8. ELECTRIC POWER SUPPLY SYSTEM

This Section provides an overview of the systems and components which serve to deliver the power generated by the plant and which assure that internal plant needs for electric power are met. The internal power supply must provide electric power to components of safety related systems for all conditions, this includes accident conditions and loss of off-site power events.

8.1 OFF-SITE POWER SYSTEM

Connections to external 330 kV power grids are provided using an open 330 kV switchyard. The plant is connected to the Lithuanian power grid using two transmission lines L-454 and L-453, 330 kV each, to the Belorussian power grid using three transmission lines L-450, L-452 and L-705, and to the Latvian power grid using one transmission line L-451.

Connections to external power grids at 110 kV are provided using the first section of the open 110 kV switchyard. The plant is connected to the Lithuanian power grid using one transmission line “Zarasai” 110 kV, and to the Latvian power grid using one transmission line L-632.

Connections between the open switchyards at 330 kV and 110 kV are established using two coupling auto-transformers AT-1 and AT-2, types ATDCTN-200000/330. Power of each autotransformer is equal to 200 MV·A. The autotransformers have a device for voltage regulation under load. The device type is RNOA-110/1000. 15 positions are provided to regulate voltage in a range (115 ± 6) kV.

The open 330 kV switchyard is designed using "4/3" principle (four circuit breakers per three connections) and consists of two sections. Circuit breakers are placed in two rows. The first section of the open switchyard 110 kV is designed using “Double system of buses with bypass” structure. The second section of open switchyard 110 kV is connected to the first section through two circuit breakers C101 and C102. The second section has the same design as the first one. The following transmission lines are connected to the second section: L-Vidzy, L-Opsa, L-Statyba, L-Dukštas. These transmission lines are intended for district power supplies, so they are not essential for electric power supply for the plant in-house operation.

Air circuit breakers of VNV-330/3150A type are used in the open 330 kV switchyard. Air circuit breakers of VVBK-110B-50/3150U1 type are used in open switchyard 110 kV. To supply power loads on voltage level 330 kV and 110 kV, aerial transmission lines are used. Electrical connections of external grids 110 and 330 kV are presented in Fig. 8.1.

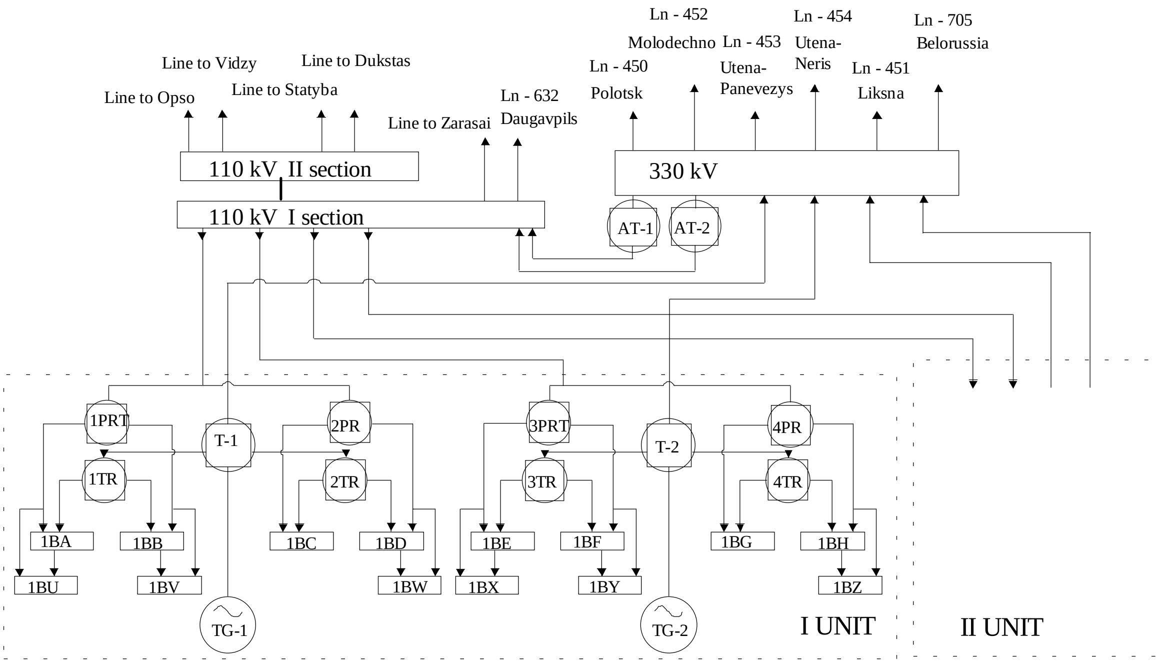

Fig. 8.1 Circuit diagram of power supply at units 1 and 2

AT-1, AT-2 - autotransformers 330/110 kV, T-1, T-2 main transformers, 1TR - 4TR - unit service transformers, 1PRT - 4PRT - unit auxiliary transformers, 1BA - 1BH - working buses (6 kV), 1BU - 1BZ - safety buses (6 kV), TG-1, TG-2 - turbogenerators

8.2 ON-SITE POWER SYSTEM

On-site power system includes normal and auxiliary power supply system for in-house operation, and also emergency power supply system. All loads are divided into three groups according to allowed power interruption time. Each group is also divided in subgroups according to a voltage level. Loads of the group I AC and DC power should not be interrupted at all or at most interrupted for intervals not exceeding 20 milliseconds. The most important components of the safety systems belong to this group (Emergency Core Cooling System (ECCS) and Auxiliary Feed Water System (AFWS) valves, Control and Protection System (CPS) logic, process protection logic, electric protection, etc.). For loads of the group II power interruption should not exceed several tens of seconds. This group encompasses the remaining components of the safety systems (ECCS and AFWS pumps, etc.). Components not belonging to these two categories are placed in group III. According to [61], they should have two independent power sources with automatic switchover provisions. They allow power interruption during automatic switchover and may not require power after reactor scram.

Normal and auxiliary power supply systems are divided into classes according to voltage level. There are three classes: 6 kV and 0.4 kV AC power and 220V DC power.

8.2.1 Normal Power Sources

Each turbine generator is connected to a step-up main transformer T-1 having windings of 24 kV, and T-2 using current conductor 24 kV mod. TEKNP-24-2400-560UI (see Fig. 8.1). Main transformer type is TC-1000000/330-69UI, and its power is equal to 1000 MV·A [62]. The windings at the high voltage of 330 kV of the main transformer is connected to the open switchyard 330 kV of Ignalina NPP by aerial transmission line by means of two circuit breakers.

Two unit service transformers for in-house operation of TRDNS-630000/35 type are connected to the current conductor of each turbine generator by joint connections of current conductors of TEKNE-24-10000-750UI type. Each unit service transformer has one winding of 24 kV and two windings of 6 kV, which are not connected to each other. Power of the 24 kV winding is equal to 63 MV·A, and power of each 6 kV winding is equal to 31.5 MV·A [62]. There are four unit service transformers 1TR, 2TR, 3TR, 4TR at one unit (see Fig. 8.1). The unit service transformer has a device for voltage regulation under load. Device type is SDV-41-1250. 19 positions are provided to regulate the voltage in a range (24 ± 9) kV [62].

One working bus 6 kV of normal power supply system is connected to each 6 kV winding of unit service transformers through two circuit breakers of VEM 6-3200 type and current conductor of TZMEP-10/3200-128 type. There are eight working buses 1BA, 1BB, 1BC, 1BD, 1BE, 1BF, 1BG, 1BH at one unit (see Fig. 8.1).

8.2.2 Auxiliary Power Supply

The auxiliary power supply system consists of the external power sources (off-site grids 110 kV and 330 kV), auxiliary transformers (four transformers per unit) of TRDCN-63000/110-75UI-1PRT, 2PRT and 3PRT type and of TRDCN-63000/110-4PRT. Power of the 110 kV windings is equal to 63 MV·A, and power of each of the two 6 kV windings, which are not connected to each other, is equal to 31.5 MV·A. The transformers have device for voltage regulation under load. Device type is PC-4. 19 positions are provided to regulate voltage in a range (110 ± 9) kV.

Using the current conductor (TZMEP-10/3200-128 type) only one working bus of 6 kV through circuit breaker of auxiliary connection (type VEM 6-3200) and one safety bus of 6 kV through circuit breaker (type VMPE-10) can be connected to one 6 kV winding of the auxiliary transformer (see Fig. 8.1). These connections are based on the principle that each auxiliary transformer backs up the corresponding unit service transformer. Auxiliary transformers are connected to different sections of the open switchyard 110 kV by two aerial transmission lines of 110 kV. Auxiliary transformers 1PRT and 3PRT are connected to the transmission line PRT-101 and auxiliary transformers 2PRT and 4PRT are connected to the transmission line PRT-102 by OD-110U/1000UI type breakers.

Switchover of power supply system to auxiliary power sources occurs in the following cases:

- if the voltage on the 6 kV bus fed through normal 6 kV connection decreases below 0.25 U_{nom} for more than 0.5 seconds,
- frequency decrease below 46 Hz for more than 0.5 seconds on at least one working 6 kV bus.

Switchover is allowed if the voltage level of the auxiliary power source exceeds 0.85 U_{nom}. If voltage of the 6 kV working buses decreases below 5.7 kV, operating procedures do not allow activation of power intensive loads.

8.2.2.1 6 kV Power Supply

Eight 6 kV working buses (1BA - 1BH) are provided for each unit of the Ignalina NPP. Each of these is connected to the unit service and auxiliary transformer. These working buses are used for power supply to high voltage electric motors and 6/0.4 kV transformers. The electromotor of each component obtaining power from a 250 kW to 5600 kW are connected individually to a power distribution device for in-house loads of working 6 kV buses in order to decrease the consequences of a bus failure. Redundant components related to turbine generators are connected to different power distribution assemblies for in-house loads to 6 kV working buses which normally take power from the working buses of another turbine generator.

During normal operation six 6 kV safety buses are connected to six 6 kV working buses through two circuit breakers (VMPE-10 type) in series (see Fig. 8.1). Maximum allowed current through the circuit breakers is equal to 1000 A.

8.2.2.2 0.4 kV Power Supply

Loads of the group III at an 0.4 kV voltage level take power from transformer assemblies (KTPSN-0.5 type), which are connected to 6 kV working buses through circuit breakers of VEM-6 or VMPE-10 type plus transformer and automatic circuit breaker "Electron" of E-16 type. The transformer assembly KTPSN-0.5 has two power sources: power from its own transformer and a standby one from a 0.4 kV safety bus.

Working and auxiliary 6/0.4 kV transformers are connected to different 6 kV working buses. Power of working and auxiliary 6/0.4 kV transformers is equal to 1000 kV·A. They refer to transformers of TSZSU-1000/10, TSZ-1000/10, TSZSA-1000/10 types with voltage regulation in the range (6±2) kV [62]. Voltage regulation is possible only during transformer maintenance.

The components requiring the most power are connected to transformer assemblies directly, namely the 0.4 kV electric motors with power demands of up to 160 kW, distribution buses for power supply to motor-operated valves, control cabinets, to components with power demands up to 10 kW and buses used for lighting.

During operation power supply to 6 kV and 0.4 kV loads is provided using unit service transformers, working 6/0.4kV transformers and connections of power distribution assemblies. The 6 kV circuit breakers of auxiliary 6/0.4 kV transformers are closed, and all 6 and 0.4 kV safety buses are at power and ready to be connected. If there is no power, to the junctions of the 6 kV or 0.4 kV busses, or to power distribution assemblies then the automatic switchover logic will switch on power distribution assemblies to auxiliary connection by automatic starting of the stand-by equipment. Power restoration time during switchover of bus 6 kV is not more than 1 second, of transformer assembly - not more than 2.5 seconds. Power interruption time during switchover of power distribution assemblies is determined by the operating time of control relays.

8.2.2.3 DC 220 V Normal Power Supply

The DC bus is intended to provide direct current for the following circuits: the control circuits of the automatic control and protection systems, the 6 kV and 0.4 kV buses, the emergency evacuation lighting in the main corridors and rooms, and the automatic control and protection of electric and process systems designed for common purposes.

During operation the DC bus takes power from a rectifier of TPPS-800 type, which is connected to a 6 kV safety bus through circuit breaker VMPE-10 and a cable connected to transformer 1BP07 (power 400 kV·A) of TSZ-400/10 type. The rectifier is connected to a DC bus by two cables through two automatic devices of ABM-10 type and to ±230 V buses of the I and III sections of the DC bus. The accumulating battery (type SK-60) is connected in parallel to the DC bus using two connections through two component commutators. Nominal battery capacity is 2160 A·hours. The battery consists of 122 cells. During normal operation 104 battery cells are connected to 220 V buses by a component commutator. ±242 V buses are intended to provide power for the solenoid drives of the 6 kV circuit breakers. These buses are connected to the I and III sections of the DC bus of 110 battery cells. During recharging of the battery the rectifier is connected to the recharging transformer (type 1BP17 of TSZ-400) through a circuit breaker of VMPE-10 type and a cable connected to a 6 kV working bus. Switchover of the rectifier from an additional charging transformer to a recharging transformer is made by the operator manually while both transformers are disconnected from the bus. Between the DC buses of unit 1 and unit 2 there are cable junctions which can be used for additional charging of accumulating batteries in case of failure of additional charging device or for power supply to loads of ± 230V in case of failure of the accumulating battery.

8.2.2.4 Cables

Cable lines from sections, assemblies and buses to consumers are housed in special cable rooms, cable wells, cable channels and placed on cable scaffold bridges. Directly close to consumers, cables are housed in corridors and process rooms. Cables are laid in cable shelves, cable trays and boxes.

Horizontal cable lines in rooms are split into cable compartments. Fire resistance limits for cable doors and cable barriers are above 0.75 hour; for safety system rooms they are above 1.5 hours. Vertical cable wells are split into compartments restricted by the building structure floors.

The 6 kV cables are laid on shelves or trays at a distance of a cable diameter from each other. The 0.4 kV cables and the control cables are laid separately. Standard cross-section cables having a diameter from 35 to 240 mm^2 are used. Vertical distance between shelves is above 250 mm, the distance between cable lines is above 700 mm. The 0.4 kV power cables are laid on shelves close together, and control cables are laid in bundles having a diameter no more than 100 mm.
In each 50 m strait section at the beginning and end of a cable line, on both sides of a barrier penetration cables are marked with tags. Cables are placed in lines in such a manner that cables for common end users are not laid in the same lines. Cable lines of different trains of safety systems are usually laid in different rooms. Only by exception it is permitted to lay cables of no more than two different safety trains in one room. In this event cables are laid on shelves of different walls in the room. Cable penetrations through walls must be separated by a distance above 500 mm.

To prevent initiation and propagation of fire cables are coated with a OPK type fire protection composition. The “Polistop” type or “Poliplast” type, provide fire resistance for up to 1.6 hour. Power cables are coated with the composition individually, and control cables - in bundles. Cable rooms and wells are equipped with an automatic fire alarm and an automatic fire extinguishing system. The alarm trips when there is a signal from a single sensor, and the automatic fire extinguishing water spray starts when there is a signal from two sensors.

8.2.3 Emergency Power Supply System

The system consists of two subsystems: a system of reliable power and a system of uninterruptible power.

8.2.3.1 Reliable Power Supply System

The system of reliable power comprises six independent trains. Each train consists of the following:

- 6 kV safety bus,
- independent emergency diesel generator,
- 0.4 kV safety buses,
- power distribution equipment.

<u>6 kV Power Grid of Reliable Power</u>

The grid includes six 6 kV safety buses 1BU, 1BV, 1BW, 1BY, 1BX, 1BZ. Each of the six safety buses is housed in a separate room, and has three incoming connections: connection to a working bus through two circuit breakers in series, connection to a diesel generator, and connection to a bus related to an auxiliary transformer (Fig. 8.2).

Electric motors of a 6 kV voltage level are connected to buses through circuit breakers and cables along with 6/0.4 kV step-down transformers providing power to 0.4 kV distribution buses of reliable power, additional 6/0.230 kV charging transformers, and rectifiers of uninterruptible power. Consumers are distributed in such a way that single purpose components are connected to different buses.

Each 6 kV safety bus has a control device for automatic switchover to auxiliary power sources. If either voltage on the bus decreases down to 0.5 U_{nom} or the frequency of the bus decreases down to 46 Hz for more than 1.5 seconds, then a control device for automatic switchover to auxiliary power sources starts the diesel generator. If the voltage level or frequency of the bus is not restored to normal, when the signal “DG ready” has been actuated, then the signal is generated to disconnect the following:

- loads of all reconnection steps except those, which can not be disconnected. All procedures of switchover to standby components are blocked (forbidden),
- both circuit breakers of working connection and circuit breaker of auxiliary connection (if it is has been on).

After disconnection of some loads the circuit breaker of the connection to the diesel generator is closed by an automatic switchover to auxiliary power sources, and loads which are still connected to the bus are restarted (I step of reconnection). After restart is completed for all loads at the I step of reconnection (time moment is determined automatically according to current decrease and voltage restoring) blocking of II step loads restart is canceled by automatic switchover to auxiliary power sources, and AFWS pumps are started by automatic switchover to auxiliary power sources. After full restarting of all loads at the II step of reconnection, which is determined according to current decrease and voltage restoring, blocking of III step loads restart is canceled by automatic switchover to auxiliary power sources, and auxiliary deaerator makeup pumps can be restarted then if necessary.

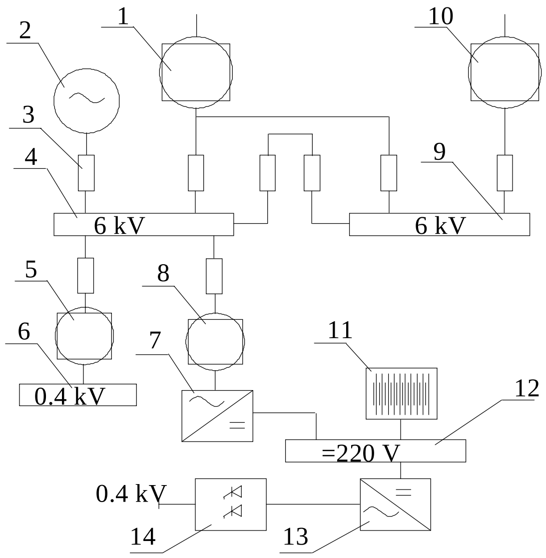

Fig. 8.2 Circuit diagram of emergency power supply system

1 - auxiliary transformer, 2 - diesel generator, 3 - 6 kV circuit breaker, 4 - safety bus (6 kV), 5 - 6/0.4 kV auxiliary transformer, 6 - safety bus (0.4 kV), 7 - rectifier, 8 - 6/0.23 kV recharging transformer, 9 - working bus (6 kV), 10 - service transformer, 11 - accumulator battery, 12 - DC buses, 13 - inverter, 14 - switch

Table 8.1 List of loads according to steps

Component	P_{nom}, kW	Step	Operational mode
Transformers of reliable power supply	1000	1	disconnection forbidden, operating
Pumps of control rod cooling circuit	250	1	disconnection forbidden, operating or in standby
Service water pumps	1600	1	disconnection forbidden, operating or in standby
AFWS pumps	800	2	in standby, start due to automatic start of standby equipment
ECCS pumps	800	2	in standby, start if necessary
ACS pumps	320	3	in standby, start if necessary
Deaerator auxiliary makeup pumps	500	3	in standby, start due to automatic start of standby equipment if lock is not actuated
Primary grade water pumps	320	3	in standby, start if necessary
Pumps of water fire extinguishing	250	3	in standby, start due to fire signal
Pumps of foam fire extinguishing	500	3	in standby, start due to fire signal
Pumps of purification and cooling system	500	3	in standby, start if necessary

Diesel Generator Control

Irrespective of how the diesel generator is started, the following procedure is observed:

- the start-up signal opens the electro-pneumatic valves of the compressed air start-up containers,
- compressed air starts up the diesel generator,
- fuel ignites and diesel generator commence operating.

Manual Start

Diesel generator can be started manually from the main control room or reserve control room, and also locally using the control cabinet in the diesel generator room. It is also possible to start all diesel generators by a group control switch for the group I equipment in the reserve control room.

Automatic Start

Automatic start can be initiated by the following three control devices:

- automatic switchover of unit loads to auxiliary power sources,
- turbine generator power drop control panel,
- automatic switchover of safety bus to auxiliary power sources.

Automatic Start Due To AZ-1 Signal

The signal to start all 6 diesel generators is generated by an automatic switchover of unit loads to auxiliary power sources due to an AZ-1 signal generated by any cause including a trip of turbine generators. This start is not related to voltage level in the 6 kV safety buses.

Automatic Start in Case of Loss of Off-Site Power

Automatic start of all six diesel generators occurs if there is a simultaneous voltage decrease on buses of the switchyard 110 kV and on 330 kV side of autotransformers AT-1 and AT-2 of open power distributing system of INPP down to 0.7 U_{nom} for more than 2 seconds, irrespective of reactor emergency protection operation. During a turbine trip and closure of steam regulating valves power drop control starts three diesel generators that can be connected to 6 kV safety buses, which normally are fed from tripped turbine generator. This start is provided independently from voltage level on these safety buses. Decrease of either voltage on 6 kV safety bus down to 0.5 U_{nom} or frequency on 6 kV safety bus down to 46 Hz for more than 1.5 seconds causes start of DG, which can be connected to this bus.

Table 8.2 The characteristics of diesel generator of ASD-5600 type [62]

Characteristic	Value
Maximum power without restrictions, kW	5600
nominal voltage, V	6300
Number of AC phase	three
Nominal frequency, Hz	50
Nominal rotational speed of the shaft, rpm	1000
Fuel consumption at full power, g/kWh	228
Specified operating time without interruption before the first diesel generator maintenance outage, h.	1600
Fuel reserve in the flow tank of every diesel, m^3	10
Fuel reserve in the outer tank of every diesel, m^3	100

In case of loss of off-site power two independent signals are generated to start the diesel generators:

- from the control device of the automatic switchover to auxiliary power sources of each 6 kV safety bus,
- due to loss of power in 6 kV working buses AZ-1 signal is actuated and automatic switchover of unit loads to auxiliary power sources actuates signal to start all six diesel generators.

Automatic Start In Case Of Simultaneous Loss Off-Site Power And Actuation of Reactor Scram

In case of simultaneous loss of off-site power and an actuation of the reactor emergency protection system three independent signals to start diesel generators are generated:

- from the control device of the automatic switchover of unit loads to auxiliary power sources due to the AZ-1 signal to start all six diesel generators,
- from the control device of the automatic switchover to auxiliary power sources of the 6 kV safety bus to start corresponding diesel generator,
- from a power drop control due to a trip of each turbine to start three diesel generators.

If connection of a diesel generator to the safety bus is not necessary (voltage and frequency on the bus do not decrease), then the diesel generator is switched off automatically in 25 seconds.

Reliable 0.4 kV Power Supply

Each 6 kV safety bus provides power to three 0.4 kV safety buses (transformer assemblies of KTPSN-0.5 type) through circuit breaker, cable and transformer (Fig. 8.2). There are 18 such 0.4 kV buses at one unit.

The 0.4 kV safety buses provide power to:

- electric motors with power from 40 to 160 kW of safety systems and most important electric motors of normal operation systems (oil pumps of turbine and sealing of main generator shaft, rotation of turbine shaft) through automatic circuit breakers of A3700 type with remote control,
- electric motors with power from 11 to 55 kW through automatic breakers and magnetic starters,
- working connections of power distribution assemblies of reliable power and auxiliary connections of power distribution assemblies of uninterruptible power, buses used for emergency lighting etc. through automatic circuit breakers with manual control. Power distribution assemblies of reliable power are intended for power supply to 0.4 kV drives with power bellow 10 kW of motor-operated valves of safety systems, for power supply to control circuits and communication equipment etc.

8.2.3.2 Uninterruptible Power Supply System

The system consists of six independent trains. Each train includes:

- accumulating batteries of SK-60 type with component commutator of 6352B/2 type,
- DC bus,
- uninterruptible power assemblies, which comprise rectifiers with an additional charging transformer and recharging transformer, inverters of PTS-200 type, thyristor switchover devices of TKEP type and thyristor switchover devices of TKEO type,
- power distribution assemblies of uninterruptible power.

Accumulating battery

The accumulating battery consist of 122 cells of the SK-60 type (S - stationary, K - for short-term discharge, 60 - battery number) [62]. An SK-60 cell consists of the following parts: jars, positive/negative plates, separators and electrolyte. Sulfuric acid solution in distilled water with the density of 1.18 g/cm^3 is used as electrolyte. Lead peroxide PbO_2 on positive plates, lead Pb on negative plates and electrolyte serve as active materials entering into electrochemical reactions. The plates are separated by acid-proof insulation which prevents them from closing onto each other. The plates of one sign are soldered to make a block. Blocks are placed in a tank filled with electrolyte. Wooden tanks lined with plastic are used in the EV01-EV07 batteries. The tanks are mounted on porcelain insulators. Cells joined together in series by lead joints make an accumulating battery.

All accumulating battery tanks are covered with glass to minimize electrolyte loss due to gas bubbles formed during charging and re-charging. The size of the glass cover is such that the gap between the edge of the glass and the tank walls amounts to 5-7 mm. Due to this gap the electrolyte present on the glass cannot drip into the casing or the racks.
Battery rooms are vented by independent in-flow and out-flow ventilation apertures to remove hydrogen and to maintain required temperature. Battery charging is terminated in the case the ventilation is not active.

DC Power Supply

DC buses in each train of the system are normally connected to TPPS-800 type rectifiers (Fig. 8.1), which are connected to 6 kV safety bus through VMPE-10 type circuit breakers and cables with transformers 1BR01(02-06) of TSZ-400/10 type (transformer power is equal to 400 kV·A, voltage - 6/0.23 kV). The rectifier is connected to a DC bus by two cables through two automatic ABM type devices to ±268 V buses of the I and III sections of the DC bus. A lead-acid accumulating battery of the SK-60 type is also connected in parallel to the DC bus using connection through component commutator. The characteristics of the rectifier of the TPPS-800 type are presented in Table 8.3 [62].

AC 380/220 V Uninterruptible Power Supply

There are no common buses of the uninterruptible power supply. Inverters (devices used to transform direct current to three-phase alternate current 380V 50Hz) of PTS-200 type are fed from buses ±268 V through automatic devices and cables. The main characteristics of PTS-200 type inverter are presented in Table 8.4 [62]. In the 1st, 2nd and 3rd trains there are 3 inverters connected, and in the 4th, 5th and 6th train there are 4 inverters connected in each train. Loads, which can not tolerate power interruption more than 0.02 seconds, are served from the output of inverters through a TKEP type and a TKEO type thyristor switchover device. Thyristor switchover device of the TKEP type has two incoming connections - a working connection from the inverter and an auxiliary connection from a 0.4 kV safety bus (Table 8.5) [62].

During normal operation inverters take power from TPPS-800 type rectifiers. In the case of loss of power, a connection inverter, takes power from an accumulating battery without additional switchover. The accumulating battery is under continuously charged during normal operation.

After the connection of diesel generator with a 6 kV safety bus the rectifier is automatically started, and it begins to charge the discharged battery, providing

Table 8.3 Main characteristics of the TPPS-800 type rectifier [62]

Characteristic	Value
Nominal output power, kW	200
Nominal rectified voltage, V	240
Nominal rectified current, A	800
Accuracy of voltage stabilization, %	2
Accuracy of current stabilization when charging battery, %	5
Regulation range of rectified voltage in case of power supplied from:	
additional charging transformer, V	190-290
recharging transformer, V	190-360
Regulation range for current stabilization, A	120-420
Output voltage ripple factor, no more than:	
- under nominal voltage and nominal load, %	8
- under nominal voltage and load 100 A, %	5
Air natural cooling	

power to the inverters. In the case of failure of the inverter, a TKEP type thyristor switchover device switches over to safety a 0.4 kV bus in 0.005 - 0.015 seconds if there is power on the bus. If there is power on both connections, then they are synchronized.

The TKEO type thyristor switchover device provides fast interruption of connection to a failed component. This is necessary to decrease the power interruption time for the other components connected to the same inverter. Interruption time is 0.015 seconds (Table 8.6).

Table 8.4 Main characteristics of inverter PTS-200 type [62]

Characteristic	Value
Input voltage, V	190-290
Output voltage, V	380-400
Output frequency, Hz	48.5-51.5
Nominal output current, A	200
Output power, kW	110
Total output power, kV·A	138
Efficiency under nominal conditions, %	87
Asymmetry of output voltage, V	8
Non-sinusoidness of linear voltage, %	5
Non-symmetry of phase loads, A, no more than	60
Air-natural cooling	

Table 8.5 Main characteristics of switching device TKEP-100 type [62]

Characteristic	Value
Nominal voltage, V	380
Nominal current, A	100
Maximum permissible time of overload in case of current value equal to:	
- $1.1 \cdot I_{nom}$, min, no more than	120
- $1.2 \cdot I_{nom}$, min, no more than	60
Air-natural cooling	

Table 8.6 Main characteristics of disconnecting device TKEO type [62]

Characteristic	Value

Nominal voltage, V		380
Nominal current, A		250
Maximum permissible time of overload in case of current value equal to:		
- $1.1 \cdot I_{nom}$, min, than	no more	2
- $1.6 \cdot I_{nom}$, min, than	no more	1
Disconnection time, ms, than	no more	15

All components of the safety systems are connected to different buses of reliable and uninterruptible power supply systems according to the permitted power interruption time.

8.2.4 Power Supply to Instrumentation and Control Systems

The system of power supply to instrumentation and control devices ensures operation of monitoring, recording and control devices, blocking devices, warning devices, emergency and preventive protections of main process equipment for all modes of unit operation. The power supply to instrumentation and control devices is designed in a way to provide power to all steady, transient and emergency modes of unit operation ensuring normal operation, limits and conditions of safe operation, equipment availability and optimization of working parameters.

Power Supply of Reactor Control and Protection System

Control cabinets of the reactor control and protection system are fed from six power distribution assemblies. Each power distribution assembly has two incoming connections for the automatic starting of standby equipment. A connection is made to one train of uninterruptible power supply system, and an auxiliary connection - to another train of uninterruptible power supply system. Control cabinets of control rod drives are fed from six power distribution assemblies. Each power distribution assembly has two incoming connections for the automatic starting of standby equipment. Connections of three power distribution assemblies are made to one train of uninterruptible power supply system, and working connections of the other three - to another train of uninterruptible power supply system. Auxiliary connections are made to corresponding train of the reliable power supply system.

Drives, selsyns of control rod drives and selsyns of position indicators are fed from the power distribution assemblies. Connection of power distribution assemble is made to a corresponding train of uninterruptible power supply, an auxiliary connection is made to a corresponding train of the reliable power supply.

Power Supply of Control Cabinets of Functional and Group Control

Control of the main systems of the plant (process protection devices of reactor, main circulation circuit, emergency core cooling system, accident confinement system and control rod cooling circuit, automatic and blocking devices of main circulation pumps and other) is provided via control cabinets of functional and group control.

Components, which are necessary for the emergency cooldown of the reactor, can be controlled from both the main and the reserve control rooms. There are two sets of control cabinets. Each set consists of six trains. Each train is connected to a corresponding train of uninterruptible power supply system, and an auxiliary connection is made to a corresponding train of reliable power supply.

A system to switch the control function to the reserve control room is powered by 220 V DC coming from the accumulating batteries. Each of the six circuits is connected to a corresponding train of the uninterruptible power supply system.

To ensure functional and group control of the equipment signals from instrumentation, control devices and protection devices are directed to the control cabinets. Also feedback signals re component status are provided to the control cabinets.

Power Supply to Instrumentation and Control Devices

The power distribution buses for the instrumentation and control devices have two incoming connections for the automatic starting of standby equipment. The buses are connected to the corresponding train of the uninterruptible power supply system. Auxiliary connections are made to either the corresponding train of uninterruptible power supply system or to the train of the reliable power supply system.

Power Supply to Process Protection Buses

Power distribution buses for process protections are connected to one of the trains of the uninterruptible power supply system and with a corresponding train of the reliable power supply system through an auxiliary connection. However, process protection systems of the main circulation circuit are connected to the uninterruptible power supply system through auxiliary connections.

Power Supply to the Information Computer System

The information computer system is fed from nine distribution buses. Each bus has two incoming connections, and the connections of each bus also have two incoming connections for automatic starting of the stand-by equipment using a TKEP type thyristor switchover device.

All six trains are connected to the uninterruptible power supply system, and three trains provide power for two distribution buses using different TKEP type thyristor switchover devices. Auxiliary connections are made to all six trains of the uninterruptible power supply system, and three trains provide power for two distribution buses. Switchover of power supply from standard to auxiliary connections is performed manually by operators.

Power Supply to Fire Extinguishing Equipment

The power supply for the fire extinguishing equipment is provided through two connections for automatic starting of standby equipment. Both units are connected to the uninterruptible power supply system. Auxiliary connections are made to the reliable power supply system on unit 1, and with the uninterruptible power supply system on unit 2.

Power Supply to the Communication Network

Power for the communication network of the main control room and the central control room is supplied through two connections using automatic starting of standby equipment. Buses of the communication network of the main control room and the central control room are connected to the uninterruptible power supply system, and working connections of the other communication network are made to the reliable power supply system. Auxiliary connections are made to the reliable power supply system.

Power Supply to Radiation Monitoring Equipment

Power to the control panel of the radiation monitoring equipment is supplied using two connections to the reliable power supply system. There is an automatic start of standby equipment for these connections. Power to the equipment used for radiation monitoring is supplied through two connections to automatic start of standby equipment. Working connections are made to either uninterruptible power supply system or reliable power supply system. Auxiliary connections are made to either reliable power supply system or normal power supply system accordingly.