values, using the Sampled Values protocol in accordance with IEC 61850-9-2; data exchange between the substation level (SCADA) and IED uses the MMS protocol in accordance with IEC 61850-8-1.

In addition to the features of Architecture II, the design of facilities in Architecture III contains the requirements applicable to data communication using the Sampled Values protocol.

2.2.1.4. All the particularities of implementing Architecture I, Architecture II, and Architecture III as related to hardware and IEC 61850 protocols are shown in Table 1.

Table 1. Particularities of implementing Architecture I, Architecture II, and Architecture III

Tools	Architecture I	Architecture II	Architecture III
Use of the MMS protocol	Yes	Yes	Yes
Use of the GOOSE protocol	No	Yes	Yes
Use of the Sampled Values protocol	No	No	Yes
Use of equipment supporting IEC 61850 at the substation level	Yes	Yes	Yes

Use of equipment supporting IEC 61850 at the connection level	Yes	Yes	Yes
Use of equipment supporting IEC 61850 at the field level	No	Yes	Yes
Use of discrete signal conversion cabinets	No	Yes	Yes
Use of analog signal conversion cabinets	No	No	Yes
Use of digital current transformers and digital voltage transformers supporting the Sampled Values protocol	No	No	Yes

2.2.1.5. DSS shall use and implement the following solutions, equipment, and materials:

- indoor DSS shall be designed using FASG;
- switching equipment rated 35 kV and above shall have electric drives with remote control, position control, and switching durability control;
- equipment for SG rated 6–20 kV and MV boards shall have special nodes and elements for the remote control of circuit breakers and the monitoring of their condition;
- ADCS shall be expanded and shall provide working and, if necessary, backup power supply for the following power receivers: RP, APCS, AISEBM devices, dispatching and process control equipment (DPCE), local SS power network, direct-current drives of switching devices, SS emergency utility systems (fire extinguishing, smoke removal, supply and exhaust ventilation, etc.), integrated security systems (ISS), fire alarm, emergency lighting, and, if necessary, DC/AC or DC/DC inverters;
- fiber-optic current leads, built into cables or separate, laid with due consideration to backup power supply, or fiber-optic cables shall comply with the requirements of IEC 60794;
- a system of the centralized monitoring and control of the condition of local automated equipment for utility systems (heating, ventilation, air conditioning, water supply, sewerage, storm drains, fire extinguishing and fire alarm systems) shall implement the following functions:

- control, registration, and analysis of main parameters (temperature, humidity, dust content, change of pressure, pressure of extinguishing substances at the entrances of the system and at the points of fire protection, consumption, equipment operation time, electricity consumption, etc.) and their deviations beyond the permissible limits;

- control of the actuation of automatic devices with the registration of discrete signals of emergency events;

- use of electronic metering transformers or alarm equipment in combination with traditional metering transformers in order to ensure:

- automatic detection of malfunctions in digital metering transformers with the generation and transmission of signals about invalid data in the digital channel;

- automatic detection of failures in the system of data communication from digital metering transformers with the generation of failure signals;

- accuracy class: not lower than specified in subsection 2.1.9 of this Technical Policy;

- calibration interval: at least 8 years;

- improved weight and size characteristics and lower labor costs during their installation and operation compared with traditional metering transformers;

- fire and explosion safety;

- security and working lighting shall be integrated with video surveillance to provide sufficient illumination for security and process video surveillance;

- process video surveillance shall ensure:

- visual control for SSCR, IDSG, and ODSG of DSS with primary process equipment (transformers, SF6/I FASG, FASG, ODSG);

- visual control for the operation and status of specific elements, functional parts, and measuring equipment;

- visual control for SSCR and IDSG of DSS equipped with security, fire alarm, and fire protection systems, with the analysis of video information and the generation of emergency signals;

- visual control for the areas of cabinets with microprocessor equipment and control cabinets;

- visual control for the positions of remotely controlled switching devices on ODSG, IDSG, and FASG (circuit breakers (as indicated by the drive), disconnectors (including transformers neutrals), grounding switches, wheeled-out cubicles);

- visual control for safe operations of maintenance crews in rooms with increased hazards, ODSG, IDSG, FASG;

- information security;

- AISEBM using digital electricity billing meters;

- meters (digital CT and VT) with at least two mutually redundant measurement channels with an accuracy class suitable for RP and for the measurement, metering, and control of PQ;

- integrated security system (ISS) with access control, event registration and data communication to the workstations of the corresponding users.
- network traffic monitoring system and a system for verifying whether data communication using the GOOSE, Sampled Values, and MMS protocols corresponds to an electronic draft (SCD file), with the monitoring of abnormal modes and event registration based on GOOSE/Sampled Values messages, including:
- assessment of the current LAN congestion;
- analysis of messages of the GOOSE, Sampled Values and MMS protocols for lost or distorted packages;
- analysis of information network configurations (analysis of whether the network corresponds to an SCD file);
- control of new MAC addresses in the information network to provide information security;
- control of authorized network messages (white noise);
- signals to APCS about malfunctions and errors in the network;
- blocking of switch ports (blocking criteria to be determined during design).

2.2.3. CIM-Based Data Integration for Digital Substations

2.2.2.1. In accordance with the OPC development concept, information interaction between systems inside NCC shall use the PAS unified integration platform based on the Common Information Model (CIM).

2.2.2.2. All measurements in the information model of measurements/signals shall be associated with the elements of the power system model.

2.2.2.3. Unambiguous data interpretation by all NCC subsystems shall be achieved by using the Common Information Model (CIM) defined by the IEC 61970-30x series. The CIM shall also ensure the unambiguous identification and classification of data involved in information interaction between subsystems.

2.2.2.4. The generalizing top-level data model (information model) shall be the Common Information Model (CIM), which includes a power system information model and a measurement/signal information model.

2.2.2.5. The grid information model shall be based on IEC 61970 and 61968 and shall be detailed to the level of a digital substation’s equipment items.

2.2.2.6. The measurement/signal information model shall be based on IEC 61970 and 61968 and shall include all measurements/signals required for NCC operation and processed by digital substations’ systems of nonoperational process data collection and communication.

2.2.4. Criteria for Using Different Architectures for Digital Substations

2.2.3.1. Architecture I shall be used for the noncomprehensive or partial rehabilitation of SS with a large amount of equipment that has worked up to 15–20 years.

2.2.3.2. Architecture II shall be used for the new construction and comprehensive rehabilitation of SS.

2.2.3.3. Architecture III shall be used only for testing new technologies, verifying or identifying new technical and economic effects.

2.2.3.4. The selection of a DSS architecture shall be determined by the need to keep down CAPEX and OPEX.

2.3. Auxiliary Supply

2.3.1. General

2.3.1.1. Auxiliary supply for SS requires as follows:

- supply for MV AC power receivers of SS from two independent sources (in the case of SS 330 kV and above, three or more, while UPS may be considered to be a third independent source);

- internal power supply sources for SS rated 110 kV and above, ensuring the self-contained operation of auxiliary power receivers directly involved in the production process for at least two hours with fully lost external MV electricity supply and the subsequent start of SS “from scratch” (power supply type: DGU or UPS, including those based on high-capacity AU, to be determined on the basis of technical and economic comparisons of options);

- with an appropriate FS, permissible auxiliary supply for SS, TSS, DSS, DTSS, and CP, which will need substantial investment as required by the applicable TSD (geographically remote facilities, one-transformer SS, initial construction phase, etc.) from VT with increased capacity of secondary windings;

- cables rated above 1 kV with cross-linked polyethylene insulation and cables rated below 1 kV with noncombustible insulation;

- separate operation of auxiliary 0.4 kV sections with ALT; separate operation of circuits with supply from different 0.4 kV sections (power supply for disconnector drives, spring charging drives of breakers, etc.) without ALT;

- protective SD with the possibility of creating visible breaks;

- selective automatic circuit breakers on the 0.4 kV side as input and sectionalizing protective devices;

In TSS, DSS, and DTSS with auxiliary alternating and rectified current, AT shall be connected through fuses, on the supply side, before the longitudinal coupling breaker, except for AT with cast (dry) insulation, which shall be connected through SD from main busbars, while transformers with cast (dry) insulation shall be equipped with thermal protection actuated by SD shutdown;

- supply for the auxiliary alternating-current network from auxiliary busbars shall be through stabilization devices with 220 V output;

- measures shall be taken to organize a centralized system with a distribution switchboard and control panel for emergency and evacuation lighting for the SS main control panel with the possibility of using standard lighting installations for emergency lighting and with integration into existing SS APCS, with self-contained testing for assemblies and units of the system and its load (lighting networks), with the possibility of analyzing the monitoring of the condition of lighting networks.

One of the main preconditions for the reliable operation of RP, APCS, AISEBM, and DCCS on SS is to organize an optimal system for their operational power supply;

- supply for external customers from auxiliary equipment of SS is not allowed.

2.3.1.2. Depending on the conditions, a decentralized auxiliary-current system (two and more components) may be used. Decentralized auxiliary-current systems are recommended if SS have remote SG and during the rehabilitation of electric grid facilities according to the location of loads on SS or according to the nature of loads from customers.

2.3.1.3. The particularities of operational auxiliary supply for SS are determined by the fact that new systems and types of equipment are currently introduced into SS, which requires new approaches compared with what exists now. Power supply sources for these systems are alternating current and auxiliary direct-current systems.

2.3.1.4. The design of auxiliary current systems shall be carried out with due consideration to the possibility of SS operation without permanent personnel on duty.

2.3.1.5. With sufficient justification, except as specified in paragraph 2.3.1.1 of this Technical Policy, auxiliary power supply shall include DGU with required capacity.

2.3.1.6. Power supply for CN EGF, APCS, DCCS, OPS, automatic firefighting equipment, SS information infrastructure, and other systems shall typically include uninterruptible power sources (UPS), both equipped with accumulators and powered by auxiliary direct current that shall meet the following main requirements:

- power supply for CN EGF, OPS, and automatic firefighting equipment from UPS equipped with accumulators typically for at least 4 hours when SS MV is off for any reason;

- power supply for APCS and DCCS from UPS (possibly without internal AU with power supply from auxiliary direct current) typically for at least 2 hours when SS MV is off;

- power supply for other systems from UPS typically without internal AU powered by auxiliary direct current when SS MV is off in accordance with the applicable TSD;

- compliance with the requirements for electromagnetic compatibility.

2.3.2. Auxiliary Direct Current

Current shall comply with design standards for alternating-current substations with a high voltage of 35–750 kV.

2.3.2.1. SS ADCS shall meet the following main requirements:

- stationary AU with an operation life of at least 20 years (in the case of auxiliary-current control cabinets, at least 15 years) and a capacity able to provide maximum rated inching currents after the prescribed (at least two hours) discharge with load current in self-contained mode (in the event of lost auxiliary supply for SS) during the entire operation life;

- electromagnetic compatibility;

- automated search for ground in an auxiliary direct-current network without shutting down connections from DCSB;

- automatic detection of decreases in insulation for each pole and simultaneous decreases in insulation for both poles of ADCS;

- SS ADCS shall have three- or two-level protection system:

• bottom level: protection for electricity supply circuits for direct users (relay protection, breaker control circuit, etc.);

• medium level: protection for ADCDC circuits and other DCSB users;

• top level: protection for DCSB busbars at AU input;

- protection for an auxiliary direct-current network at the top and middle levels shall use switching and protective devices with electrically safe fuses, automatic circuit breakers are recommended for the bottom level;

- the design of protective devices shall ensure their safety operation.

2.3.2.2. ADCS rated 220 V are recommended for distribution SS rated 35 kV and above.

2.3.2.3. The use of auxiliary direct current for SS rated 35–110 (150) kV is determined by the need to install SD and modern relay protection systems, APCS, PAS and organize digital communication channels.

2.3.2.4. The rehabilitation of distribution SS rated 35–220 kV associated with the installation of microprocessor-based protection may, in addition to existing ADCS, use new (backup) ADCS for power supply only for rehabilitated SS components.

2.3.2.5. AU connections to first-level protective devices and between elements shall be flexible (stranded) copper cables with acid-resistant insulation.

2.3.2.6. The following is also recommended for auxiliary direct current:

- device for monitoring current ADCS parameters;
- device for controlling network pole insulation from the ground;
- automated fault locator system;
- device for measuring network pole insulation from the ground without disconnection (ground search);
- ADCS disturbance recorder with data communication to APCS or telemetry (with appropriate justification);
- signal transmission to APCS and telemetry about generalized malfunctions.

2.3.2.7. Current solutions for ADCS shall be focused on:

- developing standard schemes of auxiliary power supply (ADCS, AT, UPS, DGU) and standard design solutions with due consideration to solutions of various manufacturers;
- using modern methodologies for calculating S/C currents and selecting types of protective devices and parameters of their actuation;
- considering using new alternative direct-current sources instead of AU.

2.3.2.8. Measures to organize rectified auxiliary current shall use stabilized voltage units connected to VT on the SS HV side and current-based power supply units connected by CT on the SS HV side.

2.3.2.9. Automatic or manual devices shall be used to locate ground faults without disconnections in rectified auxiliary current systems.

2.3.2.10. Operational interlock circuits shall be powered by SS ADCS with galvanic separation.

2.3.3. Auxiliary Alternating Current

2.3.3.1. It shall be recommended that auxiliary alternating current and rectified auxiliary alternating current generally be used for SS rated 35 kV, TSS, DSS, and DTSS rated 6–20 kV.

2.3.3.2. Auxiliary alternating current may be used for SS with HV of 110 kV only with additional justification.

2.3.3.3. Schematic solutions for auxiliary alternating-current supply shall provide as follows:

2.3.3.4. Auxiliary alternating-current circuits shall be provided with insulation control devices.

2.3.3.5. Auxiliary alternating-current sources for protection and control circuits shall be separate CT to which are connected power supply units and precharged capacitors.

2.3.4. Rechargers

2.3.4.1. Rechargers (RC) shall ensure:
2.3.4.1. Rechargers (RC) shall ensure:
- automatic three-stage charge (stage of limiting the initial charge current, stage of limiting voltage, stage of providing temperature-compensated voltage stabilization);
- float voltage quality (level, ripple, stability, and temperature compensation) in accordance with the technical specifications of specific accumulators;
- voltage quality in accordance with the technical specifications of auxiliary direct-current receivers (for example, relay protection devices) both for float voltage and equalizing voltage;
- power supply for constantly energized devices (such as relay protection devices) in accordance with their technical specifications for interrupted communication with AU on any reason;
- automatic full charge of AU within the shortest possible period with due consideration to the limitations defined by the technical specifications of AU;
- supply for direct-current receivers, including AU disconnected for any reason;
- recharging of AU with constant stabilized float voltage recommended by the AU manufacturer.

2.3.4.2. The capacity of two RC simultaneously used for one AU shall ensure power supply for all SS power receivers connected to the ADCS set with due consideration to simultaneously providing an accelerated charge to AU up to 90% of the nominal capacity within 8 hours.

2.3.4.3. RC shall be powered by auxiliary sections rated 0.4 kV. Power supply for mutually redundant RC shall come from different sections of ASB rated 0.4 kV.

2.3.4.4. RC shall provide at least ±1% accuracy for the stabilization of output float voltage and temperature compensation for float voltage.

2.3.4.5. Current ripple for AU with float voltage shall not exceed 5 A per 100 Ah of AU capacity, and voltage ripple for fully loaded RC for the ADCS set with AU disabled shall not exceed ±5% $U_{nom.}$

2.3.4.6. RC shall have blocking for the actuation of equalizing and accelerated voltage for AU with idle supply and exhaust ventilation in AU rooms.

2.3.4.7. RC shall automatically turn on after power outages on the alternating current side and work in charging mode corresponding to the condition of AU.

2.3.4.8. Simultaneous parallel operation on the rectified voltage side shall be provided for two RC with symmetrically divided load current, or operation shall be provided for one RC in standby mode (in the case of three RC for two AU).

2.3.4.9. RC shall not be placed in one cabinet or in adjacent cabinets.

2.3.4.10. Reliability requirements for RC:

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

2.3.5. Utility Infrastructure

2.3.5.1. An essential precondition for the operation of equipment for electric grid facilities is to provide them with utility infrastructure and ensure its reliable and efficient operation.

2.3.5.2. As related to utility infrastructure for electric grid facilities, the Technical Policy shall be aimed at:

- use of equipment, hardware, and automation with characteristics and functional capabilities that meet the modern level of utility infrastructure development;
- organizational and technical transformation associated with EGF digitalization;
- use of modern effective technologies for the construction and operation of utility infrastructure.

2.3.5.3. Basic principles of building utility infrastructure for SS rated 110 kV and above:

- use of controllers of local automation for field-level utility systems based on freely programmable controllers with a Russian interface;
- use of utility systems with due consideration to recovering heat from process equipment and energy conservation requirements;
- interconnected operation analysis and management for utility equipment that have an impact on the same parameter of regulation;
- observability of all operation parameters and modes of utility equipment;
- self-diagnostics and remote diagnostics of utility equipment;
- information exchange about the state of equipment, about the parameters of the air environment, about events in utility infrastructure subsystems through digital communication systems and equipment supporting IEC-approved protocols;
- self-contained automatic control and centralized remote control of utility infrastructure equipment.

2.3.5.4. Utility infrastructure subsystems that provide process equipment with the necessary climate mode of operation during its work, shutdown, storage, and mothballing, and the necessary parameters are the following subsystems:

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

2.3.5.5. Requirements for fire protection equipment:

- the construction (rehabilitation) of fire protection facilities shall be based on addressable devices with controlled communication lines and a ring topology;
- power supply shall be Category I reliability, come from two independent power supply sources, and use UPS, ensuring self-contained operation in on-duty mode with lost main and backup power supply for 4 hours;
- remote control shall be provided for all required parameters of fire protection equipment (position, pressure, temperature, level, voltage, etc.), operation modes, power supply by interface or dry contact;
- measures shall be implemented to ensure reliable detection for fire outbreak signs, dust control for each detector to prevent false warnings and emergency situations;
- in order to verify fire alarms actuation without calling operational mobile crews, it is necessary to ensure remote video surveillance for the premises of IDSG and SSCR and others premises with primary process equipment, using fire-extinguishing and fire alarm systems, and for primary process equipment located at ODSG;
- it is necessary to ensure the integration of fire protection systems and utility equipment into the PAS subsystem, namely a control system for fire protection and utility equipment designed to ensure the 24/7 monitoring of the performance of fire protection systems and utility equipment and, where possible, the control of the condition of utility infrastructure, remote diagnostics, repair management, forecasting, and accident prevention.

2.4. Relay Protection

2.4.1. General

2.4.1.1. The requirements for relay protection shall inherently comply with design standards for alternating-current substations with a high voltage of 35–750 kV.

2.4.1.2. Reliable RP ensures the stable operation of Russia’s UPS, lower damage from damaged electrical equipment and electricity underdelivery (decreased electricity transmission or distribution) in the event of process failures in the electric power industry.

2.4.1.3. The reliability of RP is determined by:

- architecture ideology;
- quality of the calculation and selection of actuation parameters;
- measures to ensure serviceability through timely and high-quality TO&M;
- information security.

2.4.1.4. The RP architecture ideology shall be based on:

- using modern, technologically compatible intellectual microprocessor devices with increased time between maintenance;
- building RP systems where the malfunction in an individual element or device does not lead to any failure or incorrect operation of all RP functions related to protected PL or equipment;
- implementing technical solutions in relation to controlling RP devices, namely a remotely changed operation mode of RP or individual functions (changing groups of settings, turning on an off individual levels of protection and an entire RP device);
- using standard technical solutions (standard architectures for building digital substations) and books of standard schemes of secondary switching and using standard factory-assembled cabinets (panels);
- providing RP systems with built-in information protection devices meeting the Company’s requirements for built-in PAS information protection devices;
- providing short- and long-term RP backups;
- ensuring the “resilience of RP (self-contained fulfillment of basic functions), regardless of the serviceability of other automated systems;
- using replacement microprocessor RP devices that shall be available at all times and remotely controlled.

2.4.1.5. In order to decrease OPEX associated with personnel training, reduce the time of maintenance, reduce the risk of incorrect operation of RP through the fault of personnel, uniform cabinets are recommended for use within one of the SDCs.

2.4.1.6. In selecting RP equipment, priority shall be given to devices manufactured in the Russian Federation.

2.4.1.7. Selected RP equipment, including it software, shall be compliant with IEC 61850 and shall pass the EGF quality control procedure, except where it is used for test operation.

2.4.1.8. RP devices brought into use shall ensure:

- selectivity of identifying damage to the grid's elements through the use of modern algorithms and principles;

- required operation speed;

- reliable operation, including through high-quality self-diagnostics for devices;

- correct operation with due consideration to the operation of electromagnetic CT in transient short-circuit conditions;

- measures to improve the efficiency of RP operation as a whole through the use of adaptive properties based on intelligent algorithms, including using power system models with automatically refined parameters of the current mode.

2.4.1.9. The quality of calculated and selected parameters actuating RP devices shall be ensured by:

- using the applicable guidelines for the calculation and selection of parameters actuating RP devices with due consideration to recommendations of equipment manufacturers;

- using software and hardware systems for RP services to maintain the power system model, calculate parameters of the replacement of the energy system's elements, calculate emergency mode parameters, and calculate and select parameters actuating RP devices.

- modeling existing and future grid elements, actively adaptive intelligent elements: FACTS, SRPC, CSR devices, PL series compensator, DCL, TOP, energy storage devices, etc.;

- maintaining a high level of qualifications for RP personnel dealing with the calculation and selection of parameters (settings) and algorithms for the operation of RP systems and devices; increasing control over the preparation and implementation of measures to customize RP devices (systems).

2.4.1.10. The serviceability RP devices (systems) shall be ensured by:

- maintaining a high level of the operational condition of systems and promptly modernizing RP;

- creating software and hardware systems for the automated examination and assessment of the condition of RP devices;

- organizing and conducting the required technical operation and maintenance;

- employing highly qualified RP personnel.

2.4.1.11. The technical operation and maintenance of RP devices shall be organized in accordance with the applicable maintenance rules for RP devices (systems) and shall include:

- using effective methods for examining RP devices for the timely detection and replacement of units and components exposed to malfunctions during the lifecycle of RP devices and during extended operation life;

- using remote control for functions and the control (monitoring) of the condition and correct operation of RP devices;

- using automated systems for examining and assessing the condition of RP devices.

2.4.1.12. Recruiting highly qualified RP personnel with special training and RP maintenance permits shall be a priority for the Company in the area of ensuring the reliable operation of the EGF as a whole.

2.4.1.13. In order to ensure information security, special measures shall be implemented to prevent any destructive impact on equipment.

2.4.1.14. The number of CT, secondary CT windings, and their accuracy classes shall ensure the separate connection of RP, AISEBM, and meters.

2.4.1.15. Technical characteristics of current transformers and connected RP devices shall ensure the correct operation of relay protection from short circuits, including in the event of an aperiodic component of current.

2.4.1.16. Mutually redundant RP devices, including primary and standby protection for PL (equipment), shall be connected to different secondary CT windings, powered by different auxiliary direct-current breakers, and have independent output circuits.

With the evolution of relay protection for the trunk network, consideration shall be given to the integration of relay protection systems with APCS of power facilities at the information level. However, the operation of RP devices shall be self-contained and shall not depend on the condition of APCS.

2.4.1.17. OCL rated 35 kV and above shall use ARC if cable sections are used only for entering SF6/I FASG. In other cases, ARC shall be used for OCL rated 35 kV and above if there are no cable sections with direct contact between cables with different phases. Transpositional couplings in a cable section shall not influence the use of ARC.

2.4.1.18. It is not recommended that OCL use separate RP devices for detecting S/C only in cable sections.

2.4.1.19. RP devices that used for basic protection for PL and/or ARC and installed on all sides of PL shall meet the requirements for functional compatibility.

2.4.1.20. Structurally, each RP cabinet shall be provided with the ability to completely put protection out of operation, disconnecting all external circuits that may incorrectly turn off breakers or incorrectly turn on CBFP when used in an RP cabinet.

2.4.1.21. 20 kV cable networks in megalopolises shall use RP devices that make it possible to selectively disconnect a damaged cable section without disconnecting other network sections or that are equipped with automatic self-healing for intact sections.

2.4.1.22. The technical registration and analysis of relay protection operation shall be in accordance with the Rules for the Technical Registration and Analysis of Relay Protection Operation (approved by Order of the Ministry of Energy of the Russian Federation No. 80 of February 8, 2019).

2.4.1.23. The interaction between electric power industry entities and electricity consumers in preparing, issuing, and implementing procedures for setting up relay protection devices is determined by Order of the Ministry of Energy of the Russian Federation No. 100 of February 13, 2019.

2.4.2. Particularities of Relay Protection Devices on Electricity Distribution Grids

2.4.2.1. Requirements for Relay Protection for 35 kV Transformers

2.4.2.1.1. Transformers rated 35 kV shall be provided with protection from the following types of damage:

- multiphase S/C in windings and taps (busbars);
- coiled short circuits in windings;
- currents in windings due to external S/C;
- currents in windings due to overloads;
- open-phase mode;
- overload protection for supply transformer windings;
- low level of oil;
- protection from one-phase ground faults (L/G S/C).

2.4.2.1.2. For transformers rated 35 kV and 2.5 MVA and above, it is recommended that differential protection be install.

2.4.2.1.3. Gas protection shall have insulation monitoring device for auxiliary current circuits coming to the gas relay, actuated by malfunctions in circuits with time delay for turning off gas protection and for signaling.

2.4.2.1.4. To provide sensitivity in the area of distant redundancy and performance in the area of near redundancy, reserve protection for transformers rated 35 kV shall have at least two steps.

2.4.2.1.5. Protection from overloads, a low level of oil, and open-phase mode shall typically react to signals.

2.4.2.1.6. LV input breakers of transformers rated 35 kV shall typically be equipped with ARC.

2.4.2.2. Requirements for Relay Protection for 35 kV Power Lines

2.4.2.2.1. PL rated 35 kV shall be provided with protection from the following types of damage:

- interphase S/C;
- one-phase ground faults.

2.4.2.2.2. On single lines with power supply from one end, protection from multiphase short circuits shall predominantly use stepped current protection or stepped current and voltage protection, and if such protection does not meet the requirements for sensitivity or disconnection speed, remote stepped protection shall be used, mainly with a current-activated start. In the latter case, additional protection shall be a current cutoff without time delay. All steps of current protection shall be provided with the function of protection accelerated by a breaker activated by a short circuit.

2.4.2.2.3. On single lines with power supply from two or more ends, whether or not bypass connections are available, and on the lines included in a ring distribution grid with one supply point, the same protection shall be used as on single lines with power supply from one end, if necessary, they may be directional, and remote protection shall be activated by a resistance relay.

2.4.2.2.4. Protection from one-phase ground faults shall typically by activated by a signal. Protection may use insulation control devices.

2.4.2.2.5. Protection from one-phase ground faults shall be selective, with the possibility of identifying a damaged feeder, excluding the method of alternately disconnected lines.

2.4.2.2.6. OL rated 35 kV may use blind ARC one-end power supply for supply for OL or where asynchronous actuation is unlikely and may not damage equipment or the energy system.

2.4.2.3. Requirements for Relay Protection for 6–20 kV Power Lines

2.4.2.3.1. PL rated 6–20 kV shall be provided with protection from the following types of damage:

- interphase S/C;
- one-phase ground faults.

2.4.2.3.1. PL rated 6–20 kV shall be provided with protection from the following types of damage:

- interphase S/C;
- one-phase ground faults. _

2.4.2.3.2. On single lines with power supply from one end, protection from multiphase short circuits shall typically use two-step current protection, the first step being a current cutoff, and the second step being maximum current protection with independent or dependent characteristics of time delay. All steps of current protection shall be provided with the function of protection accelerated by a breaker activated by a short circuit.

2.4.2.3.3. On single lines with power supply from two ends, whether or not bypass connections are available, and on the lines included in a ring distribution grid with one supply point, it is recommended that the same protection be used as on single lines with power supply from one end, and, if necessary, they may be directional.

2.4.2.3.4. Protection from one-phase ground faults for distribution grids with isolated neutral or neutral compensated through an arc-extinguishing reactor shall typically react to signals. Protection may use insulation control devices.

2.4.2.3.5. Protection from one-phase ground faults shall be selective, with the possibility of identifying a damaged feeder, excluding the method of alternately disconnected lines.

2.4.2.3.6. On cable networks rated 20 kV with resistively grounded neutral, a damaged section shall be selectively disconnected by protection without affecting other network sections.

2.4.2.3.7. All connections of FASG rated 6–20 kV shall have arc protection with current control on input and section breakers.

2.4.2.3.8. Connections of OL rated 6–35 kV shall be equipped with single or double ARC devices on the head breaker of a line and at sectionalizing points.

2.4.3. Disturbance Recorders and Fault Locators for Power Lines

2.4.3.1. Disturbance recording systems shall ensure:

- disturbance recording for events and processes to the extent necessary for their full analysis;
- recording of electromagnetic transitional processes (DR systems) and electromechanical processes (wide-area measurement (WAM) systems);
- automation of data collection and processing and the provision of access to databases and waveforms from network control centers;
- accessibility and visibility information received from DR;
- required accuracy of automatically locating damage to PL and automatically identifying damaged connections in the event of one-phase ground faults in networks rated 6–35 kV;
- decreasing outage duration and risks of interphase short circuits by generating sufficient information and promptly providing such information (reducing operational personnel’s decision-making time in emergency situations) in the event of one-phase ground faults in networks with insulated neutral.

2.4.3.2. WAM systems shall ensure:

- monitoring of the effectiveness of emergency control;
- verification of the reliability of calculated models;
- sufficiency of the reliability of mode assessment;

- improvement emergency management.

2.4.3.3. Design shall consider solutions for the integration of WAM and DR systems with APCS, for data communication about accidents and for the provision of waveforms for NCC and DC in automated mode.

2.4.3.4. Automatic DR data communication to the RP operation monitoring system shall be used to ensure the maintenance of RP devices.

2.4.4. Main Areas of Development for Relay Protection

2.4.4.1. The contemporary development of information technology and computing technology, and the latest advances in the development of RP equipment and metering CT and VT make it possible to revise approaches to the implementation of RP functions.

2.4.4.2. High-voltage digital CT and VT, primary and secondary equipment are provided with built-in digital communication ports, including optical ports.

2.4.4.3. Improvements are made to IEC 61850, which regulates the efficient presentation and processing of automation object data, including data exchange between microprocessor-based intellectual electronic devices.

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

- increased interference immunity of secondary equipment due to the transition to digital optical communication channels;
- unification of interfaces;
- reduced number of cases of unacceptable decreases on insulation resistance in ADCS (optimization of ADCS architecture due to the use of digital data exchange via digital interfaces);
- easier operation and maintenance of RP devices due to efficient real-time diagnostics, no distortions in transmitted signals, and the collection and display of exhaustive status information about facilities;
- unification of processes related to the design and operation of SS.

2.4.4.5. One of the main areas of the modernization (rehabilitation) of RP systems is the use of low-maintenance (unattended) intellectual electronic devices (microprocessor devices).

2.4.4.6. The implementation of innovative solutions in the area of RP shall not impair the operating reliability of RP systems or equipment, lower the achieved level of information security, or unreasonably increase operational costs.

2.4.4.7. The development of RP systems shall be based on the use of latest-generation devices and computing technology.

2.5. Overhead Power Lines

2.5.1. General

2.5.1.1. The main areas of the technical policy for the design, construction, technical upgrading, and operation of overhead lines (OL) are as follows:

- ensure the reliability and operating efficiency of OL;
- decrease construction and operation costs;
- reduce the impact on the environment, including by minimizing the width of forest clearings, using high towers and vertical pendant wires;
- reduce electricity losses on OL;
- use structures and materials ensuring resistance to vandalism, theft, and damage;
- use new standard series of towers made of weatherproof rolled steel, and lattice towers made of folded sections;
- use multifaceted steel, narrow-base lattice, reinforced-concrete sectioned, and composite towers for OL;
- use advanced, safe methods of construction, operation, and repair;
- as OL diagnostics technology advances, use diagnostics systems for the technical condition of energized OL without disconnecting them;
- use unmanned aerial vehicles and robotic systems for monitoring the technical condition of OL rated 110 kV and above;
- equip OL rated 35 kV and above with modern OL S/C locators;
- equip OL rated 6–35 kV on insulated-neutral electric grids with topographic-type OL S/C locators identifying the direction of S/C current to the place of damage and transmitting data about the damaged section to the grid;
- provide all necessary emergency reserve for equipment and materials, ensure its optimal placement, and determine routes for its delivery;
- use computer-aided design (OL CAD);
- use geoinformation systems based on satellite navigation systems (GPS, GLONASS).

2.5.1.2. OL shall comply with the following main requirements:

- OL 6 kV and above shall be provided with a 3D digital OL model with the real-time terrain display (visualization) of OL on electronic GIS maps of NCC SHS with the ability to change the scale for visualization for the points of recording measured parameters;
- OL rated 110 kV and above shall have continuous control using AMDS for their current parameters and current state (primarily, OL transmission capacity), and periodic condition monitoring using UAV and robotic systems to remotely obtain status information for 3D digital OL models and electronic GIS maps of NCC SHS;

- OL S/C locators shall be used, displaying information in 3D digital models for overhead lines and electronic GIS diagrams for NCC SHS;

- 6–35 kV grids shall use reclosers with remote control;

- 6–35 kV grids shall use relay protection devices with a logical shutdown scheme for a damaged section and with self-healing for intact sections with information displayed on electronic maps.

2.5.1.3. GIS of NCC SHS shall be based on the Common Information Model (CIM) of the grid.

2.5.2. Technical Solutions for the Design, New Construction, and Rehabilitation of Overhead Lines

2.5.2.1. The design of OL shall consider the following technical solutions:

- unified designs of towers and foundations directly developed or modified and adapted for use in accordance with the requirements of TSD for OL rated 35 kV and above;

- recording of dangers of atmospheric and ground corrosion to OL elements in accordance with the results of engineering surveys;

- technical solutions that ensure increased reliability, minimize operating costs for OL rated 35 kV and above without year-round access for their maintenance and repair;

- at the stage the preparation of OL as-built documents and reporting documents, it is necessary to prepare a layout in accordance with the rules of the description of objects in SDCs' information systems for the subsequent prompt changes to object architecture in SDCs' information systems and equipment databases;

- use of wires with protective insulating sheath for OL rated 6–35 kV in a confined area, in a populated area, in forests;

- us of self-supporting insulated wires for OL rated 0.4 kV;

- protection for wires, cables, insulators, and accessories for OL rated 35 kV and above from fatigue damage and dynamic loads shall use wind protection systems (eolian vibrations, galloping, subspan oscillations), while vibration protection using vibration suppressors shall be in accordance with the analytical method of IEC 61897, galloping protection with galloping suppressors shall be in accordance with the manufacturer's recommendations and subspan oscillation protection shall use suppressor spacers in accordance with the manufacturer's recommendations;

- OL in severe operation conditions (climate, geological and special conditions), OL for new voltages or in new versions shall typically be designed based on the relevant design and, if necessary, research work with due consideration to the experience of construction and operation of OL.

2.5.2.2. For OL in especially severe operation conditions (mountains, swamps, the Arctic, etc.), design documents shall be include organizing the repair and maintenance of OL with due consideration to the use of equipment and vehicles corresponding to the conditions of future operation.

Decisions related to increasing OL transmission capacity in designing new and rehabilitated and repaired existing OL shall based on duly approved development schemes for electric grids.

2.5.2.3. Designing PL rated 110 kV and above equipped with shunt compensators shall include calculations of operation modes for the shutdown of PL after unsuccessful TPARC or an unsuccessful start of PL from a control key.

Calculations are aimed at determining the possibility of an aperiodic component of current in intact phases due to asymmetrical S/C. For an aperiodic component of current in intact phases of OL, measures are formulated to assess its share in the total no-load current of a line switched to an unliquidated S/C and, if necessary, prepare systemwide technical solutions for its minimization by the time of its shutdown by circuit breaker, and formulate the requirements for circuit breakers regarding their ability to ensure a successful shutdown of PL.

2.5.2.4. In order to reduce the time and optimize costs for the construction, technical upgrading, and rehabilitation of OL, the following shall be considered:

- industrial construction methods, the use of factory-assembled structures to minimize the time and complexity of OL onsite operations, and minimize the amount of excavation;
- construction and cleaning of forest clearings, using modern technical solutions (high-performance felling systems, mulchers, etc.);
- use of environmentally safe clearing technologies and technologies that prevent and reduce vegetation growth;
- technologies of building tower foundations ensuring the reduction of installation time and minimizing the amount of excavation (vibropiling, bored pile, screw piles, rods in rocky soils, high-performance drilling equipment for strong rock and rocky soils);
- typically, the use of truck cranes ensuring the installation of towers without using the falling jib method;
- use of helicopters or the installation of towers using the expansion method in a hard-to-reach area or in a confined area;
- replacement of steel-aluminum wires by wires with increased transmission capacity, including high-temperature wires if it is necessary to increase transmission capacity without building new OL. When reconstructing OL, this replacement shall be technically feasible: sufficient tower strength, load-bearing ability of bases and foundations, sizes.

- typically, the use of rapidly installed accessories (compression-type, helical, wedge-type) and collet-type connectors certified by PJSC "Rosseti" or duly tested with an appropriate wire;

- typically, on electric grids rated 6–20 kV and below with branches, the use of pin insulation; without branches, suspended insulation;

- use of towers for PL rated 6–20 kV for jointly suspended SSIW and IWOL for a voltage of up to 1,000 V.

2.5.2.5. If necessary and with an appropriate FS, OL rated 6–20 kV may have the same sizes as OL rated 35–110 kV.

2.5.2.6. When designing overhead lines rated 35 kV and above, it is necessary to find technical solutions that ensure the safety of their operation, including safe lifting/lowering, movement and work at height by building stationary rigid anchor lines and stationary ladders and/or stationary anchor points on reinforced-concrete supports, multifaceted, and other types of towers with the possibility of installing flexible anchor lines without using lifting rods or lifts, with the possibility of subsequently using slider-type protection and for use as a safety system for work at height.

2.5.2.7. When designing the construction of OL for flat terrain, OL shall use at most two grades and sections of wires. For specific sections of OL (long distances across water bodies, mountains, floodplains, swamps, severe climate conditions), the use of grades and sections of wires and lightning protection cables, or designs of phases different from those used for the other sections of lines shall be technically and economically justified.

2.5.2.8. The design of OL rated up to 35 kV shall typically use standard units specified in agreed standard solutions.

2.5.2.9. OL rated 0.4 kV shall use only SSIW compliant with GOST 31946-2012. If it is necessary to ensure the required OL transmission capacity, it is allowed to use SSIW with core sections larger than specified in GOST 31946-2012. In the case of buildings and building entrances, SSIW 4 (without inner supporting cores) with flame-retardant insulation shall be used. However, core sections shall not exceed 35 mm2.

2.5.2.10. The installation of OL rated 0.4 kV (new construction, replacement of uninsulated wires by SSIW, etc.) on trunk sections shall use only SSIW 2 (with zero-phase inner supporting cores). SSIW 4 (without inner supporting cores) may be used exclusively for accident recovery work or repair work on IWOL sections where SSIW 4 has been mounted before.

2.5.2.11. In the case of designing the construction or rehabilitation of OL rated 0.4 kV:

- OL shall be full-phase, with a wire of the same section throughout the length of the line;

- if the electric grid may be expanded, it is recommended that additional current leads of 16 mm2 be provided for the connection of street lighting.

2.5.2.12. The design of OL rated 35–750 kV shall take into account the results of mathematical modeling for operation modes of energy systems.

In order to prepare such calculation models, the design organization builds an information model for the energy system to the extent necessary for the design of PL in compliance with the requirements for the preparation and updating of information models for the electric power industry and the requirements for profiles of data exchange approved by the Ministry of Energy of the Russian Federation in accordance with Resolution of the Government of the Russian Federation No. 244 of March 2, 2017, “On the Improvement of the Reliability and Safety Requirements for Electric Power Systems and Electric Power Facilities and on Amendments to Certain Resolutions of the Government of the Russian Federation.” According to the results of developed design solutions, changes shall be made to the energy system information model in relation to the commissioning (decommissioning) of PL taken into account in the design.

2.5.3. Power Towers and Foundations

Basically, the requirements of design standards for power lines rated 35–750 kV shall apply.

2.5.3.1. OL rated 35 kV and above shall use towers with the necessary height and strength complying with the applicable regulatory documents: single-circuit, double-circuit, and multi-circuit multifaceted and lattice towers of L-shaped steel sections; composite towers; reinforced-concrete towers made of centrifugally cast sectional poles.

2.5.3.2. For OL rated 35 kV and above in urban areas and areas with a high risk of vandalism, it is recommended that intermediate towers be free-standing multifaceted steel sections or reinforced-concrete towers made of centrifugally cast sectional poles.

2.5.3.3. OL 220–500 kV in agricultural land, shall use steel or reinforced-concrete sectional poles, free-standing towers (without anchoring wires). OL rated 35, 110 (150), 220 kV in agricultural land may use composite towers with insulating traverses, subject to ensuring the reliability and safety of their use, ensuring resistance to external impacts, and with appropriate technical and economic justification.

The use of towers with anchoring wires for OL rated 35-500 kV in agricultural land and populated areas, and for OL from nuclear power plants is not allowed.

2.5.3.4. Anchor and angle-tension towers of OL 220-750 kV shall, without justification, use free-standing rigid steel towers.

2.5.3.5. Geometric parameters and weights of towers and their arrangement shall be adapted for specific OL, including through the selection of materials for towers and the wide use steels with increased mechanical strength and corrosion resistance, with an appropriate FS.

2.5.3.6. The design of towers for OL 220 kV and above shall ensure the ability to maintain and repair energized OL, the maximum efficiency of installed wires and cables, and no need for special permits for transportation by road.

2.5.3.7. Steel towers and steel parts of reinforced-concrete towers and structures, metal structures of foundations, U-shaped bolts, non-corrosion-resistant steel fastenings shall be protected from corrosion by the manufacturer using hot or thermal diffusion galvanizing. If hot galvanizing is not suitable for coatings (for example, metal parts of reinforced-concrete foundations to which grillages are welded during installation), the manufacturer may use zinc varnish coatings, with the restoration of welding-damaged areas after installation.

2.5.3.8. Estimated climate loads on towers and foundations shall be based on engineering surveys, regional maps of climate zoning, the applicable TSD, and codes and rules.

2.5.3.9. It is allowed to use high towers build by additions, ensuring the operation of OL in industrial and infrastructure facilities or specially protected forest areas with minimum possible widths of clearings, with sufficient justification, with due consideration to the costs of the entire OL lifecycle (50 years). OL rated 110 kV and above in an area with frequent ground or peat fires shall use elevated towers.

2.5.3.10. It is recommended that OL in populated areas, tourism and recreational areas, near places of recreation, in national parks and nature reserves, at intersections with large highways near urban areas use decorative durable paint and varnish for towers and use individual designed towers with due consideration to increased esthetic requirements.

2.5.3.11. OL rated 0.4–20 kV may used vibrated reinforced-concrete poles, multifaceted towers, metal poles made of folded sections, composite towers, and wooden antiseptic-treated towers. Types of towers shall be selected with due consideration to a feasibility study and, in the case of OL in populated areas, compliance with esthetic requirements.

For OL rated 0.4 kV, consideration shall also be given to the replacement of three-pole angle-tension reinforced-concrete towers by one-pole multifaceted steel towers.

2.5.3.12. Wooden towers for OL rated 0.4–20 kV shall be installed directly into the ground; the installation of wooden towers for OL rated 0.4–20 kV using reinforced-concrete stubs (attachments) is not allowed for new construction, rehabilitation, or repair.

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

2.5.3.13. To prevent nestling on towers of OL rated 110 kV and above in bird habitats, towers shall be equipped with safe bird protection devices and bird guards to protect insulating strings from bird excreta. Such devices may be used for OL rated 6–35 kV with appropriate justification.

2.5.3.14. On OL towers with a height of 100 m or more, regardless of their location, shall be provided daytime markings (painting) and warning lights in accordance with the Federal Aviation Rules “Requirements for Airfields Intended for the Takeoff, Landing, Taxiing, and Parking of Civil Aircraft” (approved by Order of the Ministry of Transport of the Russian Federation No. 262 of August 25, 2015).

Warning lights for towers shall be small-, medium-, and high-performance obstruction lights installed on the top and at the ends of the longest cross-arms.

Recommended power supply for obstruction lights is renewable energy sources (solar batteries) or power from OL.

Towers with a height of 50 meters and above near airports shall be equipped with spherical radio-detectable signal markers on lightning protection cables. OL towers with a height of more than 150 m shall have daytime markings (painting) and high-performance warning lights in accordance with OS 34.01-2.2-016–2016 “Markings for Overhead Power Lines. Markings for Towers and Spans of Overhead Lines.”

2.5.3.15. OL towers in a confined area near SS shall typically make it possible to suspend two or more circuits of OL rated 220 kV and above and up to four circuits rated up to 110 kV.

2.5.3.16. Operation life for metal, reinforced-concrete, and composite OL towers shall be at least 50 years. Operation life for wooden towers shall be at least 40 years.

2.5.3.17. Accident recovery work on OL rated up to 220 kV shall use special prefabricated towers, including reusable, a mobile set of prefabricated towers complete with foundations and insulator sets (including multifaceted and composite towers), which have rapid and easy installation, able to be put into operation within a short period, with the aim of maximally reducing the time of accident recovery.

2.5.3.18. The conditions for using foundations for OL are defined by design documents subject to the requirements of the applicable TSD based on the results of soil studies (geological engineering, hydrogeological, and other surveys) in places of their installation.

2.5.3.19. In selecting types of tower foundations, preference shall be given to foundations having the least destructive impact on the structure of soil.

2.5.3.20. The design of the new construction and rehabilitation of OL shall use:

- unified prefabricated reinforced-concrete foundations (buried, shallow, surface);
- solid-cast reinforced-concrete foundations;
- pile foundations with metal grillages (reinforced-concrete piles, tubular piles, open-end piles, screw piles);
- bored piles (reinforced-concrete centrifugally cast and metal).

2.5.3.21. Consideration shall be given to the practicability of using the following for OL:

- industrial methods of work in field conditions;
- modern corrosion-resistant materials, weather-resistant steels and coatings for protection for reinforced-concrete and metal structures from corrosion;
- foundations for guy wires of towers with above-ground fastenings of U-shaped bolts;
- foundations that do not destroy soils especially severe geocryological conditions;
- guy wires made of compacted steel ropes or similar durable lightning protection cables with low aerodynamic resistance with self-extinguishing vibrations.

2.5.3.22. Towers in permafrost soils shall typically use foundations that ensure the preservation of frozen soils during construction and throughout the operation of OL. Steel (driven and screw) piles whose inner space is filled with lightweight (foamed) material at the factory, are recommended.

2.5.3.23. Fastenings for OL towers in rocky soils shall use anchor rock embeddings and foundations from bored injection piles.

2.5.3.24. OL towers in dune sands shall be installed between dunes with sand-fixing measures.

2.5.3.25. The method of installing OL towers rated 0.4–20 kV in the ground shall be uniform.

2.5.3.26. In accordance with SP 28.13330 "Protection for Construction Structures from Corrosion," reinforced-concrete structures of towers and foundations shall use concrete whose water resistance, frost resistance, and other characteristics shall ensure reliable operation throughout their operation time but at least 50 years without surface waterproofing.

2.5.3.27. In aggressive environments, foundations made of sulfate-resistant cement coated with special protective substances shall be used.

2.5.3.28. Concrete foundations shall have waterproofing to prevent the destruction of reinforced concrete from impacts of aggressive water and soil and shall have durable surface waterproofing not destroyed by ultraviolet radiation, temperature fluctuations, or external impacts.

2.5.3.29. Metal heads of reinforced-concrete foundations and metal grillages shall be protected from corrosion in accordance with the applicable regulatory documents.

2.5.3.30. Prototypes of newly used types of OL towers and foundations are shall be mechanically tested. When evaluating the possibility of using structures of towers and foundations in conditions different from those for which they designed, it is necessary to verify calculations for specific conditions of their installation. Calculations for structures shall be contained in OL design documents.

2.5.4. Wires and Lightning Protection Cables

2.5.4.1. On OL rated 35 kV and above, steel-aluminum wires shall typically be used.

2.5.4.2. With an appropriate FS, OL rated 110 kV and above may use new designs of wires, leading to a significant increase in transmission capacity without increased loads on towers and having better technical characteristics than standard wires:

- in new construction: wires with cores of steel and aluminum alloys or composite nonmagnetic materials:

• with increased transmission capacity;

• with a cylindrical surface of trapezoidal or Z-shaped wires or in a different shape with a lower aerodynamic drag factor;

• with increased corrosion resistance;

• with increased resistance to ice and wind;

• with the best deformation capacity and with better torsional rigidity;

- in rehabilitation, for the purpose of raising transmission capacity while maintaining (or reducing) tower loads, and in the construction of large spans, the following wires shall be used:

• with long permissible temperatures of up to 240 °C with conductor layers of heat-resistant and super-heat-resistant aluminum alloys;

• with corrosion-resistant cores, including cores of steel, aluminum alloys, or composites, with a view to decreasing loads on towers and foundations;

• with an appropriate FS, wires containing optical wires (OPPW).

2.5.4.3. Lightning protection cables for OL rated 35 kV and above shall use:

- ropes and wires made of galvanized or aluminum-clad steel wires, lightning protection cables made of low-alloy steel with high lighting-surge proofness, mechanical strength, corrosion resistance, resistant to wind and vibration;

- lightning protection cables containing optical power ground wires (OPGW), including with heat-resistant optical fibers meeting the requirements of PJSC "Rosseti" applicable standards.

The replacement of lightning protection cables for OL in accordance with SDCs' approved targeted and if it is necessary to build FOCL for a given OL determined in accordance with the approved FOCL development scheme, it is necessary, if technically and economically feasible, to use OPGW. _

2.5.4.4. In areas with high wind and ice loads, and on large spans, it is recommended that OL rated 35 kV and above use new designs of wires substantially increasing transmission capacity and exceeding technical characteristics of standard designs in order to:

- decrease loads on towers and foundations;
- increase the length of spans;
- decrease the aerodynamic drag factor;
- decrease the probability of galloping;
- decrease the probability of wires broken by external mechanical loads (snow and ice protection).

2.5.4.5. With an appropriate 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 OL rated 35 kV and above shall be at least 50 years.

2.5.4.7. On OL rated 6–20 kV, a steel-aluminum bare wire or a protected wire with a cross section of at least 70 mm2 shall be used. On linear branches (taps) from the mains, 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 for use on OL rated 6–35 kV in the first place:

- if OL pass through populated areas;
- if OL pass through forests;
- if OL cross water bodies;
- if it is not possible to observe overall distances when OL are in a confined area;
- with joint suspension with insulated-wire OL rated 0.4 kV.

With an appropriate feasibility study, it is allowed to use a self-supporting cable on OL rated 6–35 kV.

2.5.4.9. The new construction and rehabilitation of OL rated 0.4 kV on trunk sections shall predominantly use certified self-supporting insulated wires (SSIW-2 grade) with an insulated strength member. The use of the SSIW-4 on trunk sections is allowed exclusively for accident recovery work or repair work on IWOL sections where SSIW-4 has been mounted before.

2.5.4.10. Wires for IWOL rated 0.4 kV with an insulated strength member may be installed both on towers and on walls of buildings and structures subject to paragraph 3.1.15.

2.5.4.11. IWOL rated 0.4 kV with a distributed load along the line shall use SSIW of at least 50 mm2. The length of IWOL rated 0.4 kV shall ensure stable voltage for the customer at the end of the line in accordance with the requirements of TSD. To connect specific customers and build branches from the line, SSIW with a smaller cross-section may be used, but at least 16 mm2.

2.5.4.12. Air bushings on the sections of lines from through-type insulators of FASG cubicles before the first OL towers rated 6(10) kV, it is typically necessary to use protected insulated flame-retardant wires. The fire hazard class of wires is not below O1.8.2.5.4 in accordance with GOST 31565-2012 *Cable products. Requirements of fire safety.*

2.5.4.13. Operation life for SSIW shall be at least 40 years (rated operation life for designed IWOL).

2.5.5. Insulators and Line Accessories

2.5.5.1. The number and type of insulators in insulator strings for different applications, along with coupling, supporting, tension, protective, connecting, and branch (contact) accessories for OL, shall be selected in accordance with the applicable regulations and with due consideration to local conditions, including the availability of updated insulation pollution maps, and subject to the requirements of design documents.

2.5.5.2. The design of the new construction and rehabilitation of OL shall:

- use solid-cast polymer insulators with organosilicon protective sheathing, available for service all year round, in areas with APL I–III (except for OL in areas rated III and above in terms of wind/ice), with appropriate justification;
- use insulator strings equipped with protective accessories for OL rated 220 kV and above;
- use long-rod porcelain insulators for OL rated 110 kV and above, with appropriate justification;
- use cantilevered polymer insulation cross-arms for OL rated up to 220 kV in a confined area with access to towers by aerial platform for TO&M for accessories and insulators;
- use glass insulators on large spans of OL rated 35 kV and above, on OL located in difficult conditions (mountains, swamps, the Arctic), on OL on double-circuit and multi-circuit towers, on OL supplying power to traction substations of electrified railroads;

- use coupling, support, tension, protective, and connecting accessories that do not require maintenance, repair, or replacement during the operation life of towers and wires;

- use compression-type, wedge-type, spiral and, with sufficient justification, bolted accessories for steel-aluminum wires as tension accessories in accordance with GOST 839;

- use multi-frequency and broadband (pneumatic) vibration suppressors (at least 3 resonant frequencies);

- use ice protection in areas rated III and above;

- use galloping suppressors in areas with frequent and intense galloping;

- use interphase spacers in areas with frequent and intense galloping;

- use blind suspension for transitional intermediate towers of large spans;

- use line accessories not causing local heating in wires in places of its installation;

- use suspended glass insulators with moisture-repellent polymer coatings, with appropriate justification, in areas with APL IV and above, in areas with increased insulation pollution;

- use damping remote phase spacers in areas with frequent and intense galloping, and in combination with new designs of wires with increased rigidity for OL rated 330–750 kV;

- it is recommended that OL rated 220 kV and above use spiral stub clamps as reinforcement for welded seams in angle-tension towers;

- use anchor and branch accessories for branch connections to IWOL SSIW in a building entrance area (electricity connections for customers), using flame-retardant materials.

2.5.5.3. OL rated 35–110 kV shall mainly use glass insulators, and, with appropriate justification and flashover indicators, polymer insulators.

2.5.5.4. The design of OL rated 35 kV and above shall include calculations for protection for wires, lightning protection cables, and accessories from vibration, galloping, and subspan oscillations, using CAD.

2.5.5.5. To reduce flexural tension and increase operation life for wires and lightning protection cables, it is recommended that supporting and connecting clamps be used with built-in spiral protectors, using multifrequency or broadband vibration suppressors installed on wires in places determined based on the length of a span. For additional vibration protection and to prevent the destruction of wires (cables), it is recommended that supporting and connecting clamps use spiral protective protectors or spiral supporting clamps.

2.5.5.6. To reduce costs resulting from losses caused by transport current, supporting, connecting and tension accessories installed on OL wires shall be made of nonmagnetic materials, while accessories shall comply with GOST R 51177-

2017: energy losses caused by magnetic reversal due to the installation of tension, supporting, connecting, repair, contact, and protective accessories on the wire of one facility shall not exceed energy losses in the wire 1 m long or shall not be 1.1 times as much as those for a wire section equal to the length of accessories.

2.5.5.7. In the case of OL rated 35 kV and above, the attachment strength for a wire in tension clamps mounted on transitional anchor towers of large spans shall be confirmed by compulsory control tests;

2.5.5.8. The design of tension accessories for OL rated 35 kV and above shall not increase the length of insulating suspension components necessary to connect insulating suspension.

2.5.5.9. In areas with high insulator damageability caused by vandalism, it is recommended that long-rod polymer insulators be used in combination with flashover indicators. Polymer insulation may be used without flashover indicators if OL is equipped with fault locators with an accuracy of one span.

2.5.5.10. The design of OL rated 6–20 kV shall use:

- suspended polymer or glass insulators;
- cantilevered polymer (cantilevered with anchoring wires) insulation cross-arms;
- cylindrical-post porcelain and polymer insulators, including those with eyelets for protected wires;
- porcelain pin insulators with eyelets;
- annealed-glass pin insulators;
- polymer phase spacers;
- polymer insulation cross-arms.

2.5.5.11. IWOL rated 0.4 kV and PWOL rated 6–20 kV shall use line accessories with the corresponding designs.

Connections and branches on IWOL rated 0.4 kV and PWOL rated 6–20 kV shall use only special clamps corresponding to types of SSIW or protected wires. Branch connections to OL bushings with internal wiring shall use disposable, piercing, sealed branch clamps with breakaway heads, clamps with breakaway heads shall not be reused.

2.5.5.12. Accessories for OL rated 6–35 kV with plastic components shall be tracking-resistant.

2.5.5.13. For IWOL rated 0.4 kV and PWOL rated 6–35 kV, accessories suitable for installation at temperatures of up to –20 °C shall be used.

2.5.5.14. For IWOL rated 0.4 kV and PWOL rated 6–35 kV, branches from the main line and connections between uninsulated and insulated wires shall use accessories having different colors for voltage classes:

2.5.5.15. For IWOL rated 0.4 kV, accessories made of flammable and nonflammable materials shall have different colors.

2.5.5.16. Line accessories for OL shall not require maintenance and shall correspond to operation life for wires and cables.

2.5.5.17. Operation life shall be at least 30 years for porcelain and glass insulators and at least 40 years for polymer insulators.

2.5.5.18. For accident recovery work on OL rated up to 220 kV, it is possible to connect wires, using universal clamps (Figure 1) suitable for several wire diameters and mounted with manual tools without using compression tools or other mechanical equipment, selected with due consideration to climate condition in order to maximally reducing the time of accident recovery.

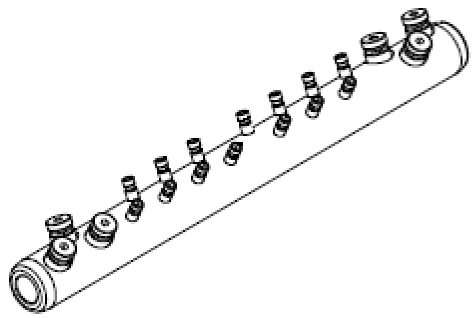

Figure 1. Universal clamp used to remedy accidents on OL rated 35–220 kV

2.5.6. Lightning Protection

2.5.6.1. The main method of protecting OL from flashovers caused by lightning strikes on OL elements is lightning protection cables and tower grounding. It is allowed to use OVS on OL rated 110 kV and above in ice areas IV and above instead of lightning protection cables.

2.5.6.2. OL rated 110 kV and above shall typically use lightning protection cables for full-length protection from lightning overvoltage and direct lightning strikes.

2.5.6.3. For OL rated up to 35 kV, the use of lightning protection cables along the OL route is not required except approaches to SG and SS. The use of cables and/or protective devices to increase the operating reliability of OL rated up to 35 kV is allowed with an appropriate FS.

2.5.6.4. Protection for OL approaches to SS shall be cables and/or protective devices.

2.5.6.5. In order to increase OL lighting-surge proofness in areas with high specific soil resistance, it is recommended that consideration be given to strengthening tower grounding circuits by using long and deep ground leads, and if this is not sufficient, lightning protection cables and surge protection devices, including line OVS or LP, shall jointly be used. In the event of using OVS as surge protection devices for OL rated 6–35 kV on electric grids with insulated (compensated) neutral, preference shall be given to OVS with external spark gaps, but OVS without external spark gaps on OL rated 110 kV and above.

2.5.6.6. On electric grids rated 110 kV and above, the new construction and rehabilitation shall use protective devices with operation counters and, for OVS, with actuation pulse current sensors able to measure currents leaks on energized equipment.

2.5.6.7. The use of lightning surge protection devices on OL rated 6–35 kV shall provide protection:

- for wires from overheating and thermal destruction;
- for approaches to SS SG;
- for OL insulation from flashovers and damage;
- for switching equipment;
- for cable couplings;
- for intersections of OL with utility facilities;
- post and mast TSS.

2.5.6.8. The design of OL with protected wires in populated areas and area with 20 or more lightning hours shall also use surge protection devices.

2.5.6.9. Metal elements of brackets and hooks for IWOL rated 0.4 kV shall be suitable for bolted connections for double-grounding leads.

2.5.6.10. It is recommended that special flexible current leads be used to connect ground conductors to ground leads for towers of IWOL rated 0.4 kV for double grounding.

2.5.7. Switching Equipment for 6–35 kV Lines

2.5.7.1. To optimize operation modes, increase electricity supply reliability, reduce costs of operation and maintenance work, the design shall include automation for automate grids rated 6–35 kV by using:

- automatic load transfer;
- outdoor vacuum breakers (reclosers) with microprocessor-based control units that program breaker operation for required operation modes for OL sectionalization;
- ARC systems for MSS line breakers and sectionalizing OL points;
- SD to disable OL branches;
- fault locators for OL;
- continuous monitoring using AMDS for OL in accordance with subsection 3.7.3 of this Technical Policy.

2.5.7.2. Sectionalizing points with vacuum breakers and automatic load transfer points shall be installed on trunk lines rated 6–35 kV and on extended OL branches with an appropriate FS.

2.5.7.3. ALT points and sectionalizing points shall be equipped with vacuum breakers and microprocessor devices for relay protection.

2.5.7.4. To disable branches from the trunk line more than 1.5 km long, it is recommended that SD be installed at the beginning of these branches.

2.5.7.5. To raise manageability and controllability for electric grids, all automation systems shall be able to send data to the NCC about the current condition of equipment use remote control for this equipment.

2.5.8. Requirements for Overhead Lines Used in Harsh Climatic and Geological Conditions and in Special Conditions

2.5.8.1. Areas with harsh climatic and geological conditions and special conditions include:

- ice area IV and above (ice thickness of 25 mm and above with a frequency of 1 time in 25 years);
- wind area V and above (rated wind pressure of 1,000 Pa and above at 10 m above ground with a frequency of 1 time in 25 years);
- areas where wind pressure in icy conditions with a frequency of 1 time in 25 years exceeds 280 Pa, regardless of the ice area;
- areas with frequent and intense galloping;
- areas with permafrost, flooded, swampy, heaving soils;
- areas with frequent ground or peat fires;
- areas with a high risk of vandalism;
- areas where OL accident rates from ice and wind loads exceeds the average for the region, regardless of the wind or ice area, according to climate zoning maps or regional maps.

2.5.8.2. When designing OL located in harsh climate and geological conditions, it is necessary to consider problems arising during the operation of OL in the considered regions such as:

- increased vibration of wires and cables;
- whipping wires and cables due to galloping, dropped ice and wind loads;
- low OL lighting-surge proofness;
- insulation flashovers due to ground and peat fires;
- cryogenic destruction of reinforced-concrete piles;
- frosty heaving of piles of tower foundations, etc.

2.5.8.3. For areas with frequent ice and in special ice areas, and in areas with high wind loads, it is necessary to consider building CL instead of OL.

2.5.8.4. In order to ensure the reliable operation of OL in areas with harsh climate conditions, it is necessary to consider measures and options to build OL:

a) in ice areas and in areas with high wind loads:

- construction of ice-resistant OL, i.e. designed for maximum observed ice and wind loads (use of towers, wires and line accessories with increased mechanical strength, use of special types of wires with high anti-icing characteristics, use of reduced lengths of anchor spans) without the use of ice melting;
- OL construction with the use of ice melting for wires and lightning protection cables;
- use of interphase insulation spacers, ice and snow protection for wires, towers with increased distances between phase wires and between wires and cables, galloping suppressors to prevent deiced wires from whipping;
- for OL rated 35 kV and above, the use of double-circuit support and tension insulator strings with circuits separately mounted on towers;
- use of glass insulators or, with appropriate justification, polymer insulators;
- use of horizontal phases for OL;
- use of AISEID;

b) in areas with intense galloping:

- for OL rated 6–35 kV, the use of interphase insulation spacers;
- for OL rated 110 kV and above, the use of galloping suppressors;
- use of towers with increased distances between phase wires and between wires and cables, taking into account possible trajectories of galloping wires;
- for OL rated 110 kV and above, the use of single-circuit OL with horizontal phases and OVS instead of lightning protection cables (with at most three lightning outages per year for OL rated 110-330 kV and one for OL rated 500 kV), the use of reduced tension (up to 25% of breaking strength) fir wires and cables with simultaneously decreased lengths of OL spans;
- for OL rated 6–110 kV, the use of reduced lengths of anchor spans and the use of composite towers;

c) in areas with a high risk of vandalism:

- use of free-standing towers, including multifaceted, reinforced-concrete sectioned and composite, the use of towers with increased protection from third-parties;
- use of polymer insulation;

d) in areas with frequent ground and peat fires:

- use of towers with an increased height of suspended wires, with appropriate economic justification. Materials of towers for OL rated 0.4-35 kV (wood, reinforced concrete, metal, composite) shall be selected depending on the area, conditions, and installation method according to FS, with due consideration to minimizing the impact of fires in the protected area of OL;
- use of glass insulators;

e) in areas with permafrost, flooded, swampy, heaving soils:

- typically, the use of free-standing towers and foundations (newly and earlier designed);
- allowed application solid-cast concrete foundations;
- to secure towers in permafrost soils, typically, the use of foundations that provide the preservation of frozen soils during construction and throughout the operation of operating OL. It is recommended that steel (driven and screw) piles with the internal cavity filled with lightweight (foamed) material at the factory be used.

2.6. Cable Lines

2.6.1. General

2.6.1.1. The main areas of the technical policy for the design, construction, technical upgrading, and operation of cable lines (CL) and cable jumpers rated 110 kV and above are as follows:

- ensure the reliability and operating efficiency of CL;
- use cables with cross-linked polyethylene (XLPE) insulation;
- use stationary systems of continuous monitoring using AMDS for CL rated 110 kV and above;
- decrease construction and operation costs;
- reduce the impact on the environment through the optimal use land, the use of structures and design solutions requiring, other than equal conditions least alienation land in permanent and temporary use;
- decrease electricity losses on CL;
- use structures and materials ensuring resistance to vandalism, theft, and damage;
- use advanced, safe methods of construction, operation, and repair;
- as CL diagnostics technology advances, use diagnostics systems for the technical condition of energized CL without disconnecting them;
- equip CL rated 35 kV and above with CL S/C locators;
- equip CL rated 6–20 kV on insulated-neutral electric grids with topographic-type CL S/C locators identifying the direction of S/C current to the place of damage and transmitting data about the damaged section to the grid.

2.6.1.2. CL shall comply with the following main requirements:

- CL rated 6 kV and above shall be indicated on electronic GIS maps of NCC SHS with a terrain layer, specifying utility networks near CL, places of couplings and using coordinate tags;
- CL rated 110 kV and above shall have continuous control using AMDS for

current parameters and current condition (primarily, CL transmission capacity) based on the use of fiber-optic digital technology that makes it possible to remotely receive information about relevant controlled parameters on electronic GIS maps of NCC SHS;

- electric grids rated 6–35 kV shall use relay protection devices based on a logical shutdown scheme for a damaged section and provided with self-healing for intact sections with information displayed on electronic GIS maps of NCC SHS.

2.6.1.3. GIS of NCC SHS shall be based on the Common Information Model (CIM) of the grid.

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

2.6.2.1. An obligatory precondition for the design of CL is permission from land users/owners for CL locations, conditions for land occupation, and consent from the owners of utility networks to intersections and approaches for designed CL and, if CL cross navigable rivers and other water bodies, from the owners of facilities and organizations that use water bodies.

2.6.2.2. When designing CL, it is recommended the uniform or standard designs be used for cable wells, cable facilities and other elements complying with the applicable LR and LRD.

2.6.2.3. At the stage of preparing as-built documents for CL and preparing reporting documents, it is necessary to prepare a model in accordance with the rules of SDCs' information systems used for facility descriptions for subsequent timely changes to the architecture of objects of SDCs' information systems and equipment databases;

2.6.2.4. CL design documents shall use technologies aimed at reducing excavation, including by using trenchless CL (horizontal directional drilling) or cable galleries to protect nature protection zones, landscaped urban areas, and places with densely located utility networks and infrastructure facilities;

2.6.2.5. CL design shall be in accordance with the principles of minimizing the number of connecting couplings and unifying equipment types.

2.6.2.6. The design of CL for special conditions (underwater laying, bridge laying), CL for new voltage classes or in new versions, and the construction of passages on special supports shall be based on relevant research and, if necessary, development, and on special technical specifications.

2.6.2.7. The design of underwater CL shall include:

- cable landings;

- backup for one-phase underwater cables rated 110 kV and above: one phase for one CL; two phases for two CL; for three and more, to be determined by design documents but not less two phases. Backup phases shall be laid so that they could be used instead of any of the existing phases.

2.6.2.8. The design of CL shall take into account:

- nominal voltage of the grid and neutral grounding;
- frequency and duration of overloads;
- current and disconnection time for S/C and L/G S/C;
- required load capacity of CL;
- climate conditions;
- special design requirements for cables (built-in optical fibers), and sealing (longitudinal or transverse) for cable insulation;
- measures to ensure the protection of CL from unauthorized persons;
- heating from close heat sources, soil temperatures, solar radiation impact;
- geometric location of one-phase cables;
- method and conditions for laying, condition of the environment (aggressiveness of ground, underground water, etc.);
- method for screen construction, the availability and location of screen transposition one-phase cables;
- factory length and number of connecting and terminal couplings, their location;
- fire safety requirements;
- compensation for thermal elongation;
- maintainability and reserve stock of connecting couplings;
- serviceability.

2.6.2.9. The design and construction of new CL shall be based on approved development schemes for electric grids. In the case of CL in a populated area, the route shall be selected in accordance with the design instructions for urban electricity networks and approved urban planning documents (general layouts for urban areas and other populated areas, schemes and projects of planning and development for territorial entities, etc.).

2.6.2.10. In urban areas, single CL shall typically be laid in the ground (trenches) on roadways, under sidewalks, in yards and lawn-type technical areas.

2.6.2.11. Technical solutions for the construction (laying) of CL (OCL) shall prevent damage to adjacent cable phases when one of the phases is damaged.

2.6.2.12. If the number of jointly laid CL is 10 and above it is recommended that they be laid in cable galleries, cable ducts, and cable tunnels. When crossing streets and squares with improved pavements and with heavy traffic, CL shall be laid in special heat-resistant nonmagnetic pipes for power cable protection, including with the possibility of cable damage locator functions.

2.6.2.13. For cables laid in confined spaces or spaces with densely located underground utility networks, or crossing roads, railroads, rivers, canals and other water bodies, wide streets and streets with heavy traffic, etc., it is recommended that closed-type laying be used for CL.

2.6.2.14. For intersections, it is recommended that reserve cables or reserve pipes be provided.

2.6.2.15. Cable pipes shall be special heat-resistant nonmagnetic pipes for power cable protection, including with the possibility cable damage locator functions. It is allowed to lay three-core cables or triangled one-phase cables in pipes made of magnetic material. However, calculations of permissible current loads shall be taken into account additional pipe losses.

2.6.2.16. Cable entries to buildings, cable facilities, etc. shall be in asbestos-cement, concrete, ceramic, or polymer pipes.

2.6.2.17. The necessity of laying reserve pipes shall be determined by FS, while for CL rated 110 kV and above with a pipe length of over 100 m, and in other cases, with appropriate justification, for rapid repair work, reserve pipes with laid reserve cables shall be used (in the case of one-phase cables, one cable for each circuit). If the pipe length is over 500 meters, at least two reserve pipes shall typically be used for each circuit. CL laid in pipes shall use special heat-resistant pipes for power cable protection, including with the possibility cable damage locator functions.

2.6.2.18. If CL are laid in aggressive soils, measures shall be taken to replace soil, and consideration shall additionally be given to CL laid in sealed pipes.

2.6.2.19. CL, including and in OCL sections, shall be protected from overvoltage (lightning and switching overvoltage), using OVS. However, lightning protection for cable inserts rated 35–220 kV long with a length of 1.5 km and above for OCL with lightning protection cables is not required.

2.6.2.20. For CL rated 35 kV and above, after the preliminary selection of cross-sections and designs for cables, clarifying thermal calculations shall be made for CL in accordance with GOST R IEC 60287 with due consideration to all factors determining cable temperatures.

2.6.2.21. Cable entries to SS buildings and other cable facilities (chambers, galleries, micro tunnels, etc.), cable branch terminals, passages through each floor structure and building structures shall be sealed with modern fireproof materials (products) with a fire resistance limit of at least EI 45, suitable for reusable applications, providing reliable waterproofing against ground water.

Cable sealing units in floor structures of SF6/I FASG shall be collapsible and suitable for reusable applications.

2.6.2.22. Cable passages (CP) for OCL located in a residential area shall be closed-type or mounted on special passage supports (gantries); CP for ODSS SG shall be open-type and mounted on the ground.

2.6.2.23. Mounted on special passage supports (gantries), CP shall meet the following requirements:

- supports shall withstand additional loads;
- cable couplings, OVS, support insulators, and other equipment shall be placed on special structures that allow equipment to be maintained without scaffolding and lifting mechanisms;
- unauthorized persons shall not have access;
- cables shall be protected from mechanical damage from the ground to base plates of terminal couplings;
- CL before terminal couplings shall have reserve cables for the reassembly of terminal couplings.

2.6.3. Cables

2.6.3.1. The construction of cable lines shall comply with the following requirements:

- cables tested for reliability in accordance with GOST R IEC 60840 (IEC 60840) and GOST R IEC 62067-2017 (IEC 62067) shall be used;
- CL rated 110 kV and above shall use cables with cross-linked polyethylene insulation and cross-sections of power cores of up to 3000 mm^2, with longitudinal core sealing, with transverse and longitudinal moisture-proof screen sealing, including a new generation of full sealing, with built-in optical fibers for cable temperature monitoring;
- underwater cables shall be armored cables with a uniform factory length, with cross-linked polyethylene insulation, ensuring the prescribed operation life under hydrostatic pressure;
- CL rated 20 kV and 35 kV shall use cables with cross-linked polyethylene insulation; the necessity of using cables with built-in optical fibers for cable temperature monitoring shall be determined by the design;
- it is recommended that CL of all voltages use cables with reinforced polyethylene sheathing for laying in the ground, preferably suitable for applications at temperatures of up to –20 °C without prior heating, with an external semi-conductor layer, including as part of fire-retardant coatings applied during laying and made of materials with reduced flammability, low smoke and gas emissions or made of halogen-free compositions with a high oxygen index for laying in utility networks;
- the design of CL passages from the coast to the sea in the presence of strong surf, cables laid in rivers with a strong current and eroded banks, and cables laid at large depths (from 40 to 60 m) shall use double metal armor cables;
- cables laid in mountains shall be armored cables placed in special utility structures;

- cables laid in seismic zones shall be armored cables. The laying method shall be determined by design documents and shall use special protection;

- CL laid in cable facilities shall be fireproof sheathed power cables, flame-retardant, with low toxic gas and smoke emissions;

- cables laid in fire protection systems and in others systems that shall remain operable under fire conditions shall be fireproof cables, flame-retardant if laid in groups, with low smoke and gas emissions;

- cables laid in soils containing substances that destruct cable sheaths (salt marshes, swamps, bulk priming with slag and construction material) and in hazardous areas exposed to electrocorrosion shall be cables with lead sheathing and reinforced protective coatings or cables with aluminum sheathing and reinforced protective coatings;

- cables laid in soils prone to tilting, shall be cables with wire armor, or technical solutions shall be found to eliminate forces impacting on cables during soil tilting;

- the laying and fastening of cables in cable facilities shall use metal structures with bolted connections, with anticorrosion coatings, made by hot galvanizing or thermal-diffusion galvanizing at the factory. Cables shall be fixed to metal structures, predominantly using cable clamps made of polymers.

2.6.3.2. The selection of cable core cross-sections shall be based on the calculation of the necessary transmission capacity, thermal S/C resistance, laying depth, air temperature, thermal soil resistance, laying method (in plane or triangled), the presence of long pipe passages, type of grounding, estimated cross-sections of cable screens, distances between circuits, cable design, and the presence of utility networks (CL, heating networks, etc.).

2.6.3.3. The transmission capacity of CL shall be determined based on electrical modes in adjacent networks for normal and repair schemes of grids with due consideration to maximum consumption in the area of potential grid development and load growth. The selection of cable core cross-sections shall 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. Distribution grids rated up to 1 kV shall use cables with neutral conductors. The cross-section of neutral conductors for CL designed mainly for one-phase loads (more than 50% in relation to power) shall not be smaller than the cross-section of phase wires. The cross-section of neutral conductors maybe be larger than the cross-section of phase wires if this is required to ensure permissible voltage deviations at the customer and if, using other means, it is impossible to provide the necessary selectivity of line protection from one-phase S/C. In all the other cases, the conductivity of neutral conductors shall not be taken less than 50%

of the conductivity of phase wires. The use of lead sheathing for three-core power cables for this purpose is allowed only for rehabilitated urban electric grids rated 220/127 and 380/220 V.

2.6.3.5. It is recommended that cables and cable accessories made by one manufacturer or different manufacturers passing joint tests (certification) be used as part of cable systems.

2.6.3.6. Cables shall comply with the fire safety requirements in accordance with GOST 31565 and meet the requirements for permissible maximum working voltages and for the value and duration of increased voltage in accordance with GOST R 57382-2017.

2.6.3.7. In accordance with the required load capacity of CL, the cross-section of conducting cable cores shall correspond to the cable section with the worst cooling conditions for cable with a length of at least 10 m in accordance with:

- GOST 31996 for cables with plastic insulation for a nominal voltage of up to 1 kV;
- IEC 60502-2 for cables with plastic insulation for a voltage of 6–20 kV;
- catalog (reference) data of manufacturers for other cables and voltages.

2.6.3.8 The operation life of cables shall be at least 30 years.

2.6.4. High-Voltage Cable Accessories

2.6.4.1. The number and types of cable accessories shall be determined by design documents for CL laying. Accessories shall be factory-assembled, minimizing human error during installation and lowering the probability of damage to couplings during installation and transportation.

2.6.4.2. When selecting cable accessories for CL rated 110 kV and above shall be guided by requirements:

- use cable accessories passed prequalification reliability tests in accordance with GOST R IEC 60840 (IEC 60840), GOST R IEC 62067-2017 (IEC 62067);
- terminal accessories (terminal couplings and SF6-insulated bushings) shall be collapsible, shall preferably have outer polymer insulation, shall not use liquid dielectric materials or auxiliary accessories (except where specified in design documents), allow insulation to be removed to perform repair preventive work, adapted for the installation cables with optical fibers built into cable screens. Composite insulators for outdoor terminal couplings shall have various lengths of leakage, depending on air pollution at the facility;
- dry (without compound filling), split-type connecting and connecting-transpositional couplings shall be used with factory-tested components, with the possibility of their placement in the ground and in cable facilities, with reliable

moisture sealing, easy to install, with optical fibers (built into cable screens), maintenance-free, with the greatest shelf life of repair kits (at least three years);

- connecting accessories shall be maintenance-free;
- accessories shall have protection from mechanical damage, water, and dust;
- terminal accessories shall use special adapters for the periodic monitoring of P/D levels using mobile measuring installations and shall allow the installation of stationary sensors for partial discharges and measurements of currents in cable screens;
- the installation and fastening of terminal couplings shall use metal structures with anticorrosion coatings, made by hot galvanizing or thermal-diffusion galvanizing at the factory;
- the operation life of cable accessories shall be at least 30 years.

2.6.4.3. Cable accessories for CL rated 1–35 kV shall be:

- accessories based on heat-shrinkable, tracking-resistant, nonflammable, and flame-retardant tubes and products;
- accessories based on cold-shrinkable, premanufactured elastomeric elements.

2.6.5. Requirements for Cable Screens

2.6.5.1. In the case of one-phase cables rated up to 500 kV with cross-linked polyethylene (XLPE) insulation, increased attention shall be paid to the selection of cross-sections, connection methods, and screen grounding.

2.6.5.2. The selection of designs, screen cross-sections, and screen grounding shall depend on permissible heating for CL in normal operation mode and on their thermal durability, including in S/C current mode, ensuring electrical safety for the maintenance of transposition boxes in accordance with the applicable requirements with due consideration to their number and location and the design of CL with a minimized number of connecting transpositional couplings.

2.6.5.3. The examination of the admissibility of selected cable screen grounding and the calculation of screen transpositions shall be carried out during design with due consideration to permissible voltages on cable screens, with maximum working current and S/C current flowing through the core during the time required by the operating conditions of relay protection.

2.6.5.4. Specialized transposition wells for cable lines shall be sealed and serviceable and shall have protection from unauthorized access.

2.6.5.5. Cable screens shall be grounded in accordance with the selected screen scheme through connection to SS grounding devices, transposition points, or cable passages. The cross section of ground leads shall be selected based on relevant calculations.

2.6.5.6. Grounding for SS metal cable screens and cable passages shall be connected directly to a grounding circuit or through a ground box. In the case of terminal couplings installed on outdoor cable passages or ODSS SG, the design of ground boxes shall be suitable for their outdoor applications. Ground boxes shall make it possible to remove cable screen grounding for testing. With one-way cable screen grounding, the place where grounding between metal screens and the grounding circuit is removed shall be provided with OVS in a terminal box.

2.6.5.7. Connection (transposition) leads and screen ground leads shall provide access to current measurement current using clamp-on meters on energized CL.

2.6.5.8. If a transpositional scheme is used for screen grounding on CL rated 110 kV and above, CL shall use screen transposition boxes (cabinets) made of nonmagnetic materials, with reliable moisture sealing, easy to install, with the possibility of reassembling transposition cables without replacing their components. It is recommended that OVS boxes be used that do not require disconnection for the duration of cable sheathing tests, with a steady voltage of 10 kV, with box sizes that allow their replacement without dismantling cable facilities (wells). Transposition (grounding) boxes shall predominantly be placed in cable facilities (transposition wells).

2.6.6. Cable Galleries and Underground Facilities

2.6.6.1. Cable galleries and underground facilities (tunnels, subways, and ducts) shall comply with the following requirements:

- provide ease of inspection, maintenance, and repair of CL;
- provide reliable and safe operation for construction structures;
- provide reliability for utility systems.

2.6.6.2. Technological solutions for the design of cable galleries and underground facilities (cable facilities) shall be selected depending on:

- practicability and economic validity;
- environmental measures in accordance with the applicable laws;
- uniform style of the appearance of facades of ventilation shafts and ventilation kiosks of cable galleries.

2.6.6.3. The use of cable facilities (passable or impassable) or closed pipe passages with horizontal directional drilling is recommended for CL in residential areas, in municipal forests, specially protected natural areas, at intersections with railroads, federal and regional highways, utility networks, and water bodies, using casings or additional reserve pipes for each CL circuit.

2.6.6.4. The selection of laying methods for cable facilities shall give preference to shield-driven passable cable facilities, especially in areas with densely located urban utility systems and underground utility networks.

2.6.6.5. Design solutions for cable facilities shall ensure the necessary angles of bent cables, changes to SF6-insulated CL bushings without the destruction of and damage to components, inspection platforms for terminal couplings without scaffolding and CL shutdown.

2.6.6.6. With sufficient justification and special technical specifications available, it is allowed to lay CL in cable facilities with CL outlets of up to 500 m.

2.6.6.7. The design of cable facilities shall provide maintenance personnel with convenient access to the cable building through entrances with stairs and shall provide personnel, vehicles, and mechanisms with unobstructed access to entrances by paved road in any season.

2.6.6.8. The design of cable facilities and construction materials shall ensure reliable operation with increased vibration and possible ground water. The clear height shall be at least 2.5 m.

2.6.6.9. The design and construction of cable facilities shall maximally limit the use of prefabricated reinforced-concrete structures.

2.6.6.10. Cubicles of cable facilities shall have openings for repair work on CL without the disassembly of construction structures (laying cables and lowering transposition boxes, connecting couplings, and metal structures).

2.6.6.11. The design of cable facilities shall allow at least two reserve CL circuits be built in each cable facility and shall make it possible to put replacements for connecting couplings in any place of cable facilities.

2.6.6.12. Cable facilities of any kinds shall be built with due consideration to the possibility of additionally laid cables accounting for 15% of the number of cables specified by the design.

2.6.6.13. Special sealed wells shall be used for cable lines made of solid-cast reinforced concrete or polymer materials, serviceable and shall have protection from unauthorized access (secondary vandalism-proof lockable lids).

2.6.6.14. The design of cable galleries and underground facilities shall consider and use technological solutions for the use of stationary utility systems with due consideration to economic feasibility, security, electricity supply reliability, and occupational health and safety:

- ventilation (forced supply ventilation);
- water removal (drainage pumps);
- working and emergency lighting;
- security and fire alarms;
- gas contamination and oxygen content control;
- temperature control;
- personnel evacuation;
- dispatching control of process equipment (pumps, fans, air valves, and

flame arrestors);

- high frequency channelized communication;
- electricity metering for operation;
- external electricity supply (Category II);
- access and intrusion control.

2.6.6.15. When designing digital electric grids, utility systems of cable facilities shall be provided with systems of automatic control, automatic actuation, remote control, video surveillance, and continuous monitoring, using AMDS for equipment and devices.

2.7. Emerging Technology

2.7.1. General

2.7.1.1. The use of emerging technology will ensure the transition to a technologically new grid with qualitatively new characteristics of reliability, efficiency, accessibility, manageability and customer-orientedness in the Russian electric grid sector as a whole.

2.7.1.2. Currently, emerging technology in the electric grid sector includes:

- superconductivity-based equipment;
- actively adaptive electric grids;
- direct current links and asynchronous electromechanical frequency converter;
- high-capacity accumulator units and energy storage devices.

2.7.1.3. The large-scale introduction of emerging technology is possible after its successful trials in accordance with the relevant technical standards and based on confirmed technical and economic performance.

2.7.2. Superconductivity-Based Equipment

2.7.2.1. The are two kinds of superconductivity:

- low-temperature superconductivity (LTSC) with a temperature of liquid helium (4.2 K);
- high-temperature superconductivity (HTSC) with a temperature of liquid nitrogen (77 K).

Historically, HTSC refers to materials with a temperature of 30 K. Currently, HTSC is related to superconductors with a critical temperature above the boiling point of nitrogen (77 K or −196 °C).

The superconductivity phenomenon occurs when electrical resistance vanishes in certain materials if their temperature becomes lower than the usual critical level.

2.7.2.2. HTSC Cables

HTSC cables (HTSC CL) are used to transport high capacity (more than 50 MW), using medium voltage, mainly in the following cases:

- megalopolis energy systems integrated into a super grid;
- supply for nonremote large customers, using generator voltage;
- electricity transportation using medium voltage as an alternative to high and ultra-high-voltage electricity transmission with a large number of transformation steps;
- electricity transportation using medium voltage as an alternative to gas-insulated power lines.

In terms of design, HTSC CL are divided into three main categories:

- one-core (one-phase) cable: one phase for one cryogenic sheathing;
- three-core (three-phase) cable: three one-phase cable cores in one cryogenic sheathing;
- triaxial cable: three phases concentrically located on a common core inside common cryogenic sheathing.

2.7.2.3. High-Temperature Superconductivity–Based Current Limiters

High-temperature superconductivity–based current limiters (HTSBCL) are cryogenic units consisting of nonlinear resistors in an insulating/cooling medium of liquid nitrogen.

The main function HTSBCL is to almost instantly limit S/C current.

HTSBCL can be used to:

- limit S/C currents in electric grids;
- reclose S/C current–disconnected grid sections.

2.7.3. Actively Adaptive Grids

2.7.3.1. The concept of actively adaptive grids is based on the development of the following technologies:

- FACTS;
- PL and direct current links based on modern microprocessor-controlled converters;
- high-speed communications systems;
- monitoring of dynamic properties of electric grids (Wide Area Measurement System (WAMS)) based on the registration of real-time vector

parameters of electric grids, using modern data processing and communication systems;

- microprocessor-based data processing and control equipment;
- introduction of digital technology for data processing and equipment control, including continuous monitoring using AMDS with predictive equipment status analysis.

2.7.4. Direct Current Links and Asynchronous Electromechanical Frequency Converters

2.7.4.1. The direct current link (DCL) is a converter SS designed to convert alternating current into direct current and subsequently convert direct current into alternating current with original or different frequencies.

2.7.4.2. DCL based on power electronics make it possible to:

- connect two electric power systems with the same nominal frequency but different unfixed phase shifts;
- connect electric power systems with different frequencies and phases.

2.7.4.3. DCL can be used to reclose S/C current–disconnected grid sections with controllable active and reactive power flow.

2.7.4.4. The asynchronous electromechanical frequency converter (ASEMFC) is an electrical device with two asynchronous motors/generators on a common shaft (Figure 2) and is functionally equivalent to DCL.

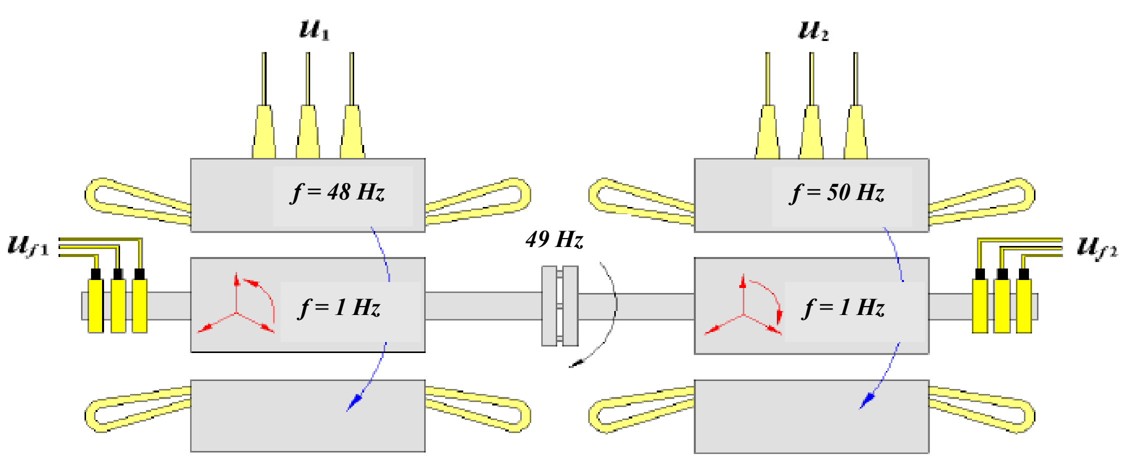

Figure 2. Asynchronous electromechanical frequency converter (schematic diagram)

2.7.4.5. ASEMFC can be used to:

- limit S/C currents in electric grids;
- reclose S/C current–disconnected grid sections;

- control active and reactive power flow.

2.7.5. High-Capacity Accumulator Units and Energy Storage Devices

2.7.5.1. The energy storage device (ESD) is an accumulator-based device capable of absorbing electrical energy, storing it for a certain time, and giving electrical energy back, which may involve processes of electrical energy transformation.

2.7.5.2. Electric grids can use ESD to:

- reduce peak loads;
- increase electricity supply reliability;
- regulate frequency and improve the reliability of electric grids in general.

2.7.5.3. ESD using AU in distribution grids rated 6–35 kV can be used:

- as devices for backup power supply;
- as devices for increasing electricity supply quality, preventing power failures and overvoltage;
- as devices for balancing daily load patterns.

2.7.5.4. Currently, ESD are based on AU using various types of accumulators (sodium sulfur (NaS), vanadium redox (VRB), lead acid (Pb), zinc bromide (ZnBr), lithium ion (Li-ion)).

2.7.5.5. The main ESD characteristics are as follows:

- energy storage capacity: the energy that ESD can store and supply to the energy system;
- response time: the time required for ESD to switch from a nonworking state (idle condition, charging) to the state of supplying energy with the necessary parameters;
- discharge time: the time of supplying power and energy to the energy system without recharging;
- power and energy density: power and energy per ESD weight.

2.8. Process Automation Systems of Electric Grid Facilities

2.8.1. General

2.8.1.1 To fulfill the functions of OPC, NCC shall be equipped with process automation systems (PAS).

2.8.1.2. PAS are controlled from NCC, which includes a set of SHP ensuring centralized control for facilities of digital electric grids, including SCADA/OMS/DMS/WFM, central grid data storage, and tools for working with the grid CIM, software and hardware systems (SHS) of AISEBM, and SHS of monitoring and setting systems for equipment.

2.8.1.3. SHS shall consist of two levels and two interlevel systems:

- level of objects of control and management (SS APCS);
- level of territorial grid organizations: NCC (SCADA with applications for NCC);
- systems for process information infrastructure management;
- systems for security information management.

The object level shall be provided with tools for sending process information to DC of JSC "SO UPS" as related to dispatching.

2.8.1.4. The SHS object level shall include a set of SHS equipment for controlling electric power infrastructure. This level includes SHS for HV SS (110 kV and above) and nodal SS rated 35 kV, DSS for MV SHS and TSS (6–35 kV), measuring converters and other equipment installed outside SS areas directly on passages (110–220 kV), cable and overhead lines, and devices for information and communication support for the activities of operational mobile crews and accident recovery crews. In addition, this level shall include SHS equipment installed and owned by customers and allied electric power industry entities.

2.8.1.5. PAS is a set of automation equipment for production control and technical and operational process control (OPC) for electric grid facilities, providing solutions for achieving the following objectives of automating processes based on modern software and hardware systems (SHS) of automation, computing technology and information technology:

- collect and transmit process information from electric grids and process and store such information;
- ensure operational switching;
- carry out maintenance and repair;
- analyze the technical condition of equipment;
- ensure observability for the condition of equipment and electric grid facilities.

2.8.1.6. PAS is designed to ensure and improve the operating efficiency of all electric grid facilities in their entirety by ensuring personnel efficiency and integrated process automation.

2.8.2. Requirements for PAS Data Model

2.8.2.1. PAS shall be based on current open standards of the International Electrotechnical Commission (IEC) and methodically and technically related standards of others international organizations.

2.8.2.2. The most important tool for building PAS is the unity of information, including calculation models for electric grids. The models shall be based on the Common Information Model (CIM), a standard adopted by the IEC (IEC 61968, 61970) for the electric power industry.

2.8.2.3. Grid models shall include tools for the integration (including those implemented on platform principles) of grid models, i.e. descriptions of allied energy systems, to ensure the transparent exchange of information about energy system models in accordance with the IEC 61970-30x series.

2.8.2.4. Using PAS on a uniform information platform for NCC makes it possible to:

- exclude the necessity of combining process control and management systems of various manufacturers and create a corporate standard for operational information systems;
- implement centralized support and operation of PAS SHS and personnel training;
- unify PAS software and reduce licensing costs.

2.8.2.5. Data exchange between PAS installed in NCC of PJSC "Rosseti" distribution grid companies, ADS of dispatching centers of a subject of operational dispatching control shall be in accordance with the ICCP/TASE.2 protocol (IEC 60870-6, IEC 62351-3).

2.8.2.6. A modern approach to building PAS shall use ADMS platform technology, which will make it possible to create:

- a uniform system and application platform;
- a uniform user interface;
- a uniform database;
- a uniform calculation model for grids rated 220/110(150)/35/20/10/6/0.4 kV;
- a uniform environment of configuration and administration.

The goal of implementing the platform solutions of ADMS is to reduce operating costs and obtain commercial benefits.

2.8.3. PAS Functionality Requirements

2.8.3.1. PAS built on ADMS technology shall fulfill all functions prescribed for individual SCADA, DMS, OMS, EMS, and other systems.

2.8.3.2. The functions of the SCADA system shall include:

- real-time visual control of the equipment and process status, and the forecasting and history of the grid operation mode (grid topologies, event logs, event archives, etc.);
- possibility of a geo-representation of electric grids in a dynamic and easy-to-use form;
- remote control of electric grid facilities (switching equipment) with the

blocking of invalid commands;

- prevention and containment of process failures in electric grids by providing signals about invalid (or close to invalid) operation modes of equipment and PL, providing signals about incorrect personnel actions and blocking them;
- monitoring and electronic logging of the status of grids, equipment, and PL;
- archiving, backup copying and restoring of information;
- databases of process, regulatory, and reference information;
- operational, process, and analytical reporting.

2.8.3.3. The graphic interface of the SCADA system shall be visual, scalable, and easy to use and shall support and communicate with the CIM when displaying graphic information (grid substitution schemes, equipment, measurements, etc.), in accordance with IEC 61970-453.

2.8.3.4. The PAS platform with its subsystems (DMS, OMS, EMS) shall be able to ensure integration and unification based on the CIM for various modules of calculation and analytical objectives unified by PJSC “Rosseti” ensuring the performance of the following features:

- flow distribution calculations;
- network loss calculations;
- switching control with the installation of caution notice boards;
- evaluation of electricity supply reliability in the event of failure in one of the elements of electric grids, based on the N-1 criterion, and identification of unreliable elements of electric grids;
- calculated indicators of SAIDI, SAIFI, and electricity underdelivery;
- identification of failure types and locations, using fault locators, telemetry, oscillograms, requests from subscribers, no-voltage events of AISEBM, and grid calculation models;
- automatic formation of switching sequences for the isolation of damaged sections and the restoration of electricity supply for maximum numbers of customers (automated FLISR) for NCC of distribution grid companies;
- status evaluation of electric grids;
- planning of the development of electric grids, including with calculations of the possibility of new network connections;
- calculation and optimization of the operation mode of electric grids;
- calculation of S/C currents;
- control of S/C current levels, including one-phase ground faults;
- optimization of the grid topology;
- voltage regulation;
- load management;
- planning of repairs to electrical equipment of SS;

- personnel training (dispatcher simulators).

2.8.3.5. The targets of implementing the calculation and analytical objectives of ADMS technology are:

- improve the safety and operating reliability of EGF;
- decrease consumption peaks and capacity losses;
- reduce outage duration;
- improve electricity quality;
- raise key performance indicators (KPI);
- increase the efficiency of using grid assets.

2.8.3.6. In relation to PAS, remote control for dispatching shall be ensured by implementing the following procedures approved by PJSC "Rosseti"; PJSC "FGC UES", and JSC "SO UPS":

2.8.3.6.1. Model principles of switching in electrical installations during remote control of RP equipment and devices of substations;

2.8.3.6.2. Model procedure for switching in electrical installations during remote control of RP equipment and devices of substations;

2.8.3.6.3. Model technical requirements for SHS of substations' APCS, microprocessor-based RP devices and the exchange of process information for the implementation of the functions of remote control of RP equipment and devices of substations from DC of JSC "SO UPS", NCC of grid organizations, and the procedure for implementing remote control.

2.8.4. Date Exchange Requirements for Operational Process Control

2.8.4.1. For the operational control and management of EGF, PAS shall be provided with:

- remote control of SD;
- remote indication of SD positions;
- telemetry of mode parameters (current, voltage, capacity, frequency);
- emergency alarm about invalid deviations from the required parameters, electric grid modes, and equipment status for SS and PL, signals of starting and actuating relay protection devices, AECS (including emergency disconnections of breakers);
- remote indication for fire safety and security;
- continuous control using AMDS for SS and PL equipment;
- reliability control for input information.

2.8.4.2. Sources of information for PAS shall primarily be APCS, DCCS, AEMS, telemetry at electric grid facilities.

2.8.5. PAS Architectures

2.8.5.1. Technical solutions for the creation of PAS shall ensure the construction of system architectures using the following principles:

- modular principle ensuring system flexibility: the ability to change functionality through adjustments to the composition of modules;
- clustering and segmentation principle ensuring the distribution of loads and objectives among software and hardware systems: measures to enhance the operating reliability of the electric grid sector as a whole and enhance information security;
- replication principle ensuring the fail safety of software and hardware systems.

2.8.6. PAS Reliability Requirements and Data Integrity

2.8.6.1. The following PAS reliability requirements shall be met:

- the availability factor shall be at least 99.98% (for NCC);
- the availability factor shall be at least 99.95% (for APCS);
- the recovery time shall not be more than four hours;
- the system shall be capable of gradual degradation (maintaining performance with a decrease in quality in the event of failures in individual elements of hardware or software);
- the system shall be based on redundancy with the automatic switching of all functions and components to a backup system in the event of failures in the main system;
- in normal mode, 24/7 continuous operation shall be ensured during the prescribed operation life, with the required maintenance and repair performed;
- software and hardware for serviceability control and failure diagnostics for the system shall make it possible to achieve the following objectives:
  • check serviceability and detect failures of equipment and elements;
  • find failures with an accuracy of a single element or a group of elements;
  • provide signals about failures and serviceability check results;
- scheduled (preventive) work on the system’s equipment shall not impair reliability;
- all of the system's equipment shall have an electricity supply scheme that ensures serviceability (emergency signals and saved information) in the event of short electricity supply interruptions and deviations of not more than ± 20% in voltage from the nominal level.

2.8.6.2. The integrity and correctness of information in the system shall not be affected by electricity supply interruptions. After the restoration of electricity supply, the required information shall automatically be recovered.

2.8.7. PAS Information Security

2.8.7.1. As part of the creation, modernization, and operation of PAS information infrastructure facilities, measures shall be carried out to assess possible consequences for the Company, social, political, economic, and environmental consequences, and consequences for national defense, national security and law enforcement in the event of computer incidents at PAS information infrastructure facilities and assign a category of significance to PAS information infrastructure facilities in accordance with Resolution of the Government of the Russian Federation No. 127 of February 8, 2018.

2.8.7.2. All information objects in PAS shall be protected using uniform security tools and systems.

2.8.7.3. Access to receiving information, changing information, entering control commands, etc. shall be protected with system tools for the delineation of user authority.

2.8.7.4. Changes to the level of access and user authority shall be made by system administrators as instructed by relevant executives. Access editing shall be confirmed with personal electronic signatures of process participants.

2.8.7.5. Changes to settings and operating parameters of PAS subsystems shall be confirmed with electronic signatures of users making such changes.

2.8.7.6. The security system shall log the actions of administrators and users of PAS subsystems.

2.8.7.7. Software integrity shall be controlled.

2.8.7.8. The security requirements shall be specified in a special section of job descriptions and/or operating instructions for NCC PAS and shall have references to user manuals for information protection devices.

2.9. Automated Control Systems of Electric Grid Facilities

2.9.1. General

2.9.1.1. EGF (SS, TSS, DSS, DTSS, PL) shall be equipped with automated systems for control, monitoring, and continuous monitoring using AMDS for elements of such facilities.

2.9.1.2. For formulating the requirements for automated systems, the following classification of EGF shall be used:

- SS rated 35–750 kV;
- DSS, DTSS, tie SS, TSS rated 6–20 kV (TSS with remotely controlled SD);

- TSS without remotely controlled SD (including pole-mounted versions);
- CL (OCL) rated 110 kV and above;
- CL rated 6–35 kV;
- OL rated 110 kV and above;
- OL rated 6–35 kV;
- sectionalization point (recloser).

2.9.1.3. In design and new construction, SS rated 35–750 kV, DSS, DTSS, tie SS, TSS rated 6–20 kV (excluding one-end substations) and sectionalization points (reclosers) shall be equipped with SD with remotely controlled drives.

2.9.1.4. The following types of automated systems shall be used:

1) SS process control (APCS) for:
- SS rated 35–750 kV;
- telemetry for:
- DSS, DTSS, tie SS, TSS rated 6–20 kV;
- TSS without remotely controlled SD (including pole-mounted versions);
- sectionalization points (reclosers);

2) continuous monitoring using AMDS for:
- equipment of SS rated 35–750 kV;
- CL, OL, OCL rated 110 kV and above.

2.9.1.5. Measurement control for APCS shall comply with subsection 3.6 of this Technical Policy (“Measurement Control”).

2.9.2. Functions of Automated Systems

2.9.2.1. Functions of APCS for SS rated 35–750 kV

2.9.2.1.1. Process functions:

- measurement, transformation, and collection of analog and discrete information about the current process modes and equipment status;
- warning and alarm systems: monitoring and recording of warning and alarm signals, their communication to workstations, filtering, processing;
- sending of current and archived information to operational personnel and other users at SS (control and visualization of the SS equipment status);
- use of mnemonic diagrams of facilities (with dynamic changes in the status) to display analog process parameters essential for maintaining modes, and display the equipment status with the indication of deviations from the required levels;
- automated control of SS equipment, including SS SD (breakers; disconnectors; grounding blades; OLVC drives; withdrawable elements and grounding blades for 6, 10, 20 kV connections; reactor disconnectors and their grounding blades; grounding blades for the transformer neutral; process

equipment: pumps, gate valves, etc.);

- remote changes to the status of software-controlled operational elements of RP and APCS systems: switching of setting groups for relay protection terminals, prompt connection and disconnection, on/off operations for individual functions through software-controlled operational keys in microprocessor terminals. Resetting and testing of alarm systems. Remote configuration of microprocessor-based relay protection;
- condition monitoring for chargers/rechargers of SS AU (rectifier units);
- software-controlled blocking of SD control (operational logical blocking of SD);
- event registration using internal tools or data exchange with secondary SS systems, and the recording and display of fault locator operation;
- data exchange with SS self-contained digital systems (RP, AISEBM, etc.) using standard protocols;
- exchange of operational information with the subject of operational dispatching control and NCC PAS;
- exchange of non-operational process information with NCC;
- control of voltages (0.4–750 kV) on SS busbars;
- integrated recording of cases of exceeding the permissible voltage levels;
- continuous control using AMDS for equipment;
- automatic control of operational switching based on program logic similar to standard switching sheets;
- remote control of voltages in lines rated 6–750 kV;
- shutdown analysis using software tools;
- use of dispatcher adviser tools for circuit and mode issues.

SS SD controls are shown in Table 2.

Table 2. SS SD controls

Item	Switching device type	Main control place	Reserve control place for high-level APCS failures	Controls in case of impossible remote control or setup operations
1	Circuit breakers, disconnectors, and grounding blades with electric drives rated 35 kV and above	Workstations of operational personnel at SS, Workstations of operational and dispatching personnel at NCC (with priority control given to duty personnel or	From the mnemonic diagram on the bay controller screen (control commands are recorded in the bay controller event log)	Local control cabinets, controls in SD locations
2	Circuit breakers, disconnectors, and grounding blades		From bottoms (keys) in cabinets of SG cubicles rated	Controls in SD locations

<table>
<tr><td></td><td>with SG electric drives 20 kV and below</td><td rowspan="3">operational mobile crews' personnel while they are on site), DC of JSC "SO UPS" (with remote control of PL SD and equipment under in dispatching control (management))</td><td>20 kV and below</td><td></td></tr>
<tr><td>3</td><td>OLVC</td><td>From bottoms (keys) in cabinets of OLVC</td><td>Controls in SD locations</td></tr>
<tr><td>4</td><td>ASB longitudinal and transversal coupling breakers rated 0.4 kV</td><td>From bottoms (keys) in cabinets of ASB</td><td>N/A</td></tr>
</table>

2.9.2.1.2. In relation to APCS, remote control for dispatching shall be ensured by implementing the following procedures approved by PJSC "Rosseti"; PJSC "FGC UES", and JSC "SO UPS":

2.9.2.1.2.1. Model principles of switching in electrical installations during remote control of RP equipment and devices of substations;

2.9.2.1.2.2. Model procedure for switching in electrical installations during remote control of RP equipment and devices of substations;

2.9.2.1.2.3. Model technical requirements for SHS of substations' APCS, microprocessor-based RP devices and the exchange of process information for the implementation of the functions of remote control of RP equipment and devices of substations from DC of JSC "SO UPS", NCC of grid organizations, and the procedure for implementing remote control.

2.9.2.1.3. Systemwide functions:

- organization of intrasystem and intersystem communications;
- data processing and data communication to adjacent and higher levels;
- testing and self-diagnostics of software, hardware, and channel (network) parts of SHS components, including input-output and data communication channels;
- synchronization of SHS components and standalone digital systems integrated into APCS, using signals of the time synchronization system;
- archiving and storage of information in specified formats and for specified time intervals;
- protection from unauthorized access, information security, and delineation of access rights (levels) for the system and functions;
- documentation; preparation and printing of reports in a specified form; operational database, daily statements, and operational log;
- automated design, programming, and configuration.

2.9.2.2. Functions of telemetry systems for DSS, DTSS, TSS, tie SS, TSS (TSS with remotely controlled SD):

- detection of S/C on CL rated 6–20 kV;

- selective detection of one-phase ground faults on CL rated 6–10 kV;

- ALT for the restoration of electricity supply through the automatic connection of backup power supply in the event of failures in the main power supply source through MBMC in the form of a software algorithm with the possibility of remote PAS I/O;

- collection and transmission of telemetry information in PAS;

- receipt and execution of remote control commands for SD from PAS;

- collection of oscillograms of emergency events.

2.9.2.3. Functions of TSS telemetry systems without remotely controlled SD (including pole-mounted versions) are the collection and transmission of telemetry signals in PAS in a minimum amount: ALT activation, voltages on busbars rated 0.4 kV (on transformer taps rated 0.4 kV), others parameters.

2.9.2.4. Functions of telemetry systems for sectionalization points (reclosers):

- collection and transmission of telemetry information in PAS;

- receipt and execution of remote control commands for SD from PAS.

2.9.2.5. Functions of continuous monitoring using AMDS for equipment shall be performed to the extent and meet the requirements specified in subsection 3.7 of this Technical Policy.

2.9.3. Technical Requirements for Automated Systems

2.9.3.1. APCS of SS rated 35–750 kV:

- building APCS shall be based on modern information technology using microprocessor-based modern software and hardware;

- designing APCS shall consider expanding hardware and software;

- APCS shall be built as a multilevel distributed man-machine real-time system and shall include the following levels (Figure 3):

• level of grids: hardware and software for data processing and storage, workstations, and grid management;

• level of substations: hardware and software for data processing and storage, workstations;

• level of connections: hardware and software for the concentration and unification of heterogeneous data flows from the level of APCS processes and standalone automation systems;

• level of processes: hardware for the conversion and direct measurement of physical values and for interfacing with control and automation objects;

- the basic data exchange protocol for devices included in APCS, microprocessor-based relay protection, and other self-contained SS systems shall be IEC 61850-8.1 GOOSE and MMS. If any systems do not support IEC 61850-

8.1 GOOSE or MMS, data exchange may use standard protocols.

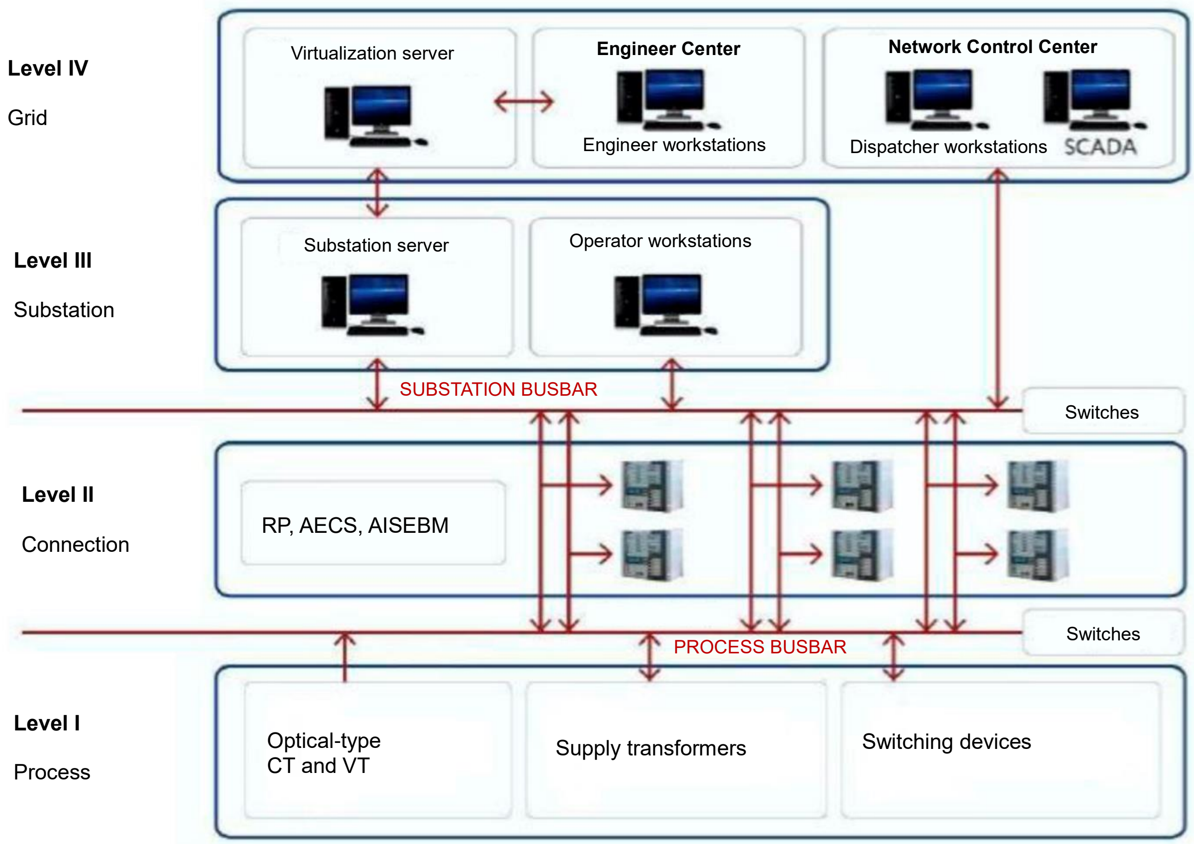

Figure 3. APCS multilevel structure

2.9.3.2. Process-level controllers shall perform the following functions:

- measurement, conversion, collection, and processing of analog and discrete connection information from secondary CT and VT windings, auxiliary contacts of primary equipment, relays contacts, sensors, and converters;
- formation of control commands for SD, OLVC, and other devices;
- software-controlled operational blocking of SD connection control (with data exchange between peer devices compliant with the IEC 61850-8.1 GOOSE protocol);
- data exchange with other connection controllers with middle-level APCS SHS using the IEC 61850-8.1 GOOSE protocol;
- SD backup control for failures in top- or middle-level devices.

2.9.3.3. The level of connection controllers and their PIU shall be used for the primary processing of input signals: filtering, linearization, verification, aperture processing, conversion of the binary code into physical values, etc. Access shall be provided for the ACS engineer workstation for the parameterization of the primary processing of PIU modules.

2.9.3.4. Connection-level controllers shall have duplicated Industrial Ethernet digital exchange modules in accordance with the requirements of ISO Ethernet IEEE 802/3. With lost connections with the top control level, controllers shall go into standalone mode with the registration of events in the internal buffer with sufficient capacity. Controllers shall support hot swap modes (except for the central processor module) and shall be provided with redundancy for main modules (processor, power supply, communication). Electromagnetic immunity shall meet the requirements of IEC 61850-3.

2.9.3.5. Connection-level controllers for equipment 110 kV and above shall be equipped with graphic control panels with russified displays ensuring local visualization for the connection equipment status, SD control to provide backup control, input/output and visualization for blocking operation, the viewing of events, the identification and authentication of access subjects and objects, security event registration with communication to a dedicated server of data collection for security monitoring subsystems.

2.9.3.6. Connection-level controllers shall be modular devices that support the flexible configuration of modules input/output. Controllers shall have serial ports to ensure the integration of information subsystems using protocols other than the IEC 61850 protocols. Controllers shall support freely programmable logic in accordance with IEC 61131.

2.9.3.7. APCS LAN shall meet the redundancy requirements and ensure sufficient performance for data communication between APCS devices and relay protection devices compliant with the IEC 61850 protocols.

Preference shall be given to LAN redundancy in accordance with IEC 62439-3 PRP/HSR.

The second- and third-level redundancy protocols for the OSI model shall provide protection from single failure of switches/routers and cable connections of LAN.

2.9.3.8. LAN shall use Industrial Ethernet switches in accordance with the requirements of IEC 61850-3. A switch shall have two power supply units and built-in diagnostics controlling switch ports, switch operation, temperature, and power supply, with data communication to SCADA, using the SNMPv3+ protocol. Switches shall comply with the requirements of OS 34.01-6-005-2019 “Switches for Power Facilities. General Technical Requirements.”

2.9.3.9. Devices connected to APCS LAN shall be provided with redundancy for communication channels between such devices and LAN equipment.

2.9.3.10. The basic environment of data communication in LAN shall be single-mode or multimode optical fibers.

2.9.3.11. The substation level of APCS includes:

- devices for data collection, processing, and archiving (SCADA servers);
- devices for displaying data to users (workstations, printers, shared screens, etc.);
- remote access servers and oscillogram collection servers;
- routers for organizing a demilitarized zone;
- time synchronization equipment;
- telemetry servers/controllers;
- data collection server of the security monitoring subsystem.

2.9.3.12. APCS SHS servers shall be provided with redundancy, each with two hot-swapped power supply units connected to different power supply sources. Storage array shall be hot-swapped RAID. Servers shall be completed with a duplicated Ethernet interface connected to different LAN switches.

2.9.3.13. As a minimum, APCS SHS shall have:

- two workstations of operational personnel (stationary, redundant), with two monitors each;
- workstation relay protection;
- workstation ACS (stationary and portable).

2.9.3.14. Operator workstations shall be equipped with SATA drives combined into a RAID array level not below 1. Workstations shall be equipped with a duplicated Ethernet interface connected to different LAN switches. Monitors (displays) of operator and engineer workstations are typically the main means of displaying operational information to users. Workstations shall use color HD LCDs, at least 24".

2.9.3.15. Workstations of operational personnel shall be based on an industrial personal computer, with MTBF of at least 20,000 hours.

2.9.3.16. Diagnostics equipment for workstations of operational personnel shall control the serviceability of HDD (SSD) drives and shall control temperature, with data communication to SCADA.

2.9.3.17. APCS shall support data exchange with the following self-contained digital systems (if available at SS):

-RP;
- automated systems of utility and auxiliary systems;
- continuous monitoring of AMDS for equipment;
- others self-contained microprocessor systems or devices installed at SS as may be required for operational personnel.

2.9.3.18. Self-contained systems shall be integrated into APCS if it is necessary to send data from APCS to final APCS users: operational personnel at SS, operational and nonoperational personnel at NCC.

2.9.3.19. As related to data exchange between APCS and integrated subsystems and devices, including for the purpose of condition monitoring, the use of intermediate OPC servers and clients is not recommended. The use of OPC servers and clients is allowed with an appropriate FS.

2.9.3.20. Automated systems shall be powered by ASB and UPS (allowed to be used without internal AU with power supply from auxiliary direct current) and shall continue operating in the event of lost auxiliary supply for SS (ASB) during the operation of the auxiliary-current system of SS.

2.9.3.21. All substation-level APCS SHS, including all stationary workstations, shall also be powered by ASB and UPS (allowed to be used without internal AU with power supply from auxiliary direct current).

2.9.3.22. UPS shall use inverters rated 220 V with a static bypass. It is allowed to use UPS with an input voltage of 220 V, using AU and power supply units with input and output direct current. To raise reliability and maintainability for power supply for APCS devices, UPSS shall use ALT modules wit a manual and automatic bypass. Supply circuits of APCS devices shall have network filters and voltage stabilizers to protect APCS equipment from surges in supply voltage.

2.9.3.23. Uninterruptible power supply shall be modular units with N -1 redundancy and parallel operation mode. It is allowed to use single-module duplicated units.

2.9.3.24. Switching devices used for UPSS shall be fast-responding, with the time of switching of not greater than 20 ms.

2.9.3.25. UPS shall provide APCS with the time of self-contained operation (when SS MV is disabled) as determined in accordance with subsection 2.3.2 of this Technical Policy (2 hours).

2.9.3.26. APCS SHS shall include a time synchronization subsystem that services all APCS devices and equipment of integrated standalone digital systems (relay protection, AECS, etc.) of SS.

Time synchronization accuracy shall be not lower than 1 ms.

2.9.3.27. Any time synchronization subsystem shall include software and hardware to receive standard time signals from external sources (GPS/GLONASS).

2.9.3.28. Any time synchronization subsystem shall support the PTPv2 protocol (including PowerProfile) subject to the requirements set forth in OS 56947007-29.240.10.261-2018 “Digital Substation. Time Synchronization Protocol for Measuring and Control Systems (Based on IEC 61588)” (or NTP (SNTP v3+) subject to the requirements set forth in paragraph 2.11.3.27 of this Technical Policy)).

2.9.3.29. If APCS is based on the IEC 61850-9.2 SV protocol, time synchronization accuracy shall be not lower than ±1 μs.

If a grid organization has an in-house time synchronization system, such time synchronization shall be given preference.

2.9.3.30. APCS shall process and analyze the following data:

- control and analysis of the SD status;
- analysis algorithms for emergency shutdowns of the line and transformer equipment;
- algorithms for operational blocking;
- control of SD control command execution (reverse control);
- identification and registration of emergency events;
- recoding of COMTRADE oscillograms;
- timestamps for discrete signals;
- calculation of mode parameters;
- schemes with two systems of main busbars shall be able to transfer VT circuits from one system of main busbars to the other;
- detection of energized sections of the schemes;
- data processing about normal mode: additional calculation of unmeasurable parameters;
- integration of oscillograms into a time-based single emergency process;
- analysis of data reliability.

2.9.3.31. APCS operation speed shall not be lower than shown in Table 3.

Table 3. APCS operation speed

Parameter	Value
Frequency of polling signals by process-level devices, ensuring compliance with the requirements for the accuracy of recorded events and values of analog signals in relation to the SHS system time (depending on the dynamic properties of the parameter): - discrete - analog - analog auxiliary	 1.0 ms 0.5-1.0 ms 0.1-1 s
Delay from the time when the operator issues a data call command to the start of the output: - on the monitor screen	1.0 s
Data renewal rate: - on the monitor screen	1.0–2.0 s
Delay in the display of spontaneously appearing warning and alarm signals on the monitor screens of operator stations	0.5–2.0 s
Time it takes for the command to pass from the time when the operator presses the button of the virtual control unit until the signal appears on the output circuits of SHS, max.	1.0 s
Delay from the time the operator when issues a remote control command until the display of the results of the command execution on the monitor, excluding the time used by the control object to process the command	1.5-2.0 s
Pulses applied to the actuator (adjustable parameter): - minimum duration	 0.1 s

- change step, max.	0.05 s
Delay from the time of receiving a query (command) from higher-level ACS to the start of its processing, max.	0.25 s

2.9.3.32. APCS shall be provided with functionality of software-controlled operational blocking.

Busbar disconnectors and grounding blades of main busbars shall have carried complete operational blocking, preventing grounding blades of main busbars from being turned on with at least one busbar disconnector in the on position and preventing any busbar disconnector from being turned on with a grounding blade of main busbars in the on position.

Factory-assembled SG provide operational blocking, preventing grounding blades of SG main busbars from being turned on with breaker trucks in the on position for any connections of SG main busbars and preventing any breaker trucks from being turned on with a grounding blade of SG main busbars in the on position.

Blocking in IDSG prevents breaker trucks in the on position from rolling inward.

Drive connection controllers shall generate separate commands:

- “Allow operation”: a command to supply voltage to a unit: an electromagnetic blocking lock or to a blocking relay winding (if any). “Allow operation” commands are generated in controllers for each SD by using logical algorithms programmed in controllers in accordance with the logic of traditional relay contact schemes;

- “Run control”: a command to use APCS to disconnect/connect the SD drive in the control circuit. Remote “Run control” commands for devices with motor drives are generated by connection controllers, activated by the operator’s workstation or the interface of connection controllers and entered in the drive control circuit, while the logical admissibility of any operation is checked at the controller level.

2.9.3.33. If any corresponding signals are contained in bottom-level controllers of APCS, additional conditions for blocking may include the nonavailability of voltage on busbars, OL, or transformer bushings, the synchronism of voltage vectors, and the nonavailability of current.

2.9.3.34. Software-controlled blocking in APCS using blocking elements in the drive (if any) shall be used for all types of disconnectors, including SD with manually driven main and grounding blades.

2.9.4. Data Exchange Requirements for Substations and Dispatching Centers

2.9.4.1. SS DCCS is an APCS subsystem that shall ensure:

- measurement and collection of primary data about the mode parameters and equipment status in accordance with the established requirements;
- transmission of collected data to NCC and dispatching centers of operational dispatching control;
- processing, storage, and communication of collected data to personnel of NCC, SS and operational services.

2.9.4.2. New DCCS of SS rated 6–20 kV or a telemetry system shall additionally ensure remote control for connections and data exchange with adjacent automation systems using standard protocols (with the adequate technical capabilities of adjacent subsystems).

2.9.4.3. SS DCCS shall meet the following requirements:

- use modern microprocessor-based telemetry systems with direct connection to secondary circuits of CT and VT or to multifunctional measuring converters;
- increase the amount and expand the range of communicated process information;
- use the modular principle of building hardware and software devices;
- support international data communication protocols IEC 60870-5-104, IEC 61850-8.1 GOOSE, MMS, and IEC 61850-9.2 SV for data communication to NCC and DC;
- enable microprocessor-based telemetry systems to be extended to and integrated into SS APCS.

2.9.4.4. The preparation of telemetry data in SS APCS for communication to control rooms of operational dispatching control shall meet the technical requirements established by JSC “SO UPS”.

The primary processing of discrete signals shall include:

- prevent the chatter of closed/opened contacts;
- remove interference (signals with a duration of less than 5–7 ms);
- assign timestamps to any discrete signal with an accuracy that provides unambiguous recognition for process situations for, for example, analyzing two sequential switches of highest-speed SD with an event time accuracy of not more than 1 ms.

Discrete signals about the SD position are checked for reliability by sending two signals from one SD - “on” and “off” - received using a normally closed and a normally open contact assigned to one SD status.

Operational and nonoperational data shall be communicated to NCC of a grid organization in accordance with its special requirements.

2.9.4.5. Data shall be communicated to NCC, using the IEC 60870-5-104 (or

IEC 61850-8.1) protocol via the main and backup data communication channels in each direction directly without intermediate processing (recommunication). Data shall be communicated to the dispatching center of a subject of operational dispatching control, using the IEC 60870-5-104 protocol via the main and backup data communication channels in each direction directly without intermediate processing (recommunication). The total time for the measurement and communication of telemetry data (except for telemetry data used for the operation of emergency and mode automation) to the dispatching center of JSC “SO UPS” shall not be greater than 2 s.

Telemetry data from SS shall be communicated to NCC and the dispatching center of a subject of operational dispatching control directly without intermediate processing via two independent (main and backup) data communication channels in each direction in duplicate mode.

For telemetry data communication, the throughput of digital communication channels shall ensure the transmission of all the necessary telemetry data about operation modes of process equipment.

DCCS SHS shall be created during the design and new construction of SS 10 kV and above and during the partial rehabilitation of SS rated 110 kV and above when the amount of rehabilitation of primary and secondary equipment is up to 30% of the total value. DCCS SHS may be created with a smaller amount of SS rehabilitation if it is not possible to expand the existing telemetry and it is necessary to input and send additional data. New DCCS SHS shall be built as a part (element) of the future design of fully functional APCS. With an increase in the amount of rehabilitation of primary equipment, DCCS SHS elements shall be fully integrated into APCS.

2.9.5. Requirements for APCS Software

2.9.5.1. APCS software as a whole and its subsystems and application tasks shall have a modular structure and an open architecture and shall ensure:

- reliable performance of process control tasks;
- potential development and modification of process control tasks;
- continuous monitoring of data reliability;
- creation and maintenance of databases for use at the local level and at higher levels of operational process control and for the purpose of operational dispatching control in the electric power industry;
- document management and the provision of operational information for personnel;
- implementation of operation protocols for process and computing networks of the system and communication with the top levels of operational process control

and the dispatching center of a subject of operational dispatching control in the electric power industry;

- self-diagnostics and diagnostics of hardware components of APCS;
- remote diagnostics from the top levels of operational process control;
- operation of devices for information and general security;
- manual input of data transmitted as part of telemetry data;
- automatic execution of commands of remote group control;
- automated generation of switching sheets.

2.9.6. Reliability and Robustness Requirements for APCS

2.9.6.1. APCS shall be provided with 24/7 continuous operation during the prescribed operation life, with the required maintenance and repair performed, shall be at least:

- 20 years for devices of the system's field level;
- 15 years for devices of the system's connection level;
- 10 years for devices of the system's substation level.

2.9.6.2. In general, the reliability of the control system shall be ensured in accordance with the requirements of GOST IEC 60870-4-2011, GOST 27.003, and GOST 24.701-86 and shall be achieved by:

- selection of a set of hardware with sufficient indicators of reliability, duplication, and redundancy;
- structural ways (distributed control, self-contained components of the system, etc.);
- compliance with the required regulations for hardware maintenance.

2.9.6.3. The quantitative indicators of reliability are as follows:

- mean time between failures for each APCS channel as related to information functions and control functions: at least 40,000 hours;
- mean recovery time for APCS as related to any function: at most 8 hours.

2.9.7. Requirements for Telemetry Systems of DSS, DTSS, Tie SS, and TSS with Remotely Controlled Switchgear

2.9.7.1. In order to ensure the observability of power facilities, organize automated dispatching control of power grids, and prevent overlapped functions of automation tools, EGF shall be equipped with systems for relay protection and telemetry, SD remote control, fault location, and data collection and communication.

All newly installed electrical equipment that requires remote control shall be equipped with PAS-controlled electric drives and blocking devices.

2.9.7.2. RP devices (systems) shall use data exchange with the server of data collection, processing, and communication using the IEC 61850-9.2 SV protocol.

The server of data collection, processing, and communication shall use data exchange with the top-level main and backup PAS via the main and/or backup connection channels using the IEC 61850-8.1 GOOSE, MMS, or IEC 60870-5-104 protocols.

Time synchronization on the server of data collection, processing, and communication shall use the top-level GLONASS/GPS system using the SNTP v3+ (NTP) protocol.

2.9.7.3. Telemetry data generated in RP devices (systems) shall contain event timestamps of primary digital sources. Synchronization accuracy shall be at least 10 ms.

Data communication formats without timestamps may not be used in communication protocols.

2.9.7.4. For telemetry data transmitted continuously or by deviation of measured values, the communication cycle shall not exceed 5 s.

The time of telemetry data signal generation for communication to the top level shall not exceed 1 s.

2.9.7.5. The probability of telemetry data errors shall comply with first the requirements for Category I telemetry systems under GOST 26.205-88.

2.9.7.6. The server of data collection, processing, and communication shall provide automated formalized descriptions of current configurations of SS automation systems in accordance with GOST R IEC 61850-2009 (Substation Configuration description Language) and in the CIM RDF format (IEC 61968-13:2008).

The server of data collection, processing, and communication shall ensure remote status monitoring through customized Web access.

2.9.7.7. The security system of a power facility automation and protection system shall be created in accordance with the requirements and provisions of Federal Law No. 187-FZ of July 26, 2017, “On the Security of the Critical Information Infrastructure of the Russian Federation” and Federal Law No. 152-FZ of July 27, 2006, “On Personal Information” and the applicable subordinate LR, depending on the established category of significance. The security of power facilities’ automation and protection systems without any established category of significance shall be ensured in accordance with Ordinance of PJSC “Rosseti” No. 140r of April 1, 2016 (as amended by Ordinance of PJSC “Rosseti” No. 178r of April 27, 2016) and this Technical Policy. To ensure security for a power facility automation and protection system at critical facilities, potentially hazardous facilities, and facilities that pose an increased danger to human life and health and to the natural environment, the security system shall meet the Information Protection Requirements approved by Order of the Federal Service for Technical and Export Control of the Russian Federation No. 31 of March 14, 2014.

2.9.7.8. Process data communication shall be organized in accordance with the design. The types of communication channels, number of communication channels, necessary redundancy, communication speed, communication quality requirements, and availability factor shall be selected by the designer in consultation with the customer from several options based on technical and economic feasibility.

2.9.7.9. The content of process data generated by the construction of DSS and electric grids shall be consistent with data flows in SCADA in accordance with the requirements of applicable standards.

2.9.8. Requirements for Telemetry Systems of TSS and DSS rated 6–20/0.4 kV (Including SS with Remotely Controlled Switchgear) and Pole-Mounted TSS rated 6–20 kV

2.9.8.1. TSS, DSS rated 6–20 kV (including with remotely controlled SD) and pole-mounted TSS rated 6–10 kV shall use a telemetry system with a minimum set of telemetry data and remote control.

The system shall consist of a controller (device) for data collection and communication (level of data processing systems of electrical installations (DPS(EI)) and modules (nodes) for collection and control.

2.9.8.2. The system shall have the following functionalities:

- expansion of connected modules and sensors using Ethernet standard interfaces, RS-485, RS-232, or other interfaces with equivalent performance and functionality; and sensors with various types of interfaces (dry contact, current loop, etc.);

- local data processing with data communication about settings for the top level via the main and backup radio communications channels (LPWAN, various generations of cellular networks, etc.) to the top level;

- time synchronization using a standard protocol (NTP, etc.);

- self-diagnostics for a controller or a device that performs its functions, analog data input modules, status monitoring for communication channels and power supply.

2.9.8.3. The system shall be provided with tools for safe remote and local configuration, monitoring, and control for a controller (device) for data collection, processing, and communication (DPS(EI) level).

2.9.8.4. When power supply is restored after it spontaneous interruption a controller (device) for data collection, processing, and communication and other elements shall correctly continue operation with unimpaired data integrity.

2.9.8.5. Telemetry system modules or devices that perform their functions shall have MTBF of at least 120,000 hours.

2.9.8.6. Discrete and analog data input modules shall have discrete entry points with filters without false operation and with speed that prevents useful signals from being lost.

2.9.8.7. The time of telemetry data signal generation for communication to the top level shall not exceed 5 s.

2.9.8.8. The delay time of telemetry data communication from a power facility to the top level shall not exceed 30 s with no delays in data communication channels.

2.9.8.9. When communication channels fail, the system shall operate in self-contained mode. After communication channels are restored, data exchange with the top control level shall automatically be restored with the all accumulated in self-contained mode to be transmitted. The storage period for telemetry data accumulated in self-contained mode shall be at least 24 hours.

2.9.8.10. Minimum requirements for collected and communicated telemetry data and remote control:

a) for telemetry data:

- collection of data about electricity transportation and consumption on 0.4 kV supply bushings in accordance with Section 13 of these Regulations;

- collection of data about electricity quality on 0.4 kV supply bushings in accordance with Section 14 of these Regulations;

- per-phase control of voltage on LV bushings of 0.4 kV sections;

- facility access control (movement detectors, photographic recording, video surveillance (if necessary), switching protection) with a signal from the door closing control sensor;

- control of flooding in cable pits (if any);

- control of actuated fire alarm detectors: generalized signal by section (if available);

- data collection from subscriber meters in accordance with subsection 2.12 of this Technical Policy;

- control of actuated ALT (if any);

- control of exceeded temperatures for supply transformer bodies (if necessary);

b) for remote control (for facilities with SD):

- grid manageability through SD control (with sufficient SD functionality);

c) for telemetry data of system self-diagnostics:

- diagnostics of communication with modules (nodes) of collection and control;

- diagnostics od malfunctions or critical operation modes of the system's computing module;

- control of the system's independent backup power supply.

2.9.8.11. System power supply at EGF shall be from two auxiliary sections rated 0.4 kV (if any).

Controllers (devices) for data collection and communication (DPS(EI) level) and modules (nodes) for collection and control shall have independent power supply (based on super capacitors), ensuring the operation of data collection and communication and correct operation termination. The main operation characteristics of independent backup power supply shall correspond to the system parameters.

In the event of a power failure, the system shall send a signal to the top-level system about the nonavailability of external power supply and/or the nonavailability of voltage on 0.4 kV bushings and shall be turned off correctly.

2.9.9. Requirements for Telemetry Systems of Sectionalization Points

2.9.9.1. The requirements for this type of telemetry are the same as the requirements for telemetry systems of TSS (pole mounted) subject to the requirements listed below.

2.9.9.2. Telemetry modules shall be able to receive and send remote control commands.

2.9.9.3. Minimum requirements for collected and communicated telemetry data:

a) telemetry data:

- per-phase control of voltage;

b) remote control:

- switching devices.

2.9.10. Requirements for Automated Monitoring Systems of Automated Systems

2.9.12.1. Automated systems shall be provided with automated monitoring systems of automated systems and their subsystems.

2.9.12.2. Automated monitoring systems of automated systems and their subsystems shall be based on SHS making it possible to:

- interact with all automated SS systems and subsystems via 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;
- continuously monitor the correct operation and serviceability of microprocessor-based SS equipment;
- analyze collected data based on built mathematical models for systems and equipment;
- make condition forecasts for monitored facilities;
- receive self-diagnostics signals from controllers, PIU, relay protection, LAN equipment, servers, etc.;
- implement auto collection and control of changes in settings, configurations, versions firmware and installed software;
- automatically collect and analyze data from automated systems and subsystems:
• analyze the serviceability of analog channels of connection-level controllers, relay protection, and DR and monitor PQ and AISEBM by comparing indications of one connection;
• analyze the serviceability of discrete channels of connection-level controllers, relay protection, and DR and monitor PQ and AISEBM by comparing indications of one connection and by using forecast models to forecast sequences of signals received by an automated system;
- automatically analyze the correct operation of relay protection functions, including software-controlled operational blocking, switching sheets, etc.;
- make adaptive adjustments to the current (operating) settings of relay protection devices (selectivity, response time, sensitivity).

2.10. Electricity Metering System

2.10.1. The goal of the Technical Policy in the area of electricity (capacity) metering is to form unified approaches to creating automated electricity metering systems (metering systems) at the Company's grid facilities.

2.10.2. Metering systems are aimed at:
- measuring the reliable volume of services provided by the Company;
- measuring and monitoring of the volume electricity network losses;
- providing the Company's divisions, electric power industry entities, and customers with information about measurements of electricity (capacity) at electric grid facilities of the Company in accordance with the prescribed procedure.

2.10.3. Electricity metering systems shall be created as geographically distributed multilevel information systems with centralized management and a common center for the collection, processing, storage, and transmission of measurement information at branches (SDCs) of the Company.

2.10.4. Electricity metering systems shall cover all electricity meters related to active and reactive energy and power for the purpose of receiving complete information about a facility's electricity balance, including balances by voltage, by busbar section, and by auxiliary power supply.

2.10.5. An electricity metering system shall include electricity measurement systems consisting of electricity meters, metering current and voltage transformers, and secondary measuring circuits. The construction of metering systems at grid facilities may use DCCD or industrial controllers, devices for receiving and sending information (equipment for data communication channels). Data collection and processing shall be carried out by software and hardware systems equipped with time synchronization systems. DCCD in electricity metering systems shall be used with an appropriate FS.

2.10.6. Metering systems shall comply with the requirements of LR, including (in the case of connections that are part of sections of delivery to WECM) the requirements for AISEBM in accordance with regulations of the wholesale electricity (capacity) market and (in the case of distribution grid companies (in the retail electricity market) the General Provisions of Retail Electricity Market Operation and the Rules for Providing Access to the Minimum Set of Functions of Intelligent Electricity (Capacity) Metering Systems.

2.10.7. Measurement control for meters that are part of electricity metering systems shall be in accordance with the provisions of the "Measurement Control" subsection of this Technical Policy and shall comply with the requirements set forth in the laws of the Russian Federation.

2.10.8. Depending on the grid topology, with the aim of balancing distribution grid sections, it is recommended that metering at grid facilities shall be organized for the Company's ownership demarcation points.

2.10.9. SS rated 35 kV and above shall be equipped with measuring systems and DCCD using data communication to the data acquisition and processing center (DAPC). Electricity meters shall be installed on all connections.

2.10.10. In order to protect electricity meters and/or metering systems from unauthorized access, sealing of terminal covers of metering devices and test boxes, and test and intermediate terminal blocks of current and voltage circuits, identification and authentication of subjects and objects of access, functions of security event registration with communication to a dedicated data collection server of the security monitoring subsystem, firmware integrity control, and data communication integrity assurance, a dedicated APN (VPN) of data network operators and a hub-and-spoke network topology shall be used.

2.10.11. If technically and economically feasible, responsible connections of SS rated 35 kV and above may use electricity meters performing the functions of oscilloscope registrars of parameters of normal and emergency modes, transitional processes, and PQI nonconformities with GOST 32144-2013.

2.10.12. TSS, DSS, and DTSS rated 6–20 kV shall be equipped with 0.4–20 kV measuring systems using data communication devices.

2.10.13. Measures to ensuring the synchronization of metering and telemetry systems as related to process data communication to NCC for the purposes of operational process control (current, voltage, capacity, etc.)

2.10.13.1. For the efficient use of resources in designing the new construction and/or rehabilitation of 0.4–20 kV distribution facilities, it is recommended that uniform devices be used to support the collection and transmission of telemetry signals and metering data (with appropriate economic and/or technical justification).

2.10.13.2. Metering and telemetry systems shall use shared communication channels.

2.10.13.3. Telemetry data received and communicated through metering systems shall be used to organize remote monitoring and control for 0.4–20 kV distribution facilities:

a) at the level of measuring systems:

- grid manageability through SD control (if technically feasible for SD);

b) at the level of DCCD (controller, electricity meter (external module) with remote control functions):

- amount of telemetry data in accordance with paragraph 2.11.8.10 (a) of this Technical Policy;

- grid manageability through SD control (if technically feasible for SD);

- amount of telemetry data about self-diagnostics in accordance with paragraph 2.11.8.10 of this Technical Policy.

2.10.13.4. Uniform primary current and voltage converters (sensors, transformers) shall be used to connect meters of metering and telemetry systems.

2.10.13.5. Metering and telemetry systems may be separate from each other only with the consent of the Services Sale Division and the Technical Policy Division, with sufficient justification (in accordance with the criteria of economic feasibility or with the required level of electricity supply reliability for the designed grid section).

2.10.14. Organization of electricity metering for 6–10 kV overhead lines

2.10.14.1. For the organization of electricity metering, including in the case of an ownership demarcation point corresponding to the customer’s grid facilities, electricity metering shall use remote (including high-voltage) electricity billing meters.

2.10.14.2. Electricity meters shall be equipped with measuring systems using data communication devices.

The selection of communication channels is prioritized in Table 4.

Table 4. Selection of communication channels from MIS MP (if any)

Metering object	Communication protocols		Communication channels from MIS MP-DPS(EI) (data processing system)				
	RS-485	Ethernet	PLC and HF	Ethernet - VPN on outside grids	RF*	GPRS	Digital system of data communication
SS rated 35 kV and above	2	1	4	5	2	3	1
TSS rated 6, 10 kV	2	1	2	4	3	5	1
Apartment building	2	1	1	3	2	4	N/A
Detached house	N/A	N/A	1	4	2	3	N/A

** RF includes channels implemented in various radio frequency ranges, such as the ZigBee, LPWAN, Bluetooth protocols, etc.*

2.10.14.3. To protect traditional versions of electricity meters from mechanical impacts and unauthorized access, they shall be installed in cabinets equipped with security alarms.

2.10.14.4. If it is not technically and/or economically feasible to install meters directly at ownership demarcation points, they may be installed at other grid points at the smallest distance from ownership demarcation points.

2.10.15. Organization of electricity metering for 0.4 (0.23) kV input switchgear of detached houses and corporate entities

2.10.15.1. Electricity meters for corporate entities and detached houses connected to 0.4 (0.23) kV grids shall be equipped with measuring systems using data communication devices (cellular networks, radio channels, PLC technologies, and interfaces of access to remote data reading). It is allowed to use electricity meters equipped with remote (remote) data displays.

2.10.15.2. In the case of individuals living in detached houses, meters shall be installed at ownership demarcation points outside residential premises at house entrances (on OL towers, house walls) or on OL towers, using split-architecture electricity meters or remote electricity billing meters.

2.10.15.3. In the case of corporate entities, meters shall be installed at ownership demarcation points, using split-architecture electricity meters or remote electricity billing meters.

2.10.16. Requirements for components of metering systems

2.10.16.1. Requirements for metering CT and VT for electricity metering:

- for the new construction and rehabilitation of MSS rated 110 kV and above, preference shall be given to the installation of digital metering CT and VT;

- metering CT and VT shall comply with the requirements set out in subsection 2.1.9 “Metering transformers” of these Regulations.

2.10.16.2. Requirements for electricity meters installed on connections of grid facilities and distribution grids:

- electricity meters shall ensure the accumulation of statistics about accidental events (voltage failures and interruptions, overvoltage);

- newly installed electricity meters shall each have at least two digital interfaces or a multi-access interface for working in the metering system of the Company. DSS electricity meters shall have a digital Ethernet interface (or an external converter) to work in the metering system and a digital interface for local testing and configuration;

- accuracy classes of electricity meters for various metered facilities shall be as follows:

• not lower than 0.2S for connections rated 110 kV and above;

• not lower than 0.5S for connections rated 0.4-35 kV.

The accuracy class of a reactive-energy meter may be one stage below the corresponding accuracy class of active-energy meters.

- electricity meters shall comply with the requirements of the Rules for Providing Access to the Minimum Set of Functions of Intelligent Electricity (Capacity) Metering Systems;

- digital electricity meters shall comply with the requirements of GOST 22261-94, GOST 31819.22-2012, GOST 31819.23-2012, IEC 61850-8.1 GOOSE, MMS, and IEC 61850-9.2 SV or shall be technically capable of being promptly switched over to data exchange in accordance with IEC 61850 with the appropriate readiness the higher control level (NCC) without additional costs and with no need to replace (remove) the electricity meter or DCCD.

2.10.17. Requirements for communication channels

2.10.17.1. The selection of types of communication channels in each case shall consider the location of metered facilities and the maximum use of in-house telecommunications connections.

2.10.17.2. Communication channels intended for data communication shall ensure stable connections between devices at various levels of electricity metering systems. Cellular networks may be used as the main communication channel (for example, high-level data processing systems for DCCD (DPS(EI)) only if any other communication channels ensuring stable connection are not available.

If cellular networks are used, measures shall be taken to ensure data communication integrity, and a dedicated APN (VPN) of data network operators and a hub-and-spoke network topology shall be used.

The selected types of communication channels shall be economically feasible.

2.11. Communications Network of Electric Grid Facilities

2.11.1. General

2.11.1.1. The main areas of the technical policy for the development of the communications network are as follows:

- enable the Company to coordinate the development of telecommunications infrastructure of SDCs and their interaction with each other;
- ensure accelerated upgrading and modernization;
- introduce modern telecommunications and information technology and expand the range of new services;
- build an integrated grid resource management system;
- introduce advanced operation technologies using modern devices for diagnostics and monitoring;
- improve the regulatory and technical framework and methodological support.

2.11.1.2. The communications network of electric grid facilities (CN EGF) is a system of interacting communications networks of the Company's SDCs, which includes communication facilities and communication lines and is designed to control production processes of electricity transmission and distribution, dispatching control, and production activities in the electric grid sector.

2.11.1.3. The communications network of electric grid facilities includes the communications network of transmission grid facilities with access to UNEG facilities and communications networks of distribution grid companies. The key principle of planning communications networks of grid companies is to ensure the interconnection and synchronization of development plans and the shared use of network resources to support an integrated production process and improve the reliability of communications networks.

2.11.1.4. The communications network is designed to transmit all kinds of information (voice, data, video) in order to ensure the management of production processes in electricity transmission and distribution, operational process control, production and administrative activities of the Company and SDCs, and operational dispatching control in the electric power industry.

2.11.1.5. The goal of creating the EGF communications network is to meet the needs of users of process control and corporate management systems of PJSC "Rosseti" and SDCs by using a modern set of communication services with the preset indicators of service quality with optimal development and operation costs of the communications network in order to achieve the required reliability and development level of the integrated electric grid sector.

2.11.1.6. The EGF communications network shall ensure:

- data exchange between electric power facilities, DC and NCC for operational dispatching control and operational process control;
- operation of relay protection systems;
- data exchange between grids companies to implement process control and corporate management;
- information security of data communication;
- potential integration with energy companies, government agencies, and communications network operators interested in creating communications networks based on the electric power industry's infrastructure;
- integration of IT systems of electric utility companies into a single infocommunication space;
- nondiscriminatory access of electric power industry entities to resources of the communications network.

2.11.1.7. Achieving the above-mentioned objectives will make it possible to:

- enhance the robustness and reliable operation of electric grids by ensuring EGF management in normal and emergency mode;
- improve the scalability of technical solutions and the efficiency of integrating newly built or rehabilitated EGF;
- raise EGF observability and manageability by ensuring providing operation divisions, accident recovery crews, and executives at all levels with up-to-date and reliable information and by promptly communicating decisions and tasks to each company or officer;
- ensure the introduction and operation of the automatic and automated dispatching and process control systems and the corporate information management system at all management hierarchy levels;
- promote digital transformation in the electric grid sector and ensure the construction of a new-generation electric grid and the introduction of digital substations.

2.11.2. Principles of Building and Developing the EGF Communications Network

2.11.2.1. Building and developing the communications network shall follow the following basic principles:

- network digitalization and work on introducing packet switching equipment, subject to compliance with the technical requirements for organizing the exchange of process information between electric grid facilities of the

Company. Decommissioning of analog communication systems;

- broadband technology: possibility of selectively changing data transmission using a simplified procedure for a specific subsystem or service, depending on the current needs;
- network scalability: possibility of expanding a network without changing the fundamental technical principles of its organization or replacing all of its channeling equipment;
- physical- and logical-level separation of the process and corporate segments of the communications network. The process segment shall be created and developed pursuant to the principles of organizing communication channels in accordance with the Target Model for Transmitting Commands and Organizing Communication Channels and for Communicating Telemetry Data Between Dispatching Centers and Network Control Centers of Grid Organizations and Substations (jointly approved by JSC "SO UPS" and PJSC "FGC UES" on January 29, 2007);
- prioritization of critical data delays by type through the introduction of mechanisms for ensuring quality of service (QoS);
- information security aimed at preventing unauthorized access to the resources of the communications network;
- access invariance: providing user access to automated and information systems, regardless of user technology;
- multiservice: simultaneous transmission of all kinds of traffic (voice, data, video) over a network;
- network modernization, provided that it is technically and economically feasible;
- reduction of CAPEX and OPEX by using unified standard solutions and process automation for diagnostics and management;
- interaction with existing and new communications networks of electric power industry entities and with communications network operators;
- use of open and standardized protocols and interfaces;
- use of forecasts of potential needs for telecommunication and information services for 5–10 years;
- deployment communications networks without interrupting the operation of the existing telecommunications infrastructure, i.e. the construction of new user networks in addition to existing networks;
- priority: building CN EGF shall unconditionally give priority to process traffic with due consideration to the guaranteed reliability and security of delivery;
- hybridity: compliance with the requirements for transportation networks with the interaction among various types of process systems, such as relay protection, telemetry, and voice communication, as related to delay time, delay

asymmetry, and delay irregularity (jitter);

- control over the condition of critical elements of the communications network by using monitoring systems.

2.11.2.2. The process segment of CN EGF shall be created and developed in accordance with the condition of ensuring the principles organization of communication channels in accordance with the Regulations for the Process Interaction Between JSC “SO UPS”, and PJSC “FGC UES” of May 17, 2019, the Communications Network Concept for the Electric Grid Sector, and other technical standard documents of PJSC “Rosseti” governing the creation and development of communications networks.

2.11.2.3. The boundary routers with access to the Internet shall be routers certified for compliance with the information security requirements (as related to their implemented security features).

2.11.2.4. Developing the information and communication infrastructure involves using services and cloud solutions of leading communications network operators. The creation and modernization of internal communications networks and data storage and processing systems shall be based on assessing their efficiency and economic feasibility.

2.11.3. Basic Requirements for EGF Communications Network Services

2.11.3.1. The EGF communications network at all management levels shall ensure the exchange of all types of information (voice, video, data) with guaranteed quality in accordance with federal and corporate standards for communication channels, including in accordance with G/L 45.046-99, ITU-T G.823, ITU-T G.825, ITU-T Y.1540, and ITU-T Y.1541.

Information transmission services characterized have the following quality parameters:

- accessibility;
- availability factor and recovery time;
- information transmission quality;
- transmission capacity;
- delay time;
- delay asymmetry;
- delay irregularity (jitter);
- 24/7 operation of the telecommunications infrastructure with redundancy ensuring the continuity of operational dispatching control and operational process control in the electric power industry.

2.11.3.2. Availability is determined by the compliance of parameters of telecommunication signal transmission with the requirements of standards for electric parameters of main digital channels and paths of the trunk network and intrazonal primary networks of interconnected communications networks in the Russian Federation.

2.11.3.3. The availability factor for every data exchange direction of the process and corporate segments of the communications network shall meet the reliability requirements of working control subsystems.

2.11.3.4. The selected bandwidth of digital channels shall ensure the transmission of all traffic related to control objectives with the required quality parameters (including the operation of the telephone network for operational communications and the telephone network for production and process purposes) and the transmission of telemetry data about process operation modes of equipment, and the electric power industry's operational dispatching control objectives of the subject of operational dispatching control in the electric power industry, etc.

2.11.3.5. The organization of data exchange between electric power facilities of grid organizations and DC of JSC "SO UPS", including the requirements for the telephone network for operational communications, shall comply with the technical requirements contained in the existing process interaction agreements between JSC "SO UPS", and grid organizations in order to ensure the reliable operation of Russia's UPS.

2.11.3.6. Communication centers of NCC, SS, electric grid companies, and other electric power industry entities shall be connected to the EGF communications network at the network hosts of the EGF communications network over at least two mutually redundant standalone communication channels with transmission capacity specified in design documents and applicable TSD. In this regard, the organization of data exchange shall mutually use the telecommunications infrastructures of PJSC "Rosseti", SDCs, and other electric power industry entities.

2.11.3.7. The EGF communications network shall ensure the provision of the following main services in relation to the transmission of process and corporate information:

- telephone network for operational communications;
- telemetry (telemetry data, remote indication, and remote control);
- process data of video surveillance;
- relay protection signals and commands with the remote monitoring of relay protection devices, viewing of oscillograms, and settings of relay protection terminals;
- data communication for AISEBM and the Electricity Quality Monitoring and Management System;
- data communication for corporate IT systems;

- recording of operational communications;
- production and process telephone communication;
- operational radio communication;
- access to services and facilities of public telephone networks (local, long-distance, and international calls);
- videoconferencing;
- recording of videoconferences;
- facsimile transmission;
- transmission of other process information;
- information and reference services.

2.11.4. Structure and Components of the EGF Communications Networks

2.11.4.1. CN EGF is a system of interacting communications networks of the Company's SDCs.

The communications networks of the Company's SDCs are divided into the following components:

- primary (trunk and distribution) communications network, which is a set of networks, lines, and channels of communication ensuring the delivery of all kinds of information;
- secondary (overlay) networks, which are composed of devices ensuring the transmission, switching, and distribution of a certain kind of information.

2.11.4.2. Building the primary communications network with its redundancy may used the following types of networks, lines, and channels of communication:

- wired communication:
• fiber-optic communication lines (FOCL);
• high-frequency communications network over OL (HF-OL);
• cable communication lines (CCL);
• power line communication (PLC) channels;
• leased communication resources (channels) of communications network operators' wired facilities;
- wireless communication:
• radio relay lines (RRL);
• satellite communication network;
• leased communication resources (channels) of communications network operators' wireless facilities, except for mobile (cellular) networks.

2.11.4.3. The secondary networks include:

- data communication network;
- telephone communication network;

- teleconferencing network (audio and video);
- mobile radio communication network;
- base stations of mobile radio communication networks.

2.11.4.4. The architecture of the EGF communications network is a system of SDCs' communications networks combined over at least two mutually redundant communication channels implemented as a ring-star network (Figure 4).

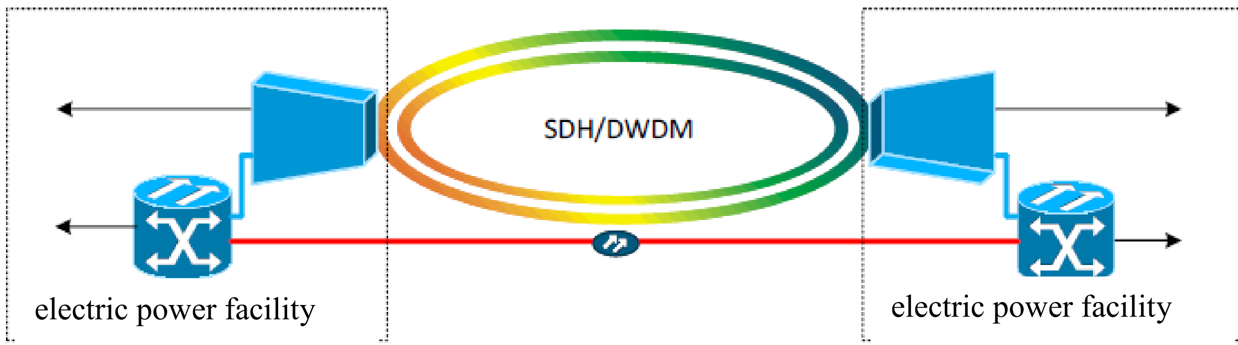

Figure 4. FOCL ring architecture

2.11.4.5. The primary communications network shall predominantly be based on a ring topology. Additionally, the primary communications network may use the following topologies:
- cells;
- point to point;
- point to many points;
- chain;
- multipath ring.

2.11.4.6. To ensure the fail safety of the communications network, duplication or redundancy shall be used for equipment and channels, depending on applied technologies, restrictions on data exchange, or economic feasibility.

2.11.4.7. With an appropriate FS, it is recommended that the trunk network's sections requiring large transmission capacity and/or having prospects for increased traffic use wavelength-division multiplexing (WDM) equipment. Additionally, the use of WDM is a method of logical separation for the process and corporate segments of the network, which makes it possible to organize the necessary number of SDH and/or Ethernet channels with the required transmission capacity.

2.11.4.8. To ensure the subsequent transfer of the communications network to IP/Ethernet while maintaining previously made investment, it is recommended that SDH or OTN communication equipment be used with the number of Ethernet interfaces necessary for a specific network topology.

2.11.4.9. Any equipment and materials used for the construction of the communications network shall comply with the requirements of the applicable TSD. The compliance of equipment shall be confirmed by certificates of conformity, and the compliance of materials shall be confirmed by declarations of conformity issued by the federal executive authority in charge of telecommunications.

2.11.5. Data Communication Network

2.11.5.1. The data communication network of CN EGF shall be a three-level communications network shown in Figure 5.

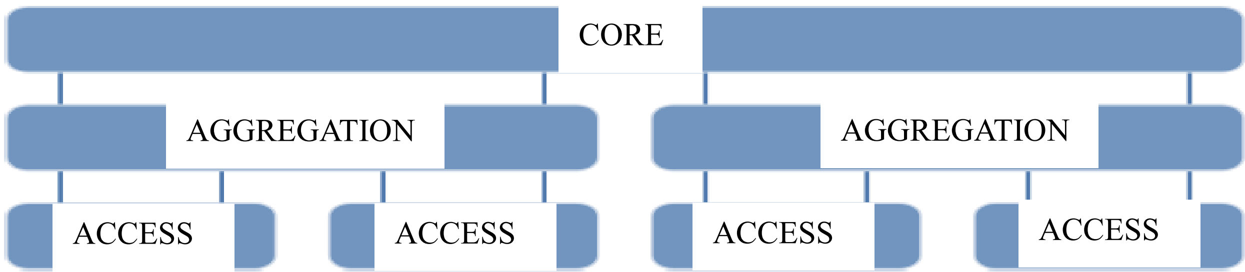

Figure 5. Three-level model of CN EGF

2.11.5.2. The data communication network of CN EGF (Figure 6) shall include:

- base/trunk level (core) (high-speed, long-distance connections between geographically remote sections; integration of several sites (groups of buildings) into a distributed network; fast and reliable transmission of large traffic);
- distribution/aggregation level (routing, filtering; and access to an integrated network; (if necessary) rules for packet access to the base level);
- access level (access for users, workgroups, and local process systems to an integrated network).

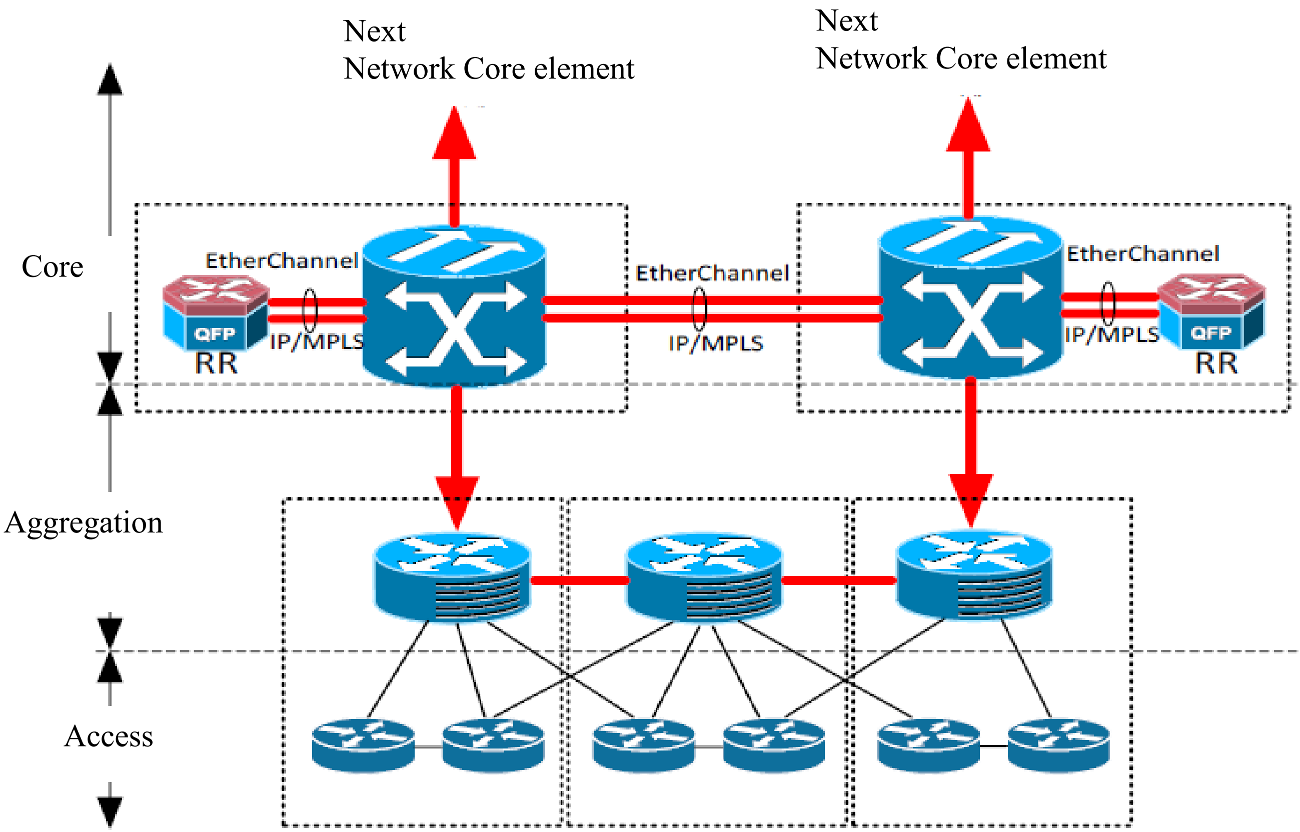

Figure 6. Structure of the CN EGF data communication network

2.11.5.3. The structure of the CN EGF data communication network shall ensure the integration of communication centers at all levels of process control and corporate management of electric grid companies and JSC “SO UPS”. Implementing the separation of the segments of the data communication network at the logical level shall include measures to ensure secure network integration, including segmentation and firewalling.

2.11.5.4. Communication centers of NCC, SS, electric grid companies, and other electric power industry entities shall be connected to the EGF communications network over at least two mutually redundant standalone communication channels at the network hosts of the EGF communications network, which are CN EGF access nodes.

CN EGF access nodes shall be SS communication centers, regional communication centers (RCS), and district communication centers (DCS) using resources of electric grid companies’ branches, and access nodes of alternative communications network operators.

2.11.5.5. The basic development area of CN EGF is digitalization for the transportation network and access network based on the wide implementation of modern digital switching nodes by building networks of FOCL and RRL, deploying the satellite communication network (SCN) and the digital mobile radio (DMR) network, and using wavelength-division multiplexing (WDM) equipment and IP-based packet switching technology.

2.11.5.6. In order to improve EGF observability and consequently enhance operational dispatching control and operational process control, strategic priority shall be given to digitalization for access networks at the level “facility–dispatching center/network control center.”

2.11.5.7. When organizing connections between NCC and EGF rated below 35 kV and connections with customers’ electricity meters, it is allowed to use dedicated APN technology for GSM/GPRS/3G/4G networks (excluding the transmission of remote control commands) and a hub-and-spoke network topology.

An FOCL-based network section is described in Figure 7.

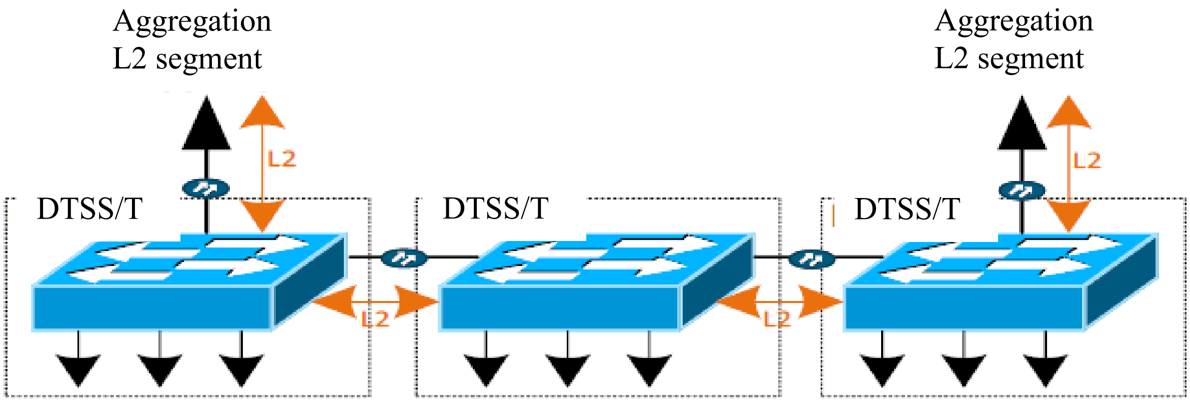

Figure 7. FOCL-based network section

An APN-based network section is described in Figure 8.

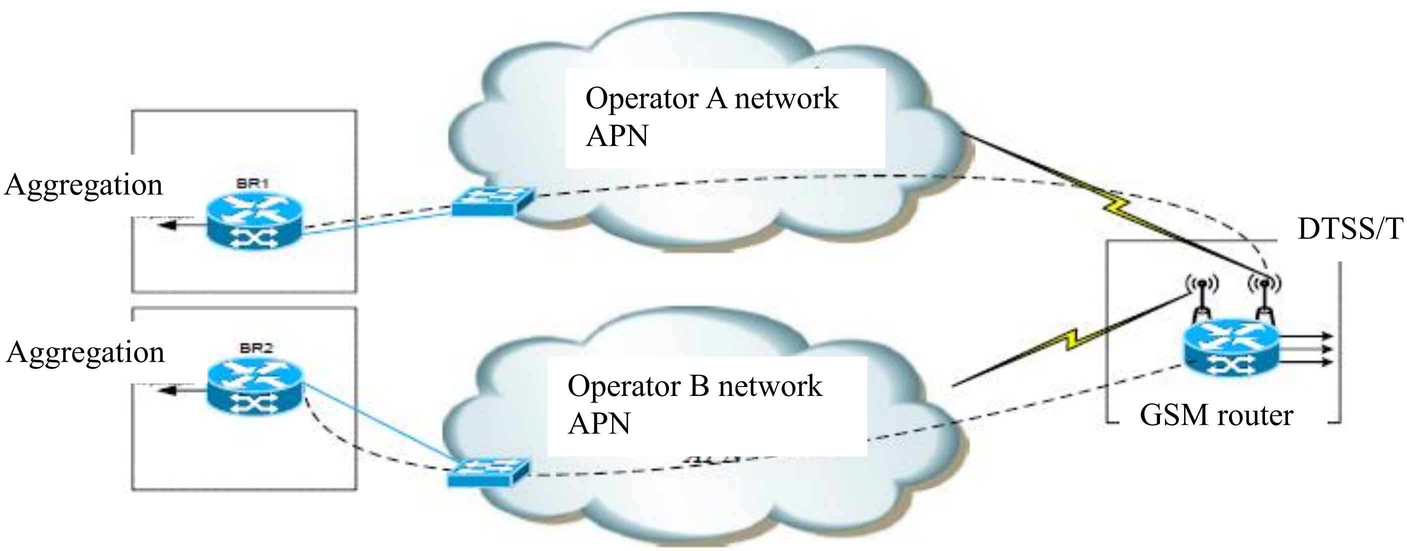

Figure 8. APN-based network section

2.11.5.8. Wireless technologies make it possible to connect NCC to a large number of facilities in a relatively large area with minimum network deployment and maintenance expenses.

PLC technology may be used in the areas between facilities rated below 35 kV and customers' electricity meters, building shared connection points (gateways) to a communication channel.

A PLC-based network section is described in Figure 9.

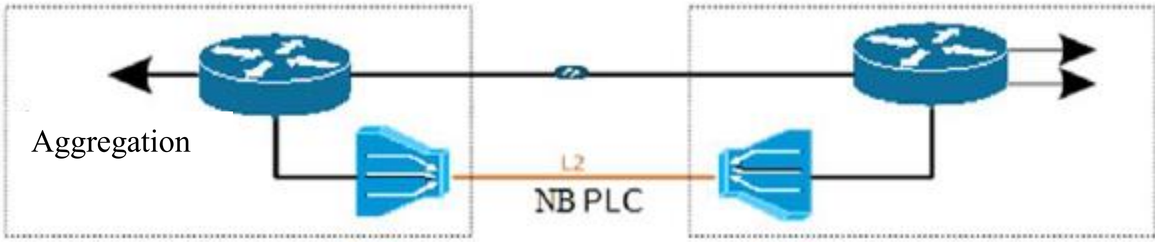

Figure 9. PLC-based network section

2.11.5.9. Materials and equipment used for the construction of the process network, including optical cables, accessories and couplings, data communication systems, switching and routing equipment, and SHS shall comply with the established requirements, shall be duly certified for use in the electric power industry, and shall have a certificate of conformity issued by the federal executive authority in charge of telecommunications.

2.11.6. Fiber-Optic Communication Lines

2.11.6.1. FOCL are the main method of building of a trunk communications network.

2.11.6.2. The construction of FOCL on OL rated 35 kV and above mainly uses optical power ground wires (OPGW).

2.11.6.3. The construction of FOCL may use self-supporting optical cables (SSOC) (Figure 10), optical power phase wires (OPPW) (Figure 10 and Figure 11), or optical attached cables (OPAC).

2.11.6.4. The construction in buildings uses fiber-optic cables (FOC) (Figure 12), for example, composed of a central member (fiberglass core, steel wire, polyethylene-sheathed steel wire) carrying optical elements, each containing up to 32 optical fibers, with protective sheathing of corrugated steel or fiberglass rods, and outer sheathing of high-density polyethylene.

FOC for indoor applications shall have the same design, except that outer sheathing shall be made of flame-retardant materials.

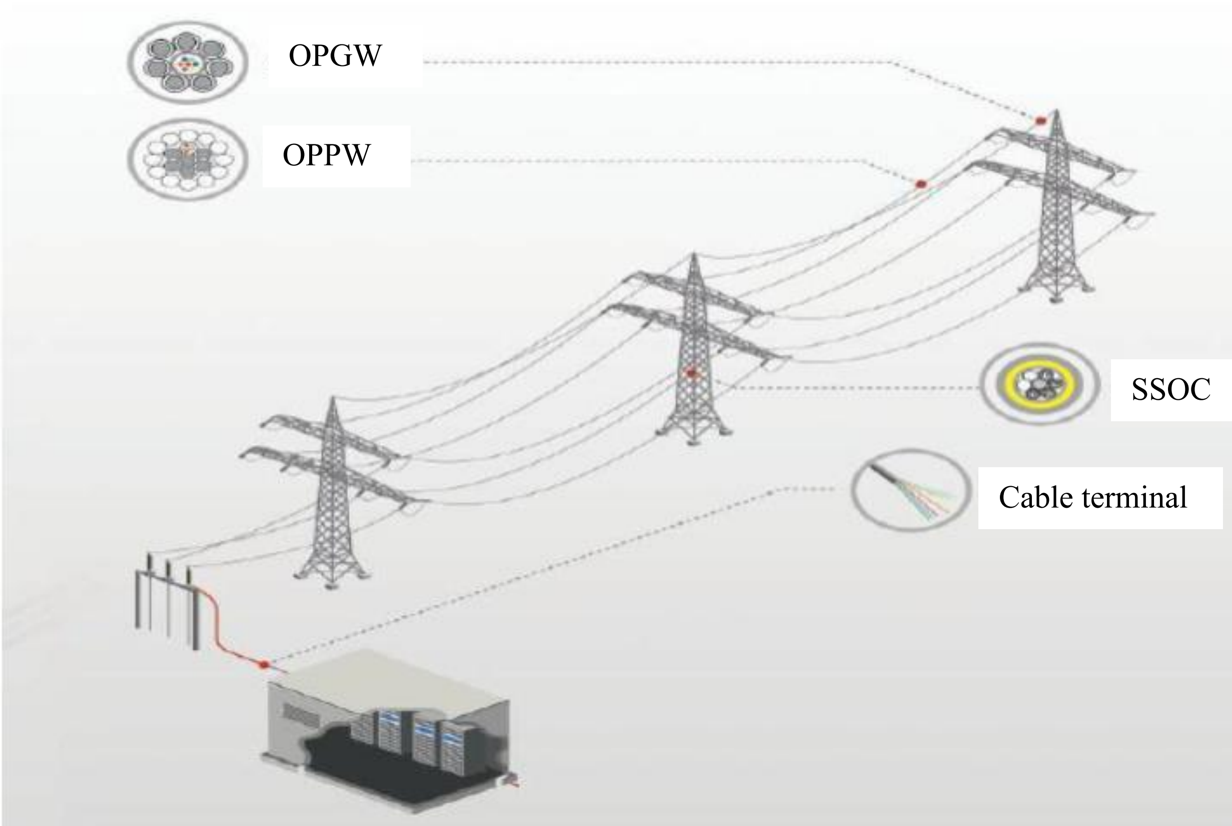

Figure 10. Self-supporting optical cable (SSOC), optical power phase wire (OPPW), and optical power ground wire (OPGW)

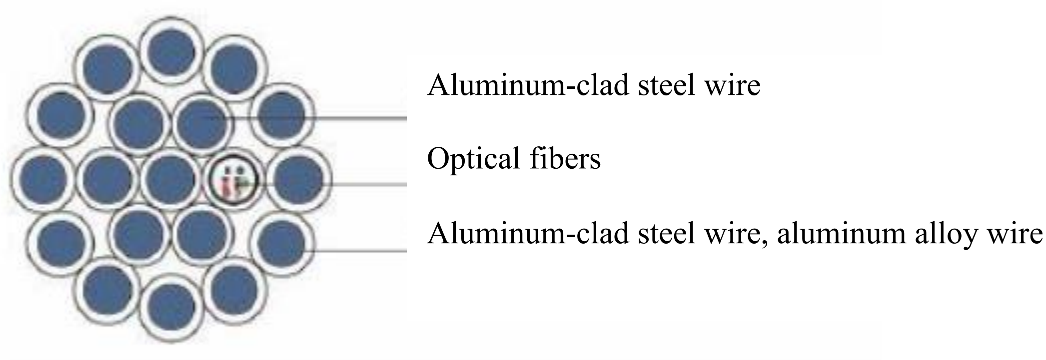

Figure 11. Optical attached cable

2.11.6.5. It is not recommended that SSOC be used in areas with high industrial pollution, in areas up to 5 km from sea and ocean coasts, or in climates with long periods of drought and rare periods of rain precipitation and fog.

2.11.6.6. The method of attaching OPAC to phase wires or lightning protection cables (LPC) also has limitations. It is allowed to attach optical cables to phase wires on OL rated up to 150 kV or LPC in areas with an average annual period of thunderstorms of less than 20 hours.

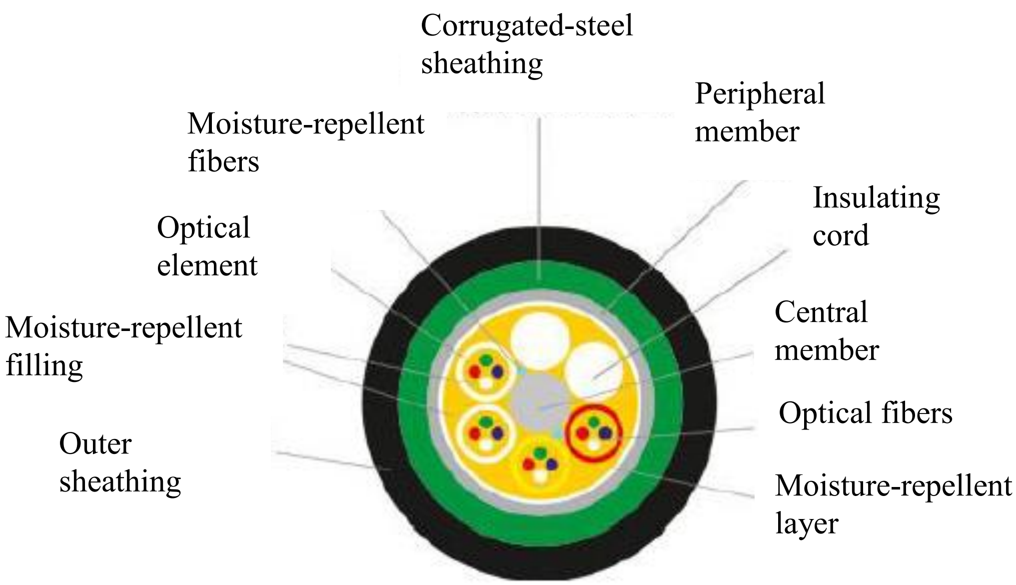

Figure 12. Fiber-optic cable for indoor applications

2.11.6.7. FOCL mounted on CL may use high-voltage underground or underwater cables with built-in optical cables.

2.11.6.8. The selection of types of cables shall be economically feasible, with due consideration to the condition of OL and the possibility of OL shutdowns for the construction and possible repair of FOCL.

2.11.6.9. The number of optical fibers in an optical cable and the capacity of communication systems shall be determined in the design documentation phase or in the design phase with due consideration to current and future needs.

2.11.6.10. The construction of FOCL on OL may use investment other than tariff-based financing (obtained from communications network operators) by providing them with the temporary limited use of electric grid infrastructure for FOCL.

2.11.6.11. The construction of FOCL shall predominantly use the ring-type integration of communication centers to provide physical redundancy for communication channels.

2.11.6.12. The construction of FOCL may use several OL with different voltages with the same route as FOCL.

2.11.6.13. When fiber-optic cables are attached to OL, design and survey work shall include examining the condition of foundations and metal structures of towers and their mounting in the ground, taking into account additional loads from the installation of fiber-optic cables.

2.11.6.14. Data communication technologies for FOCL shall be selected at the stage of design with due consideration to the current and future use of communication lines and types of traffic.

2.11.6.15. Optical fibers shall meet GOST R IEC 793 and the recommendations of ITU-T G.652, G.653, G.654, and G.655. Any specific requirements for the parameters of optical fibers shall be specified in the design documentation phase for data communication systems for specific FOCL on OL.

2.11.6.16. The design, construction, and operation of FOCL on OL shall be in accordance with the applicable LR and TSD.

2.11.6.17. As-built documents shall comply with the requirements of OS 56947007-33.180.10.172-2014, G/L 45.156-2000, and G/L 45.190-2001, and as-built documents for the line section of FOC on OL shall be in accordance with G/L 34.20.504-94.

2.11.6.18. Due to increased requirements for the operating reliability of the trunk network, it is necessary to examine the feasibility of installing automated systems for monitoring optical fibers in order to provide real-time monitoring for the physical condition of optical fibers.

2.11.6.19. In order to unify technical operation and ensure certification, planned measurements and measurements related to accident recovery work, optical fibers and modules in FOC shall have the following colors: blue, orange, green, brown, gray, white, red, black, yellow, purple, pink, turquoise.

2.11.6.20. The basic principles and areas of developing FOCL are as follows:

- build new physical high-speed communication channels for power infrastructure facilities;
- provide quality assurance and control for work at the stages of designing and building FOCL on OL;
- use investment other than tariff-based financing for the construction and development of FOCL from communications network operators, energy companies, and other organizations with their own FOCL infrastructure, with which it is allowed and possible to use the long-term exchange of optical fibers and telecommunication resources on a contractual basis;
- switch over from TDM equipment to packet switching systems.

2.11.6.21. FOCL applications are a priority type of infrastructure for building the trunk network and communications networks for facilities with all voltages.

2.11.7. High-Frequency OL Communications Network

2.11.7.1. High-frequency communication systems are used to control production processes in normal conditions and in emergency situations. These channels transmit all kinds of information needed for such process control:

- voice (telephone communication);
- telemetry signals;
- machine-to-machine data;
- APCS data;
- AISEBM data.

2.11.7.2. HF communication channels use phase wires and lightning protection cables of OL for transmission (as communication lines).

2.11.7.3. The use of digital HF communication is useful for network sections that required the transmission of a limited amount of information, while the use of others types of communication does not ensure the necessary reliability of data communication or is economically unfeasible. The transmission capacity of digital HF communication paths shall be calculated in the design phase, with due consideration to specific features of equipment, the condition of OL, the availability of taps, and additional attenuation caused by weather conditions and broken OL. On OL rated 35 kV and above, communication speed is also limited by free frequencies of 16–1000 kHz.

2.11.7.4. Depending on the frequency band, HF equipment makes it possible to ensure information transmission with a speed of up to several hundreds of kbps.

2.11.7.5. HF communication channels shall be organized with due consideration to redundancy for overlapped attenuation caused by adverse weather conditions (fog, drizzle, ice, rain). Communication channels shall meet the requirements for electromagnetic compatibility.

2.11.7.6. It is not allowed transmit HF signals of OL protection via HF channels over lightning protection cables.

2.11.7.7. The basic principles and areas of developing HF communication lines are to increase the functionality, reliability, and quality of HF communication, namely:

- introduce multifunctional digital systems that meet the modern increased requirements for HF communication channels (advanced types of modulation, algorithms of anti-noise coding, etc.);
- introduce special HF communication channels for HF protection and emergency control systems with the digital processing of signals meeting the modern increased requirements for these types of channels;
- decommission obsolete analog HF communication equipment and, on a phased basis, replace them by modern HF communication systems, suitable for operation in digital and analog mode;
- use the digital processing of signals in transmission and reception paths ensuring the efficient use of the frequency band of HF communication channels by

increasing equipment selectivity and ensuring the effective use of the nominal frequency band;

- create an integrated information system of selecting frequencies for HF communication channels.

2.11.7.8. In the case of electric grids rated 6–10 kV, HF communication systems shall be used to organize communication channels between electric power facilities and electricity meters.

2.11.8. Mobile Radio Communication Network

2.11.8.1. The mobile radio communication network shall develop through the expansion of coverage and the replacement of obsolete analog radio stations by modern digital equipment. In modernizing analog systems of mobile radio communication, the main standard for creating a mobile radio communication network at the level of production units (distribution zone/transmission grid entity) shall be the Digital Mobile Radio (DMR) standard, allowing the gradual abandonment of analog VHF radio networks without losing previous investment.

2.11.8.2. The DMR system shall have a subsystem of terminal location (for portable and vehicle-mounted radio stations) and location display for the dispatcher’s workstation.

2.11.8.3. Radio stations shall be able to quickly change working frequencies for to be used on other radio networks for accident recovery purposes. DMR radio stations shall have a GLONASS receiver for terminal location.

2.11.8.4. Charged batteries of portable radio stations shall provide them with self-contained operation for 12 hours in 5/5/90 (transmission/reception/standby) mode.

2.11.8.5. Permission for the allocation and assignment of radio frequencies for electric grid facilities is granted as resolved by the State Commission for Radio Frequencies:

- Decision of the State Commission for Radio Frequencies No. 11-13-01 of December 20, 2011, (as amended on February 10, 2015) “On the Approval of the Procedure for Considering Documents and Issuing, Reissuing, and Amending Decisions on the Allocation of Radio Frequency Bands”;

- Decision of the State Commission for Radio Frequencies No. 16-39-01 of November 7, 2016, “On the Approval of the Procedure for Examining the Possibility of Using Declared Radioelectronic Equipment and Their Electromagnetic Compatibility with Existing and Planned Radioelectronic Equipment and for Considering Documents and Issuing Decisions on the Allocation (Assignment) of Radio Frequencies or Radio Frequency Channels Within Allocated Radio Frequency Bands.”

2.11.8.6. Mobile radio communication, mobile (cellular) communication, and satellite-based mobile communication (“mobile communication equipment”) are the main communication systems used by dispatching and operational personnel for communication with line and accident recovery crews and the backup communication systems for the operational process control of the electricity distribution grid.

When determining the need for mobile communication equipment, it is necessary to consider the structure of OL services at each company, operating areas of line sections, the quality of cellular (GSM/UMTS) and satellite-based communication in the operating area of each line section.

2.11.8.7. It is allowed to use stationary radio stations and VHF radio modems to organize the main and backup data communication channels to low- and medium-voltage facilities and organize backup communication channels for facilities rated 35–110 kV if other data communication technologies cannot be used or are economically unfeasible.

2.11.9. Satellite Communication Network

2.11.9.1. Fixed-satellite service channels may be used as communication channels (not more than one channel in one direction) subject to the requirements for the telephone network for operational communications and for information transmission for automated and automatic control systems if the use of other data communication technologies is impossible or economically unfeasible.

2.11.9.2. The satellite communication network is also an additional mobile communication system if the mobile radio communication network or radio coverage is not available in the area of work of line and accident recovery crews, providing redundancy for communication between dispatching and operational personnel and line and accident recovery crews.

2.11.9.3. The basic principles and areas of developing the satellite communication network are as follows:

- introduce modern systems meeting the requirements set by the Ministry of Information Technologies and Communications of the Russian Federation;
- ensure continuous monitoring for quality indicators of channels (service level agreements);
- use satellite communication channels in standby mode if landline communication channels are available;
- decrease the impact of weather and climate conditions on the operation of the communications network;
- ensure regional development using resources of one operator and uniform technology.

2.11.10. Telephone Communication Network

2.11.10.1. The telephone communication network is also composed of corporate and process segments.

2.11.10.2. The corporate segment of the telephone communication network is designed to ensure the production (administrative and economic) activities of the electric power industry, including voice transmission. The corporate segment shall develop through the replacement of subscriber devices by IP terminals and the use of switching equipment for terminals using the SIP and/or H.323 protocols.

2.11.10.3. The main objectives of developing the corporate telephone network are as follows:

- create an integrated corporate telephone network based on a corporate multiservice communications network;
- introduce a unified dialing plan;
- introduce distributed IP PBXs consisting of a central module and media gateways. In this regard, if the central PBX is temporarily unavailable, media gateways shall use standalone IP PBXs providing basic voice services;
- use the SIP and H.323 protocols;
- use normalized compression (G.726 and G.729 codecs);
- introduce and develop an integrated control and monitoring system at the level of the central PBX;
- ensure convergence with other communication types (introduce unified communication technologies).

2.11.10.4. The process segment of the telephone communication network, including the network for operational communications, is designed to ensure production process management.

2.11.10.5. The telephone network for operational communications shall ensure the transmission of commands and the prompt interaction among operational personnel of NCC, operational personnel of electric power facilities, and dispatchers of JSC “SO UPS”. This network shall have at least two standalone telephone communication channels.

2.11.10.6. The telephone network for operational communications shall be built on channel switching technology (time division multiplexing (TDM)) with the forced release of a busy channel, with the possibility of a subsequent smooth and gradual transition to packet switching technology (MPLS VPN, traffic engineering). However, the telephone network for operational communications shall comply with rigid reliability and fail safety requirements for individual nodes and for the entire network. The channels and equipment allocated for these purposes shall ensure guaranteed delivery and quality in normal and emergency operation modes for electric power facilities using packet switching technology.

2.11.10.7. Switching equipment used to build the telephone network for operational communications shall have 100% hot redundancy for station processors, interface cards, interfaces, and power supply sources. It is allowed to use switching equipment for building the telephone network for operational communications without 100% hot redundancy; however, operational personnel shall have at least two switching equipment sets without common fault points in the workplace. Switching equipment used to build the telephone network for operational communications shall pass quality control tests for use at EGF.

Switching equipment used to build the telephone network for production and process purposes may have less than 100% hot redundancy for station processors, interface cards, interfaces, and power supply sources.

2.11.10.8. Automatic registration (recording) shall be provided for all communications of operational personnel, with such records to be stored in accordance with the prescribed procedure.

2.11.10.9. The telephone network for operational communications shall use a radial-nodal topology with a ring topology added, which is the most consistent with the hierarchy of dispatching control and process control in the electric power industry.

2.11.10.10. Digitalization for the process and corporate segments of the telephone communication network shall be based on the transition to an open numbering system with prefixes: two-, three-, or four-digit short numbering for intrastation communications and seven-digit uniform numbering for interstation communications. The principles of the uniform dialing plan shall comply with OS 56947007-33.040.35.203-2015 “Process Communication. Guidelines for the Uniform Numbering System of PBXs of Electric Grid Facilities.”

2.11.11. Videoconferencing Network

2.11.11.1. The videoconferencing (VC) system shall ensure the organization of videoconferences on a hierarchical basis according to the organizational structure of grid companies.

2.11.11.2. To ensure optimum quality, VC equipment shall use mechanisms of automatic adaptation for coding parameters depending on the available bandwidth and quality characteristics of communication channels.

2.11.11.3. The VC system shall ensure:

- registration software- and hardware-based video terminals and call management calls at the central PBX;

- connection of remote video clients from external networks, including the Internet (subject to the information security requirements);

- multicast videoconferencing;
- unified and centralized bandwidth control for communication channels of telephony and VC services;
- interactive control from the user video terminal for the screen layout, content, and list of participants;
- centralized planning and management of VC sessions and VC equipment monitoring;
- electronic recording of videoconferences;
- videoconference confidentiality;
- use of VC equipment for online learning;
- support for voice and video transmission quality of not lower than HD (720p) at the level of the Company's executive arm and not lower than 4CIF at the level of branches;
- support for workgroup document management.

2.11.12. CN EGF Monitoring and Control System

2.11.12.1. Grid companies' communications network management shall be technically and economically feasible, using centralized systems at the level of production units (distribution zone/transmission grid/transmission grid entity), with the following functionalities:
- configuration, monitoring, and control of malfunctions;
- inventory management (registration of physical and logical resources of the network);
- performance management (monitoring of network parameters and performance analysis);
- troubleshooting supervision;
- service quality management (service level agreements);
- security management (network access control).

2.11.12.2. The network management level shall make it possible to observe the entire network, manage it and its separate elements, and control its overall condition.

2.11.12.3. The level of monitoring and controlling network elements shall make it possible to monitor parameters and control separate network elements, including the management of events and errors, redundancy, acquisition, primary diagnostics, and event storage for network elements, providing support for hardware and software, and power supply status management for CN EGF equipment.

2.11.12.4. All information required for network management shall be contained in a single database, which may be changed and supplemented with descriptions of new control objects, and the entire official data exchange of the control system shall use the existing controllable network.

2.11.13. Clocking Network

2.11.13.1. The communications network of transmission grid facilities shall be provided with a clocking network with its primary reference clocks and secondary master clocks, and the clocking network shall interact with the base clocking network of PJSC “Rostelecom” in pseudosynchronous mode, and they shall together form the clocking network of the Company’s communications network. It is not practicable to use -house primary reference clocks (PRC) or secondary master clocks (SMC) for the communications network of distribution grid facilities. It is recommended that the base network of the Company’s branches be connected to the clocking network of PJSC “Rostelecom” or the clocking network of transmission grid facilities.

2.11.13.2. The clocking network shall be designed to operate in the long term, use the most advanced technological solutions, and be a branched homogeneous network for the generation, delivery, and distribution of clock signals.

2.11.13.3. The main purpose of the clocking network is to ensure the configuration and maintenance of specific clock frequencies of digital signals intended for digital switching and digital transit in order to keep the timing relationships between these signals within specific limits.

2.11.13.4. The reliability and robustness of the clocking network shall be ensured by the homogeneity of the communications network, the availability of direct and backup synchronization routes, the justified use of additional clock signals from GLONASS, PRC, and SMC, and the use of a combined operation mode of the clocking network in emergency situations in accordance with the master-slave and distributed-PRC hierarchies. Synchronization shall use a force method on a hierarchical basis in accordance with a tree (radial-nodal) scheme without closed rings.

2.11.13.5. The basic principles of building the clocking network of digital communications networks shall comply with the requirements of the technical guidelines on building the clocking network on the digital communications network of the Russian Federation (approved by the State Commission for Telecommunications on November 1, 1995).

2.11.13.6. Synchronization signals shall have quality determined by the signal source. The qualitative characteristics of the clocking network shall meet the requirements of G/L 45.230-2001, the recommendations of ITU-T 6.811, 6.812, and 6.813, and standards 300 462-1.23.4.5.6 of the National Telecommunications

Network of the Russian Federation.

2.11.14. Power Supply for Communication Equipment

2.11.14.1. Power supply for CN EGF equipment shall typically be centralized via two power supply inputs:

- from uninterruptible power sources (UPS) rated 36–72 V DC or 220 V AC;
- from a one-/three-phase alternating-current grid with a nominal voltage of 220/380 V with a permissible deviation of +10%/–20%, a frequency of 50 Hz with a permissible deviation of +2.5/–2.5 Hz, with Category 1 reliability, and, if necessary, with voltage stabilization.

2.11.14.2. Power supply for UPS shall have Category 1 reliability, come from a one-/three-phase alternating-current grid with a nominal voltage of 220/380 V with a permissible deviation of +10%/–20%, a frequency of 50 Hz with a permissible deviation of +2.5/–2.5 Hz, or come from an auxiliary direct-current network.

2.11.14.3. UPS shall be connected to ALT and provide a guaranteed and reliable power supply for loads. UPSD shall include groups of sealed and maintenance-free AU with an operation life of at least 10 years.

2.11.14.4. AU capacity for UPS for CN EGF shall ensure backup power supply for communication and data transmission equipment for:

- at least 4 hours at power facilities rated 110 kV and above, and for transit equipment for the transportation network of CN EGF at any facilities;
- at least 2 hours at power facilities rated 35 kV and below.

2.11.14.5. UPS equipped with AU shall have rectifier units without transformers and, if necessary, offline inverters with switching time of less than 20 ms with microprocessor-based control and automatic control and signaling devices. UPS powered by auxiliary direct current shall typically be equipped with offline inverters switching time of less than 20 ms and DC/DC converters with microprocessor-based control and automatic control and signaling devices.

2.11.14.6. Any uninterruptible power source (UPS) containing AU shall ensure:

- simultaneous power supply for loads and charges (continuous buffer recharges) for AU;
- AU protection from discharges below the permissible level (deep discharges);
- changes to settings of output voltage from charge voltage to permanent recharge voltage after AU charging;
- S/C protection for battery circuits, rectifier output circuits, and load circuits;

- selective shutdown of any faulty rectifier of UPS;
- temperature compensation and AU tests;
- galvanic load separation from the alternating current network;
- even distribution of load current among UPS rectifiers;
- remote diagnostics and interaction with monitoring systems using the SNMPv2 or SNMPv3 protocols.
- shutdown of low-priority loads for discharged AU;
- local and remote UPS alarms.

2.11.14.7. The design of UPS shall make it possible to increase output capacity by installing additional rectifiers and shall be built on the unit-type and modular principle.

2.11.15. CN EGF Operation Management

2.11.15.1. The operation of the EGF communications network shall be in accordance with the Operating Rules for Electric Power Plants and Networks of the Russian Federation, the Rules for Organizing the Maintenance and Repair of Electric Power Facilities, Operating Rules for Primary Networks of the Unified Communications System of the Russian Federation, and other applicable LR and TSD.

2.11.15.2. Operation determines the system of maintenance methods and algorithms for CN EGF, the set of technical communication devices, software, and hardware, and technical personnel ensuring the operation of CN EGF with the required quality.

2.11.15.3. CN EGF operation encompasses line paths of cable and overhead communication lines, network paths, communication and transmission channels, sections of communication and transmission and paths (multiplex and regeneration sections), communication and data transmission devices and equipment, and cable line facilities.

2.11.15.4. CN EGF operation shall be carried out by special divisions using a centralized maintenance method.

2.11.15.5. The main objectives of CN EGF operation are as follows:

- ensure the stable, efficient, uninterrupted, and high-quality operation of equipment and communication cable line facilities included in CN EGF;
- ensure stable operation with the required quality and operational reliability;
- make efficient use and maintenance of resources and content in accordance with technical standards and requirements;
- carry out timely and high-quality repair and reliability enhancement;
- remedy all failures, damage, and accidents within the required period;
- maintain production documents and statistical and technical records in

accordance with the approved forms and instructions.

2.11.15.6. CN EGF operation includes maintenance, accident recovery, and current, intermediate, and major repairs.

2.11.15.7. CN EGF maintenance is a set of operations aimed at maintaining operability or serviceability, preventing malfunctions in a timely manner, identifying malfunctions, and remedying defects.

2.11.15.8. The proper organization of maintenance shall increase the operation life of CN EGF equipment, maintain their high quality and operating reliability, and contribute to increased MTBF and decreased repair costs.

2.11.15.9. Operation of communication equipment

2.11.15.9.1. The process of operating CN EGF devices and equipment consists of performance measurements, failure alarm monitoring, fault and damage detection, redundancy, and performance restoration and includes:

- measurements and checks;
- repair and adjustment;
- maintenance;
- current and medium repairs;
- recording and analysis of equipment failures;
- documentation;
- regular security updates for built-in software.

2.11.15.9.2. The serviceable condition of CN EGF devices and equipment is determined by:

- compliance of parameters of devices and equipment with technical standards and specifications;
- content and completeness;
- serviceability of alarm devices and switching components;
- absence of mechanical damage; good appearance;
- use of meters meeting the requirements of subsection 3.6 of this Technical Policy, and their timely maintenance for metering purposes.

2.11.15.9.3. The operation of CN EGF devices and equipment includes the following maintenance methods:

- preventive maintenance, performed at certain intervals or in accordance with preset criteria and aimed at preventing failures or impaired operation in a timely manner;
- corrective maintenance, performed after detecting failures and aimed at restoring the required serviceability;
- controlled maintenance, performed by systematically using status analysis methods using the monitoring of performance characteristics, transmission quality management tools, and troubleshooting tools and aimed at minimizing preventive maintenance and reducing corrective maintenance.

2.11.15.9.4. The maintenance of CN EGF devices and equipment shall be performed by maintenance personnel shifts and permanent maintenance personnel:

a) maintenance personnel shifts are responsible for:

- operational and technical management;
- operational control and routine maintenance of equipment, routes, communication channels, and data communication channels;
- prompt troubleshooting;
- acceptance for verification and post-verification or post-restoration commissioning of paths, communication channels, and data communication channels;
- maintenance of operational and technical documents.

Maintenance personnel shifts shall be guided by the algorithms, instructions, and provisions of the main regulations for management, operation, and operational interaction;

b) permanent maintenance personnel are responsible for:

- operational control, routine maintenance, current repair, development, adjustment, and restoration;
- acceptance and commissioning of equipment, routes, communication channels, and data communication channels;
- preparation and maintenance of production documents necessary for maintenance and operational and technical management;
- recording and analysis of the operation of equipment, routes, communication channels, and data communication channels;
- proposals to improve quality and operating reliability.

2.11.15.10. Operation of communication cable line facilities

2.11.15.10.1. The operation of CN EGF cable line facilities includes maintenance, accident and damage recovery, and current and major repairs.

2.11.15.10.2. The maintenance of CN EGF cable line facilities is a system of operations aimed at maintaining operability and serviceability, preventing malfunctions in a timely manner, identifying malfunctions, and remedying defects.

2.11.15.10.3. Depending on the amount and frequency of work, maintenance is divided into routine maintenance and scheduled preventive maintenance.

2.11.15.10.4. Routine maintenance shall be carried out systematically, is obligatory, and is not specially scheduled.

2.11.15.10.5. Routine maintenance shall also include security protection measures, the monitoring of communication cable line facilities and, if possible, troubleshooting on communication lines to prevent interruptions in normal communication operation.

2.11.15.10.6. Scheduled preventive maintenance shall be carried out periodically, mostly through inspections of facilities and troubleshooting, and through electrical and optical measurements on cable lines and fiber-optic communication lines.

2.11.15.10.7. The scheduled preventive maintenance of cable line facilities shall include:

- inspection and preventive maintenance of cable line facilities;
- scheduled and control measurements of electrical and optical characteristics of communication lines;
- verification of new cables, wires, cable terminals, equipment, and accessories for subsequent operation;
- preparation of cable line facilities for work in the heat deficit period, flood period, and thunderstorm period.

2.11.15.10.8. Current repair is the minimum volume of scheduled repair, involving carrying out work on systematic and timely protection for cable line facilities from premature wear and tear and from damage through the replacement and/or restoration of elements of cable line facilities.

2.11.15.10.8. The volume of current repair shall be determined by analyzing the technical condition of cable line facilities.

2.11.15.10.9. Major repair for cable line facilities is the largest volume of scheduled repair, involving replacing worn-out parts and structures or replacing them by more durable and efficient parts and structures that improve the performance of facilities.

2.11.15.10.10. Major repair shall include modernizing cable line facilities if it is technically and economically feasible. Modernization is the partial improvement of parts or elements of communication facilities typically simultaneously with major repair.

2.11.15.10.11. The objectives of major repair for cable line facilities are to ensure their modernization and uninterrupted operation throughout their operation life.

2.11.15.10.12. Major repair for cable line facilities shall be carried out periodically, depending on the overhaul cycle and technical condition of cable line facilities and shall be planned on a case-by-case basis according to the results of technical inspections, findings of electrical and optical measurements, examination and inspection reports, and related defect list.

2.11.15.10.13. CN EGF operation shall use various means, including measurement instruments, analyzers, testers, and other necessary special equipment: gasoline generators, motorized pumps, cable tightening devices, etc. In addition, continuous operation monitoring shall use software and hardware systems that make it possible to monitor the operation of communication devices in real time and promptly notify maintenance personnel shifts about possible malfunctions.

2.11.15.11. Accident recovery and remedial work on communication equipment and communication cable line facilities

2.11.15.11.1. Accident recovery work is a system of urgent measures and work aimed at immediately remedying accidents (defects, failures, and damage) and restoring the required quality to ensure the trouble-free operation of equipment for dispatching and process control.

2.11.15.11.2. Urgent remedial work is a system of urgent work aimed at promptly remedying detected (found) malfunctions and damage to restore the required quality and prevent (avoid) impaired parameters and characteristics capable of causing accidents in the dispatching and process control system.

2.11.15.11.3. Accident recovery and remedial work on communication equipment and cable line facilities of CN EGF may be performed by specialist contractors under framework contract agreements.

2.11.16. Protection of Communications Networks and Data Communication from Unauthorized Access

2.11.16.1. With the aim of protection from unauthorized access to communications networks and data communication, organizational and technical measures shall be taken to prevent access to communication equipment, lines, and facilities located inside and outside facilities and to information transmitted over communications networks.

2.11.16.2. Organizational and technical measures shall define:

- organization of access control for the secured area of communication facilities (“secured area”) and the protection procedure for the secured area;
- procedures for using technical devices for protection, detection, and alarm annunciation in the secured area;
- list and sample documents authorizing access to the secured area and to communication buildings and specific premises located within the secured area;
- procedure for giving permits to work on communication facilities and lines and work related to the technological possibility of accessing information transmitted via the communications network, and procedure for selecting the persons authorized to perform such work;
- procedure for registering events related to access to communication equipment, lines, and facilities;
- access control devices used for communication equipment and facilities;
- locks for rooms and cable line facilities containing communication equipment and lines.

2.11.16.3. Protection from unauthorized access to software of communication centers and communications networks shall be ensured by:

- measures to prevent unauthorized access to communication equipment;

- control of connections to communication equipment of hardware and software used during the operation of communication equipment and facilities;

- registration and subsequent control of maintenance personnel's activities during the operation of communication equipment and facilities;

- delineation of access rights, including the use of maintenance personnel's identification and authentication codes;

- registration and subsequent control of individuals', including maintenance personnel's, access to communication equipment and facilities during operation and construction;

- authentication procedures for maintenance personnel in the case of remote access to communication equipment and facilities.

2.11.16.4. With the aim of protection from unauthorized access to communication equipment outside the secured area, the following measures shall be implemented:

- rooms and buildings containing communication equipment shall be equipped with locks, intrusion alarms, and security alarms;

- communication equipment shall be installed in places preventing or substantially hindering unauthorized access;

- communication equipment cabinets shall be equipped with locks and intrusion sensors against unauthorized access;

- inspections shall be conducted for cable line facilities, including telephone conduit and cable terminals, and an inspection log shall be maintained.

2.11.16.5. Events related to unauthorized access to communications networks and communication facilities and data communication shall be documented and certified with the signature of a responsible officer.

Any registration entry for such events shall specify:

- communication equipment or lines affected by unauthorized access and their designations;

- description of the event and its consequences;

- time and date of the event and/or event registration;

- person who discovers the event.

2.11.16.6. In order to prevent events related to unauthorized access to the communications network and data communication during the operation of the communications network, discovered events and their causes shall be analyzed.

The results of such analysis shall be used as a basis for a report and a schedule of work on preventing future events related to unauthorized access to the communications network. The results of work completed in accordance with the schedule shall be specified in operation documents.

2.12. Limitations on the Use of Equipment, Technology, and Materials

2.12.1. The construction and rehabilitation of electric grid facilities rated 35 kV and above shall not use:

- concrete current-limiting reactors;
- rotating electrical reactive-power compensation machines, except for asynchronous compensators or ASEMFC, with a special FS;
- air and oil circuit breakers rated 110–750 kV;
- self-generated circuit breakers rated 6–10 kV;
- minimum-oil circuit breakers rated 6–220 kV;
- pneumatically and electromagnetically driven circuit breakers rated 110 kV and above with;
- CT and VT with winding accuracy classes for AISEBM, APCS, and measurements unless they meet the requirements of this Technical Policy;
- all unapproved types of measurement devices (including metering transformers, and built-in MD), i.e. not registered with the Federal Information Fund for Ensuring the Uniformity of Measurements and not having the required verification/calibration;
- vertically cutting disconnectors rated 110–750 kV;
- disconnectors rated 35 kV and above without motor drives except for disconnectors rated 35 kV for one-end substations branch substations rated 35/0.4 kV;
- gravel-filled oil receivers for T/AT and Sh/R;
- oil-filled boxes for connecting T/AT to SF6/I FASG;
- oil-filled cable boxes for connecting cables rated 110–500 kV to supply T/AT;
- valve arresters;
- electricity supply schemes without ALT;
- oil-filled cables with paper-oil insulation;
- power cables failing to meet the applicable fire safety requirements and emitting large concentrations of toxic combustion products;
- AU with fiberglass separators in ADCS;
- AU with an operation life of less than 15 years;
- equipment (including SCB) using trichlorobiphenyl (TCD);
- towers with pin insulators in large birds' nesting places;
- CL laid in trenches on the site of SS rated 35 kV and above;
- CL laid in the area of quays, wharfs, harbors, ferry crossings, and regular winter moorings of ships and barges;
- CL rated 110 kV and above laid in cable galleries jointly with cables rated 0.4–20 kV and utility systems (except for auxiliary cables of galleries);

- epoxy compounds used as waterproofing in cable accessories;

- construction materials with specific efficient activity of natural radionuclides of over 370 Bq/kg;

- electrical equipment using polychlorinated biphenyls and terphenyls (sovol, sovtol, etc.) as insulation;

- lighting equipment that require special measures for their disposal (containing mercury vapor or mercury compounds).

2.12.2. It is not recommended that comprehensive rehabilitation, expansion, or new construction use USO-type reinforced-concrete poles for SS.

2.12.3. The construction and rehabilitation of facilities shall not use:

- electrical safety devices with bakelite paper insulation;

- high-voltage indicators with grounding for their working parts;

- voltage indicators using gas-discharge lamps;

- high voltage pointers without sound alarms;

- caution notice boards and safety signs made of hygroscopic materials.

2.12.4. The rehabilitation, technical upgrading, and new construction of electricity distribution grid facilities shall not use:

2.12.4.1. In the case of SS rated 35–220 kV:

- primary connection schemes of SS rated 35–110 (220) kV with isolators and short-circuiters;

- primary connection schemes SS rated 35–110 (220) kV with OL splicing;

- open-type AU;

- flexible insulated current leads for automatic breakers from lines to 0.4 kV busbars on MV SS boards;

- open auxiliary cabinets without electric shock protection for personnel.

2.12.4.2. In the case of TSS rated 6–20/0.4 kV, DSS rated 6–20 kV:

- cabinet-type PTSS rated 6–20/0.4 kV with vertically arranged equipment;

- air circuit breakers and minimum-oil circuit breakers;

- unsealed supply oil transformers;

- DSS containing separate cubicles of factory-assembled outdoor switchgear;

- RVO-series valve arresters.

2.12.4.3. In the case of OL rated 0.4–20 kV:

- uninsulated wires for OL rated 0.4 kV during rehabilitation and new construction;

- uninsulated stranded aluminum wires (in accordance with GOST 839-80);

- PF6-A and PF6-B suspended disk insulators;

- LP- and LPIS-series polymer insulators with polyolefin-containing sheathing;

- polymer insulators with sequentially assembled protective sheathing;

- impregnation technologies for wooden poles that do not ensure an operation life of 40 years;

- tubular arresters or valve arresters based on silicone carbide, spark gaps (except for spark gaps as part of lightning arresters and line OVS) or arcing horns on OL rated 6–20 kV used as protection from lightning overvoltage.

2.12.5. The rehabilitation, technical upgrading, and new construction of OL rated 35 kV and above shall not use:

- nongalvanized metal poles (except for poles made of weatherproof steel) or uncertified poles;
- LP- and LPIS-series polymer insulators with polyolefin-containing sheathing;
- polymer insulators with sequentially assembled protective sheathing;
- porcelain insulators, except for long-rod porcelain insulators (with appropriate justification) on high towers for OL rated 110 kV and above;
- compression-type (shortened) tension anchor clamps supporting roller suspensions without using protectors, except for tightened-lay wires and special-shape wires that typically use only compression-type accessories;
- uncertified painted and varnished coatings and related technologies for metal structures of towers;
- ground-drawn wires and lightning protection cables, including OPGW;
- hole burning for angle-shaped shelves of towers;
- bituminous varnishes for metal structures;
- steel lightning protection cables without anticorrosion coatings;
- aluminum-iron-steel or steel-bronze wires and lightning protection cables;
- valve arresters or tubular arresters;
- single-frequency vibration suppressors;
- support and tension clamps on OL wires with parts made of magnetic materials (steel and cast iron).

2.12.6. In the area of fire safety, it is not allowed to use:

- cables noncompliant with the fire safety requirements for buildings and structures;
- construction materials (decoration, finishing, or facing materials, floorings) for buildings and structures if their fire hazard class does not meet the applicable requirements;
- uncertified fire barriers;
- water with foaming agents, wetting agents, or salts as extinguishing agents for energized electrical installations;
- uncertified automatic fire protection equipment;
- water-based fire extinguishers for energized electrical installations;
- powder as an extinguishing agent in rooms with equipment based on microprocessor devices (server rooms, APCS);

- fire-retardant organic-based materials and compounds containing toxic components or organic solvents in buildings and structures with people;

- ionization-smoke (radioisotope) fire annunciators;

- SSIW with flammable insulation on building walls, structures, branches to building entrance areas.

2.12.7. In the area of measurement control, it is not allowed to use:

- technical devices other than measurement devices;

- unapproved types of measurement devices (not registered with the Federal Information Fund for Ensuring the Uniformity of Measurements) or measurement devices not approved for use in the Russian Federation;

- measurement devices with an expired period of periodical checks for metering purposes (verification/calibration).

2.12.8. In addition to the foregoing, the construction of DSS or the rehabilitation of SS to be converted into DSS shall not use any technical solutions, equipment, or materials that do not comply with the requirements of subsection 2.2 of this Technical Policy.

3. Production Processes in the Electric Grid Sector

3.1. Development of the Electric Grid Sector

3.1.1. General Requirements for Development Schemes and Programs for the Electric Power Industry and Electric Grids

The electric grid of Russia’s United Power System is functionally divided into facilities of the Unified National (All-Russian) Electric Grid (UNEG) and facilities of the territorial distribution grid.

UNEG is a network of electric grids and other of electric grid facilities owned, by virtue of ownership or on another basis provided for in federal laws, by electric power industry entities and ensuring a stable electricity supply, wholesale market operation, and the parallel operation of the Russian electric power system and electric power systems of foreign countries.

The territorial distribution grid ensures electricity transportation from UNEG SS, generation facilities, and facilities of others owners to main substations (MSS)—distribution substations (DSS)—to ultimate customers, and ensures electricity transmission and distribution from power plants connected to this grid.

3.1.2. As electric grids develop, it is necessary to meet the following main criteria:

• accessibility: the electric grid shall enable all wholesale/retail electricity and capacity market entities to supply their products (electricity and capacity) to the market without obstruction and on a competitive basis if there is a demand for them; enable all wholesale/retail market entities to obtain the necessary amount of electricity and capacity with the required reliability and quality, meeting the regulatory requirement;

• cost effectiveness: grid development shall ensure maximum cost effectiveness, provided that the required level reliability is ensured, including contributing to decreased expenses and losses associated with electricity transmission and equipment operation;

• manageability: grid development shall be aimed at increasing grid manageability and observability through the introduction of managed elements and digitalization;

• efficiency: grid development shall be aimed at achieving the best economic indicators of PJSC "Rosseti" Group's entities and the energy system as a whole, with the maximally optimized use of available production assets, regardless of ownership of electric power facilities;

• innovativeness: grid development shall be designed with due consideration to the latest advances in science and technology;

• environmental friendliness: grid development shall meet environmental protection requirements and use innovative solutions that contribute to reducing the adverse environmental impact of electric power facilities and preventing damage to the environment;

• security: grid development shall be aimed at ensuring the energy security of Russia's UPS.

3.1.3. The objective of development schemes is to produce technical and economic justification for decisions with due consideration to new technology and digital transformation in grids to determine the efficient and reliable development of energy systems with the aim of meeting the demand for electricity and capacity and creating the stable and favorable conditions for attracting investment in the construction of electric power facilities.

3.1.4. Planning the development of energy systems includes formulating the following documents:

- in accordance with Resolution of the Government of the Russian Federation No. 823 of October 17, 2009, "On Long-Term Development Schemes and Programs for the Electric Power Industry":

• General Layout of Electric Power Facilities, effective for 15 years (adjusted at least once every three years), broken down by IPS;

• development schemes and programs for Russia's UPS, formulated every year with due consideration to the General Layout of Electric Power Facilities and defining balanced development plans for grid infrastructure and generation facilities for seven years;

• development schemes and programs for the electric power industry of constituent entities of the Russian Federation, formulated every year for five years with due consideration to development schemes and programs for Russia's UPS;

- in accordance with Order of PJSC "Rosseti" No. 4 of January 10, 2019 "On the Improvement of Development Planning Quality for Electric Grids":

• comprehensive development programs for electricity networks of constituent entities of the Russian Federation, formulated every year for five years with due consideration to development schemes and programs for Russia's UPS;

- in accordance with the applicable regulatory documents, the following documents are prepared:

• comprehensive development programs for utility infrastructure systems of settlements and urban districts, capacity delivery schemes of power plants, external electricity supply schemes of industrial facilities, pump stations of oil, gas, and product pipelines, canals, land reclamation systems, electrified railroad sections, and energy sections of urban district and general layouts. These schemes are formulated subject to development schemes for the electric power industry of constituent entities of the Russian Federation.

3.1.5. Any formulated long-term development schemes and programs, grid development schemes for power plant capacity delivery, grid development schemes for external electricity supply shall be governed by the following documents:

- Process Operation Rules for Electric Power Systems (approved by Resolution of the Government of the Russian Federation No. 937 of August 13, 2018);

- Guidelines for Energy System Resilience (approved by Order of the Ministry of Energy of the Russian Federation No. 630 of August 3, 2018);

- Recommended Guidelines for Designing the Development of Energy Systems (approved by Order of the Ministry of Energy of the Russian Federation No. 281 of June 30, 2003);

- Production Design Guidelines for Power Lines with Voltages of 35–750 kV (subject to approval by the Ministry of Energy of the Russian Federation);

- Production Design Guidelines for AC Substations with Upper Voltages of 35–750 kV (subject to approval by the Ministry of Energy of the Russian Federation);

- Rules for Formulating and Coordinating the Capacity Delivery Schemes of Power Generation Facilities and the External Electricity Supply Schemes of Power-Receiving Equipment of Electricity Consumers.

3.1.2. Requirements for the Use of Self-Contained Power Supply for Distribution Grid Customers

3.1.2.1. The special group of Category 1 customers that shall not be affected by power outages shall, with grid redundancy in accordance with the applicable LR and LRD, be provided with self-contained (emergency or backup) power supply, which include mobile or stationary diesel power plants, gas reciprocating power plants, gas turbine power plants, or other types of power plants or accumulator-based energy storage devices (ESD). It is recommended that, with an appropriate FS, the special customer groups that shall not be affected by short power outages use uninterruptible power sources.

Customers shall be assigned to the Category 1 special group at the stage of issuing and approving technical specifications for electricity connections based on customers' connection requests.

3.1.2.2. The conditions for backup power supply for special group of Category 1 customers shall be defined in accordance with the requirements of LR.

3.1.2.3. Self-contained (emergency or backup) power supply sources shall be connected to special busbars of guaranteed power supply.

3.1.2.4. The necessity of ensuring the availability of self-contained power supply sources, the possibility of enabling them to work with distribution grids, and grid redundancy shall be determined when technical specifications for electricity connections are issued.

3.1.3. Short-Circuit Current Level Coordination

3.1.3.1. In order to ensure that switching capabilities correspond to the actual levels of short-circuit (S/C) currents and reduce S/C current levels in grids, it is necessary to calculate S/C currents and select measures to limit them with due consideration to the development of grids and generation sources. In operating conditions, it is necessary to verify whether equipment is consistent with potential S/C current levels and whether the requirements are met with respect to the thermal and electrodynamic resistance of equipment and the breaking capabilities of circuit breakers. Calculations of S/C currents shall be made in the event of changes in the grid scheme and the content of electric grid and generation equipment.

3.1.3.2. To ensure normal operating conditions for equipment and elements of electric grids, development schemes for electric grids shall implement the following methods and measures to limit S/C currents:

- use a higher voltage, including by building load-center SS and switching some electrical installations in electric grids to a higher voltage;
- optimize the neutral grounding mode in electric grids, including using reactor-resistor installations for T/AT neutrals;
- sectionalize electric grids' elements by using ALT;
- install current-limiting devices;

- install ultrafast breakers using thyristor switching or special fast arc-extinguishing devices;
- use transformers with split windings for low voltage;
- use transformers with increased reactance;
- use direct and alternating current links based on fully controlled valves.

3.1.3.3. S/C current levels raised in the course of grid development shall have limitations determined by parameters of installed equipment (nominal breaking currents of circuit breakers, thermal durability, electrodynamic withstand).

S/C currents shall not cause unacceptable heating to current leads or equipment or create any electrodynamic impact higher than the permissible level defined by manufacturers of equipment and materials.

The maximum S/C current level for electric grids rated 35 kV and above shall be limited by parameters of circuit breakers, transformers, conductor material, and other equipment.

The maximum S/C current level for distribution grids rated 6–20 kV shall be limited by parameters of electrical SD, current leads, and thermal resistance of cables and insulated and protected wires.

3.1.3.4. Resistant to S/C currents are device and current leads that, in calculated conditions, withstand such currents without any electrical, mechanical, and other destruction or deformation that prevent their further normal operation.

3.1.3.5. If it is necessary to limit S/C currents on the 6–20 kV side, the following equipment shall be used:

- three-winding transformers with maximum resistance between HV and LV windings and two-winding transformers with increased resistance;
- transformers with split windings rated 6–20 kV;
- current-limiting reactors in circuits of transformer bushings, with outgoing lines typically unreacted.

The selection of limitations on S/C currents shall be justified with technical and economic comparisons.

3.1.4. Particularities of Grid Development for Megalopolises

3.1.4.1. CL of different types shall mainly be used in megalopolises, and OL located in residential areas of megalopolises shall gradually be replaced by CL.

3.1.4.2. The construction of the main electric grids of megalopolises shall use load centers with a nominal voltage of up to 500 kV.

3.1.4.3. The design of new and rehabilitated electric grid facilities for megalopolises, primarily Moscow and Saint Petersburg, shall take account of heavy calculation disturbances in relation to the stability requirements:

• shutdown of SG of any voltage at SS;
• shutdown of SG of any voltage at power plants;
• simultaneous shutdown of CL located in the same cable gallery.

3.1.4.4. It is recommended that the rehabilitation of existing facilities rated 110 kV involve switching over to a higher voltage of 220 kV.

3.1.4.5. The development of electricity distribution grids of megalopolises shall consider the possibility and feasibility of using and developing electric grids rated 20 kV.

3.1.4.6. Megalopolises' electric grid rated 20 kV shall typically be designed using low-resistance resistive neutral grounding with automatically closed ground faults.

3.1.4.7. The rehabilitation of existing electric grid facilities rated 35–220 kV and distribution grid facilities rated 6–10 kV shall involve the replacement of cables with paper-oil insulation and oil-filled cables by cross-linked polyethylene CL.

3.1.4.8. The development of distribution grids of megalopolises shall not involve the development of electric grids rated 6 kV, and their rehabilitation shall use a higher voltage.

3.1.4.9. In the case of CL laid in different soils and conditions, the selection of cable facilities and cross-sections shall be based on the cable section with the most severe conditions. With a considerable length of different cable sections with different conditions, each of them may be provided with the corresponding facilities and cross-sections. In the case of CL laid in different cooling conditions, the selection of cable cross-sections shall be based on the cable section with the worst cooling conditions if its length is more than 10 m. In the case of CL rated up to 20 kV, except for underwater cables, cables with different cross-sections may be used, provided that the number of such cables is not more than two and that the length of the shortest section is not less than the factory length.

3.1.4.10. The new construction and rehabilitation shall use indoor SS rated 10–220 kV (including, if necessary, modular underground and buried SS), using:

- FASG rated 6–35 kV with overhead insulation, including combination insulation, SF6-insulated (with an appropriate FS);
- SF6-insulated FASG rated 110–220 kV;
- oil-free SD (vacuum SD for a voltage of 10–35 kV, SF6-insulated SD for a voltage of 110–220 kV);
- oil-free metering transformers rated 6–20 kV with cast insulation (oil VT rated 6–20 kV, with sufficient justification);
- SF6-insulated metering transformers rated 35–220 kV;
- optical-type electronic current transformers for a voltage of 110–220 kV (with sufficient justification).

SS shall have minimal sizes without detriment to their safety, including environmental safety, or their serviceability, and shall fit into the architectural appearance of megalopolises.

3.1.4.11. The new construction of distribution grids rated 20 kV and the rehabilitation of existing distribution grids rated 6–10 kV shall use supply transformers in closed chambers inside SS buildings.

With the new construction SS rated 110–220 kV and rehabilitation SS rated 35–220 kV, supply T/AT rated 35–220 kV shall be placed in indoor cubicles SS buildings.

3.1.4.12. The construction of underground SS, built-in SS or SS adjacent to administrative buildings shall use equipment, including supply transformers, with noncombustible insulation and without mineral transformer oils.

3.1.4.13. OL designed for outdoor street lighting shall use insulated wires or insulated self-supporting wires.

3.1.4.14. Newly built SS rated 110 kV and above shall use SF6/I FASG located in SS buildings.

3.1.4.15. For the maintenance of oil-filled equipment for SS rated 330–500 kV located in megalopolises, it is allowed (with appropriate justification) to organize centralized oil farms equipped oil storage tanks; pumps; equipment for cleaning, drying, and regenerating oils; mobile oil-cleaning and degassing installations; and containers for oil transportation.

3.1.4.16. The new construction and rehabilitation of SS rated 110 kV and above shall give consideration to the feasibility of providing supply T/AT with main insulation in the form of dielectric liquids with improved fire safety characteristics and meeting the requirements of IEC 61099 *Specifications for unused synthetic organic esters for electrical purposes.*

3.1.4.17. It is recommended that newly built SS rated 110–220 kV in residential areas of megalopolises use supply T/AT provided with main insulation in the form of dielectric liquids with improved fire safety characteristics and meeting the requirements of IEC 61099 *Specifications for unused synthetic organic esters for electrical purposes.*

3.1.4.18. Newly built load-center high-voltage SS (220 kV and above) in megalopolises shall be located in centers of electrical loads (consumption centers).

3.1.4.19. Electric grid facilities in megalopolises shall extensively be located in underground spaces, provided with deep high-voltage cable bushings, provided with spaces for potential cable facilities associated with urban development projects and the rehabilitation and new construction of infrastructure facilities.

3.1.4.20. Electricity supply schemes in megalopolises shall ensure the minimum time of electricity supply restoration in the event of power outages by using grid redundancy, grid sectionalization, high-speed breakers in combination with ALT devices with reverse (after ALT) recovery, ARC (including on OCL), and technical solutions for automated control and remote control systems of SD.

3.1.4.21. In post-accident mode, electricity supply restoration shall be in the order dependent on facilities' importance for the city's operation and life (heating, water supply and wastewater disposal systems, subway networks, high-rise buildings, hospitals, children's institutions, railroad stations, railroads, road traffic control, communication, television, radio, etc.). Such customers shall additionally have in-house utility systems equipped with self-contained power supply sources.

3.1.4.22. If electricity supply from general-service electric grids is not available, the customer's utility system shall safely ensure the uninterrupted production process (in full or reduced mode) or shall ensure the implementation of all technical and organizational measures aimed at the safe and accident-free shutdown of the production process.

3.1.4.23. Customers shall independently define the reliability requirements for in-house electricity supply systems and consequently for utility system characteristics.

3.1.4.24. Utility systems shall operate both with complete power outages of the general-service electric grid and with changes in the electric grid's parameters, including within a short period, making it impossible to continue normal operation or creating potential hazards. Customers shall ensure the permanent operability of utility systems and their being ready for actuation at any time.

3.1.4.25. In order to secure a reliable electricity supply for special customer categories, it is recommended that electricity distribution grids rated 6–35 kV in megalopolises appropriate use two-way power supply for TSS from different MSS, preventing short-term power outages, and CL length from MSS shall typically not exceed 20 km, and the number of connected intermediate TSS shall typically not exceed eight. Any special customer category shall be determined at the stage of issuing technical specifications for electricity connections.

3.1.4.26. General-service electricity connections for the Category 1 special group shall include the requirement for in-house utility systems and related constant status monitoring. Such requirements may be governed by related regulatory documents.

3.1.4.27. Power supply systems in megalopolises shall implement measures to limit the growth of S/C currents and prevent them from exceeding the level of permissible SD capabilities, and it is necessary to gradually abandon traditional measures, such as TSS downscaling, grid sectionalization and division, or the use of different current limiters for busbars of SG and DSS, ultimately leading to impaired grid reliability, and consider introducing and using current limiters, ASEMFC, and DCL and ensuring electric grids with controllable reactive-power compensators.

3.2. Operational Process Control and Situation Control

3.2.1. In accordance with Federal Law No. 35-FZ of March 26, 2003, "On the Electric Power Industry," operational process control is included in organizational and technologically interrelated measures to ensure electricity transportation through technical devices of electric grids in accordance with the mandatory requirements for electricity transportation services.

3.2.2. Operational process control of electric grid facilities (OPC EGF) is a system of measures to control the operation processes and technical condition of electric grid facilities in accordance with the requirements of the subject of operational dispatching control in the electric power industry in relation to power lines (PL), equipment and devices of substations that are dispatched facilities and, independently or in coordination with others electric power industry entities and electricity consumers, in relation to PL, equipment and devices of substations that are not dispatched facilities.

3.2.3. Situation control of electric grid facilities (SC EGF) is activities aimed at preventing and remedying accidents and other abnormal situations at electric grid facilities through analysis and made and implemented relevant management decisions with due consideration to the current operational status, available resources, and forecasts about the consequences of management decisions.

3.2.4. The structure, goals, creation and operation principles, and main functions of OPC EGF and SC EGF in the electric grid sector shall comply with the provisions of the Concept of Developing the Operational Process Control and Situation Control System for Electric Grid Facilities of PJSC "Rosseti".

3.2.5. To perform the functions of OPC EGF and SC EGF, the OPC EGF and SC EGF divisions in the electric grid sector shall be equipped at all management levels with information technology systems to fulfill the relevant functions of OPC EGF and SC EGF, including data collection and communication systems, dedicated communication channels for operational communications and process purposes, and software and hardware systems (SHS).

3.3. Acceptance of Completed Electric Grid Facilities

3.2.1. The acceptance of completed electric grid facilities for operation shall be in accordance with the legal requirements of the Russian Federation.

3.2.2. Work on accepting completed facilities for operation shall be in accordance with the Model Procedure for Commissioning Completed Facilities of Subsidiaries and Dependent Companies of PJSC "Rosseti" (approved by Ordinance No. 87r of February 20, 2015, and by the Board of Directors of PJSC

"Rosseti" (Minutes of the Meeting No. 191 of June 5, 2015).

3.2.3. The acceptance of completed facilities for operation may relate to the entire construction unit, construction stages (phases), temporary buildings and structures for general construction purposes, specific buildings and structures, specific equipment units or systems (to the extent specified in design documents approved in accordance with the applicable laws).

3.2.4. Acceptance is not allowed for specific construction stages (phases) if they are not specified in design documents approved in accordance with the applicable laws.

3.2.5. Acceptance is not allowed for specific equipment units if auxiliary systems ensuring their safe operation are not available or operable.

3.2.6. The acceptance of electric grid facilities for operation in accordance with the Operating Rules for Electric Power Plants and Networks of the Russian Federation shall be preceded by the testing of specific equipment units and the test operation of all equipment. The test operation of all equipment shall be preceded by obtaining permits from the Federal Service for Environmental, Technological and Nuclear Supervision of the Russian Federation to operate power installations if required under the Network Connection Rules for Power-Receiving Equipment of Electricity Consumers, Power Generation Facilities, and Electric Grid Facilities Owned by Grid Organizations and Other Persons (approved by Resolution of the Government of the Russian Federation No. 861 of December 27).

3.2.7. In accordance with Order of the Ministry of Energy of the Russian Federation No. 229 of June 19, 2003, "On the Approval of the Operating Rules for Electric Power Plants and Networks of the Russian Federation," the acceptance of facilities shall be carried out by working and acceptance commissions.

3.2.8. Before appointing any acceptance commission, measures shall be taken to organize training for operational personnel of electric grid facilities in order to prepare them for their occupational functions and maintain their qualifications. The requirements for operational personnel are contained in OS 153-34.20.501-2003.

3.2.9. The acceptance of electric grid facilities for operation is not allowed without permits from the Federal Service for Environmental, Technological and Nuclear Supervision of the Russian Federation to operate power installations and without the state construction supervision agency's opinions about compliance by built, rehabilitated, or repaired capital construction facilities with the requirements of technical regulations and design documents if such documents shall be issued with respect to such facilities in accordance with the applicable laws.

3.2.10. The commissioning of information infrastructure facilities is allowed only if a report (certificate) of acceptance tests is issues with a positive opinion about the compliance and effectiveness of their security systems with the applicable security requirements.

3.2.11. The acceptance of completed facilities for operation shall be followed by permission for their commissioning in accordance with the Town Planning Code of the Russian Federation if such documents shall be issued with respect to such facilities in accordance with the applicable laws.

3.4. Technical Operation and Maintenance

3.4.1. General

3.4.1.1. In order to ensure the reliable, safe, and efficient operation of electric grid facilities, technical operation and maintenance shall be provided for equipment, PL, buildings, structures, and utility and process systems.

3.4.1.2. High-quality planning and timely and high-quality technical operation and maintenance (technical impacts) for equipment, PL, buildings, structures, and utility and process systems are important factors in ensuring the serviceability of electric grid facilities to ensure the required level of electricity supply reliability, safety, and quality.

3.4.1.3. The technical operation and maintenance system shall comply with the legal requirements of the Russian Federation, the applicable LR, relevant documents in the area of technical regulation, including in accordance with the urban planning laws of the Russian Federation, legislation on industrial security, safety of buildings and structures, GC, the Rules for Organizing the Maintenance and Repair of Electric Power Facilities, and the applicable LR establishing the reliability and safety requirements for electric power systems, electric power facilities, and power receivers.

3.4.1.4. Ensuring and improving the efficiency of technical operation and maintenance shall be achieved through the introduction and implementation of uniform principles and approaches to processes of planning, organizing, and carrying out repairs and maintenance, processes of monitoring and evaluating the effectiveness of technical operation and maintenance, with measures implemented to ensure compliance with the applicable requirements.

3.4.1.5. Planning repairs to dispatched equipment of SS and PL shall be in accordance with the applicable requirements of Resolution of the Government of the Russian Federation No. 484 of July 26, 2007, “On the Repair and Decommissioning of Electric Power Facilities.”

3.4.1.6. HPF facilities shall meet the requirements of Federal Law No. 116-FZ of July 212, 1997, “On Industrial Safety of Hazardous Production Facilities” and the applicable LR relating to industrial security.

3.4.1.7. In the case of equipment with an expired operating life and equipment that is in unsatisfactory condition (TCI ≤ 50), if its operation conforms to the nominal parameters, restrictions on its further operation may be lifted subject to the following conditions:

- timely technical examination in accordance with the applicable technical standard documents (TSD);
- AMDS installed on the most responsible and expensive equipment, which will make it possible to decide on the impact on equipment in a timely manner;
- use of modern methods and means of technical diagnostics, predominantly for energized equipment (vibroacoustic control, measurement of partial discharges), including in the case of accelerated control of the technical condition.

As related to equipment of electric grid facilities, PL, and structures, the Strategy for Development of the Electric Grid Sector of the Russian Federation prescribes the transition from scheduled preventive types of repairs at electric grid facilities to repairs based on the actual technical condition with due consideration to the consequences of failure of primary process equipment (risks).

3.4.1.8. The system of planning and organizing technical operation and maintenance is an integral part of the production asset administration system (PAAS) and shall be consistent with the goals, principles, and objectives of production asset administration of this Technical Policy of the Company.

3.4.1.9. Technical operation and maintenance require mandatory and adequate organizational and technical preparation, M&E, and maintenance personnel with qualifications corresponding to the content of work in accordance with the applicable requirements.

3.4.2. General Requirements for Planning and Organizing Technical Operation and Maintenance

3.4.2.1. Repairs to equipment for SS, PL, buildings and structures, and utility and process systems are divided into two types:

- scheduled preventive repairs;
- condition-monitored repairs.

3.4.2.2. Scheduled preventive repairs shall be carried out at the intervals set forth in repair documents in accordance with the requirements of LR, the manufacturer’s instruction manuals, and LRD.

3.4.2.3. Plans to organize and carry out scheduled preventive repairs shall include:

- developing long-term repair plans for 5 years;
- developing annual and monthly repair schedules.

3.4.2.4. Long-term repair plans shall be approved and adjusted annually, with due consideration to assessing technical condition and changes in operating conditions.

3.4.2.5. Long-term repair plans and schedules shall be developed in accordance with the Rules for Organizing the Maintenance and Repair of Electric Power Facilities (approved by Order of the Ministry of Energy of the Russian Federation No. 1013 of October 25, 2017), and LRD.

3.4.2.6. The scope of scheduled preventive repairs shall be determined in accordance with the standard list of work, with due consideration to actual technical condition, shall include additional above-standard repair work to correct defects found during operation according to the results of previous repairs (if any), and shall include the work prescribed by state regulation and supervision authorities (if any).

3.4.2.7. Depending on the scope of work, scheduled preventive repairs and condition-monitored repairs are subdivided into:

- current repairs;
- medium repairs;
- major repairs.

3.4.2.8. Current repairs shall ensure the restoration of serviceability with the replacement or restoration of elements or parts in the amount provided for in relevant repair documents.

3.4.2.9. Medium repairs shall ensure the restoration of serviceability with the replacement or restoration of specific elements or parts as provided for in relevant repair documents.

3.4.2.10. Major repairs shall ensure the restoration of serviceability according to functionality, while the goal of major repairs to equipment is the restoration of serviceability for equipment status by ensuring that its technical and economic characteristics are restored to the level close to the design characteristics.

3.4.2.11. Depending on the character and list of repair work, repairs can be subdivided into standard repairs and above-standard repairs.

3.4.2.12. Condition-monitored repairs are repairs with the scope determined according to the results of monitoring and assessing technical condition based on measurements, tests, and inspections performed in accordance with the applicable requirements.

3.4.2.13. Planning for condition-monitored repairs shall include:

- developing long-term repair plans for 5 years;
- developing annual and monthly technical operation and maintenance plans;
- long-term repair plan reapproved and adjusted annually, with due consideration to assessing technical condition and changes in operating conditions.

3.4.2.14. In planning condition-monitored repairs, diagnostics for the technical condition of PL and SS equipment shall be carried out during current repairs to SS equipment and during maintenance of PL and SS equipment.

3.4.2.15. Long-term plans and schedules for monitoring technical condition shall be developed in accordance with the Rules for Organizing the Maintenance and Repair of Electric Power Facilities and LRD.

3.4.2.16. In organizing condition-monitored repairs, the list and scope of repair work shall be determined according to the results of measurements, tests, inspections, technical diagnostics, and assessment of technical condition in accordance with the applicable requirements and shall include the work prescribed by state regulation and supervision authorities (if any).

3.4.2.17. In the case of equipment for SS, PL, and structures covered by the completed transition from scheduled preventive repairs to condition-monitored repairs in accordance with the applicable LR (Technique for Evaluating the Technical Condition of Primary Process Equipment and Power Lines of Power Plants and Electric Grids (approved by Order of the Ministry of Energy of the Russian Federation No. 676 of July 26, 2017) and the Rules for Organizing the Maintenance and Repair of Electric Power Facilities (approved by Order of the Ministry of Energy of the Russian Federation No. 1013 of October 25, 2017)), LRD (Organization Standards) shall be formulated to establish the frequency, methods, scope and technical means of control, system of technical condition indicators and their permissible values in accordance with the applicable LR, including GC, the Requirements for the Scope and Standards of Electrical Equipment Tests, the manufacturer's instruction manuals, and existing experience of operation, which make it possible to reliably assess actual technical condition (serviceable, defective, operable, inoperable, marginal).

3.4.2.18. In the case of SS equipment, PL, and structures covered by the planning of repairs (technical impacts) according to the results of assessing technical condition in accordance with the applicable Technique for Evaluating the Technical Condition of Primary Process Equipment and Power Lines of Power Plants and Electric Grids, scenarios shall annually be developed for each unit of equipment, PL, and structures to select technical impacts based on the calculated technical condition index and the assessed damage (failure), which shell be used as a basis for annual and, thereafter, monthly programs for repairs (technical impacts), while, in accordance with the Technique for Evaluating the Technical Condition of Primary Process Equipment and Power Lines of Power Plants and Electric Grids (approved by Order of the Ministry of Energy of the Russian Federation No. 676 of July 26, 2017), it is necessary to:

- calculate the technical condition index (TCI) on an annual basis to determine the planned type of technical impact in accordance with the applicable requirements and regulations;

- recalculate the technical condition index upon completion of technical impacts as scheduled;

- assess the risks associated with failures for each unit of equipment with an assessment of the consequences of equipment failures in accordance with the requirements of the applicable Guidelines for Calculating the Failure Probability of Functional Parts and Units of Primary Process Equipment and Assessing the Consequences of Such Failures;

- assess changes in parameters of the technical condition of the equipment and forecast changes in TCI and the level of technical risk for 1 year.

3.4.2.19. The list of SS equipment, PL, and structures covered by the planning of condition-monitored repairs according to the results of calculating TCI and developing scenarios to select technical impacts shall comply with the requirements of the applicable LR, including the Technique for Evaluating the Technical Condition of Primary Process Equipment and Power Lines of Power Plants and Electric Grids (approved by Order of the Ministry of Energy of the Russian Federation No. 676 of July 26, 2017).

3.4.2.20. Repairs to SS equipment, PL, and structures shall be in accordance with process flow charts with formulated repair plans.

3.4.2.21. Process flow charts for repairs to SS equipment, PL, and structures shall contain:

- list and sequence of repair operations;
- working conditions and safety measures;
- list of controlled indicators (parameters);
- requirements for the composition and qualifications of personnel (repair worker);
- repair-related labor costs;
- list of tools, fixtures, devices, mechanisms, test installations, shared and personal protective devices.

3.4.2.22. The repair plan shall define the production technology, repair procedures, procedure and scope of providing resources, and security measures in accordance with the applicable LR and LRD and the manufacturer's instruction manuals.

3.4.2.23. The acceptance of repaired SS equipment, PL, and structures and the evaluation of the quality of completed work shall be in accordance with the applicable LR, GC, the Rules for Organizing the Maintenance and Repair of Electric Power Facilities, and LRD.

3.4.2.24. The planning, preparation, and performance of repairs and the acceptance of repaired APCS subsystems and TIC devices shall in accordance with the boundaries of responsibilities (maintenance).

3.4.2.25. Depending on the scope of work, the maintenance of APCS subsystems and TIC devices is subdivided into:

- continuously monitored maintenance;

- periodically monitored maintenance.

3.4.2.26. Continuously monitored maintenance for APCS subsystems and TIC devices shall be carried out according to the results of the continuous monitoring of technical condition during their operation in combination with primary and auxiliary equipment.

3.4.2.27. Periodically monitored maintenance for APCS subsystems and TIC devices shall ensure the good and efficient technical condition of APCS subsystems and TIC devices to provide their operation with manageability, process control, and protection for primary and auxiliary equipment to ensure its operating reliability.

3.4.2.28. Periodically monitored maintenance for APCS subsystems and TIC devices shall be carried out on an annual basis in accordance with the Rules for Organizing the Maintenance and Repair of Electric Power Facilities and the manufacturer's instruction manuals.

3.4.2.29. Maintenance for RP and automatic protection devices shall be carried out in accordance with annual and monthly maintenance schedules based on long-term maintenance plans in accordance with the Rules for Organizing the Maintenance and Repair of Electric Power Facilities and other applicable LR establishing the reliability and safety requirements for electric power systems, electric power facilities, and power receivers.

3.4.2.30. Technical operation and maintenance for DPCE, alarm devices, and MD shall be carried out in accordance with annual and monthly schedules of scheduled maintenance agreed upon with the relevant subject of operational dispatching control in charge of DPCE.

3.4.2.31. The maintenance of DPCE shall use the following types of maintenance:

- scheduled maintenance, carried out at the intervals set forth in approved schedules and aimed at preventing the possibility of malfunctions or impaired DPCE operation;

- unscheduled maintenance, carried out upon the detection of system nonserviceability and aimed at repairing malfunctions in order to completely restore DPCE operation.

3.4.2.32. Scheduled repairs to DPCE shall carried out in accordance with annual DPCE repair schedules.

3.4.2.33. Planning for repairs to buildings and structures not covered by any bans under the laws of the Russian Federation and the LRD shall be based on an assessment of technical condition in accordance with the applicable requirements.

3.4.2.34. Maintenance for buildings and structures shall include measures of supervision and control over the serviceability of buildings and structures and their utility systems and measures to correct any defects in a timely manner. The frequency and scope of maintenance work shall be determined in accordance with the repair documents. Responsible persons shall be appointed, the procedure shall be defined for monitoring the technical condition of each building and structure, and the scope of work on technical operation and maintenance.

3.4.2.35. Repairs to buildings and structures by type are divided into current and major repairs.

The scope of major repairs shall be based on repair design documents or based on bills of quantities.

The scope of current repairs shall be based on bills of quantities based on inspection reports on buildings and structures and maintenance logs for buildings and structures.

3.4.2.36. Planning for repairs to buildings and structures shall include developing annual and long-term repair schedules. Schedules shall consider the results of inspections, including comprehensive inspections, the results of technical examination, and the frequency of major repairs to buildings and structures and their structural elements.

3.4.2.37. Condition-monitored repairs may not be carried out to the following facilities:

- facilities in relation to which, in accordance with the requirements set forth in the laws of the Russian Federation, a ban is imposed on organizing and carrying out condition-monitored repairs;
- newly commissioned test-operated equipment and structures;
- facilities not covered by repair documents required by the Rules for Organizing the Maintenance and Repair of Electric Power Facilities (approved by Order of the Ministry of Energy of the Russian Federation No. 1013 of October 25, 2017) or facilities for which the methods and scope of technical condition monitoring do not make it possible to reliably identify actual technical condition or forecast their serviceability until the following monitoring.

3.4.2.38. Depending on planning, repairs are subdivided into:

- scheduled repairs;
- unscheduled repairs;
- emergency repairs.

3.4.2.39. Scheduled repairs shall be carried out in accordance with approved schedules.

3.4.2.40. Unscheduled repair shall be carried out with the aim of correcting malfunctions and defects that affect serviceability and safety operation and according to the results of monitoring current technical condition; if unscheduled repairs require the shutdown of any dispatched facility, then repairs shall be agreed upon with the relevant subject of operational dispatching control.

3.4.2.41. Emergency repairs shall be carried out in order to remedy accidents and damage to recover serviceability; in relation to the dispatched facility, the interaction with the relevant the subject of operational dispatching control shall be in accordance with the applicable requirements.

3.4.2.42. The list of repair documents shall meet the requirements of the Rules for Organizing the Maintenance and Repair of Electric Power Facilities (approved by Order of the Ministry of Energy of the Russian Federation No. 1013 of October 25, 2017) and LRD.

3.4.2.43. Qualifications of repair personnel shall meet the requirements of the applicable LR as related to compliance with the applicable safety requirements, federal safety rules and regulations for hazardous production objects (subject to the applicable requirements) and occupational safety regulations.

3.4.2.44. Repairs shall be preceded by measures to ensure the serviceability of process equipment and devices for diagnostics and control and ensure compliance with the measurement control requirements in accordance with the legal requirements of the Russian Federation.

3.4.2.45. Measurement devices used for technical operation and maintenance shall comply with the requirements of GOST R 8.674-2009 *State system for ensuring the uniformity of measurements. General requirements for measuring instruments and systems and devices with measuring functions.*

3.4.2.46. The use of devices shall ensure such accuracy of measurements as specified in documents and technical specifications for repairs, process documents, and measurement methodologies;

3.4.2.47. Planning is required for the content and quantity of emergency stock, ensuring the storage conditions and timely replenishment and replacement of emergency stock in accordance with the applicable LR and LRD.

3.4.3. Principles of the Technical Policy for Technical Operation and Maintenance at Electric Grid Facilities

3.4.3.1. The basic principles of the Technical Policy in the area of technical operation and maintenance at electric grid facilities shall be as shall:

- ensuring compliance with the provisions and requirements of the laws of the Russian Federation and regulations for planning and organizing technical operation and maintenance under this Technical Policy;
- ensuring processes of planning, carrying out, and monitoring technical operation and maintenance, using qualified personnel;
- ensuring that SDCs have prepared and approved multiyear schedules, annual and monthly technical operation and maintenance plans for production assets, and capex programs for the period of tariff regulation, with due consideration to the technical condition of assets, in accordance with the applicable

requirements for the frequency of technical operation and maintenance.

3.4.3.2. Planning for technical operation and maintenance shall include:

- assessing and analyzing the parameters and indicators of the technical condition of equipment, buildings, structures, and utility and process systems according to the results of measurements, tests, and inspections before technical impacts;
- assessing and analyzing the consequences and risks of equipment failures;
- ensuring compliance with budgetary restrictions;
- taking account of targeted programs to improve reliability;
- ensuring cost optimization for technical operation and maintenance the through optimal combination of outsourced and in-house resources;
- ensuring the availability and efficient operation of systems for monitoring, planning, and evaluating the results of technical operation and maintenance;
- formulating and improving LRD of the Company to ensure compliance with the established requirements and improve the efficiency of PAAS;
- ensuring the safe performance of work on technical operation and maintenance;
- conducting a technical examination of equipment, PL, buildings, and structures in accordance with the applicable LR and LRD of the Company;
- conducting comprehensive inspections of equipment, buildings, and structures at electric grids facilities in accordance with the applicable LR and LRD of the Company;
- using modern, high-technology, and safe techniques, tools, equipment, and accessories;
- ensuring safe work on repairs to energized electric grids;
- ensuring the availability of all necessary process equipment, tools, equipment, materials, and spare parts for the technical operation and maintenance of equipment, PL, buildings, structures, and utility and process systems;
- ensuring the availability standards, regulations, and bylaws for technical operation and maintenance in accordance with the applicable requirements;
- studying, developing, and introducing modern methods and technologies for the technical operation and maintenance of equipment, PL, buildings, structures, and utility and process systems and for monitoring their technical condition;
- developing and improving methods for the organization and management of technical operation and maintenance in accordance with the principles of PAAS.

3.4.3.3. The main areas of developing and improving PAAS in relation to the automation of planning, managing, and controlling technical operation and maintenance are as follows:

- improve and enhance the process of logistical support for production activities in relation to technical operation and maintenance in accordance with the principles of PAAS;

- improve workforce productivity and economic efficiency;
- develop information systems and databases used to automate processes of planning and controlling technical operation and maintenance;
- automate the planning of physical amounts, costs, and resources for the organization, performance, and control of technical operation and maintenance;
- ensure digitalization for technical documents to ensure the planning, performance, and control of technical operation and maintenance;
- ensure automation and digitalization for the collection of information intended for the planning of work and resources for technical operation and maintenance, and the collection of information on completed work and used resources;
- ensure automation and digitalization for the preparation and agreement of work completion certificates and related documents, accounting source documents using automated document management systems;
- building and supporting an efficient system of analytical reporting on technical operation and maintenance.

3.5. Production Asset Administration

3.5.1. General

3.5.1.1. The Company's and SDCs' production asset administration is systematic and coordinated activities for finding an optimal balance between the costs of maintaining the technical condition of equipment in accordance the applicable requirements, prospects for grid development, the risks associated with failure to achieve the required level of service reliability and electricity quality, and the requirements of regulators with the aim of achieving the strategic goals of the Company.

3.5.1.2. The production asset administration system of the Company and SDCs shall be consistent with the goals and principles and shall ensure the achievement of the objectives of the Strategy for Development of the Electric Grid Sector of the Russian Federation with due consideration to the Digital Transformation 2030 Concept.

3.5.1.3. Main functional areas of the production asset administration system:

- management of operational activities in relation to maintenance, repair, and equipment, utility networks and systems, buildings and structures;
- management of investment activities as related to the modernization, technical upgrading, and rehabilitation of electric grid facilities;

- management of an asset at all stages of the lifecycle with due consideration to the current and predicted technical condition, risks, consequences of failures, cost of ownership, and grid development prospects;

- management of methodological and regulatory support for production asset administration processes;

- management of databases and reference data for automated production asset administration systems;

- management of process solutions and IT infrastructure to ensure efficient production asset administration;

- management of personnel and organizational and resource support for production asset administration processes.

3.5.2. Goals of Production Asset Administration

The goals of production asset administration shall be as follows:

- improve the efficiency of operating and investment expenses while ensuring the required electricity supply reliability.

3.5.3. Principles of Production Asset Administration

The basic principles of the Company's production asset administration shall be as follows:

- focus on achieving the strategic goals of the government, the Company and SDCs;

- systematic decision-making, application of uniform criteria, principles, rules, methods for the processes of the planning, implementation, control, and evaluation of the efficiency of work on operational and investment activities;

- focus on improving the efficiency of production asset administration throughout the lifecycle of assets obtaining positive effects in the short, medium, and long term;

- measures to ensure the operation of the production asset administration system in all SDCs of the Company, which are an integral part of the overall asset administration system of the Company;

- reduction of the proportion of equipment, power lines and structures that have high and medium technical risk levels with due consideration to the consequences of their failure.

3.5.4. Goals of Developing the Production Asset Administration System

The goals of developing the production asset administration system shall be as follows:

- ensure the transition from the production asset administration system based on the scheduled preventive types of repairs to repairs based on the actual technical condition with due consideration to the consequences of failure of primary process equipment (risks);
- introduce and develop of modern technologies and digitalize business processes of production asset administration;
- improve the system of evaluating performance indicators for production asset administration at corporate, functional, and operational organizational levels, allowing the evaluation of individual processes for timely management decisions;
- building and using key performance indicators (KPIs) of processes at all levels of production asset administration of the Company and SDCs;
- develop and unify bylaws, regulations, and methodologies for production asset administration;
- efficiently distribute financing for all kinds of impacts, including the repair, modernization, or technical upgrading of SS equipment and PL, depending on technical condition (critical, unsatisfactory, satisfactory, good, very good);
- ensure the operation and improvement of the system of monitoring and calculating integrated indicators of the condition of electric grid facilities, including indicators of physical deterioration and energy efficiency in accordance with the requirements of the current LR;
- ensure the calculations and monitoring of the indices of the technical condition of equipment for SS, PL, and structures with an assessment of the probability of failure, the assessment of the risk due to failure and the assessment of the cost of ownership for planning the type and scope of technical impact in accordance with the requirements of the current LR;
- optimize costs for repairs, modernization, technical upgrading for equipment, utility and engineering systems, buildings and structures while ensuring the necessary level of safety, operational reliability and ensuring the required level of quality of electricity supply;
- synchronize the development of the production asset administration system of the Company and SDCs with departmental programs of relevant and related agencies.

3.6. Information Security

3.6.1. Goals and Objectives of Information Security

Goals: Ensure the stable operation of the information infrastructure for power entities of the Rosseti Group (hereinafter, the "Entities") when affected by computer attacks, prevent unauthorized access to processed information, prevent such information from being destroyed, modified, blocked, and distributed, and protect such information from any other illegal actions.

Objectives: Create a security system for information infrastructure facilities and ensure its operation, including:

• as part of the certification of new equipment and systems in the electric grid sector, independently testing the security functions of information infrastructure facilities for compliance with not higher than confidence level 4 for software security (in relation to safety functions implemented in information infrastructure facilities) and conducting the statistical analysis of codes for undeclared functionalities in software;

• as part of the creation, modernization, and operation of information infrastructure facilities, conducting a regular assessment of the scale of possible consequences for the Company, social, political, economic, and environmental consequences, and consequences for national defense, national security and law and order in the event of computer incidents at the Company's information infrastructure facilities, assigning one of the significance categories to information infrastructure facilities;

• ensuring technological safety and independence from imported equipment, hardware, components, services (work) of foreign companies and the use of foreign software at electric grid facilities by replacing software, microcontrollers, and integrated circuits, and using, on a priority basis, only such software, information about which is included on the uniform register of Russian programs for computers and databases;

• developing industry standards of information security;

• ensuring the safety of information infrastructure facilities during operation:

○ preventing illegal access to information processed by information infrastructure facilities, preventing such information from being destroyed, modified, blocked, copied, disclosed, and distributed, and protect such information from any other illegal actions;

○ preventing any impact on data processing hardware, as a result of which the operation of information infrastructure facilities and the processes ensured (managed, controlled) by such operation can be disrupted and/or terminated;

○ automating the processes of detecting and preventing computer attacks on information infrastructure facilities of power facilities of the Rosseti Group, using machine learning algorithms and heuristic analysis;

○ ensuring the operation of tools for information protection in accordance with the developer's instruction manuals;

○ carrying out regular instrumental assessments of the effectiveness of information infrastructure facilities' security system of power facilities of the Rosseti Group;

○ ensuring the fastest recovery (self-healing) of information infrastructure facilities;

○ interacting with the national system for detecting, preventing, and remedying the consequences of computer attacks on information resources of the Russian Federation;

○ using risk-based asset administration of information infrastructure and organizing, as part of the operation process, the checking and installing of critical software updates for network elements;

• ensuring the safety of information of infrastructure facilities during the decommissioning process;

• conducting internal control procedures in the area of ensuring the security of information infrastructure facilities through the implementation of scheduled or unscheduled inspections;

• providing the security divisions of energy industry facilities with qualified personnel in the field of protection for information systems, automated control systems, and information and telecommunication networks;

• increasing the level of knowledge among employees on information security, organizing (re)training of engineers, technicians, administrators, and operators in information security.

3.6.2. Basic Principles of Development

In order to secure a reliable electricity supply, it is necessary to take an integrated approach to protecting the information infrastructure of the electric grid, including setting up the Cybersecurity Monitoring Center of the Rosseti Group.

The security system of information infrastructure facilities shall be created in accordance with the requirements and provisions of Federal Law No. 187-FZ of July 26, 2017, 'On the Security of the Critical Information Infrastructure of the Russian Federation,' Federal Law No. 152-FZ of July 27, 2006, 'On Personal Information,' and the applicable subordinate legal regulations as a typical, territorially distributed system, including forces and means designed to detect and prevent computer attacks and remedy the consequences of computer incidents.

In order to increase the efficiency of planning and developing organizational and technical measures to ensure the security of information infrastructure facilities, ensure the security of confidential information in using information and communication technology (hereinafter, "information security measures") and ensure their operation on the principles of unified approaches, requirements, efficiency and reliability, the Rosseti Group set up the Competency Center for

Information Security.

The information security measures taken for information infrastructure facilities shall not adversely affect the operation of PAS, the exchange of process information, or the remote-control functions of electric grid equipment or intelligent devices from remote network control centers of the Rosseti Group or from dispatching centers of JSC “SO UPS”.

The result of ensuring the security of information infrastructure shall be the preservation of the achieved effects as related to ensuring the reliability, technological and economic efficiency of electricity supply, and other strategic goals of the digital transformation of the Russian electric power industry.

3.6.3. Basic Requirements

3.6.3.1. The objects of protection in the context of ensuring the security of information infrastructure shall be as follows:

• corporate information systems (including computer media; workstations; servers; devices for processing alphanumeric, graphic, video, and speech information; firmware, system-wide and application software) that ensure the stability of financial and economic activities;

• automated control systems (including automated workstations, industrial servers, programmable logic controllers, industrial and process equipment (actuating devices) having the functions of both local and remote control, or having operation network interfaces, firmware, system-wide and application software), ensuring a reliable electricity supply;

• corporate and technological information and telecommunication networks (including telecommunications equipment, software, control systems, communication lines) that form a single information space and a 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) about the parameters (state) of a managed (controlled) object or process (including input (output) information, control (command) information, control and measurement information, other critical (technological) information of commercial value due to being unknown to unauthorized persons.

3.6.3.2. The security of significant information infrastructure facilities shall be ensured, depending on the established category of significance of objects, in accordance with the requirements established by the federal executive agency authorized to ensure the security of the critical information infrastructure of the Russian Federation.

3.6.3.3. The security of critical information infrastructures of PAS without any established category of significance shall be ensured in accordance with Ordinance of PJSC “Rosseti” No. 140r of April 1, 2016 (as amended by Ordinance of PJSC “Rosseti” No. 178r of April 27, 2016) and this Technical Policy.

3.6.3.4. In order to ensure the security of critical information infrastructures of PAS without any established category of significance that are operated at critical facilities, potentially hazardous facilities, and facilities that pose an increased danger to human life and health and to the natural environment, these requirements shall apply subject to the Information Protection Requirements approved by Order of the Federal Service for Technical and Export Control of the Russian Federation No. 31 of March 14, 2014.

3.6.3.5. In order to ensure the security of information infrastructure facilities that are personal information systems, these requirements shall be applied subject to the requirements for the protection of personal information when they are processed on personal information systems approved by Resolution of the Government of the Russian Federation No. 1119 of November 1, 2012.

3.6.3.6. Depending on the category of significance and current information security threats, the following organizational and technical measures shall be implemented for information infrastructure facilities’ security system:

- identification and authentication (IAF);
- access control (AC);
- software environment restriction (SER);
- protection of machine-readable media (PMM);
- security audit (SA);
- antivirus protection (AVP);
- intrusion (computer attack) prevention (IPS);
- integrity control (IC);
- accessibility control (AC);
- protection of hardware and systems (PHS);
- protection of the information (automated) system and its components (PIS);
- planning of safety measures (PLN);
- configuration management (CM);
- software update management (SUM);
- response to information security incidents (INC);
- support for actions in emergency situations (AES);
- information and training for personnel (ITP).

Technical measures to ensure information security shall be implemented through the use of operating systems included on the Russian software register, and the use of the following classes of software and hardware as information security tools (including those built into systemwide and application software):

• means of protecting information from unauthorized access (including firewalls at the node level built into systemwide and application software);

• firewalls at the network level and at the level of the logical boundaries of the network;

• firewalls at the industrial network level;

• means of detection (prevention) of intrusions (computer attacks) at the network level;

• firewalls at the web server level;

• unidirectional gateway (data diode);

• means of detection (prevention) of intrusions (computer attacks) at the node level;

• means of general-purpose antivirus protection;

• means of antivirus protection for workstations of production personnel, industrial servers;

• means of antivirus protection at the network level;

• means (systems) of control (analysis) of security;

• means of registration and management of security events;

• means of protection for data communication channels;

• means of preventing computer attacks;

• systems of secure remote access to the LAN, including terminal access;

• backup systems, including tools for creating and storing backup copies;

• key information management systems.

3.6.3.7. In order to ensure the security of information and telecommunication networks, these requirements shall apply along with legal regulations of the federal executive agency responsible for the development and implementation of national policy and legal regulation in the area of communications, and GOST R 62443 *Industrial communication networks. Network and system security*, GOST R 56498-2015/IEC 62443-3:2008 *Industrial communication networks. Network and system security. Part 3. Security for industrial process measurement and control*.

3.6.3.8. The boundary routers with access to the Internet shall be routers certified for compliance with the information security requirements (as related to their implemented security features).

If it is not technically feasible to use any boundary routers certified for compliance with the information security requirements, the security functions of boundary routers shall be assessed for compliance with the security requirements as part of acceptance or tests.

Rationale for the fact of being not technically feasible shall be contained in the design documents for facilities (security subsystems of facilities) developed in accordance with the technical specifications for such facilities and/or the technical specifications (technical component specifications) for security subsystems of facilities.

3.6.3.9. As related to information security tools, priority shall be given to information security tools built into the software and/or hardware (if any).

3.6.3.10. Built-in information protection tools for automated process control systems shall be consistent with the goals of information security as specified in Ordinance of PJSC "Rosseti" No. 282r of May 30, 2017, "Requirements for Built-in Information Protection Tools for Automated Process Control Systems of the Rosseti Group's Electric Grid Facilities."

3.6.3.11. If it is not possible to achieve the declared goals by using built-in information protection tools, the required functionality shall be implemented by using add-on information protection tools.

3.6.3.12. Information protection tools shall be operated in accordance with the instructions (rules) for operation developed by the developers (manufacturers) of such tools, and other operational documents for tools for information protection.

3.6.3.13. The tools used for information protection shall be provided with warranty and technical support.

3.6.3.14. The procedure for creating information systems, automated control systems, control systems for information and telecommunication networks, the stages of work, and the development of technical and working documents shall comply with GOST R 51583-2014 *Information protection. Sequence of protected operational system formation. General provisions*, the provisions of Federal Law No. 187-FZ of July 26, 2017, "On the Security of the Critical Information Infrastructure of the Russian Federation" and subordinate legal regulations.

At the stages (in the phases) of the lifecycle during the creation (modernization) of information infrastructure facilities, the following shall be 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 security for information infrastructure facilities;

• formulation of organizational and technical measures to ensure information security, development of working (operational) documents;

• implementation of organizational and technical measures to ensure information security and bringing them into use, conformity assessment in the form of tests or acceptance, which are carried out by information security entities independently or with the involvement of organizations that have licenses for activities in the area of information security in accordance with the laws of the Russian Federation;

• formalization of information security processes during operation.

3.6.3.15. The results of designing the security system for information infrastructure facilities shall be included in the design documents (draft (technical) design and/or working documents) developed with due consideration to GOST 34.201 *Information technology. Set of standards for automated systems. Types, sets and indication of documents for automated systems design* (hereinafter, "GOST 34.201") and organization standards, in accordance with the established significance category.

3.6.3.16. Information protection related to virtualization technologies shall be in accordance with GOST R 56938-2016 *Information protection. Information security with virtualization technology. General.*

3.6.3.17. The requirements for functional safety of automated ERP systems, operational process control, and process control shall be equivalent to GOST R/IEC 61508-1-2012, 61508-2-2012, and 61508-3-2012.

3.6.3.18. Putting information infrastructure facilities into operation is allowed only if there is an acceptance test report (certificate) with a positive conclusion on the compliance and effectiveness of the security subsystem with the established safety requirements.

3.6.4. Assessment of Compliance with the Information Security Requirements

3.6.4.1. Assessment shall be understood as a document confirming the effectiveness of the organizational and technical protection measures taken by the Entity.

3.6.4.2. To ensure the security of information infrastructure facilities without assigned categories of significance, information protection tools may be used if they are assessed for compliance with the mandatory information security requirements set forth in legal regulations or with the requirements specified in the technical specifications (safety specifications) of not lower than confidence level 4 (GOST R ISO/IEC 15408) as part of tests or acceptance carried out by the Entities independently or with the involvement of organizations that have, in accordance with the laws of the Russian Federation, licenses for relevant activities in the area of information security.

Tests (acceptance) of information protection tools shall be separate or within a significant object of information infrastructure in accordance with the program and methodologies for tests (acceptance) approved by the Entity.

3.6.4.3. To ensure the security of significant information infrastructure facilities, information protection tools shall be used if they are assessed for compliance with the safety requirements in the form of mandatory certification provided for in the laws of the Russian Federation.

If it is not technically feasible to use any certified information protection tools for compliance with the information security requirements at significant facilities, the security functions of information protection tools shall be assessed for compliance with the security requirements as part of tests or acceptance.

Rationale for the fact of being not technically feasible shall be contained in the design documents for significant facilities (security subsystems of significant facilities).

3.6.4.4. The assessment of compliance by information infrastructure facilities with the technical requirements, including information security requirements, may be conducted as part of certification (quality control) in the electric grid sector (subsection 5.2 of this Technical Policy) with the preparation and approval of the security specifications (GOST 15408) with due consideration to analyzed security information threats relevant to the environment of using equipment, materials, and systems in the electric grid sector.

3.6.4.5. The certification of information infrastructure facilities that process publicly available data is not required.

3.6.4.6. The certification of information infrastructure facilities that process personal information shall be carried out as resolved by the Entity to assess the effectiveness of measures taken to ensure the security of personal information with the involvement of an organization that has licenses for activities in the area of information protection in accordance with the laws of the Russian Federation.

3.6.4.7. The certification of information infrastructure facilities that process national security information or interact with national information systems shall mandatorily be carried out to assess the effectiveness of measures taken to ensure information security with the involvement of organizations that have, in accordance with the laws of the Russian Federation, licenses for activities in the area of information protection.

3.6.5. Limitations on the Use of Technology/Equipment

3.6.5.1. When selecting information security tools, including the accompanying embedded software, the possible presence of limitations imposed by developers (manufacturers) or other persons on the use of such tools throughout the Russian Federation shall be taken into account.

3.6.5.2. Certified information protection tools shall be used where provided for in the laws of the Russian Federation and as resolved by the Entity.

3.6.5.3. When implementing technical measures to protect information, it is not allowed to use the SHA-1 cryptographic hashing algorithm, SNMPv1 or SNMPv2 protocols.

3.6.5.4. The following is not allowed for information infrastructure facilities:

• direct remote access to software and hardware, including information security tools, for updating or management by persons who are not employees of the Entity;

• local access to software and hardware, including information security tools, for updating or management by persons who are not employees the Entity without the control of the Entity;

• transfer of information, including process information, to any developer (manufacturer) of software and hardware, including information security tools or to other persons without the control of the Entity.

3.6.5.5. The software and hardware tools of significant information infrastructure facilities that store and process information shall be located within the Russian Federation (except where such tools are located at foreign separate divisions of the Entity (branches, representative offices) and where provided for in the laws of the Russian Federation and/or international treaties of the Russian Federation).

3.6.5.6. Russian-made operating systems shall be used as mobile operating systems.

3.7. Measurement Control

3.7.1. General

3.7.1.1. The goal of measurement control is to ensure the uniformity and required accuracy of measurements in all production processes in the activities related to the receipt, transformation, transportation, and distribution of electricity (grid mode control, grid parameter control, power quality, energy metering, continuous monitoring using AMDS for equipment, etc.) in accordance with the legal requirements of the Russian Federation for measurement control.

3.7.1.2. Measurement control shall be ensured throughout the lifecycle of electric grid facilities (design, commissioning, continuous operation).

3.7.1.3. The priorities of the Technical Policy in the area of measurement control are as follows:

- ensure compliance with the legal requirements of the Russian Federation for measurement control;
- introduce modern methods of using measurements, using automated control and measuring equipment, and providing measurement laboratories with modern calibration/verification devices and reference devices and necessary computers and vehicles;
- introduce modern and efficient measurement devices ensuring the required

accuracy of measurements in the required range of parameters, the stability of measurement characteristics throughout operation time, and greater intervals for regular checks for metering purposes;

- introduce automated systems of registering measurement devices, planning and monitoring their metering maintenance and ensure the transition to electronic datasheets for measurement devices in the electric grid sector;
- confirm technical competencies of measurements departments at all levels that perform work on the calibration of measurement devices in the Company's calibration system and, if this is economically feasible, provide them with accreditation in the area of ensuring the uniformity of measurements with the right to perform work on the verification (calibration) of measurement devices.

3.7.2. Measurement Requirements

3.7.2.1. Measurements shall be in accordance with the accuracy standards for measurements related to a specific measured parameter in accordance with the applicable requirements.

3.7.2.2. Measurements (except for direct measurements) shall be in accordance with the duly certified measurement techniques (methods).

3.7.3. Requirements for Units of Measurement

3.7.3.1. Units of measurement shall be in accordance with GOST 8.417-2002 and the Regulations for Units of Measurement Permitted for Use in the Russian Federation (approved by Resolution of the Government of the Russian Federation No. 879 of October 31, 2009).

3.7.4. Requirements for Measurement Techniques (Methods)

3.7.4.1. Measurement techniques (methods) shall meet the following requirements:

- developed in accordance with GOST R 8.563-2009;
- certified in accordance with the procedure for ensuring the uniformity of measurements and registered on the Federal Register of Measurement Techniques (with the Federal Information Fund for Ensuring the Uniformity of Measurements).

3.7.5. Requirements for Measurement Devices

3.7.5.1. MD shall be verified (calibrated) in accordance with the prescribed procedure and shall have valid certificates and/or signs of verification/calibration, records in operational documents on MD; in the case of MD used to monitor process parameters without standardized accuracy, serviceability shall be monitored.

3.7.6. Requirements for Measuring Information System

3.7.6.1. Measuring information systems (including their components) shall be supported for metering purposes at all stages of the lifecycle in accordance with GOST R 8.596-2002, the applicable standards, and R&O of the Company;

3.7.6.2. Standard software and hardware systems used to set up measuring information systems used in government regulation to ensure the uniformity of measurements require approval (registration with the Federal Information Fund for Ensuring the Uniformity of Measurements).

3.7.6.3. In the design phase, design documents relating to measuring information systems (as related to measurements covered by government regulation, in accordance with Federal Law No. 102-FZ of June 26, 2008, “On Ensuring the Uniformity of Measurements”) shall be examined for the purposes of measurements in accordance with the applicable requirements.

3.7.7. Requirements for Reference Standards

Reference standards used for measurements shall:

- have certificate of the approved type of reference standard;
- be fit for use (with an unexpired period of validity);
- be used in accordance with the requirements of the measurement methodology and regulatory documents relating to its operation conditions.

3.8. Diagnostics and Monitoring of the Technical Condition of Equipment for Substations and Power Lines

3.8.1. General

3.8.1.1. The content, scope, and frequency of the diagnostics of the technical condition of equipment for SS and PL shall comply with the Requirements for the Scope and Standards of Electrical Equipment Tests, the Company’s LR and LRD, and the manufacturer’s instruction manuals.

3.8.1.2. The continuous monitoring of the technical condition of electric grid equipment shall use automated devices, monitoring systems, and technical diagnostics.

Automated monitoring and diagnostics systems are aimed at:

preventing emergency processes due to internal equipment defects and promptly preventing the uncontrolled development of defects;

measuring load capacity;

improving electrical safety for operational personnel and reducing the influence of human error on the collection, processing, and generation of diagnostics results;

integrating the monitoring and diagnostics results into APCS and corporate information systems;

using the AMDS results for assessing technical condition and planning the strategy of maintaining production assets.

3.8.1.3. The introduction of automated monitoring and diagnostics systems shall be based on the relevant technical and economic feasibility study.

3.8.1.4. Newly built and rehabilitated SS shall use electrical equipment in a version that ensures the installation and use of AMDS for assessing the technical condition of energized equipment.

3.8.1.5. Automated diagnostics tools and AMDS shall have remote access to up-to-date information about the current technical condition of equipment.

3.8.1.6. The introduction of new methods and indicators for monitoring the technical condition of equipment shall be accompanied by:

- evaluating the diagnostic value (informativeness) of the method (indicator) used;

- having a feasibility study of the used method (indicator);

- establishing the permissible value of the monitored indicator and/or the value limiting the scope of normal operation, and/or the boundary values;

- providing guidelines for using the method (indicator) with recommendations for decision-making for its use.

3.8.1.7. Measurement control for MD used for continuous monitoring using AMDS for SS equipment shall be in accordance with the provisions of Section 3.6 of this Technical Policy.

3.8.1.8. Measurements of insulation characteristics of energized electrical equipment are allowed subject to the use of devices that ensure occupational safety and protection for normally grounded low-potential taps of controlled facilities from the dangerous voltage in the event of faulty ground connection.

3.8.2. Requirements for the Diagnostics and Monitoring of the Technical Condition of Equipment for SS

3.8.2.1. The diagnostics and assessment of the technical condition of equipment for SS shall be based on test and measurement results and conducted within the scope and in accordance with the Requirements for the Scope and

Standards of Electrical Equipment Tests, Order of the Ministry of Energy of the Russian Federation No. 676 of July 26, 2017, and the Company's LRD.

3.8.2.2. Automated continuous monitoring and diagnostics systems shall provide operational diagnostics for the current technical condition of equipment and shall ensure the timely detection of the occurrence and development of defects.

3.8.2.3. Automated continuous monitoring and diagnostics systems shall be used as follows:

a) supply T/AT rated 220 kV and above (in the case of UNEG, T/AT rated 330 kV and above), supply transformers rated 110 kV and 63 MVA and above within the following scope:

- control of hydrocarbon gas content dissolved in transformer tank oil (ethane, methane, ethylene, acetylene);
- control of hydrogen content dissolved in transformer tank oil;
- control of temperatures of upper oil layers in transformer tanks;
- control of moisture content in transformer tank oil;
- control of P/D for the following: P/D regularity, dangerous apparent P/D charge, duration of one P/D registration cycle;
- control of an angle tangent for dielectric losses and isolation capacitance for high-voltage bushings rated 110 kV and above (in the case of UNEG, 330 kV and above and bushings rated 110 kV and above on T/AT rated 330 kV and above);

b) supply transformers rated 110 kV and below 63 MVA, MSS and supply transformers rated 35 kV and 16 MVA and above for tie SS within the following scope:

- control of hydrogen content dissolved in oil transformer tank;
- control of temperatures of upper oil layers in transformer tanks;
- control of moisture content in transformer tank oil;

c) SF6/I FASG rated 110 kV and above within the following scope:

- control of P/D for the following: P/D regularity, dangerous apparent P/D charge, duration of one P/D registration cycle;
- control of SF6 pressure in gas compartments;

d) circuit breakers rated 220 kV and above (in the case of UNEG, 330 kV and above), circuit breakers rated 110 kV on MSS with supply transformers rated 63 MVA and above within the following scope:

- control of mechanical durability for drives of circuit breakers with respect to the number of on/off operations;
- control of switching durability with respect to the number of disconnected working currents and S/C currents and their value, using the automatic calculation of time to maintenance, repair, and decommissioning;
- in the case of circuit breakers rated 500 kV and above, oscillograms of closing and opening currents.

3.8.2.4. Assessing the technical condition of SS equipment may additionally use the following kinds of diagnostics, provided that measurement methods and permissible values of measured parameters are available:

- infrared control of all equipment;
- optical control of porcelain and polymer rod-type support insulators (UV diagnostics);
- sonic and ultrasonic control of microcracks in porcelain rod-type support insulators and porcelain insulators of metering transformers and breakers;
- acoustic control of closed air busbar ducts and current ducts;
- control of P/D in busbars and current leads with cast insulation;
- X-ray control of all equipment, especially SF6-insulated switchgear.

3.8.3. Requirements for the Diagnostics and Monitoring of the Technical Condition of OL

3.8.3.1. The diagnostics and assessment of the technical condition of OL shall be based on test and measurement results and conducted within the scope and in accordance with the Requirements for the Scope and Standards of Electrical Equipment Tests, Order of the Ministry of Energy of the Russian Federation No. 676 of July 26, 2017, and the Company’s LRD.

3.8.3.2. Assessing the technical condition of OL may additionally use the following kinds of diagnostics for the technical condition of functional parts and elements of OL, provided that measurement methods and permissible values of measured parameters are available:

- infrared control of current-carrying and insulating elements of OL;
- magnetometric nondestructive control of metal structures of towers;
- ultrasonic control of anchor fastenings of foundations;
- seismoacoustic and ultrasonic control of foundations and reinforced-concrete structures;
- detection of flaws of cable guys of towers, wires, and lightning protection cables;
- measurement of amplitude-frequency characteristics of wires and cables;
- acoustic assessment of physical and mechanical properties of reinforced-concrete and wood towers based on the comparison of mechanical impact vibrations of towers with vibrations of the “perfect” tower having the same height and firmly built into the ground;
- magnetic assessment of the corrosion condition of steel cores of current-carrying wires and lightning protection cables;
- seismoacoustic and ultrasonic assessment of the length of reinforced-concrete and metal piles in the ground for foundations of towers;

- ultrasonic and differentially optical assessment of the strength of materials and the condition of welded seams of metal elements of towers and foundations;

- vibration-based assessment of accumulated fatigue for the brittleness of metal towers and materials of wires and lightning protection cables;

- UV control of OL insulation pollution.

3.8.3.3. It is recommended that temperature monitoring systems be used for wires of OL equipped with ice melting (with special justification for OL) if such wires systematically work with loads close to maximum permissible level.

3.8.3.4. As technology advances, a promising area of monitoring the condition of OL is the monitoring of energized OL.

3.8.3.5. To monitor the condition of the OL in order to prevent emergency shutdowns, abandon expensive helicopter inspections and inspections at height, and reduce foot inspections, it is recommended that the following be used:

a) unmanned aerial vehicles (UAV) equipped with video cameras, thermal imagers, laser scanners, suitable software, and other devices that make it possible to measure and transmit information to the workstations of relevant users, making it possible to determine:

- location and condition of elements of OL towers (tower deviation from the axis, sagging of cross-arms, protective sheathing, guy cables, etc.);

- condition and sizes of wires and lightning protection cables (sagging, sizes, forest clearings, broken wires, lightning protection cables, loops);

- availability of vibration suppressors;

- availability of ground insulation and the condition of insulator strings;

- presence and amount of icing and sticking snow;

- presence of foreign objects in the protected area of OL;

- broken wires and lightning protection cables;

b) special robotic systems able to move on OL wires and lightning protection cables and equipped with video cameras, thermal imager, contact devices and sensors, suitable software, and other devices that make it possible to measure and transmit information to the workstations of relevant users, making it possible to determine:

- heating of wires;

- damaged wires, lightning protection cables, and contact connections, including losses in cross-sections of lightning protection cables and broken steel wire cores;

- malfunctions in suspensions and accessories, including malfunctions in fastenings and connections of wires and cables, excessive deflections of insulating supporting suspensions from the design;

- mechanical damage to porcelain or glass insulators, traces of overlapped insulator strings and individual insulators;

- malfunctions in grounding devices, including unsatisfactory contacts in bolted connections between lightning protection cables and ground leads or tower bodies;

- presence of foreign objects in the protected area of OL;

- dangerous trees;

- sizes of OL routes, including sags, wire-to-ground distances, and to wire-to-object distances, and phase-to-phase distances;

- defects in arresters on towers and mismatched values of external spark gaps;

- excessively sloping towers in longitudinal and transversal directions;

- deformation of tower parts;

- nonalignment of poles and footboards of towers with guy cables, nonavailability of bolts and nuts, nonavailability of dowels and wedges, loose bolted connections, poor quality of fastening brackets, burning and splitting tower parts;

- presence of overlapping objects, broken (burst) or burned wires, and traces of overlapping objects, melted or swelling the upper lays (“lanterns”).

3.8.3.6. UAV shall be noise-resistant, with UAV navigation signals protected from interference caused by power lines.

3.8.3.7. With appropriate justification, it is recommended that stationary monitoring systems be used for critical sections of OL, using various control devices (optical fibers built into lightning protection cables or phase wires, sensors, video cameras, current and voltage transformers, etc.), typically for:

- temperature control of wires heated in places of installed sensors;

- control of the presence and amount of icing and sticking snow;

- control of sizes of wires and lightning protection cables (sagging, sizes) at intersections with utility networks and roads;

- control and monitoring of weather conditions (data obtained from self-contained weather stations).

3.8.4. Requirements for the Diagnostics and Monitoring of the Technical Condition of CL

3.8.4.1. The content, scope, and frequency of the diagnostics of the technical condition of CL shall comply with the Requirements for the Scope and Standards of Electrical Equipment Tests, the Company’s LR and LRD, and the manufacturer’s instruction manuals.

3.8.4.2. In the case of CL rated 110 kV and above, continuous monitoring shall be used for working voltages, using AMDS as follows:

- control of P/D for terminal couplings for the following indicators: P/D frequency, dangerous apparent P/D charge, duration of one P/D registration cycle in couplings;

- thermal control of CL using built-in optical fibers.

3.8.4.3. Assessing the technical condition of CL may additionally use the following kinds of diagnostics, provided that measurement methods and permissible values of measured parameters are available:

- acoustic control of terminal cable couplings;
- radio frequency control of terminal cable couplings.

3.8.4.4. As technology advances, a promising area of monitoring the condition of CL is the monitoring of energized CL.

3.9. Regulation of Voltages and Electricity Quality

3.9.1. Measures to prevent deviations from exceeding from the acceptable indicators of power quality in electric grids rated 6–750 kV shall include:

- efficient electricity supply schemes (transition to the use of a higher voltage, increased cross-sections of current leads of PL, replacement of transformers by more powerful transformers, construction of additional TSS, construction of additional PL, even distribution of one-phase and two-phase loads for all three phases of electric grids);
- use of VC and RPC;
- use of inductive resistance compensators for PL;
- use uncontrollable balancing devices that convert one-phase or two-phase static large loads significant into three-phase loads.

3.9.2. VC and RPC for electric grids rated 35–750 kV shall include:

- automatically or manually switched SCB, Sh/R, and VRG;
- OLVC, AOLVC, and O/S TCO of transformers;
- various types of uncontrollable and controllable series compensators (SC and CSC);
- automatically controlled RPC based on power electronics (CSR with bias, transformer type CSR, installations with shunting: SRPC, CSR with bias, SCB, STATCOM);
- FCD and FED.

3.9.3. The selection of types, capacity, locations, and connection points for RPC in electric grids rated 110 kV and above shall based on calculations in accordance with the power system design guidelines.

3.9.4. VC and RPC for distribution grids rated up to 20 kV shall include:

- DSS, DTSS 10(20) kV;
- sources of distributed generation;
- synchronous motors rated 6, 10 kV;

- OLVC and AOLVC, O/S TCO of transformers;
- factory-assembled, automatically or manually switched SCB, FCD and FED;
- SRPC and STATCOM for SS supplying power to sharply alternating or asymmetrical loads;
- BT and adjusting line autotransformers;
- voltage converters, energy storage devices, and UPSU based on high-capacity AU.

The measures and devices listed above are designed to:

- maintain the phasor power factor (tgφ) on MSS busbars in accordance with regulatory requirements;
- ensure voltage and power quality in normal and steady post-accident mode subject to the regulatory requirements for the power factor on MSS busbars and the SS VC performance requirements in accordance with GOST 32144, GOST R 55195, and GOST 29322;
- ensure acceptable conditions for PL connections;
- decrease resonant and switching overvoltage;
- filter current harmonics and balance voltages;
- increase grid transmission capacity;
- decrease electricity and capacity losses.

3.9.5. In order to normalize the power factor for MSS, ensure normalized voltage, and ensure power quality at electricity transportation points, the design of the new construction, expansion, rehabilitation, modernization, and technical upgrading of existing distribution grids rated 6–110 kV shall use:

- automatically or manually switched B/C and Sh/R in general-purpose grids rated 35, 110 (150) kV;
- switched B/C, adjusting line AT on PL rated 10 kV, BT on PL rated 0.4 kV in distribution grids rated (20)10(6)–0.4(0.66) kV.

3.9.6. To reduce asymmetrical loads in general-purpose grids rated 0.4 kV, it shall be recommended that new construction and rehabilitation existing distribution grids of 6–10 kV use TSS rated 6–10/0.4 kV with three-phase transformers with windings of Δ/Yn-11 (in the case of transformers with installed capacity of 100–1000 kVA) and Y/Zn-11 (in the case of transformers with installed capacity of below 100 kVA).

3.9.7. Adjusting line AT shall be used at the beginning of agricultural PL rated 10 kV and connected to MSS with load schedules different from agricultural load schedules, for example, when connected to traction SS and industrial SS.

The use of adjusting line AT shall also be considered in order to reduce voltage losses in existing main PL rated 10 kV if this does not have sufficient voltage control in MSS, and for customers powered from LV windings of three-winding transformers with OLVC to provide independent voltage control (with an appropriate FS).

3.9.8. The feasibility of installing BT in the gap of PL rated 0.4 kV shall be considered in accordance with the BT installation guidelines for distribution grids rated 0.4 kV (MI BP 10/01-01/2012):

- in the case of electricity supply for customers with low consumption;
- for PL with continuing operation life when standard levels of voltage for remote customers are not met (typically, with a feeder length of more than 1.0 km);
- in exceptional cases, to resolve the issue of low voltage on OL rated 0.4 kV with a large length (more than 1.0 km) if it is not possible to rehabilitate MSS 10–35, 110 (150) kV;
- in a confined area where it is not possible to install additional TSS or if a new OL rated 0.4 kV costs several times as much as BT and its installation;
- near SS rated 35 kV with transformers with winding branches switched without excitation if voltage control does not meet the initial requirements;
- if any supply transformer of SS is not overloaded even at peak loads, with a long grid that does not have prospects for further development;
- in the case of clearly pronounced seasonal loads in long grids that do not have prospects for further development.

3.9.9. SRPC, CSR, and STATCOM shall be used if switched B/C and Sh/R do not meet the local technical or mode requirements or their installation and operation costs are higher than the costs for the above-mentioned devices.

3.9.10. Selecting RPC containing SCB in grid sections with regular distortions of current and voltage curves shall include examining RPC, and specifically SCB, for possible overloads caused by higher harmonics of currents. The selection of RPC connections on SS rated 35–750 kV shall be determined in accordance with the design standards for alternating-current substations with a high voltage of 35–750 kV.

3.9.11. For compensation for harmonic distortions and voltage fluctuations and for voltage balancing on electric grids supplying sharply alternating, nonlinear, asymmetric loads, preference shall be given to FCD, FED, and automatically controlled high-speed RPC with per-phase control.

3.9.12. Long or short asymmetrical modes of currents and voltages may be lowered by the even distribution of one-phase and two-phase loads for all three phases.

If these measures are not sufficient, it is recommended the balancing devices be used. For one-phase or two-phase powerful static loads, uncontrollable balancing devices that convert them into three-phase loads shall be used.

3.9.13. Designing the system of power supply for power receivers with sharply alternating load may use active filter-compensating and filter-equalizing devices (AFED) based on modular multilevel voltage converters to stabilize voltage, filter harmonics, and balance voltage in real time.

3.9.14. Some power receivers for industrial production with a continuous production process, computer equipment, communication equipment of special customer categories in megalopolises, etc. may use UPS with AU or supercapacitors. The feasibility of using such devices shall be justified.

3.9.15. The design of electric grids shall specify voltage controllers, installation places of relevant voltage controllers, and control systems (manual or automatic).

3.9.16. Adjusting devices of electricity distribution grids rated up to 1 kV shall include CB and BT.

3.9.17. The minimum and maximum permissible voltages at shared connection points for power receivers shall comply with GOST 32144.

3.9.18. The feasibility and installation places of BT shall be considered in the following cases:

- in the case of electricity supply for customers with low consumption if the installation of additional TSS is not reasonable due to the small number of customers located in hard-to-reach areas and due to the unfeasibility of grid modernization;
- for OL with continuing operation life when standard levels of voltage for remote customers are not met (typically, with a feeder length of more than 1.0 km);
- in exceptional cases, to resolve the issue of low voltage on OL rated 0.4 kV with a large length (more than 1.0 km) if it is not possible to rehabilitate MSS 10–35, 110 (150) kV;
- in a confined area where it is not possible to install additional TSS or if a new OL rated 0.4 kV costs several times as much as BT and its installation;
- if any supply transformer of SS is not overloaded even at peak loads, with a long grid that does not have prospects for further development.

4. Instruments of Implementing the Technical Policy

4.1. Technical Standard Regulation

4.1.1. The Company’s and SDCs’ technical standard support is a system of LRD, including regulations and orders, organization standards, instructions, regulations, guidelines, etc.

4.1.2. LRD are prepared in order to ensure compliance with:

- legal requirements of the Russian Federation;
- documents relating to technical regulation, including regulations of the Eurasian Economic Union (technical regulations of the Customs Union);

- functions and objectives of the Company;
- technical policy of the Company.

4.1.3. The technical standard support management system shall ensure:

- timely preparation of LRD in accordance with applicable and up-to-date requirements of regulatory authorities; timely revision and updating of existing LRD in accordance with new and up-to-date requirements of regulatory authorities; timely preparation and updating of existing LRD in accordance with the functions and objectives of the Company in relation to the implementation of the Technical Policy of the Company;
- availability and timely updating of the list of LR, documents relating to technical regulation, and LRD of the Company governing and ensuring compliance with the requirements and provisions of the Technical Policy of the Company, with such documents to be posted on the corporate website of the Company;
- necessary level of unification and typification of LRD;
- compliance with the Company's requirements and procedures for the development and review of drafts of relevant LRD and their approval;
- participation of the Company in the preparation of LR and documents relating to technical regulation in accordance with the functions and objectives of the Company.

4.2. Quality Verification (hereinafter, "Certification") of Equipment, Materials, and Systems

4.2.1. System of quality verification of PJSC "Rosseti" ("certification") is an internal quality verification system aimed at meeting the Company's need for modern, reliable, safe, and efficient equipment, materials, and systems to ensure the operational, repair and investment activities of the Company and ensure the reliable and trouble-free operation of Russia's UPS.

4.2.2. Quality verification for equipment, materials, and systems aims to achieve the following goals:

- ensure the reliability and safe operation of equipment, materials, and systems by preventing the Company's and SDCs' facilities from receiving equipment, materials, and systems with characteristics failing to meet the technical requirements, security requirements, and the goals and conditions of use;
- prevent the Company's and SDCs' facilities from receiving equipment, materials, and systems failing to meet the applicable requirements of LR, TSD, LRD, and the Company;
- ensure compliance with the requirements of the Technical Policy of the Company.

4.2.3. Quality verification for equipment, materials, and systems supplied to electric grid facilities shall be in accordance with internal documents of the Company (LRD of the Company).

Quality verification procedures include examining the compliance of equipment, materials, and systems with the requirements of PJSC "Rosseti" standards developed to ensure the quality of products, work, and services under Article 3 and Article 21 of Federal Law No. 162-FZ of June 29, 2015, "On Standardization in the Russian Federation."

4.2.4. The result of certification is the certification commission's opinion approved in accordance with the prescribed procedure and applying to equipment, materials, and systems supplied to and operated at facilities of the Company and SDCs.

The results of positive quality verification are documented as the List of Equipment, Materials, and Systems Recommended for Use at Facilities of the Company and SDCs posted on the Company's website.

4.2.5. In the event of a decision to purchase equipment, materials, and systems not listed as approved for use at facilities of the Rosseti Group, quality verification shall be carried out in accordance with the prescribed procedure.

The responsibility for passing quality verification and obtaining a document approving the use of tested equipment, materials, and systems at the customer's facilities and determining the scope of applications shall lie with the supplier/contractor.

The information base of quality verification for proposed products is the package of relevant technical documents (test reports, certificates, etc.) provided by the supplier/contractor in accordance with the requirements of the industry's technical standard documents and the Company's standards and technical standard documents.

4.2.6. The construction and rehabilitation of electric grid facilities shall use equipment, materials, and systems with completed quality verification procedures in accordance with the prescribed procedure.

4.3. Innovative Development

4.3.1. One of the key instruments for implementing a uniform technical policy as related to using and developing new technical solutions is the Innovative Development Program (hereinafter, the "Program").

The Program is binding upon divisions of the executive arm of PJSC "Rosseti" and SDCs, provided that it is recognized as such (in whole or in part) by SDCs' management bodies.

The Program contains the most advanced technical solutions that shall, in the near future, come to replace traditional technical solutions and additionally defines the common approaches, goals, objectives, priorities, indicators, and control points of carrying out innovation activities, and the performance and effectiveness indicators of innovation projects and events.

The development, implementation, and replication of new technical solutions may be carried out in several stages:

- research work;
- development;
- pilot implementation;
- test operation;
- adjustments to technical standard documents;
- proposals for the large-scale replication of innovative solutions as part of developing model projects or replicable projects;
- register of innovative products.

4.3.2. The organization of innovation activities under the Program is aimed at implementing the algorithm of the development, testing, and subsequent wide use of innovative solutions, namely:

- identification of the needs for solutions and technologies in the areas of innovative development under the Program;
- benchmarking for the domestic and foreign markets;
- in the case of offers on the market, the organization of pilot implementation and test operation; in the case of no offers on the market, the organization of R&D, pilot implementation, and test operation.

The most efficient technologies or solutions may be included on the Uniform Technical Policy of PJSC “Rosseti” as basic technical solutions for use as part of a project for new construction or comprehensive rehabilitation upon receipt of certification from PJSC “Rosseti”.

4.4. Environmental Policy

The Environmental Policy of the Electric Grid Sector is subject to approval by the Board of Directors of the Company and governed by federal laws and other legal regulations of the Russian Federation and international commitments of the Russian Federation in the area of environmental protection. In its activities, the Rosseti Group ensures the use of the most promising requirements aimed at reducing environmental impacts and demonstrates and has all necessary mechanisms to prevent environmental risks.

4.4.1. The principal environmental goals of the Technical Policy shall be as follows:

- comply with requirements and standards in the area of environmental protection and environmental safety under the environmental laws of the Russian Federation and international regulations;

- conserve, reproduce, and efficiently use natural resources for the design, construction, rehabilitation, operation, and liquidation of electric grid facilities;

- limit production and construction activities in specially protected natural areas;

- make management and investment decisions with due consideration to the analysis and assessment of environmental consequences, and measures to reduce and prevent environmental impacts;

- use production processes with best available techniques and technical solutions, including innovative solutions, aimed at minimizing the impact of production activities on the environment;

- manage production and consumption waste and dismantled equipment in accordance with the applicable legal requirements of the Russian Federation.

4.4.2. Technologies and activities aimed at meeting the requirements in the area of environmental protection and environmental safety are as follows:

- phased decommissioning of equipment containing polychlorinated biphenyls to be replaced by environmentally safe equipment until 2025 and followed by its transfer for destruction to duly licensed specialist organizations;

- biodiversity conservation, including activities in the area of ornithological safety at electric grid facilities, including using self-supporting insulated wires that also make it possible to substantially reduce forest clearings and using higher towers with wires above valuable trees;

- construction of a system of SS oil receivers using modern technologies (including polymer coatings for oil receivers);

- land reclamation for sites of the construction, rehabilitation, technical upgrading, and operation of electric grid facilities;

- construction and rehabilitation of local treatment facilities for the purpose of minimizing impacts on water bodies.

4.4.3. In order to achieve environmental safety, it is necessary to implement the following measures:

- comply with the legal requirements of the Russian Federation and applicable LR, applicable regulatory documents, and contractual obligations in the area of environmental protection;

- ensure the operation and permanent improvement of the environmental management system in accordance with GOST R ISO 14001:2015;

- ensure the registration of negative environmental impacts, the improvement of industrial environmental control, and the use of precautionary measures to reduce negative impacts;

- provide systematic personnel training and improve competencies in environmental protection;

- provide free access to information related to environmental protection activities of electric grid companies.

4.4.4. As related to environmental protection, the design, construction, and rehabilitation of electric grid facilities shall meet the requirements and standards established by the environmental laws of the Russian Federation and international regulations in the area of environmental protection.

4.4.5. The construction and rehabilitation of electric grid facilities shall be in accordance with the approved design documents that have a positive regulatory audit opinion and, where required under the applicable laws, a positive regulatory environmental audit opinion at regional or federal level in compliance the environmental protection requirements, sanitary and building requirements, standards, and rules.

4.5. Energy Conservation and Energy Efficiency Enhancement

4.5.1. Energy conservation at an electric grid company is a system of organizational, legal, technical, technological, economic, and other measures aimed at reducing the amount energy consumption while maintaining the relevant useful effect of their use (including the quantities of products, work, and services).

Energy conservation at electric grid companies shall be achieved by implementing all of these measures, thus creating synergies.

Energy efficiency enhancement at electric grid companies is the improvement of the ratio between the useful effect of energy consumption and energy costs associated with achieving such effect in relation to products and production process.

Electric grid companies shall ensure the economically feasible efficiency of using energy resources with the existing level of engineering and technology development in compliance with environmental protection requirements.

4.5.2. The Technical Policy in the area of energy conservation and energy efficiency enhancement shall aim to comply with the legal requirements of the Russian Federation in the area of energy conservation and energy efficiency enhancement, provide comprehensive technical support for achieving the strategic goals and objectives of the Company in the area of energy conservation and energy efficiency enhancement, ensure the sustainable use of natural and energy resources (NER) for production and business activities.

4.5.3. The goals of this Technical Policy of the Company in the area of energy conservation and energy efficiency enhancement are as follows:

- reduce consumption of all types of NER, including reducing electricity network losses;

- achieve the targets and indicators of energy efficiency related to NER.

4.5.4. The achievement the Company's goals of energy conservation and energy efficiency enhancement is ensured by developing measures to meet the following objectives:

- decrease electricity losses in transmission and distribution grids;
- decrease energy consumption in production and administrative buildings and structures, including by using automated NER consumption control and management systems;
- decrease fuels and lubricants used by vehicles and special-purpose equipment for the Company's production and business activities;
- equip facilities with energy meters and organize the collection of information based on energy metering;
- set up and implement innovative demonstration projects ensuring the energy efficiency enhancement of electric grid facilities and facilities involved in production and business activities;
- conduct energy surveys with the development of activities aimed at the efficient use of energy resources;
- formulate and improve the Company's LRD relating to energy conservation and energy efficiency enhancement;
- build an energy conservation management system for electric grid companies by introducing (developing) energy management in accordance with international best practices and analyze and introduce advanced experience and technology;
- provide continuous training for personnel of electric grid companies in energy conservation and energy efficiency enhancement;
- formation customer's energy consumption culture;
- analyze and introduce advanced experience and best available techniques;
- use modern energy-efficient electrical equipment with standardized indicators of energy efficiency.

4.5.5. As part of ensuring energy conservation and maintaining high indicators of energy efficiency, it is necessary to create the conditions for saving not only electricity but also water, heat, and motor fuel.

4.5.6. With the aim of improving the efficiency of energy management, it is necessary to introduce energy management.

4.5.7. Energy management at electric grid companies shall be continuous, constantly declared in quarterly and annual reports, and mandatory.

4.5.8. As part of energy management, electric grid companies shall:

- form a team (working group) for energy management from among experienced employees and executives;

- identify the scope of applications and boundaries of the energy management system;

- formulate and approve the energy policy of an electric grid company to constantly comply with the principles of energy conservation and energy efficiency enhancement for reliable and high-quality power supply;

- formulate energy goals, objectives, and action plans in accordance with the development strategy of an electric grid company;

- create the register of process and energy-consuming equipment;

- establish the basic values of target performance indicators (energy characteristics) based on targets of the energy conservation and energy efficiency enhancement program of an electric grid company;

- compare actual technical characteristics of power equipment with the manufacturer's specifications and process requirements;

- update and expand the register of energy-consuming equipment (by adding smaller, previously unregistered items) every 1–2 years;

- tighten the energy efficiency and accuracy requirements for electrical equipment and perform process and production work every 2–3 years.

4.5.9. Electric grid companies shall constantly raise the share of implemented intelligent metering systems that comply with the Rules for Providing Access to the Minimum Set of Functions of Intelligent Electricity (Capacity) Metering Systems with electronic data collection and data processing by replacing existing electricity meters (primarily, integral meters) and creating new metering points equipped with intelligent metering systems. It is necessary to ensure that intelligent metering systems are used in combination with digital data analysis, constantly raising the share of work performed by AI-based software.

4.5.10. Standard energy conservation measures for electric grid companies:

- identify unbilled electricity consumption and analyze electricity balances;
- ensure the formation of correct net electricity delivery;
- provide optimal loads for transformers;
- control the power factor;
- use LED fixtures;
- use local lighting schemes;
- install automatic lighting on/off for SS SG and SS premises;
- install automatic heating on/off for SS equipment, SS SG, and maintenance rooms;
- use windows and enclosing structures with high thermal resistance (insulated walls, replaced doors and windows);
- optimize transportation routes and the loading of vehicles and special-purpose equipment;
- use natural lighting;

- use infrared heaters at SS;
- use electricity consumption control sensors;
- use the cross-sections of cables and wires specified in project documents;
- ensure even distribution of phase loads;
- minimize the number of connections;
- use SSIW and protected wires;
- use modern S/C protection devices;
- periodically control insulation resistance and check electrical contacts on electric grids;
- use frequency-controlled drives;
- use a new generation of current-limiting reactors.

4.5.11. Design documents for new construction and the rehabilitation of existing facilities shall include energy conservation measures in accordance with the requirements of Resolution of the Government of the Russian Federation No. 87 of February 16, 2008, “On the Sections of Design Documents and the Requirements for Their Contents” (Section 10 “Measures to Ensure compliance with Energy Efficiency Requirements”).

4.6. Import Substitution in the Electric Grid Sector

4.6.1. As a type of the government’s economic strategy and industrial policy, import substitution is aimed at replacing imported industrial goods in demand in the domestic market by domestically made goods.

4.6.2. Import substitution is a mechanism for innovative development for the energy and related industries and a mechanism for developing domestic power engineering, electrical engineering, and sectoral and fundamental science to ensure Russia’s technological security.

4.6.3. As related to import substitution, Resolution of the Government of the Russian Federation No. 719 of July 17, 2015, defines the requirements for industrial products in order to classify them as products manufactured in the Russian Federation, and Resolution of the Government of the Russian Federation No. 925 of September 16, 2016, specifies that goods of Russian origin shall have priority over goods produced in any foreign country.

4.6.4. Order of the Ministry of Industry and Trade of the Russian Federation No. 1327 of April 16, 2019, approved the Action Plan for Import Substitution in the Power Engineering, Electrical, and Cable Industries of the Russian Federation, which specifies priority groups of equipment and sets the target for the share of imported equipment in purchases by 2024.

4.6.5. The implementation of import substitution in the electric grid sector based on the improvement of domestic manufacturers’ competencies and technology transfer shall be achieved by:

- creating the conditions for providing EGF with modern domestic equipment;
- finding modern and innovative technologies necessary for the implementation of these Regulations and their transfer with the required level of localization for production and R&D.

4.6.6. The priority areas of technical policy on import substitution shall be as follows:

- minimize the use of imported equipment and materials for design solutions and technical specifications. The use of imported goods shall be substantiated by an appropriate feasibility study and shall be allowed in the absence of domestically made equivalents;
- ensure the typification of equipment used in the electric grid sector through the development and implementation of organization standards for electrical products in order to consider the production capabilities of domestic manufacturers and eliminate excessive requirements for equipment that lead to the need to purchase imported equipment;
- develop the localization of production of high-technology equipment and components within the Russian Federation.

5. Abbreviations

AU	:	accumulator unit
UPSU	:	uninterruptible power supply unit
ALT	:	automatic load transfer
DASU CBSC	:	dry arc-suppression unit with capacitor-based stepless control
AEMS	:	automated electricity metering system
AISEBM	:	automated information system of electricity billing metering
AISEM	:	automated information system of electricity metering
AISEID	:	automated information system of early icing detection
ASAOE	:	automatic system of asynchronous operation elimination
ARC	:	automatic reclosing
AFA	:	automatic fire alarm
WS	:	workstation
AOLVC	:	automatic on-load voltage control
ADS	:	automated dispatching system
ASC	:	asynchronous compensator

AMDS	:	automated monitoring and diagnostics system
PAS	:	process automation system
ACS	:	automated control system
APCS	:	automated process control system
ASEMFC	:	asynchronous electromechanical frequency converter
B/C	:	bank of capacitors
SCB	:	static capacitor bank
UAV	:	unmanned aerial vehicle
BT	:	booster transformer
SMC	:	secondary master clock
VC	:	videoconferencing
OL	:	overhead line
PWOL	:	protected-wire overhead line
IWOL	:	insulated-wire overhead line
HV	:	high voltage
FOCL	:	fiber-optic communication line
DCL	:	direct current link
VRG	:	vacuum reactor group
ISG	:	input switchgear
HTSC	:	high-temperature superconductivity
HTSBCL	:	high-temperature superconductivity–based current limiter
HF	:	high frequency
GIS	:	geographic information system
GFEA	:	gas fire-extinguishing agent
LPC	:	lightning protection cable
A-SC	:	arc-suppression coil
DGU	:	diesel generator unit
SDCs	:	subsidiaries and dependent companies that are engaged in electricity transmission and distribution and whose shares are held by PJSC "Rosseti"
DC	:	dispatching center
UNEG	:	Unified National (All-Russian) Electric Grid
UPS	:	United Power System
IDSG	:	indoor switchgear
IDTSS	:	indoor transformer substation
GD	:	grounding device
UPS	:	uninterruptible power source
MIS MP	:	measuring information system of measurement points
MIS	:	measuring system (measuring information system)

TCI	:	technical condition index
SD	:	switching device
CB	:	capacitor bank
OCL	:	overhead cable line
S/C	:	short circuit
CL	:	cable line
FASG	:	factory-assembled switchgear
A/I FASG	:	air-insulated factory-assembled switchgear (mixture of nitrogen (N_2) and oxygen (O_2))
SF6/I FASG	:	SF6-insulated factory-assembled switchgear
FA FASSG	:	front-accessible factory-assembled stationary switchgear
PTSS	:	package transformer substation
PQ	:	power quality
LAN	:	local area network
LRD	:	local regulatory documents of PJSC “Rosseti”
PL	:	power line
OI/AB	:	oil-immersed natural cooling/air-blast oil-immersed natural cooling
OI/AB/ABOF	:	oil-immersed natural cooling/air-blast oil-immersed natural cooling/air-blast oil-forced cooling
M&E	:	materials and equipment
MBMC	:	microprocessor-based multifunctional controller
IEC	:	International Electrotechnical Commission
R&D	:	research and development
LV	:	low voltage
LR	:	legal regulations
TSD	:	technical standard documents
LTSC	:	low-temperature superconductivity
ESD	:	energy storage device
L/G S/C	:	line-to-ground short circuit
SCADA	:	supervisory control and data acquisition
OPGW	:	optical power ground wire
OVS	:	overvoltage suppressor
HPF	:	hazardous production facility
SSCR	:	substation control room
R&O	:	regulations and orders of PJSC “Rosseti”
ODSG	:	outdoor switchgear
WECM	:	wholesale electricity and capacity market
OPC	:	operational process control

OPC EGF	:	operational process control of electric grid facilities
IPS	:	Integrated Power System
AECS	:	automatic emergency control system
I/S	:	industrial safety
O/S TCO	:	off-circuit tap-change operation
PVC	:	polyvinyl chloride
PQI	:	power quality index
CP	:	cable passage
FR	:	foam rubber
SS	:	substation
SHS	:	software and hardware package
GC	:	grid code
DR	:	disturbance recorder
DRP	:	disturbance recording process
G/L	:	guidelines
CCD A-SC	:	capacitor-controlled dry arc-suppression coil
RP	:	relay protection
LP	:	lightning protector
DSS	:	distribution substation
OLVC	:	on-load voltage control
RRL	:	radio relay link
DGC	:	distribution grid companies (SDCs of PJSC “Rosseti”)
DTSS	:	distribution transformer substation
SG	:	switchgear
RSB	:	relay switchboard
PDZ	:	power distribution zone
C/C	:	command center
UPSS	:	uninterruptible power supply system
APL	:	air pollution level
MD	:	measurement device
SSIW	:	self-supporting insulated wire
RPC	:	reactive power compensator
MV	:	medium voltage
TSS	:	time synchronization system
ADCS	:	auxiliary direct-current system
PAECS	:	public address and evacuation control system
CPB	:	combined process building
XLPE	:	cross-linked polyethylene
VC	:	voltage controller

DCCS	:	data collection and communication system
CN EGF	:	communications network of electric grid facilities
SCN	:	satellite communication network
STATCOM	:	static compensator based on voltage converters
SRPC	:	static reactive-power compensator
OS	:	organization standard
OSMS	:	occupational safety management system
PAAS	:	production asset administration system
SC EGF	:	situation control of electric grid facilities
TIC	:	thermal instrumentation and control
TPARC	:	three-phase automatic reclosing
T/AT	:	transformer/autotransformer
VT	:	voltage transformer
TO&M	:	technical operation and maintenance
TSS	:	transformer substation
TU&R	:	technical upgrading and rehabilitation
TRG	:	thyristor reactor group
AT	:	auxiliary transformer
CT	:	current transformer
FS	:	feasibility study
TER	:	fuel and energy resources
UPSD	:	uninterruptible power supply device
AD	:	access node
SPD	:	surge protection device
VHF	:	very high frequency
RPC	:	reactive-power compensator
SC	:	inductance series compensator of PL
IAPSD	:	intentional asynchronous pole-switching device
CBFP	:	circuit breaker failure protection
PIU	:	process interface unit
DCCD	:	data collection and communication device
CSC	:	controlled series compensator
UVI	:	ultraviolet inspection
CSR	:	controlled shunt reactor
FCD	:	filter-compensating device
FED	:	filter-equalizing device
MSS	:	main substation (stepdown substation) rated 35–110 (220)/6–20 kV
DAPC	:	data acquisition and processing center

TSC	:	Technical Supervision Center, a branch of PJSC “Rosseti”
NCC	:	network control center
P/D	:	partial discharge
Sh/R	:	shunt reactor
ADCDC	:	automatic direct-current distribution cabinet
DCSB	:	direct-current switchboard
ASB	:	auxiliary switchboard
EMC	:	electromagnetic compatibility
EGF	:	electric grid facilities
SCADA/DC	:	supervisory control and data acquisition of dispatching control
ADMS	:	advanced distribution management system
DMS	:	distribution management system
OMS	:	outage management system
CIM	:	common information model

Appendix 1

List of Regulatory Documents Containing Basic Terms and Definitions Related to the Electric Power Industry

• Federal Law No. 35-FZ of March 26, 2003, “On the Electric Power Industry”
• Federal Law No. 522-FZ of December 27, 2018, “On Amendments to Specific Legislative Acts of the Russian Federation in Connection with the Development of Electricity (Capacity) Metering Systems in the Russian Federation”
• Federal Law No. 123-FZ of July 22, 2008, “Technical Regulations for Fire Safety”
• Resolution of the Government of the Russian Federation No. 937 of August 13, 2018, “On the Approval of the Process Operation Rules for Electric Power Systems and on Amendments to Certain Resolutions of the Government of the Russian Federation”
• Resolution of the Government of the Russian Federation No. 1401 of December 19, 2016, “On the Comprehensive Defining of Technical and Economic Condition Indicators for Electric Power Facilities, Including Physical Deterioration and Energy Efficiency Indicators for Electric Grid Facilities and on the Monitoring of Such Indicators”
• Resolution of the Government of the Russian Federation No. 846 of October 28, 2009, “On the Approval of the Rules for Investigating into the Causes of Accidents in the Electricity Industry”
• Resolution of the Government of the Russian Federation No. 244 of March 2, 2017, “On the Improvement of the Reliability and Safety Requirements for Electric Power Systems and Electric Power Facilities and on Amendments to Certain Resolutions of the Government of the Russian Federation”
• Order of the Ministry of Energy of the Russian Federation No. 229 of June 19, 2003, “On the Approval of the Operating Rules for Electric Power Plants and Networks of the Russian Federation”
• Order of the Ministry of Energy of the Russian Federation No. 676 of July 26, 2017, “On the Approval of the Technique for Evaluating the Technical Condition of Primary Process Equipment and Power Lines of Power Plants and Electric Grids”
• Order of the Ministry of Energy of the Russian Federation No. 1013 of October 25, 2017, “On the Approval of the Reliability Requirements for Electric Power Systems and the Reliability and Safety Requirements for Electric Power Facilities and Power Receivers ‘Rules for Organizing the Maintenance and Repair of Electric Power Facilities’”

• Order of the Ministry of Energy of the Russian Federation No. 97 of February 13, 2019, "On the Approval of the Requirements for Communications Channels for the Operation of Relay Protection"
• Order of the Ministry of Energy of the Russian Federation No. 100 of February 13, 2019, "On the Approval of the Interaction Rules for Electricity Industry Entities and Electricity Consumers in Preparing, Assigning, and Performing Tasks of Setting up Relay Protection Devices"
• Order of the Ministry of Energy of the Russian Federation No. 101 of February 13, 2019, "On the Approval of the Requirements for Equipping Electric Power Facilities' Power Lines and Equipment Rated 110 kV and Above with Relay Protection Devices and Systems and for the Operating Principles of Relay Protection Devices and Systems"
• Order of the Ministry of Energy of the Russian Federation No. 630 of August 3, 2018, "On the Approval of the Reliability Requirements for Electric Power Systems and the Reliability and Safety Requirements for Electric Power Facilities and Power Receivers 'Guidelines for Energy System Resilience'"
• Order of the Federal Service for Technical and Export Control of the Russian Federation No. 31 of March 14, 2014, "On the Approval of the Information Protection Requirements for Automated Production and Process Control Systems of Critical Facilities, Potentially Hazardous Facilities, and Facilities That Are Extremely Hazardous to the Life and Health of People and the Environment"
• Order of the Ministry of Civil Defense, Emergencies and Disaster Relief of the Russian Federation No. 91 of February 24, 2009, "On the Approval of the Registration Form and Procedure for the Fire Safety Declaration"
• Order of the Ministry of Transport of the Russian Federation No. 262 of August 25, 2015, "On the Approval of the Federal Aviation Rules 'Requirements for Airfields Intended for the Takeoff, Landing, Taxiing, and Parking of Civil Aircraft'"
• Order of the Ministry of Industry and Trade of the Russian Federation No. 1327 of April 16, 2019, "On the Approval of the Action Plan for Import Substitution in the Power Engineering, Electrical, and Cable Industries of the Russian Federation"
• GOST R 57114-2016 *United power system and isolated power systems. Electric power systems. Operational dispatching control in power industry and operational technological control. Terms and definitions*
• GOST 19431-84 *Power and electrification. Terms and definitions*
• GOST R 55105-2012 *United power system and isolated working systems. Operative-dispatch management. Automatic emergency control of modes of power systems. Emergency control of power systems. Norms and requirements*
• GOST R 55438-2013 *United power system and isolated power systems. Operative-dispatch management. Relay protection and automation. Interaction of*

actors, consumers of electrical energy in creating (modernization) and the exploitation. General requirements

- GOST R 55608-2013 *United power system and isolated power systems. Operative-dispatch management. Switching in electrical facilities. General requirements*
- GOST R 55890-2013 *United power system and isolated power systems. Operative-dispatch management. Frequency control and control of active power. Norms and requirements*
- GOST R 56302-2014 *United power system and isolated power systems. Operative-dispatch management. Dispatch names of electric power facilities and equipment of electric power facilities. General requirements*
- GOST R 56303-2014 *United power system and isolated power systems. Operative-dispatch management. Normal connection diagrams of electric power facilities. General requirements of graphical presentation*
- Order of the Ministry of Energy of the Russian Federation No. 856 of August 16, 2019, "On the Approval of the Production Design Guidelines for AC Substations with Upper Voltages of 35–750 kV"
- Order of the Ministry of Energy of the Russian Federation No. 855 of August 16, 2019, "On the Approval of the Production Design Guidelines for Power Lines with Voltages of 35–750 kV"